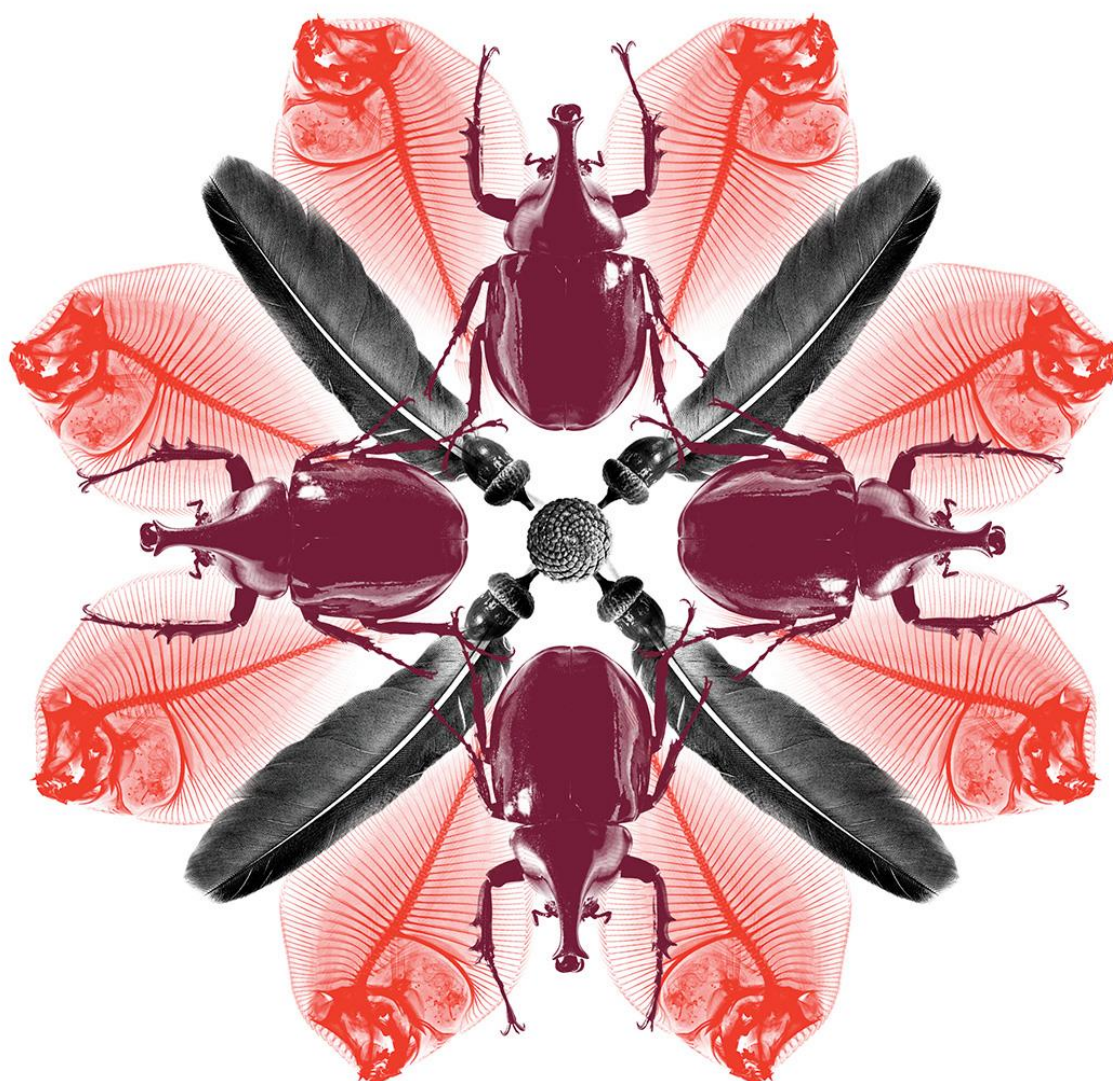




Australian Government
Department of Agriculture

Final review of import conditions for brassicaceous vegetable seeds for sowing

September 2019



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Acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
ALOP	Appropriate level of protection
BIRA	Biosecurity Import Risk Analysis
FAO	Food and Agriculture Organization of the United Nations
IPC	International Phytosanitary Certificate
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NSW	New South Wales
NPPO	National Plant Protection Organisation
NT	Northern Territory
PCR	Polymerase Chain Reaction
PRA	Pest risk analysis
SPS Agreement	WTO agreement on the Application of Sanitary and Phytosanitary Measures
the department	The Department of Agriculture
USD	United States Dollar
WTO	World Trade Organization

Summary

Australia depends heavily on imported seeds to produce a wide range of crops, including vegetables, and imports large quantities of these seeds annually.

The distributions of seed-borne pathogens are expanding globally and new risks continually emerge. The vegetable seeds trade has become globalised and is evolving—seed lines are usually developed, commercially multiplied and processed in various countries rather than at a single origin. Therefore, the risks of seeds' exposure to new pathogens and that these pathogens may enter Australia via imported seeds has increased.

Acknowledging the change in risk profile associated with this trade, the department is undertaking a series of seed reviews of the import conditions for four key vegetable families: Apiaceae, Cucurbitaceae, Brassicaceae and Solanaceae. These reviews were funded by the Australian Government's Agricultural Competitiveness White Paper and are one means by which Australia is strengthening biosecurity surveillance and analysis. This review of brassicaceous vegetable seeds for sowing is the first of the series finalised.

Under Australia's existing import policy, all seeds for sowing, including brassicaceous vegetable seeds are subject to the department's standard import conditions. However, this review of import conditions identified two quarantine pests associated with the seeds of several brassicaceous vegetables.

Colletotrichum higginsianum is seed-borne in:

- *Brassica rapa*
- *Raphanus sativus*.

Fusarium oxysporum f. sp. *raphani* is seed-borne in:

- *Eruca vesicaria*
- *Raphanus sativus*.

The unrestricted risks of these quarantine pests on the seeds for sowing pathway do not achieve the appropriate level of protection (ALOP) for Australia. Consequently, additional pest risk management measures are required to mitigate the risk posed by the identified quarantine pests to achieve the ALOP for Australia.

In addition to the department's standard seeds for sowing import conditions, four pest risk management options (see Chapter 4) are recommended for *Brassica rapa*, *Eruca vesicaria* and *Raphanus sativus*:

- Option 1. Broad spectrum fungicidal treatment—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.
- Option 2. Heat treatment—to manage the risk of *Colletotrichum higginsianum* only.
- Option 3. Polymerase Chain Reaction (PCR) test—to manage the risk of *Fusarium oxysporum* f. sp. *raphani* only.

- Option 4. Heat treatment and PCR test combined—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.

If the required treatment or testing is undertaken off-shore, phytosanitary certification is required with the additional declaration that the testing or treatment has been conducted in accordance with Australia's requirements.

Brassica rapa, *Eruca vesicaria* and *Raphanus sativus* seeds for sprouting or micro-greens production for human consumption are exempt from these additional measures if imported directly for germination at a production facility operated under an Approved Arrangement. This is to mitigate risks from the diversion of seeds to other end-uses.

Alternatives to testing or treatment, such as sourcing seed from pest-free areas or pest-free places of production, or sourcing seed produced under a systems approach, may be considered. However, supporting documentation demonstrating pest free area status, pest free place of production status, or details of a proposed systems approach will be required for the department to consider these options on a case-by-case basis.

Seeds of most brassicaceous vegetable species reviewed were not found to be hosts of quarantine pests for Australia and they will continue to be subject only to the department's standard seeds for sowing import conditions.

Comments raised by stakeholders on the 'Draft review of import conditions for brassicaceous crop seeds for sowing into Australia' were taken into consideration in the preparation of the final report (responses are presented in Appendix 2).

The key changes made in the final report are:

- The inclusion of other pest risk management options (heat treatment and PCR testing) that are suitable for both organic and non-organic seeds sectors
- The removal of measures previously proposed for *Brassica oleracea* due to insufficient evidence for *Colletotrichum higginsianum* to be considered seed-borne in this host.

The department considers that the pest risk management measures recommended in this review will mitigate the risks posed by the identified quarantine pests associated with brassicaceous vegetable seeds to a level that achieves the ALOP for Australia.

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The risk analysis process is an important part of Australia's biosecurity policy development. It enables the Australian Government to formally consider the level of biosecurity risk that may be associated with proposals to import goods into Australia. If the biosecurity risks do not achieve the appropriate level of protection (ALOP) for Australia, risk management measures are recommended to reduce the risks to an acceptable level. If the risks cannot be reduced to an acceptable level, the goods will not be imported into Australia until suitable measures are identified or developed.

Successive Australian Governments have maintained a stringent, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of the ALOP for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's risk analyses are undertaken by the Department of Agriculture using technical and scientific experts in relevant fields and involves consultation with stakeholders at various stages during the process.

Risk analyses may take the form of a biosecurity import risk analysis (BIRA) or a review of biosecurity import requirements (such as scientific reviews of existing policy and import conditions, pest-specific assessments, weed risk assessments, biological control agent assessments or scientific advice).

Further information about Australia's biosecurity framework is provided in the *Biosecurity Import Risk Analysis Guidelines 2016* located on the [Department of Agriculture](#) website.

1.2 This risk analysis

1.2.1 Background

Seeds are essential to the agri-food system, with the global commercial seed market valued at around 48.5 billion USD in 2015 (Bonny 2017; IIGB 2016). Safe seed trade demands appropriate phytosanitary measures.

The global vegetable seed sector has evolved through several waves of expansion, consolidation and technological innovation (Bonny 2017; Bruins 2009). It operates inter-continental and counter-seasonal production cycles with extensive pathways for exchange of seeds, which range from small lots for breeding or selection purposes to commercial wholesale and retail supplies. Processes such as seed multiplication, conditioning (drying, cleaning, sorting, priming and coating), testing and packing occur on a global scale. Frequently, these activities are sub-contracted in regions with relatively lower production costs and often occur over lengthy periods (IIGB 2016).

The increasing globalisation of the vegetable seed trade and changing seed industry production practices have increased the risk of the introduction of seed-borne pathogens to new areas. Illustrating the risk to Australia, *Cucumber green mottle mosaic virus* was detected in 22 of 631 test samples of cucurbit seeds intended to enter Australia from Europe, the Middle East, Africa and North, Central and South America (Constable et al. 2018). Similarly, tomato and capsicum seeds intended to enter Australia from 18 countries have tested positive for the presence of pospiviroids (Constable et al. 2019).

Acknowledging the change in risk profile, the department is undertaking an extensive review of the existing import conditions for vegetable seeds including those for brassicaceous vegetables. The analysis is being conducted as a review of import conditions, consistent with the *Biosecurity Act 2015*, to assess the biosecurity risks associated with seeds being imported into Australia. The review of the seed pathway for several commodity groups, including brassicaceous vegetables, was funded under the Australian Government's Agricultural Competitiveness White Paper and is one means by which Australia is strengthening its biosecurity.

1.2.2 Scope

The family Brassicaceae (Cruciferae) has 338 genera with a total of about 3,700 species (Mabberley 2008). The taxonomy of brassicaceous crops is complex, and the physical characteristics and uses of individual species can vary widely, as evidenced in Table 1.

It should be noted that the scope of this review is limited to seeds used for production of brassicaceous vegetable commodities, and excludes, for example, those species used for production of ornamental plants and cut flowers (e.g. *Alyssum* species, *Matthiola* species), and species used as oilseed crops such as *Brassica napus*.

This review aims to:

- identify the pathogens associated with seeds of the brassicaceous vegetables listed in Table 1
- evaluate the effectiveness of the existing risk management measures for these pathogens
- recommend additional risk management measures, where necessary.

Table 1 Brassicaceous vegetables under review

Scientific name	Synonyms or subordinate taxa	Common name
<i>Armoracia rusticana</i> G. Gaertn. et al.	<i>Armoracia lapathifolia</i> Gilib. ex Usteri; <i>Cochlearia armoracia</i> L.; <i>Nasturtium armoracia</i> (L.) Fr.; <i>Radicula armoracia</i> (L.) B.L. Rob.; <i>Rorippa armoracia</i> (L.) Hitchc.	Horseradish, Cran
<i>Barbarea verna</i> (Mill.) Asch.	–	Early winter-cress, Scurvy-grass, Upland cress
<i>Barbarea vulgaris</i> W.T. Aiton	–	Bitter cress, Yellow rocket, Winter rocket, Rocket cress

Scientific name	Synonyms or subordinate taxa	Common name
<i>Brassica carinata</i> A. Braun	<i>Brassica juncea</i> var. <i>agrestis</i> Prain; <i>Brassica juncea</i> var. <i>cuneifolia</i> Prain	Abyssinian cabbage, Abyssinian mustard, Ethiopian rapeseed, Ethiopian kale
<i>Brassica elongata</i> Ehrh.	<i>Brassica elongata</i> subsp. <i>integrifolia</i> (Boiss.) Breistre.; <i>Brassica elongata</i> subsp. <i>pinnatifida</i> (Schmalh.) Greuter & Burdet; <i>Brassica elongata</i> subsp. <i>subscaposa</i> (Maire & Weiller) Maire; <i>Brassica elongata</i> var. <i>integrifolia</i> Boiss.; <i>Brassica elongata</i> var. <i>pinnatifida</i> Schmalh.; <i>Brassica subscaposa</i> Maire & Weiller	Elongated mustard, Long-stalk rape
<i>Brassica juncea</i> (L.) Czern.	<i>Brassica besseriana</i> Andr. ex Trautv.; <i>Brassica integrifolia</i> (H. West) Rupr.; <i>Brassica japonica</i> (Thunb.) Siebold ex Miq.; <i>Brassica juncea</i> subsp. <i>rugosa</i> (Roxb.) Prain; <i>Brassica juncea</i> var. <i>crispifolia</i> L.H. Bailey; <i>Brassica juncea</i> var. <i>integrifolia</i> (Stokes) Sinskaya; <i>Brassica juncea</i> var. <i>japonica</i> (Thunb.) L.H. Bailey; <i>Brassica juncea</i> var. <i>juncea</i> ; <i>Brassica juncea</i> var. <i>megarrhiza</i> Tsen & S.H. Lee; <i>Brassica juncea</i> var. <i>multiceps</i> Tsen & S.H. Lee; <i>Brassica juncea</i> var. <i>napiformis</i> (Pailleux & Bois) Kitam.; <i>Brassica juncea</i> var. <i>oleifera</i> Prain; <i>Brassica juncea</i> var. <i>rugosa</i> (Roxb.) Prain; <i>Brassica juncea</i> var. <i>tsatsai</i> Z.I. Mao; <i>Brassica juncea</i> var. <i>tumida</i> Tsen & S.H. Lee; <i>Brassica napiformis</i> (Pailleux & Bois) L.H. Bailey; <i>Brassica rugosa</i> (Roxb.) L.H. Bailey; <i>Sinapis japonica</i> Thunb.; <i>Sinapis juncea</i> L.; <i>Sinapis juncea</i> var. <i>napiformis</i> Pailleux & Bois; <i>Sinapis rugosa</i> Roxb.	Brown mustard, Chinese mustard, Indian mustard, Jie cai, Vegetable mustard
<i>Brassica nigra</i> (L.) W.D.J. Koch	<i>Brassica nigra</i> var. <i>abyssinica</i> A. Braun; <i>Sinapis nigra</i> L.	Black mustard
<i>Brassica oleracea</i> L.	<i>Brassica alboglabra</i> L.H. Bailey; <i>Brassica cauliflora</i> Garsault; <i>Brassica caulorapa</i> (DC.) Pasq.; <i>Brassica gongylodes</i> (L.) Mill.; <i>Brassica oleracea</i> var. <i>acephala</i> DC.; <i>Brassica oleracea</i> var. <i>alboglabra</i> (L.H. Bailey) Musil; <i>Brassica oleracea</i> var. <i>botrytis</i> L.; <i>Brassica oleracea</i> var. <i>bullata</i> DC.; <i>Brassica oleracea</i> var. <i>capitata</i> L.; <i>Brassica oleracea</i> var. <i>caulorapa</i> DC.; <i>Brassica oleracea</i> var. <i>conica</i> DC.; <i>Brassica oleracea</i> var. <i>costata</i> DC.; <i>Brassica oleracea</i> var. <i>gemmifera</i> DC.; <i>Brassica oleracea</i> var. <i>gongylodes</i> L.; <i>Brassica oleracea</i> var. <i>italica</i> Plenck; <i>Brassica oleracea</i> var. <i>rubra</i> L.; <i>Brassica oleracea</i> var. <i>sabauda</i> L.; <i>Brassica oleracea</i> var. <i>sabellica</i> L.; <i>Brassica oleracea</i> var. <i>trunchuda</i> L.H. Bailey; <i>Brassica oleracea</i> var. <i>viridis</i> L.	Broccoli, Brussel sprouts, Cabbage, Cabbage turnip, Cauliflower, Chinese broccoli, Kale, Kai-lan, Kohlrabi, Collard greens, Savoy cabbage, Sukuma wiki
<i>Brassica rapa</i> L.	<i>Brassica campestris</i> L.; <i>Brassica campestris</i> subsp. <i>campestris</i> L.; <i>Brassica campestris</i> subsp. <i>chinensis</i> (L.) Makino; <i>Brassica campestris</i> subsp. <i>rapifera</i> (Metzg.) Sinskaya; <i>Brassica campestris</i> var. <i>dichotoma</i> (Roxb.) G. Watt; <i>Brassica campestris</i> var. <i>purpurea</i> L.H. Bailey; <i>Brassica campestris</i> var. <i>rapa</i> (L.) C. Hartm.; <i>Brassica campestris</i> var. <i>sarson</i> Prain; <i>Brassica campestris</i> var. <i>toria</i> Duthie & J.B. Fuller; <i>Brassica chinensis</i> L.;	Bird's rape mustard, Bok choy, Chinese cabbage, Chinese flat cabbage, Choisum, Indian rape, Italian kale, Mizuna, Napa cabbage, Pak-choi,

Scientific name	Synonyms or subordinate taxa	Common name
	<i>Brassica dubiosa</i> L.H. Bailey; <i>Brassica narinosa</i> L.H. Bailey; <i>Brassica nipposinica</i> L.H. Bailey; <i>Brassica oleracea</i> var. <i>chinensis</i> (L.) Prain; <i>Brassica parachinensis</i> L.H. Bailey; <i>Brassica pekinensis</i> (Lour.) Rupr.; <i>Brassica perviridis</i> (L.H. Bailey) L.H. Bailey; <i>Brassica pe-tsai</i> L.H. Bailey; <i>Brassica purpurea</i> (L.H. Bailey) L.H. Bailey; <i>Brassica rapa</i> subsp. <i>campestris</i> (L.) A.R. Clapham; <i>Brassica rapa</i> subsp. <i>chinensis</i> (L.) Hanelt; <i>Brassica rapa</i> subsp. <i>chinensis</i> var. <i>parachinensis</i> (L.H. Bailey) Hanelt; <i>Brassica rapa</i> subsp. <i>chinensis</i> var. <i>purpuraria</i> (L.H. Bailey) Kitam.; <i>Brassica rapa</i> subsp. <i>dichotoma</i> (Roxb.) Hanelt; <i>Brassica rapa</i> subsp. <i>narinosa</i> (L.H. Bailey) Hanelt; <i>Brassica rapa</i> subsp. <i>nipposinica</i> (L.H. Bailey) Hanelt; <i>Brassica rapa</i> subsp. <i>nipposinica</i> var. <i>perviridis</i> L.H. Bailey; <i>Brassica rapa</i> subsp. <i>pekinensis</i> (Lour.) Hanelt; <i>Brassica rapa</i> subsp. <i>rapa</i> ; <i>Brassica rapa</i> subsp. <i>rapifera</i> Metzg.; <i>Brassica rapa</i> subsp. <i>sarson</i> (Prain) Denford; <i>Brassica rapa</i> subsp. <i>trilocularis</i> (Roxb.) Hanelt; <i>Brassica rapa</i> var. <i>amplexicaulis</i> Y. Tanaka & Ono; <i>Brassica rapa</i> var. <i>campestris</i> (L.) Peterm.; <i>Brassica rapa</i> var. <i>chinensis</i> (L.) Kitam.; <i>Brassica rapa</i> var. <i>dichotoma</i> (Roxb.) Kitam.; <i>Brassica rapa</i> var. <i>narinosa</i> (L.H. Bailey) Kitam.; <i>Brassica rapa</i> var. <i>rapa</i> ; <i>Brassica rapa</i> var. <i>septiceps</i> L.H. Bailey; <i>Brassica rapa</i> var. <i>sylvestris</i> Briggs; <i>Brassica rapa</i> var. <i>trilocularis</i> (Roxb.) Kitam.; <i>Brassica septiceps</i> (L.H. Bailey) L.H. Bailey; <i>Brassica trilocularis</i> (Roxb.) Hook. f. & Thomson; <i>Sinapis dichotoma</i> Roxb.; <i>Sinapis glauca</i> Roxb.; <i>Sinapis pekinensis</i> Lour.; <i>Sinapis trilocularis</i> Roxb.	Tendergreen, Turnip, Turnip greens
<i>Crambe abyssinica</i> Hochst. ex R. E. Fr.	–	Abyssinian Kale, Crambe
<i>Crambe cordifolia</i> Steven	–	Colewart, Greater sea-kale
<i>Crambe maritima</i> L.	–	Crambe, Scurvy-grass, Sea kale
<i>Crambe tatarica</i> Sebeók	–	Tartar Bread Plant
<i>Eruca vesicaria</i> (L.) Cav.	<i>Brassica eruca</i> L.; <i>Brassica erucoides</i> Roxb.; <i>Brassica vesicaria</i> L.; <i>Eruca longirostris</i> Uechtr.; <i>Eruca sativa</i> Mill.; <i>Eruca sativa</i> subsp. <i>longirostris</i> (Uechtr.) Jahand. & Maire; <i>Eruca stenocarpa</i> Boiss. & Reut.; <i>Eruca vesicaria</i> subsp. <i>sativa</i> (Mill.) Thell.	Arugula, Rocket, Roquette, Salad rocket
<i>Eutrema wasabi</i> (Siebold) Maxim.	<i>Cochlearia wasabi</i> Siebold; <i>Eutrema japonicum</i> (Miq.) Koidz.; <i>Lunaria japonica</i> Miq.; <i>Wasabia japonica</i> (Miq.) Matsum.; <i>Wasabia pungens</i> Matsum.; <i>Wasabia wasabi</i> (Maxim.) Makino.; <i>Lunaria japonica</i> Miq.	Japanese-horseradish, Wasabi
<i>Lepidium campestre</i> (L.) W. T. Aiton	<i>Thlaspi campestre</i> L.	Field cress, Field peppergrass

Scientific name	Synonyms or subordinate taxa	Common name
<i>Lepidium meyenii</i> Walp.	<i>Lepidium peruvianum</i> G. Chacon de Popovici	Peruvian ginseng, Maca
<i>Lepidium perfoliatum</i> L.	–	Clasping pepperweed
<i>Lepidium ruderae</i> L.	–	Narrow-leaf pepperwort
<i>Lepidium sativum</i> L.	–	Garden cress, Pepperwort, Rashad, Tongue cress
<i>Lepidium squamatum</i> Forssk.	<i>Cochlearia coronopus</i> L.; <i>Coronopus squamatus</i> (Forssk.) Asch.	Crowfoot, Greater swine cress, Swine-cress
<i>Lepidium virginicum</i> L.	<i>Lepidium intermedium</i> var. <i>pubescens</i> Greene; <i>Lepidium medium</i> Greene; <i>Lepidium menziesii</i> DC.; <i>Lepidium virginicum</i> var. <i>medium</i> Greene; <i>Lepidium virginicum</i> var. <i>menziesii</i> (DC.) C.L. Hitch.; <i>Lepidium virginicum</i> var. <i>pubescens</i> (Greene) Thell.	Poor-man's pepperweed, Virginia pepperweed
<i>Nasturtium microphyllum</i> Boenn. ex Rchb.	<i>Rorippa microphylla</i> (Boenn. ex Rchb.) Hyl. ex A. Love & D. Love	One-row watercress
<i>Nasturtium officinale</i> W.T. Aiton	<i>Radicula nasturtium</i> Cav.; <i>Radicula nasturtium-aquaticum</i> (L.) Rendle & Britten; <i>Rorippa nasturtium</i> Beck; <i>Rorippa nasturtium-aquaticum</i> (L.) Hayek; <i>Sisymbrium nasturtium</i> (Moench) Willd.; <i>Sisymbrium nasturtium-aquaticum</i> L.	Watercress
<i>Raphanus sativus</i> L.	<i>Raphanus caudatus</i> L.; <i>Raphanus sativus</i> var. <i>caudatus</i> (L.) Hook. F. & T. Anderson; <i>Raphanus sativus</i> var. <i>longipinnatus</i> L.H. Bailey; <i>Raphanus sativus</i> var. <i>niger</i> (Mill.) J. Kern.; <i>Raphanus sativus</i> var. <i>oleiferus</i> Stokes; <i>Raphanus sativus</i> var. <i>oleiformis</i> Pers.	Chinese radish, Daikon, Garden radish, Luo bo, Radish, Black radish, Tail-pod radish
<i>Rorippa islandica</i> (Oeder) Borbas	–	Marsh cress, Yellow-watercress
<i>Rorippa palustris</i> (L.) Besser	<i>Rorippa islandica</i> auct.; <i>Sisymbrium amphibium</i> var. <i>palustre</i> L.	Marsh cress, Marsh yellow cress, Yellow water cress
<i>Sinapis alba</i> L.	<i>Brassica alba</i> (L.) Rabenh.; <i>Brassica hirta</i> Moench; <i>Sinapis alba</i> cv. <i>melanosperma</i> Alef.; <i>Sinapis alba</i> subsp. <i>alba</i> L.; <i>Sinapis alba</i> subsp. <i>dissecta</i> (Lag.) Simonk.; <i>Sinapis dissecta</i> Lag.	White mustard, Yellow mustard, Mustard
<i>Sinapis arvensis</i> L.	<i>Brassica arvensis</i> (L.) Rabenh.; <i>Brassica kaber</i> (DC.) L.C. Wheeler; <i>Brassica kaber</i> var. <i>pinnatifida</i> (Stokes) L.C. Wheeler; <i>Brassica sinapistrum</i> Boiss.; <i>Sinapis allionii</i> Jacq.; <i>Sinapis arvensis</i> subsp. <i>allionii</i> (Jacq.) Baillarg.; <i>Sinapis arvensis</i> subsp. <i>arvensis</i> L.; <i>Sinapis arvensis</i> var. <i>orientalis</i> (L.) W.D.J. Koch & Ziz; <i>Sinapis arvensis</i> var. <i>schkuhrana</i> (Rchb.) Hagenb.; <i>Sinapis orientalis</i> L.; <i>Sinapis schkuhrana</i> Rchb.	California-rape, Charlock, Corn mustard, Field mustard
<i>Sinapis eruroides</i> L.	<i>Diplotaxis eruroides</i> L.	Scorpion Rocket, White Wall Rocket

1.2.3 Existing policy

International policy

Seeds of many species, including those of brassicaceous vegetables (Table 1) can be imported from all sources under the department's standard seeds for sowing import conditions. These import conditions require that:

- each shipment must be packed in clean, new packaging and be clearly labelled with the full botanical name of the species.
- where the seed lot is greater than 10 kilograms and contains seed of less than eight millimetres in diameter, mandatory International Seed Testing Association (ISTA) sampling of each consignment to establish freedom from contamination including weed seed. This testing may be performed at department approved ISTA laboratories overseas or on arrival at Australian accredited facilities.
- where the seed lot is less than or equal to 10 kilograms in weight, or contains seed of greater than eight millimetres in diameter, a biosecurity officer is to conduct a visual inspection of each consignment on arrival in Australia for freedom from live insects, soil, disease symptoms, contaminant seed, other plant material (for example, leaf and stem material, fruit pulp, and pod material), animal material (for example, animal faeces and feathers) and any other extraneous contamination of biosecurity concern.

All consignments imported into Australia regardless of end use (including seeds for sowing) must meet department standards for seed contamination and tolerance.

Following inspection and provided the standard import conditions are met, the consignment can be released from biosecurity control without further requirements.

Domestic arrangements

The Australian Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within their individual jurisdiction. Legislation relating to resource management or plant health may be used by state and territory government agencies to control interstate movement of plants and their products. After imported plants and plant products have been cleared by Australian Government biosecurity officers, they may be subject to interstate movement regulations/arrangements. It is the importer's responsibility to identify and ensure compliance with all requirements.

1.2.4 Consultation

The department provided a draft pest categorisation to state and territory governments for their advance consideration prior to the formal release of the draft report.

The draft report was released on 14 February 2018 (Biosecurity Advice 2018-02) for comment by stakeholders, for a period of 60 days that concluded on 19 April 2018. The department received 21 written technical submissions on the draft report. All submissions were carefully considered and, where relevant, changes were made to the final report.

A summary of key stakeholder comments and the department's responses are provided in Appendix 2 of this report. Supplementary details of potential risk mitigation options proposed by stakeholders, and their consideration, are also provided in the report (Appendix 3).

Further consultation with domestic stakeholders was undertaken during and after close of the stakeholder comment period.

In addition, the department also established the Imported Seeds Regulation Working Group (ISRWG) to engage across industry and government on effective regulatory management of seed biosecurity risks, including the progression of this review. The working group comprised representatives from the Australian Seed Federation, Grain Producers Australia, Nursery and Garden Industry Australia, AUSVEG, Australian Organic, Plant Health Australia, state and territory government agencies and the Department of Agriculture.

1.2.5 Next steps

This final report will be published on the department's website with a notice advising stakeholders of its release. The department will also notify the WTO Secretariat about the release of the final report. The biosecurity requirements recommended in this final report will form the basis of the revised import conditions published in the Biosecurity Import Conditions (BICON) system.

2 Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2019a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019c) that have been developed under the 'World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures' (WTO 1995).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it' (FAO 2019b). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2019b). This definition is also used in the *Biosecurity Act 2015*.

Biosecurity risk consists of two major components: the likelihood of a pest entering, establishing and spreading in Australia from imports, and the consequences should this happen. These two components are combined to give an overall estimate of the risk.

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, the department will verify that the consignment received is as described on the commercial documents and its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2019b).

A glossary of the terms used in the risk analysis is provided at the end of this report.

The PRAs are conducted in the following three consecutive stages: initiation, pest risk assessment and pest risk management.

2.1 Stage 1 Initiation

The initiation of a risk analysis involves identifying the pest(s) and pathway(s) that should be considered for risk analysis in relation to the identified PRA area.

The identity of the pests considered in this review is given in Appendix 1. The species name is used in most instances, but a lower taxonomic level is used where appropriate. Synonyms are provided where the current scientific name differs from instances where the cited literature has used a different scientific name.

A list of pathogens of the brassicaceous vegetables under review was tabulated from the available published scientific literature including, but not limited to, reference books, journals and database searches. This list identifies the pathway association of the pests recorded on brassicaceous vegetables under review and their status in Australia, their potential to establish or spread, and their potential for economic consequences. This information is set out in Appendix 1, and forms the basis of the pest categorisation process. The department

acknowledges that several pathogens in the genera *Cercospora*, *Mycosphaerella*, *Phoma*, *Septoria* and *Xanthomonas* are seed-borne in other hosts. However, at the time of publishing this document no evidence of their seed transmission with brassicaceous vegetables was available. Similarly, at the time of publishing this document, no evidence was available on the potential economic consequences of some of the pathogens associated with the seed pathway. Consequently, these pathogens were not considered further. The department will continue to review the literature in relation to the seed-borne nature and pest status of pathogens of brassicaceous vegetables and may amend this policy accordingly.

For this risk analysis, the 'PRA area' is defined as Australia for pests that are absent, or of limited distribution and under official control. For areas with regional freedom from a pest, the 'PRA area' may be defined on the basis of a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

2.2 Stage 2 Pest risk assessment

A pest risk assessment is an 'evaluation of the probability of the introduction and spread of a pest, and the magnitude of the associated potential economic consequences' (FAO 2019b). The pest risk assessment provides technical justification for identifying quarantine pests and for establishing phytosanitary import requirements.

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is 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 (FAO 2019b).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- identity of the pest
- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

The results of pest categorisation are set out in Appendix 1. The quarantine pests identified during categorisation *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani* (*F. o. f. sp. raphani*) were carried forward for pest risk assessment and are listed in Table 7.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2019c). The SPS Agreement (WTO 1995) uses the term likelihood rather than probability for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry,

establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

A summary of this process is given, followed by a description of the qualitative methodology used in this risk analysis.

Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. ISPM 11 (FAO 2019c) states that the likelihood of entry of a pest depends on the pathways from the exporting country to the destination, and the frequency and quantity of pests associated with them. ISPM 11 (FAO 2019c) lists various factors which should be taken into account when assessing the likelihood of entry.

For the purpose of considering the likelihood of entry, the department divides this step into two components:

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia when a given commodity is imported.
- **Likelihood of distribution**—the likelihood that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2019b). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology and survival) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs, and expert judgement used to assess the likelihood of establishment.

Likelihood of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2019b). The likelihood of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the likelihood of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the likelihood of spread.

Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2). Definitions for these descriptors and their indicative probability ranges are given in Table 2. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors and are not

used beyond this purpose in qualitative PRAs. These indicative probability ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table 2 Nomenclature of likelihoods

Likelihood	Descriptive definition	Indicative range
High	The event would be very likely to occur	$0.7 < to \leq 1$
Moderate	The event would occur with an even likelihood	$0.3 < to \leq 0.7$
Low	The event would be unlikely to occur	$0.05 < to \leq 0.3$
Very low	The event would be very unlikely to occur	$0.001 < to \leq 0.05$
Extremely low	The event would be extremely unlikely to occur	$0.000001 < to \leq 0.001$
Negligible	The event would almost certainly not occur	$0 < to \leq 0.000001$

Combining likelihoods

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 3). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

For example, if the likelihood of importation is assigned a descriptor of 'low' and the likelihood of distribution is assigned a descriptor of 'moderate', then they are combined to give a likelihood of 'low' for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of 'high' to give a likelihood for entry and establishment of 'low'. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of 'very low' to give the overall likelihood for entry, establishment and spread of 'very low'. This can be summarised as:

importation x distribution = entry [E]

low x moderate = low

entry x establishment = [EE]

low x high = low

[EE] x spread = [EES]

low x very low = very low

Table 3 Matrix of rules for combining likelihoods

	High	Moderate	Low	Very low	Extremely low	Negligible
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases. The department normally considers the likelihood of entry on

the basis of the estimated volume of one year's trade. However, in the case of a high risk propagative commodity such as seeds for sowing, the import volume may be restricted in order to effectively manage the biosecurity risks they present. Other factors listed in ISPM 11 (FAO 2019c) may not be relevant to seeds for sowing.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2019b) and ISPM 11 (FAO 2019c).

Direct pest effects are considered in the context of the effects on:

- plant life or health
- other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:

- eradication, control
- domestic trade
- international trade
- non-commercial and environmental.

The direct and indirect consequences were estimated over four geographic levels, defined as:

Local—an aggregate of households or enterprises (a rural community, a town or a local government area).

District—a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').

Regional—a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).

National—Australia wide (Australian mainland states and territories and Tasmania).

The magnitude of the potential consequence at each of these levels was described using four categories, defined as:

Indiscernible—pest impact unlikely to be noticeable.

Minor significance—expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.

Significant—expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to

significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.

Major significance—expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic ‘value’ of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A–G) using Table 4. For example, a consequence with a magnitude of ‘significant’ at the ‘district’ level will have a consequence impact score of D.

Table 4 Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographical scales

Magnitude	Geographic scale			
	Local	District	Region	Nation
Indiscernible	A	A	A	A
Minor significance	B	C	D	E
Significant	C	D	E	F
Major significance	D	E	F	G

Note: In earlier qualitative PRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating ‘indiscernible’ at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A to F has been changed to become B–G and a new lowest category A (‘indiscernible’ at all four levels) was added. The rules for combining impacts in Table 5 Decision rules for determining the overall consequence rating for each pest were adjusted accordingly.

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 5). These rules are mutually exclusive, and are assessed in numerical order until one applies.

Table 5 Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of ‘G’; or more than one criterion has an impact of ‘F’; or a single criterion has an impact of ‘F’ and each remaining criterion an ‘E’.	Extreme
2	A single criterion has an impact of ‘F’; or all criteria have an impact of ‘E’.	High
3	One or more criteria have an impact of ‘E’; or all criteria have an impact of ‘D’.	Moderate
4	One or more criteria have an impact of ‘D’; or all criteria have an impact of ‘C’.	Low
5	One or more criteria have an impact of ‘C’; or all criteria have an impact of ‘B’.	Very Low
6	One or more but not all criteria have an impact of ‘B’, and all remaining criteria have an impact of ‘A’.	Negligible

2.2.4 Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread, and potential consequences are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 6) to combine the estimates of

the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the product of likelihood and consequence.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (for example, low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a 'low' likelihood combined with 'high' consequences, is not the same as a 'high' likelihood combined with 'low' consequences—the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of 'moderate', whereas, the latter would be rated as a 'low' unrestricted risk.

Table 6 Risk estimation matrix

Likelihood of pest entry, establishment and spread	Consequences of pest entry, establishment and spread					
	Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

2.2.5 The appropriate level of protection (ALOP) for Australia

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which is defined in the *Biosecurity Act 2015*, is a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 6 marked 'very low risk' represents the ALOP for Australia.

2.3 Stage 3 Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve the ALOP for Australia, while ensuring that any negative effects on trade are minimised.

The conclusions from a pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate does not achieve the ALOP for Australia, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve

the ALOP for Australia. The effectiveness of any recommended phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to achieve the ALOP for Australia.

ISPM 11 (FAO 2019c) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the likelihood of entry of the pest.

Examples of risk management measures which may be applied to seeds for sowing consignments include:

- Import from pest-free areas only (ISPM 4 and 10)—the establishment and use of a pest-free area by a National Plant Protection Organisation (NPPO) may provide for the export of seeds from the exporting country to the importing country without the need for the application of additional phytosanitary measures when certain requirements are met.
- Testing for freedom from regulated pests—this is a practical measure for management of pests which do not produce visible symptoms.
- Inspection and certification (ISPM 7, 12 and 23)—the exporting country may be asked to inspect the shipment and certify that the shipment is free from regulated pests before export.
- Specified conditions for preparation of the consignment—the importing country may specify steps that must be followed in order to prepare the consignment for shipment. These conditions can include the requirement for seeds to be produced from appropriately tested parent material.
- Removal of the pest from the consignment by treatment or other methods—the importing country can specify chemical or physical treatments that must be applied to the consignment before it may be imported.
- Prohibition of commodities—the importing country may prohibit the commodity if no satisfactory measure can be found.

Risk management measures are identified for each quarantine pest where the level of biosecurity risk does not achieve the ALOP for Australia. Relevant measures are presented in Chapter 4 of this report.

3 Pest risk assessment for quarantine pests

When conducting a pest risk analysis (PRA), the department considers the factors described by ISPM 11 (FAO 2019c) to determine if a pest is a quarantine pest. The emphasis in ISPM 11 is on the pest risk assessment and risk management components of the PRA. The pest risk assessment provides technical justification for identification of quarantine pests and for establishment of phytosanitary import requirements.

Pests of brassicaceous vegetables considered in this review are listed in the pest categorisation table (Appendix 1), and identified seed-borne quarantine pests are listed in Table 7.

Table 7 Quarantine pests associated with seeds of brassicaceous vegetables

Scientific name	Common name	Host(s)
<i>Colletotrichum higginsianum</i>	Anthraxnose	<i>Brassica rapa</i> , <i>Raphanus sativus</i>
<i>Fusarium oxysporum</i> f. sp. <i>raphani</i>	Fusarium wilt	<i>Eruca vesicaria</i> , <i>Raphanus sativus</i>

In the preparation of this final report, the department has further reviewed available evidence to support the seed-borne status of the two identified quarantine pests. Consequently, in contrast to the action proposed in the draft report, *Brassica oleracea* has been removed from this final report on the basis of insufficiency of evidence for *Colletotrichum higginsianum* as a seed-borne pest in this host.

- *Brassica oleracea* is a well-studied host, but the body of available evidence for seed association with *Colletotrichum higginsianum* is limited to only one reference (Chinese Vegetable Network 2019)
- The single reference presents a statement to support the association of *Colletotrichum higginsianum* with *Brassica oleracea* seeds without providing underpinning evidence.

The department will however continue to review the literature in relation to the seed-borne status of *Colletotrichum higginsianum* in all brassicaceous vegetables, and may amend this policy accordingly.

3.1 Assessment of the likelihood of entry, establishment and spread

This review collectively assesses the likelihood of entry, establishment and spread of the quarantine pests identified in Table 7. Assessments of the potential consequences of entry, establishment and spread are individually presented for each pest to estimate the magnitude of the potential consequences.

ISPM 11 (FAO 2019c) states that the intended end-use of a commodity affects the risk of introduction and spread of associated pests. For example, an end-use such as seeds for sowing poses a higher risk of a pest establishing or spreading than an end-use such as processing (FAO 2019c).

Seeds also play an important role in the survival, introduction and spread of associated pests (Elmer 2001). Seed transmission provides a mechanism whereby a pathogen can survive under conditions in which other sources of inoculum have been eliminated (Stace-Smith & Hamilton 1988). Seed-infection is epidemiologically important because it ensures that the pest is physically associated with and distributed throughout the planted crop by means of infected

seeds which are randomly dispersed in the field. The resultant infected seedlings can further serve as sources of inoculum from which secondary spread can occur (Stace-Smith & Hamilton 1988). Seeds for sowing are deliberately introduced, distributed and aided to establish. As a result, any pest that is associated with seeds of brassicaceous vegetables intended for sowing will be aided in its entry, establishment and spread in Australia.

3.1.1 Likelihood of entry

The likelihood of entry is considered in two parts, the likelihood of importation (the likelihood that the identified pathogens will arrive when host brassicaceous vegetable seeds for sowing are imported) and the likelihood of distribution (the likelihood that the identified pathogens will be viable and be transferred to a suitable host in Australia).

Likelihood of importation

The likelihood that the identified quarantine pests will be imported on host brassicaceous vegetable seeds for sowing is assessed as High.

This is because the identified quarantine pests are known to be seed-borne, and are likely to remain viable during transport and storage. They are also likely to be present but effectively undetectable in the large volumes of brassicaceous vegetable seeds for sowing which Australia imports each year.

It is highly likely that the identified pests are associated with the pathway

- Infected or infested seeds for sowing are one of the main pathways for the introduction of seed-borne pathogens into new areas. Global trade and the movement of infected or infested seeds across borders is known to have introduced seed-borne pathogens into new areas (Constable et al. 2019; Constable et al. 2018; Cromney et al. 1987; Vannacci et al. 1999).
- A low incidence in the field may enhance a pathogen's chances of escaping detection. If the level of infection is very low and symptomatic plants are randomly scattered in the field, an infection may go undetected at the time of harvest.
- Large volumes of brassicaceous vegetable seeds are imported into Australia each year for planting. Seed-borne pathogens associated with the seed internally (endospore and/or embryo) or externally (seed surface) may not be detected during on-arrival visual inspection (Elmer 2001). Therefore, there is high potential for the identified pests to repeatedly enter Australia through the seeds for sowing pathway.
- *Fusarium oxysporum* and *Colletotrichum* species have the potential to be associated with the seed coat of a range of hosts and remain viable. For example, *Fusarium oxysporum* f. sp. *vasinfectum* (causal agent of cotton wilt) is known to be associated with the seed coat of cotton (Doan & Davis 2015). *Colletotrichum* species were also detected in the seed coat of chili (Kumar, Singh & Khare 2004), soybean (Begum et al. 2008; Begum et al. 2007) and common bean (*Phaseolus vulgaris*) (LeClair et al. 2015).

Colletotrichum higginsianum

- This fungal pathogen causes anthracnose leaf spot disease of a wide range of brassicaceous vegetables including broccoli, Brussels sprouts, Chinese cabbage, collards, kale, mustard, radish, rutabaga and turnip (Cook et al. 2010; Rimmer, Shattuck & Buchwaldt 2007).

- *Colletotrichum higginsianum* mainly infects the leaves and overwinters in plant debris and cruciferous weeds, and can be spread through infected seeds of *Brassica rapa* and *Raphanus sativus* (Chinese Vegetable Network 2019; Cook et al. 2010).
- *Colletotrichum higginsianum* is reported as seed-borne in *Brassica rapa* and *Raphanus sativus* (Daly & Tomkins 1997; Li 1989; Rimmer, Shattuck & Buchwaldt 2007; Scheffer 1950).
- Scheffer (1950) conducted seed transmission tests and provided explicit evidence that *Colletotrichum higginsianum* is seed-transmitted in radish (*Raphanus sativus*). In *Brassica rapa*, infected seed was considered to be the most important pathway for the long-distance transmission of this pathogen (Li 1989).

***Fusarium oxysporum* f. sp. *raphani* (*F. o.* f. sp. *raphani*)**

- *Fusarium oxysporum* forms a complex of cosmopolitan fungi (the *Fusarium oxysporum* species complex, FOSC) (Edel-Hermann & Lecomte 2018). Collectively, members of the complex can infect a broad range of hosts, but each *Fusarium oxysporum* forma specialis (f. sp.) usually has one or a few closely related hosts (Edel-Hermann & Lecomte 2018).
- Recently, horizontal gene transfer (HGT) and horizontal chromosome transfer (HCT) in *Fusarium oxysporum* have been demonstrated under experimental conditions (Ma et al. 2010; Mehrabi et al. 2011; van Dam et al. 2017). These experiments also demonstrated that co-cultivation of genetically distinct strains can generate new pathogenic genotypes, and suggest that these events might also occur in nature.
- Of the more than 200 ff. spp. of *Fusarium oxysporum* described so far, *F. o.* f. sp. *raphani* has been described as the causal agent of fusarium wilt of radish (*Raphanus sativus*) (also known as radish yellows) (du Toit & Pelter 2003; Kim et al. 2017; Toyota, Yamamoto & Kimura 1994) and wilt of wild (*Diplotaxis muralis*) and cultivated (*Eruca vesicaria*) rocket (Catti et al. 2007; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004; Gullino, Gilardi & Garibaldi 2014b; Srinivasan et al. 2012).
- Bomberger (2013) recovered *Fusarium oxysporum* from samples of commercial stock seed of radish and daughter seed collected from wilted parent plants. Bomberger (2013) also reported the association of *Fusarium oxysporum* with red radish (*Raphanus sativus*) in the field, and confirmed that *Fusarium oxysporum* isolates obtained from affected radish plants were pathogenic on radish, consistent with the causative agent being *F. o.* f. sp. *raphani*.
- However, extended host range tests of these isolates were not undertaken, meaning that the possible involvement of other f. sp. of *Fusarium oxysporum* could not be technically excluded. Nevertheless, and despite elements of inconsistency in the scientific literature (Bosland, Williams & Morrison 1988; du Toit & Pelter 2003), it is considered reasonable to conclude on the basis of available evidence that *Fusarium oxysporum* isolated from red radish seeds by Bomberger (2013) was *F. o.* f. sp. *raphani*.
- Garibaldi et al. (2004) isolated *Fusarium oxysporum* from commercial rocket seeds, carried out pathogenicity tests of the isolates, and confirmed some of the isolates were pathogenic on wild and cultivated rocket.
- Garibaldi, Gilardi and Gullino (2006) used isolates from infected stem tissue of rocket to conducted pathogenicity studies and concluded *F. o.* f. sp. *raphani* was the causal agent of the previously reported fusarium wilt of cultivated and wild rocket in Italy (Garibaldi et al.

2004). Catti et al. (2007) and Srinivasan Srinivasan et al. (2012) also concluded *F. o. f. sp. raphani* to be the causal agent of fusarium wilt of rocket.

- Movement of infected rocket seed was stated to be the only credible explanation for the sudden appearance and rapid spread of the fusarium wilt disease in Italy (Catti et al. 2007; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004).

It is highly likely that the identified pests will survive storage and transport

- *Colletotrichum higginsianum* is associated with the seed coat of turnip without producing visual symptoms (Holliday 1995). *F. o. f. sp. raphani* has been isolated from radish seeds surface sterilised with bleach (NaClO) and non-sterilised seeds indicating that it can be present on the seed coat and within internal seed tissues (Bomberger 2013).
- *Colletotrichum higginsianum* and *F. o. f. sp. raphani* are considered to be transmitted through infected seeds (Bomberger 2013; Chinese Vegetable Network 2019; Gaetán, Garbagnoli & Irigoyen 1995; Garibaldi, Gilardi & Gullino 2006; Rimmer, Shattuck & Buchwaldt 2007; Scheffer 1950) and therefore are likely to persist during standard harvesting, handling and shipping operations.
- The identified pathogens are highly likely to survive during transport and storage since the primary conditions for their survival are fulfilled by the presence of the live host material and the associated environmental conditions. Conditions such as temperature and humidity are unlikely to affect the viability of the associated pathogens.
- Most seed-borne pathogens infect and use seeds as a vehicle for transport and survival (Elmer 2001). Seed associations can provide long-term survival mechanisms for pathogens, and survival is not likely to be diminished during transport and storage (Elmer 2001).
- Previous interceptions of seed-borne pests in various countries demonstrate generally that these pests are highly likely to persist during processes of storage and transport to Australia.

Likelihood of distribution

To have an impact a pest must be transported in or on a pathway and must then be capable of transferring to a suitable host. The probability of this transfer occurring depends on the dispersal mechanisms of the pest and the intended use of the commodity.

The likelihood that the identified quarantine pests will be distributed across Australia on imported brassicaceous vegetable seeds for sowing and be transferred from the resulting plants to a suitable host is assessed as High.

This assessment is based on the facts that brassicaceous vegetable seeds intended for sowing are commercially distributed throughout Australia, and that seed to seedling transmission has been reported for the identified pathogens. This transmission mechanism provides the means by which these pests encounter a new host plant, most notably, the new seedling that is germinated from the seed.

It is highly likely that imported brassicaceous vegetable seeds will be distributed throughout Australia

- Imported brassicaceous vegetable seeds are intended for commercial sale in vegetable growing areas throughout Australia. The imported seeds will be distributed through

commercial and retail outlets to multiple destinations throughout Australia. Following sale, any infected imported seeds will be planted in suitable habitats.

- The distribution of infected imported seeds to commercial seedling nurseries may also facilitate the distribution of the identified seed-borne pathogens. Asymptomatic seedlings that develop from infected seeds may be overlooked and sold to commercial growers and householders.

It is highly likely that the identified seed-borne pests will be imported in a viable state

- Seed-associated pests have evolved many different types of associations with their seed host. Pathogens associated with seeds can be transmitted as an internal infection of endosperm and/or embryo, or as an infestation of the seed surface (Agarwal & Sinclair 1996). The pathogen's ability to survive on or in a seed acts to ensure their viability on route to, and during distribution across Australia.
- Conditions during transport and storage, such as temperature and humidity, are unlikely to affect the viability of the associated pathogens.
- Seeds for sowing are imported specifically for the purpose of propagation, and are therefore likely to be sown directly into suitable habitats at multiple locations throughout Australia. The distribution of infected or infested seeds for sowing for commercial purposes is likely to facilitate the distribution of the associated pathogens.
- Seed-borne fungi such as *Colletotrichum higginsianum* and *F. o. f. sp. raphani* exist in seeds as spores and hyphae, and can survive for long periods on the seed coat and in the internal diseased tissues (Elmer 2001).

It is highly likely that the identified seed-borne pests will be transferred to a suitable host

- The identified pests in imported seeds for sowing are already associated with suitable hosts that will be planted and grown under favourable conditions. The pests will have no need to move from the import pathway to a suitable host.
- The seed-borne nature and seed transmissibility of the identified pests, and establishment of an infected plant, provide the means by which these pests become associated with a new host plant in Australia. The new seedling is the new host.
- In addition, it is well documented that *Colletotrichum* spp. and *Fusarium oxysporum* formae speciales are both soil-borne and can be transferred to the environment (e.g. water, soil) and then infest a host plant under natural conditions (CABI 2019; Saremi, Okhovvat & Ashrafi 2011; Zveibil & Freeman 2009).

Overall likelihood of entry

The likelihoods of importation and distribution of the identified quarantine pests are combined to give an overall likelihood of entry using the matrix of rules for combining likelihoods (Table 3).

The overall likelihood that the identified quarantine pests will enter Australia and be transferred to a suitable host via seeds for sowing is High.

3.1.2 Likelihood of establishment

In overview, the likelihood of establishment of the identified quarantine pests within Australia will depend upon availability of hosts and suitable climate, and the reproductive strategies and methods of persistence of the pests. Based on a comparison of factors that affect pest survival and reproduction in the source and destination areas, the likelihood of establishment is assessed as High.

This assessment is based on the extensive planting of brassicaceous vegetables in Australia, the deliberate introduction and establishment of plants grown from imported seeds for sowing, the reported potential for the transmission of the identified quarantine pests from infected seed to seedlings, the wide distribution of suitable hosts, and the broad availability of suitable climates in Australia.

It is highly likely that the identified seed-borne pests will establish in Australia given the broad availability of host plants

- Although the identified pests are specific to brassicaceous vegetables (Bomberger 2013; Yuan et al. 2016), these crops are widely cultivated throughout Australia, with many residential and semi-rural properties in metropolitan areas growing vegetables in their backyards.
- The identified pests are already associated with the seeds of host plants, giving them a distinct advantage for establishment in Australia. The importation and distribution of imported seeds intended for sowing through commercial and retail outlets provides seed-borne pests with the means to establish in multiple brassicaceous vegetable growing areas across Australia.
- Imported brassicaceous vegetable seeds are intended for propagation and are deliberately introduced, distributed and aided in establishment. Imported seeds will enter, potentially in substantial numbers, and then be maintained in a suitable habitat. Therefore, the introduction and establishment of plants from imported seeds in essence establishes those pests associated with the seed.
- Asymptomatic infection or infestation of the seed by a pathogen can facilitate long-distance movement and establishment in new areas. This can allow a pathogen to repeatedly enter a new site and go unnoticed for an extended period of time (Elmer 2001).
- A low incidence of a pathogen in or on seeds can affect detection in routine seed health tests (McGee 1995). Therefore, a low incidence of the pathogen in the field may enhance a pathogen's chance of escaping detection. If the level of infection is very low and symptomatic plants are randomly scattered in the field, the infection may go undetected for some time. This would provide further opportunity for the pest to proliferate and establish in new areas.

It is highly likely that the identified seed-borne pests will establish in Australia given the suitability of climatic conditions

- The identified quarantine pests have established in areas with a wide range of climatic conditions (Bomberger 2013; Garibaldi, Gilardi & Gullino 2006; Rimmer, Shattuck &

Buchwaldt 2007). There are similar climatic regions in parts of Australia that would be suitable for the establishment of these pests.

- Extensive cultivation of imported seeds potentially infested/infected with the identified pests, and seed-to-seedling transmission will help establish these pathogens in brassicaceous vegetable growing areas in Australia. As host plant material is likely to be maintained in places with similar climates to the area of production, climatic conditions are expected to favour the identified pest's establishment.
- Seed-borne pathogens commonly have traits that help them establish, such as an ability to rapidly infect new hosts and/or survive long-term in the soil.
- The establishment of seed-borne pathogens may be influenced by the length of time the commodity remains in production. For example, short crop cycles such as those of annual crops like *Eruca vesicaria* (Rimmer, Shattuck & Buchwaldt 2007), may limit the pathogen build-up and establishment. The opposite might be true for perennial crops which are kept longer in production, providing a greater opportunity for pathogen build-up that results in a high likelihood of survival and establishment.

3.1.3 Likelihood of spread

The likelihood of spread describes the likelihood that the identified quarantine pests, once having entered Australia on imported brassicaceous vegetable seeds and become established, will spread from a point of introduction to new areas.

Based on a comparison of factors relevant to the potential expansion of the geographic distribution of the pest in the source and destination areas, the assessed likelihood of spread for the identified pests is assessed as Moderate.

This assessment is based on the suitability of the natural and managed environments for natural spread, the ability of seed-borne pathogens to survive for long periods of time on seeds, the symptomless nature of some pathogens in assisting the inadvertent multiplication and distribution of pathogens across continental borders, and the known role of seeds in the spread of pathogens globally.

It is highly likely that the environment in Australia will support the spread of the identified seed-borne pests

- Brassicaceous vegetables are grown in various regions of Australia. Distribution of imported infected seeds throughout production areas will help spread the identified pests across Australia.
- The managed environments in nurseries, garden centres and private gardens are all favourable for the spread of the identified pests, as host plants are abundantly available. The plants are closely placed and sprinkler irrigation favours pests' local spread. Nursery (transplant) trade networks, which are common between Australian nurseries, favour wider spread of these pests.
- The natural environments in brassicaceous vegetable growing areas in Australia are conducive to the spread of the identified pests. The pests will be within suitable host growing areas where biotic factors such as wind, water, rain splash dispersal or mechanical transmission could aid spread once established.

The presence of natural barriers in Australia could limit the spread of the identified pests

- Natural barriers, such as arid areas, mountain ranges, climatic differentials and possible long distances between suitable hosts in parts of Australia may hinder or prevent the long-range natural spread of the identified seed-borne pests. However, commercial seed distribution systems would help the identified seed-borne pests to overcome natural barriers and establish throughout Australia, providing a high risk for continued spread post-border.

There is potential for domestic trade to facilitate the spread of the identified pests

- Human-mediated movement of infected seeds and seedlings (transplants) is considered the primary method for the introduction of plant pathogens into new areas. As visual symptoms may not be present, infected seeds or seedlings could easily be moved into new areas. The introduction of infected seeds/seedlings establishes the pests in new areas and unregulated movement may accelerate the spread of the identified pests across Australia.
- Infected and/or infested seeds are the most effective way to spread seed-borne pests over long distances (Constable et al. 2019; Constable et al. 2018; Vannacci et al. 1999). The distribution and sowing of infected seeds will help the introduction and spread of these seed-borne pests throughout the crop-growing areas of Australia. Infected seeds can play a significant role in pathogens spreading over greater distances and can also serve as a reservoir for the pathogens in the soil (du Toit & Pelter 2003; Elmer 2001; Elmer & Lacy 1987).
- In the absence of statutory control, it is likely that the identified pests will spread within Australia through the trade of seeds/seedlings for propagation. Planting of infected seeds and seedlings in production fields is likely to introduce the identified pests into the environment.

3.1.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the individual likelihoods of entry, of establishment and of spread using the matrix of rules for combining descriptive likelihoods (Table 3).

The overall likelihood that the identified quarantine pests will enter Australia, be distributed in a viable state to susceptible hosts, establish in that area and subsequently spread within Australia is assessed as Moderate.

3.1.5 Assessment of potential consequences

The entry, establishment and spread of the quarantine pests is likely to have unacceptable economic consequences, particularly for Australia's agricultural and food production sectors. Seed-borne pests are known to be able to affect germination, growth and crop productivity (Bomberger 2013; du Toit & Pelter 2003; Rimmer, Shattuck & Buchwaldt 2007).

The introduction and spread in Australia of pests with wide host ranges would affect both the imported host and alternate hosts. Once a pest gains entry into a new region or crop it may establish and spread quickly, requiring the implementation of costly and/or environmentally-damaging control measures. New control measures to minimise economic impacts may result in changes to the supply and production chain.

The establishment of new quarantine pests in Australia could also result in phytosanitary regulations being imposed by foreign or domestic trading partners. Trade restrictions on affected commodities could lead to loss of markets.

This section examines the potential consequences of *Colletotrichum higginsianum* and *F. o. f. sp. raphani*, were they to enter, establish and spread in Australia.

Consequences of *Colletotrichum higginsianum*

The consequences of entry, establishment and spread of *Colletotrichum higginsianum* in Australia have been estimated according to the methods section described in Table 4.

Based on the decision rules described in Table 5, and specifically, where the potential consequences of a pest with respect to one or more (but not all) criteria have an impact of 'D', the overall consequence of entry, establishment and spread of *Colletotrichum higginsianum* in Australia is assessed as **Low**.

Criterion	Estimated impact score and rationale
Direct	
Plant life or health	D—Significant at the district level The direct impact of <i>Colletotrichum higginsianum</i> on plant life or health would be of major significance at the local level, significant at the district level, and of minor significance at the regional level, which has an impact score of 'D'. <i>Colletotrichum higginsianum</i> causes anthracnose leaf spot disease of a wide range of brassicaceous vegetables including broccoli, Brussels sprouts, Chinese cabbage, collards, kale, mustard, radish, rutabaga and turnip (Cook et al. 2010; Rimmer, Shattuck & Buchwaldt 2007). - On Chinese cabbage (<i>Brassica rapa</i>), water-soaked leaf lesions caused by <i>Colletotrichum higginsianum</i> have led to 30–40% yield loss yearly in South China (Yuan et al. 2016). <i>Colletotrichum higginsianum</i> is considered to be a destructive disease in countries such as China and the United States of America (USA), and has also been recorded in Jamaica, Japan, Puerto Rico, South Africa and South America (Rimmer, Shattuck & Buchwaldt 2007).
Other aspects of the environment	A—Indiscernible at the local level The direct impact of <i>Colletotrichum higginsianum</i> on other aspects of the environment would be indiscernible at the local, district, regional and national levels, which has an impact score of 'A'. <i>Colletotrichum higginsianum</i> can infect broccoli, Brussel sprouts, Chinese cabbage, collards, kale, mustard, radish, rutabaga and turnip (Cook et al. 2010; Rimmer, Shattuck & Buchwaldt 2007). No impact of the pathogen has been reported on the environment internationally or domestically.
Indirect	
Eradication, control, etc.	A—Indiscernible at the local level The indirect impact of <i>Colletotrichum higginsianum</i> on eradication and control would be indiscernible at the local, district, regional and national levels, which has an impact score of 'A'. - Eradication or containment of <i>Colletotrichum higginsianum</i> would be easily achieved through cultural practices including crop rotation and fungicidal seed treatment (Cook et al. 2010). - The spread of <i>Colletotrichum higginsianum</i> into new areas can be controlled by treating seeds with hot water prior to sowing (Cook et al. 2010).
Domestic trade	C—Significant at the local level

	The indirect impact of <i>Colletotrichum higginsianum</i> on domestic trade would be of significance at the local level, minor significance at the district level, and indiscernible at the regional level, which has an impact score of 'C'. • The presence of <i>Colletotrichum higginsianum</i> could threaten economic viability at the local level through reduced commodity trade or loss of domestic markets. Biosecurity measures to prevent the movement of plant material out of the initial incursion area would affect plant industries and business at the local level. • The introduction of <i>Colletotrichum higginsianum</i> into a state or territory would disrupt interstate trade due to the biosecurity restrictions on the domestic movement of host propagative material.
International trade	D—Significant at the district level The indirect impact of <i>Colletotrichum higginsianum</i> on international trade would be of major significance at the local level, significant at the district level, and of minor significance at the regional level, which has an impact score of 'D'. • The presence of <i>Colletotrichum higginsianum</i> could threaten economic viability at the local level through loss of commodity trade and export markets. • The introduction and spread of <i>Colletotrichum higginsianum</i> in Australia could result in restrictions on Australian exports of brassicaceous vegetables, seeds and propagative material. <i>Colletotrichum higginsianum</i> is a quarantine pest of <i>Brassica rapa</i> seed for India and <i>Brassica oleracea</i> seed for Japan.
Environmental and non-commercial	B—Minor significance at the local level The indirect impact of <i>Colletotrichum higginsianum</i> on the environment would be of minor significance at the local level, and indiscernible at the district, regional and national levels, which has an impact score of 'B'. • The introduction of <i>Colletotrichum higginsianum</i> may result in additional fungicide use which may cause minor damage to the local environment. For example, copper-based fungicide residues in the soil can be lethal to or inhibit growth and reproduction of soil invertebrates, in turn affecting soil processes such as the breakdown of plant litter (Wightwick et al. 2008).

Consequences of *F. o. f. sp. raphani*

The consequences of entry, establishment and spread of *F. o. f. sp. raphani* in Australia have been estimated according to the methods section described in Table 4.

Based on the decision rules described in Table 5, and specifically, where the potential consequences of a pest with respect to a single criterion have an impact of 'D', the overall consequence of entry, establishment and spread of *F. o. f. sp. raphani* in Australia is assessed as **Low**.

Criterion	Estimated impact score and rationale
Direct	
Plant life or health	D—Significant at the district level The direct impact of <i>F. o. f. sp. raphani</i> on plant life or health would be of major significance at the local level, significant at the district level, and of minor significance at the regional level, which has an impact score of 'D'. • <i>F. o. f. sp. raphani</i> infects all parts of <i>Raphanus sativus</i> (radish) (du Toit & Pelter 2003). The host range of this fungus was thought to be limited to <i>Raphanus sativus</i> (du Toit & Pelter 2003); however, recent research has indicated that it can also infect <i>Diplotaxis tenuifolia</i> (wild rocket) and <i>Eruca vesicaria</i> (cultivated garden rocket) (Garibaldi, Gilardi & Gullino 2006; Rimmer, Shattuck & Buchwaldt 2007).

Criterion	Estimated impact score and rationale
	<i>F. o. f. sp. raphani</i> causes radish yellows or fusarium wilt (Rimmer, Shattuck & Buchwaldt 2007). This damaging disease of radish is particularly important in the USA (du Toit & Pelter 2003). - On <i>Eruca vesicaria</i>, diseased plants are stunted and chlorotic with brown or black streaks in the vascular system. Vascular tissues of affected plants appear red or brown (Garibaldi, Gilardi & Gullino 2003).
Other aspects of the environment	A—Indiscernible at the local level The direct impact of <i>F. o. f. sp. raphani</i> on other aspects of the environment would be indiscernible at the local, district, regional and national levels, which has an impact score of 'A'. <i>F. o. f. sp. raphani</i> has a narrow host range and infects only <i>Diploaxis tenuifolia</i>, <i>Eruca vesicaria</i> and <i>Raphanus sativus</i> (du Toit & Pelter 2003; Garibaldi, Gilardi & Gullino 2006; Rimmer, Shattuck & Buchwaldt 2007). No impact of the pathogen has been reported on the environment internationally or domestically.
Indirect	
Eradication, control, etc.	C—Significant at the local level The indirect impact of <i>F. o. f. sp. raphani</i> on eradication and control would be of significance at the local level, minor significance at the district level, and indiscernible at the regional level, which has an impact score of 'C'. - Impacts of management activities for <i>F. o. f. sp. raphani</i> could be expected to threaten economic viability at a local level through a large increase in costs for containment, eradication and control (for instance, through the application of fungicides). - Containment and eradication costs and activities could also cause disruption to Australia's agribusiness and associated trades at the local level.
Domestic trade	C—Significant at the local level The indirect impact of <i>F. o. f. sp. raphani</i> on domestic trade would be of significance at the local level, minor significance at the district level, and indiscernible at the regional level, which has an impact score of 'C'. - The presence of <i>F. o. f. sp. raphani</i> could threaten economic viability through reduced trade or loss of domestic markets at the local level. Biosecurity measures to prevent the movement of plant material out of the initial incursion area would affect plant industries and business at the local level. - The introduction of <i>F. o. f. sp. raphani</i> into a state or territory would disrupt interstate trade due to the biosecurity restrictions on the domestic movement of radish and rocket propagative material.
International trade	A—Indiscernible at the local level The indirect impact of <i>F. o. f. sp. raphani</i> on international trade would be indiscernible at the regional level, which has an impact score of 'A'. <i>F. o. f. sp. raphani</i> is not currently regulated by Australia's trading partners. Therefore, it is considered that the introduction and spread of this pathogen in Australia would not result in restrictions on Australian exports of radish and rocket propagative material.
Environmental and non-commercial	B—Minor significance at the local level The indirect impact of <i>F. o. f. sp. raphani</i> on the environment would be of minor significance at the local level, and indiscernible at the district, regional and national levels, which has an impact score of 'B'. The introduction of <i>F. o. f. sp. raphani</i> may result in additional fungicide use that causes minor damage to the local environment. For example, copper-based fungicide residues in the soil can be lethal to or inhibit growth and reproduction of soil invertebrates, in turn affecting soil processes such as the breakdown of plant litter (Wightwick et al. 2008).

3.1.6 Unrestricted risk estimate

Unrestricted risk is the result of combining the likelihood of entry, establishment and spread with the outcome of overall consequences. Likelihoods and consequences are combined using the risk estimation matrix shown in Table 6. Table 8 summarises the unrestricted risk estimates for *Colletotrichum higginsianum* and *F. o. f. sp. raphani*.

Table 8 Unrestricted risk estimates for quarantine pests of brassicaceous vegetable seeds for sowing

Pest name	Likelihood of			Consequences		URE
	Entry	Establishment	Spread	P[EES]		
<i>Colletotrichum higginsianum</i>	High	High	Moderate	Moderate	Low	Low
<i>F. o. f. sp. raphani</i>	High	High	Moderate	Moderate	Low	Low

3.1.7 Pest risk assessment conclusions

The unrestricted risk estimates for *Colletotrichum higginsianum* and *F. o. f. sp. raphani* do not achieve the ALOP for Australia. Accordingly, risk management measures against these pests are required.

4 Pest risk management

The quarantine pests (*Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*) identified in this review present unrestricted risks that do not achieve the appropriate level of protection (ALOP) for Australia. Consequently, the department recommends risk management measures to reduce the risk posed by these pests to levels that achieves the ALOP for Australia.

The department has evaluated existing measures to determine whether alternative or additional measures are required to manage the risks associated with the identified seed-borne pathogens.

The department considers that the brassicaceous vegetable seeds to be imported will have been produced commercially and were subject to production quality controls.

4.1 Existing risk management measures

Under Australia's existing policy, all seeds for sowing, including brassicaceous vegetable seeds are subject to the department's standard import conditions:

- Each shipment must be packed in clean, new packaging and be clearly labelled with the full botanical name of the species.
- Where the seed lot is greater than 10 kilograms and contains seed of less than eight millimetres in diameter, mandatory International Seed Testing Association (ISTA) sampling of each consignment must be used to establish freedom from contamination including weed seed. This testing may be performed at department approved ISTA laboratories overseas or on arrival at Australian accredited facilities.
- Where the seed lot is less than or equal to 10 kilograms in weight, or contains seed of greater than eight millimetres in diameter, a biosecurity officer must conduct a visual inspection of each consignment on arrival in Australia for freedom from live insects, soil, disease symptoms, contaminant seed, other plant material (for example, leaf and stem material, fruit pulp, and pod material), animal material (for example, animal faeces and feathers) and any other extraneous contamination of biosecurity concern.

All consignments imported into Australia regardless of end use (including seed for sowing) must meet departmental standards for seed contamination and tolerance. Brassicaceous vegetable seeds can be released from biosecurity control if these import conditions are met.

Under the International Plant Protection Convention (IPPC) and World Trade Organisation (WTO) SPS Agreement, phytosanitary measures against the introduction of new pests must be technically justified. As part of this review, the department evaluated the appropriateness of the existing measures to determine if alternative or additional measures are required for the identified brassicaceous seed-borne pathogens. This section presents the results of that evaluation.

4.2 Recommended risk management measures

This review recommends that brassicaceous vegetable seeds for sowing should be subject to:

- The department's standard seeds for sowing import conditions; AND

- Additional mandatory treatment or testing for *Brassica rapa*, *Eruca vesicaria* and *Raphanus sativus* to manage the risk of introduction of *Colletotrichum higginsianum* and *F. o. f. sp. raphani*.

The department recommends that where Polymerase Chain Reaction (PCR) testing is required, the seed sample should be drawn prior to any treatment of seeds.

4.2.1 Species that remain subject to standard seeds for sowing import conditions

Most brassicaceous vegetable seeds species reviewed were not found to be hosts of quarantine pests for Australia and will therefore remain subject to the department's standard seeds for sowing import conditions.

The brassicaceous species that will remain subject to standard seeds for sowing import conditions are: *Armoracia rusticana*, *Barbarea verna*, *Barbarea vulgaris*, *Brassica carinata*, *Brassica elongata*, *Brassica juncea*, *Brassica nigra*, *Brassica oleracea*, *Crambe abyssinica*, *Crambe cordifolia*, *Crambe maritima*, *Crambe tatarica*, *Eutrema wasabi*, *Lepidium campestre*, *Lepidium meyenii*, *Lepidium perfoliatum*, *Lepidium ruderales*, *Lepidium sativum*, *Lepidium squamatum*, *Lepidium virginicum*, *Nasturtium microphyllum*, *Nasturtium officinale*, *Rorippa islandica*, *Rorippa palustris*, *Sinapis alba*, *Sinapis arvensis* and *Sinapis eruroides*.

4.2.2 Species requiring additional measures

The department recommends treatment or testing to manage the two identified quarantine pests associated with the seeds of *Brassica rapa*, *Eruca vesicaria* and *Raphanus sativus*, including their synonyms or subordinate taxa as listed in Table 1. These requirements are in addition to the standard seeds for sowing import conditions.

4.2.3 Treatment or testing

Colletotrichum higginsianum is seed-borne in *Brassica rapa* and *Raphanus sativus*, and *Fusarium oxysporum* f. sp. *raphani* is seed-borne in *Eruca vesicaria* and *Raphanus sativus*. Consequently, additional risk management measures for *B. rapa*, *E. vesicaria* and *R. sativus* seeds for sowing are required to achieve the ALOP for Australia. Four risk management options are recommended:

- **Option 1.** Broad spectrum fungicidal treatment—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.
- **Option 2.** Heat treatment—to manage the risk of *Colletotrichum higginsianum* only.
 - Heat treatment conditions: dry heat at 70°C for 90 minutes, OR hot water at 53°C for 10 minutes, OR hot water at 50°C for 20 minutes.
- **Option 3.** PCR test—to manage the risk of *Fusarium oxysporum* f. sp. *raphani* only.
 - PCR test using sample size of 20,000 seeds or 20% of small seed lots to verify freedom from detectable presence of *F. o. f. sp. raphani*.
- **Option 4.** Heat treatment AND PCR test combined—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.
 - Heat treatment conditions: dry heat at 70°C for 90 minutes, OR hot water at 53°C for 10 minutes, OR hot water at 50°C for 20 minutes.

- PCR test using sample size of 20,000 seeds or 20% of small seed lots to verify freedom from detectable presence of *F. o. f. sp. raphani*.

4.2.4 PCR testing protocol

PCR testing is recommended as an option to verify freedom from *F. o. f. sp. raphani*. A PCR testing protocol for *F. o. f. sp. raphani* based on the protocol of Kim et al. (2017) is in the process of validation. When validated, the department's Biosecurity Import Conditions (BICON) database will be amended and testing (on-shore or off-shore) can commence.

4.2.5 Phytosanitary certification

Seed lots of *Brassica rapa*, *Eruca vesicaria* and *Raphanus sativus* that are treated with fungicide off-shore must be accompanied by an official government Phytosanitary Certificate endorsed with the following respective additional declarations:

- ***Raphanus sativus*:** 'The consignment of [*botanical name(s) Genus species*] comprises [*insert seed lot numbers*] seed lot(s); for each seed lot, seed were treated with a broad spectrum fungicide [*insert name and chemical name and dosage*] for *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.'
- ***Eruca vesicaria*:** 'The consignment of [*botanical name(s) Genus species*] comprises [*insert seed lot numbers*] seed lot(s); for each seed lot, seed were treated with a broad spectrum fungicide [*insert name and chemical name and dosage*] for *Fusarium oxysporum* f. sp. *raphani*.'
- ***Brassica rapa*:** 'The consignment of [*botanical name(s) Genus species*] comprises [*insert seed lot numbers*] seed lot(s); for each seed lot, seed were treated with a broad spectrum fungicide [*insert name and chemical name and dosage*] for *Colletotrichum higginsianum*.'

Seed lots of *Eruca vesicaria* and *Raphanus sativus* that are tested off-shore for *F. o. f. sp. raphani* must be accompanied by an official government Phytosanitary Certificate endorsed with the following additional declaration:

- 'The consignment of [*botanical name (s) (Genus species)*] comprises [*insert number of brassicaceous vegetable seed lots*] seed lot(s); for each seed lot, seeds were tested by PCR [*insert laboratory name(s) and report number(s)*] on a sample size of 20,000 seeds (or 20% of small seed lots) and found free from detectable presence of *Fusarium oxysporum* f. sp. *raphani*.'

Seed lots of *Brassica rapa* and *Raphanus sativus* that are heat treated off-shore for *Colletotrichum higginsianum* must be accompanied by an official government Phytosanitary Certificate endorsed with the following additional declaration:

- 'The consignment of [*botanical name (s) (Genus species)*] comprises [*insert number of brassicaceous vegetable seed lots*] seed lot(s); for each seed lot, seeds were treated with dry heat at 70°C for 90 minutes.
- OR
- 'The consignment of [*botanical name (s) (Genus species)*] comprises [*insert number of brassicaceous vegetable seed lots*] seed lot(s); for each seed lot, seeds were treated with hot water at 53°C for 10 minutes (or 50°C for 20 minutes).

4.2.6 Summary of additional risk management measures

The additional pest risk management measures for brassicaceous vegetable seeds that are associated with the identified quarantine pests are summarised in Table 9.

Table 9 Additional pest risk management measures for the identified quarantine pests

Management measures for identified pests in identified hosts	<i>Brassica rapa</i>	<i>Eruca vesicaria</i>	<i>Raphanus sativus</i>
<i>Colletotrichum higginsianum</i>	Required	Not required	Required
<i>Fusarium oxysporum</i> f. sp. <i>raphani</i>	Not required	Required	Required
Options applicable to host	1 or 2	1 or 3	1 or 4
Option details	Option 1. Broad spectrum fungicidal treatment OR Option 2. Heat treatment	Option 1. Broad spectrum fungicidal treatment OR Option 3. PCR test	Option 1. Broad spectrum fungicidal treatment OR Option 4. Heat treatment AND PCR test combined.
Phytosanitary certification (if measures applied off-shore)	Yes	Yes	Yes

Option 1: removing the fungicide from the seed prior to planting is not permitted.

Options 2, 3 and 4 do not impact the organic status of seeds.

4.3 Evaluation of recommended risk management measures

The recommended pest risk management measures (Table 10) are designed to reduce the pest risk for each identified quarantine pest to a very low level, which will achieve the ALOP for Australia.

Table 10 Evaluation of the recommended pest risk management measures impact on risk estimates

Recommended measure	Effect of the measure	Risk estimates after measures (restricted risk)
Option 1. Broad spectrum fungicidal treatment	Treatment of seeds with an effective broad spectrum fungicide will reduce the risk of introducing <i>Colletotrichum higginsianum</i> and <i>F. o. f. sp. raphani</i> .	Very low
Option 2. Heat treatment (dry heat or hot water treatment)	Treatment will reduce the risk of introducing heat-sensitive <i>Colletotrichum higginsianum</i> into Australia.	Very low
Option 3. PCR test	Testing to verify freedom from <i>F. o. f. sp. raphani</i> will reduce the risk of introducing this pest into Australia.	Very low
Option 4. Heat treatment AND PCR test combined	Heat treatment will reduce the risk of introducing heat-sensitive <i>Colletotrichum higginsianum</i> into Australia, while PCR test will reduce the risk of introducing <i>F. o. f. sp. raphani</i> into Australia.	Very low

4.4 Seeds imported for sprouting or micro-greens

Brassicaceous vegetable seeds imported for the end use of sprouting or micro-greens production for human consumption are currently subject to the department's standard seeds for sowing import conditions.

Brassica rapa, *Eruca vesicaria* and *Raphanus sativus* seeds used for sprouting or micro-greens production are exempt from the additional measures for seeds for sowing if imported directly for germination at a production facility operated under an Approved Arrangement.

Facilities that operate under an Approved Arrangement will be required to demonstrate that seeds imported for the intended end use of sprouting or micro-greens production are not diverted for other purposes, and that other risks are managed appropriately. Details of the requirements for registration and operation of an Approved Arrangement for the importation of brassicaceous vegetable seeds for sprouting or micro-greens production are available on the department's website: [Approved Arrangements for 3.0 – Produce Processing – Requirements](#).

Approval for an Approved Arrangement is subject to a range of requirements which will include assessment of standard operating procedures and pre-approval audit and verification by the department.

Brassica rapa, *Eruca vesicaria* and *Raphanus sativus* seeds that are not directly imported to be germinated at a production facility operated under an Approved Arrangement will require additional measures as specified in Chapter 4.2.

4.5 Alternative measures for seeds for sowing

Australia recognises the principle of equivalence, namely, '*the situation where, for a specified pest risk, different phytosanitary measures achieve a contracting party's appropriate level of protection*' (FAO 2019b). ISPM 24 (FAO 2017c) provides guidelines for the determination and recognition of equivalence of phytosanitary measures.

Where formal recognition of equivalence is required, the NPPO of the exporting country must provide a technical submission detailing relevant evidence for the proposed measures for consideration by the department.

Several ISPMs provide further guidance on alternative pest risk management options that may be appropriate to achieve the objective of freedom from the quarantine pests identified in this review. These include:

- ISPM 4: *Requirements for the establishment of pest free areas* (FAO 2017b)
- ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2016a)
- ISPM 14: *The use of integrated measures in a systems approach for pest risk management* (FAO 2019d)

These alternative pest risk management options are discussed in the following sections.

4.5.1 Sourcing seeds from pest-free areas

The establishment and use of a pest free area (PFA) by an NPPO provides assurance that specific pests are not present in a delimited geographic area. The delimitation of a PFA should be relevant to the biology of the pest concerned.

The requirements for establishing PFAs are set out in ISPM 4 (FAO 2017b). This ISPM defines a PFA as ‘an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained’. A PFA may concern all or part of several countries and is managed by the NPPO of the exporting country. The establishment and use of a PFA by an NPPO allows an exporting country to export plants and other regulated articles to an importing country without having to apply additional phytosanitary measures providing certain requirements are met.

Requirements for an NPPO to establish and maintain a PFA include:

- systems to establish freedom (general surveillance and specific surveys)
- phytosanitary measures to maintain freedom (regulatory actions, routine monitoring, and extension advice to producers)
- checks to verify freedom has been maintained.

NPPOs that propose to use area freedom as a measure for managing risks posed by the quarantine pests identified in this review must provide the Department of Agriculture with an appropriate submission demonstrating area freedom for its consideration.

4.5.2 Sourcing seeds from pest-free places of production

Requirements for establishing pest free places of production are set out in ISPM 10 (FAO 2016a). The concept of ‘pest freedom’ allows exporting countries to provide assurance to importing countries that plants, plant products and other regulated articles are free from a specific pest or pests and meet the phytosanitary requirements of the importing country. Where a defined portion of a place of production is managed as a separate unit and can be maintained pest free, it may be regarded as a pest free production site.

Requirements for an NPPO to establish and maintain a pest free place of production or a pest free production site as a phytosanitary measure include:

- systems to establish pest freedom
- systems to maintain pest freedom
- verification that pest freedom has been attained or maintained
- product identity, consignment integrity and phytosanitary security.

Where necessary, a pest free place of production or a pest free production site must also establish and maintain an appropriate buffer zone.

Administrative activities required to support a pest free place of production or a pest free production site include documentation of the system and maintenance of adequate records about the measures taken. Review and audit procedures undertaken by an NPPO are essential to

support assurance of pest freedom and for system appraisal. Bilateral agreements or arrangements may also be needed.

NPPOs that propose to use pest free places of production as a measure for managing risks posed by the quarantine pests identified in this review must provide the Department of Agriculture with an appropriate submission demonstrating pest free place of production status, for its consideration.

4.5.3 Sourcing seeds produced under a systems approach

ISPM 14 (FAO 2019d) provides guidelines on the use of systems approaches to manage pest risk. According to ISPM 14 (FAO 2019d), 'a systems approach requires the integration of different measures, at least two of which act independently, with a cumulative effect' to achieve the appropriate level of protection.

A systems approach could provide an alternative to relying on a single measure to achieve the ALOP of an importing country or could be used where no single measure is available. A systems approach is often tailored to specific commodity–pest–origin combinations and may be developed and implemented collaboratively by exporting and importing countries. The importing country specifies the appropriate approach after considering technical requirements, minimal impact, transparency, non-discrimination, equivalence and operational feasibility.

NPPOs that propose to use a systems approach as a measure for managing risks posed by the quarantine pests identified in this review must provide the Department of Agriculture with an appropriate submission describing their preferred systems approach and rationale, for its consideration.

4.5.4 Consideration of additional potential alternative options raised by stakeholders

After the release of the *'Draft review of import conditions for brassicaceous crop seeds for sowing into Australia'*, the department received several responses from stakeholders, including from the organic sector, about potential alternative risk mitigation measures to the proposed mandatory fungicidal treatment. In preparing this final report, consideration has been given to a broad range of these potential alternative options, details of which are provided in Appendix 3.

4.6 Review of import conditions

The department reserves the right to review these import conditions if there is reason to believe that the pest or phytosanitary status of these organisms has changed or is likely to change. Similarly, a review may be required, for example, where scientific evidence or other information subsequently becomes available which improves knowledge of, or decreases uncertainty in treatment efficacy and/or the equivalence of measures.

5 Conclusion

Under Australia's existing import policy, all seeds for sowing, including brassicaceous vegetable seeds, are subject to the department's standard import conditions. This review of import conditions identified two quarantine pests associated with the seeds of several brassicaceous hosts.

Colletotrichum higginsianum is seed-borne in:

- *Brassica rapa*
- *Raphanus sativus*.

Fusarium oxysporum f. sp. *raphani* is seed-borne in:

- *Eruca vesicaria*
- *Raphanus sativus*.

The unrestricted risks of these quarantine pests on the seeds for sowing pathway do not achieve the appropriate level of protection (ALOP) for Australia. Consequently, additional pest risk management measures are required to mitigate the risk posed by the identified quarantine pests to achieve the ALOP for Australia.

In addition to the department's standard seeds for sowing import conditions, four pest risk management options (see Chapter 4) are recommended for seeds of *Brassica rapa*, *Eruca vesicaria* and *Raphanus sativus*:

- Option 1. Broad spectrum fungicidal treatment—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.
- Option 2. Heat treatment—to manage the risk of *Colletotrichum higginsianum* only.
- Option 3. Polymerase Chain Reaction (PCR) test—to manage the risk of *Fusarium oxysporum* f. sp. *raphani* only.
- Option 4. Heat treatment and PCR test combined—to manage the risk of both *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani*.

If the treatment or testing is undertaken off-shore, phytosanitary certification is required with the additional declaration that the testing or treatment has been conducted in accordance with Australia's requirements.

Brassica rapa, *Eruca vesicaria* and *Raphanus sativus* seeds for sprouting or micro-greens production for human consumption are exempt from these additional measures if imported directly for germination at a production facility operated under an Approved Arrangement.

Alternative options to testing or treatment, such as sourcing seeds from pest-free areas or pest-free places of production, or sourcing seeds produced under a systems approach may be proposed. However, supporting documentation demonstrating pest free area status, pest free place of production status, or details of a proposed systems approach will be required for the department to consider these options on a case-by-case basis.

Seeds of most brassicaceous vegetable species reviewed were not found to be hosts of quarantine pests for Australia and will therefore continue to be subject only to the department's standard seeds for sowing import conditions. The brassicaceous species (including their synonyms or subordinate taxa) that will continue to be subject to standard seeds for sowing import conditions are: *Armoracia rusticana*, *Barbarea verna*, *Barbarea vulgaris*, *Brassica carinata*, *Brassica elongata*, *Brassica juncea*, *Brassica nigra*, *Brassica oleracea*, *Crambe abyssinica*, *Crambe cordifolia*, *Crambe maritima*, *Crambe tatarica*, *Eutrema wasabi*, *Lepidium campestre*, *Lepidium meyenii*, *Lepidium perfoliatum*, *Lepidium ruderae*, *Lepidium sativum*, *Lepidium squamatum*, *Lepidium virginicum*, *Nasturtium microphyllum*, *Nasturtium officinale*, *Rorippa islandica*, *Rorippa palustris*, *Sinapis alba*, *Sinapis arvensis* and *Sinapis erucoides*.

The findings of this final review for brassicaceous vegetable seeds for sowing are based on a comprehensive scientific analysis of relevant literature.

The Australian Government Department of Agriculture considers that the risk management measures recommended in this report will provide an appropriate level of protection against the identified quarantine pests associated with brassicaceous vegetable seeds.

Appendix 1: Pest categorisation of pathogens associated with Brassicaceae species in scope

Pest categorisation determines whether the formal criteria for classification of a pest organism as a quarantine pest are satisfied. The process is based on the identity of the pest, its presence or absence in the pest risk analysis (PRA) area, regulatory status, potential for establishment and spread in the PRA area, and potential for economic (including environmental) consequences in the PRA area (FAO 2019c).

Appendix 1 identifies pests that affect the brassicaceous vegetables under review from a worldwide perspective, and considers their status in Australia. It also identifies any region in Australia in which legislation governing that region lists the pest as prohibited. Regional pests are considered further if they are absent from the region, or present and under official control in the region as defined by the International Plant Protection Convention (FAO 2019b).

Estimates of each pest's potential for creating economic consequences is based on the assessment of its likelihood of meeting the ISPM 5 definition of a quarantine pest.

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
BACTERIA						
<i>Agrobacterium rhizogenes</i> (Riker et al. 1930) Conn 1942 [Rhizobiales: Rhizobiaceae] (synonym: <i>Rhizobium rhizogenes</i> (Riker et al. 1930) Young et al. 2001)	<i>Brassica</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Bradbury 1986)	Assessment not required	Assessment not required	Assessment not required	No
<i>Agrobacterium tumefaciens</i> (Smith & Townsend 1907) Conn 1942 [Rhizobiales: Rhizobiaceae] (synonym: <i>Rhizobium radiobacter</i> (Beijerinck & van Delden 1902) Young et al. 2001)	<i>Armoracia</i> , <i>Brassica</i> , <i>Raphanus</i>	Yes (Bradbury 1986)	Assessment not required	Assessment not required	Assessment not required	No
<i>Erwinia carotovora</i> subsp. <i>atroseptica</i> (van Hall 1902) Dye 1969 [Enterobacteriales: Enterobacteriaceae] (synonym: <i>Pectobacterium atrosepticum</i> (van Hall 1902) Gardan et al. 2003)	<i>Brassica</i>	Yes (Bradbury 1986; Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pectobacterium carotovorum</i> subsp. <i>carotovorum</i> (Jones 1901) Hauben et al. 1999 [Enterobacteriales: Enterobacteriaceae] (synonym: <i>Erwinia carotovora</i> subsp. <i>carotovora</i> (Jones 1901) Bergey et al. 1923)	<i>Armoracia</i> , <i>Brassica</i> , <i>Eutrema</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pectobacterium wasabiae</i> (Goto & Matsumoto 1987) Gardan et al. 2003 [Enterobacteriales: Enterobacteriaceae]	<i>Brassica</i> , <i>Eutrema</i>	Not known to occur	No: This bacterium has been reported naturally occurring on <i>Brassica</i> and <i>Eutrema</i> species (Golkhandan et al. 2013; Goto & Matsumoto 1987). To date there is no available evidence demonstrating that this bacterium is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this bacterium.	Assessment not required	Assessment not required	No
<i>Pseudomonas cichorii</i> (Swingle 1925) Stapp 1928 [Pseudomonadales: Pseudomonadaceae]	<i>Brassica</i>	Yes (Bradbury 1986; Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudomonas fluorescens</i> Migula 1895 [Pseudomonadales: Pseudomonadaceae]	<i>Armoracia</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudomonas marginalis</i> pv. <i>marginalis</i> (Brown 1918) Stevens 1925 [Pseudomonadales: Pseudomonadaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Bradbury 1986; Persley, Cooke & House 2010). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pseudomonas cannabina</i> pv. <i>alisalensis</i> Bull et al. 2010 [Pseudomonadales: Pseudomonadaceae] (synonym: <i>Pseudomonas syringae</i> pv. <i>alisalensis</i> Cintas et al. 2000)	<i>Brassica</i> , <i>Eruca</i> , <i>Radish</i>	Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom. Yes (Bull & Rubio 2011; Persley, Cooke & House 2010). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudomonas syringae</i> pv. <i>maculicola</i> (McCulloch 1911) Young et al. 1978 [Pseudomonadales: Pseudomonadaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010; Peters et al. 2004)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudomonas syringae</i> pv. <i>syringae</i> van Hall 1902 [Pseudomonadales: Pseudomonadaceae]	<i>Brassica</i>	Yes (Whitelaw-Weckert et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pseudomonas viridiflava</i> (Burkholder 1930) Dowson 1939 [Pseudomonadales: Pseudomonadaceae]	<i>Brassica</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ralstonia solanacearum</i> (Smith 1896) Yabuuchi et al. 1996 [Burkholderiales: Ralstoniaceae] (synonym: <i>Pseudomonas solanacearum</i> (Smith 1896) Smith 1911)	<i>Brassica</i>	Yes. Race 1 and 3 are present in Australia (Graham, Jones & Lloyd 1979). However, other strains are not known to occur.	No: This bacterium has been reported naturally occurring on <i>Brassica</i> species (Pradhanang, Elphinstone & Fox 2000). To date there is no available evidence demonstrating that this bacterium is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this bacterium.	Assessment not required	Assessment not required	No
<i>Rhodococcus fascians</i> (Tilford 1936) Goodfellow 1984 [Actinomycetales: Nocardiaceae]	<i>Brassica</i> , <i>Nasturtium</i>	Yes (Pilkington et al. 2003). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Spiroplasma citri</i> Saglio et al. 1973 [Entomoplasmatales: Spiroplasmataceae]	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This bacterium has been reported naturally occurring on <i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> and <i>Raphanus</i> species (CABI	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Streptomyces aureofaciens</i> Duggar 1948 emend. Groth et al. 2003 [Actinomycetales: Streptomycetaceae]	<i>Raphanus</i>	Not known to occur	2019; EFSA 2014b). To date there is no available evidence demonstrating that this bacterium is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this bacterium. No: This bacterium has been reported naturally occurring on the roots of <i>Raphanus</i> species (Singh, Gaut & Gautam 1997). To date there is no available evidence demonstrating that this bacterium is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this bacterium.	Assessment not required	Assessment not required	No
<i>Streptomyces scabeie</i> (Thaxter 1891) Waksman & Henrici 1948 [Actinomycetales: Streptomycetaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Horne, de Boer & Crawford 2002)	Assessment not required	Assessment not required	Assessment not required	No
<i>Xanthomonas campestris</i> (Pammel 1895) Dowson 1939 [Xanthomonadales: Xanthomonadaceae]	<i>Crambe</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Xanthomonas campestris</i> pv. <i>aberrans</i> (Knosel 1961) Dye 1978 [Xanthomonadales: Xanthomonadaceae]	<i>Brassica</i>	Yes (Tesoriero 2004)	Assessment not required	Assessment not required	Assessment not required	No
<i>Xanthomonas campestris</i> pv. <i>armoraciae</i> (McCulloch 1929) Dye 1978 [Xanthomonadales: Xanthomonadaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Raphanus</i>	Yes (CABI 2019; Conn & Rosenberger 2013)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Xanthomonas campestris</i> pv. <i>barbareae</i> (Burkholder 1941) Dye 1978 [Xanthomonadales: Xanthomonadaceae]	<i>Barbarea</i>	Not known to occur	No: This bacterium has been reported naturally occurring on <i>Barbarea</i> species (Horst 2008). To date there is no available evidence demonstrating that this bacterium is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this bacterium.	Assessment not required	Assessment not required	No
<i>Xanthomonas campestris</i> pv. <i>campestris</i> (Pammel 1895) Dowson 1939 [Xanthomonadales: Xanthomonadaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Shivas 1989; Tesoriero 2004)	Assessment not required	Assessment not required	Assessment not required	No
<i>Xanthomonas campestris</i> pv. <i>raphani</i> (White 1930) Dye 1978 [Xanthomonadales: Xanthomonadaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Tesoriero 2016)	Assessment not required	Assessment not required	Assessment not required	No
CHROMALVEOLATA						
<i>Phytophthora brassicae</i> de Cock & Man [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Not known to occur	No: <i>Phytophthora brassicae</i> has been reported naturally occurring on <i>Brassica</i> species (Bertier et al. 2013; Man in't Veld et al. 2002). To date there is no published evidence that <i>Phytophthora brassicae</i> is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for <i>Phytophthora brassicae</i> .	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Phytophthora cactorum</i> (Lebert & Cohn) Schrot [Peronosporales: Peronosporaceae]	<i>Brassica</i> , <i>Lepidium</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora capsici</i> Leonian [Peronosporales: Peronosporaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Weinert et al. 1998)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora citrophthora</i> (Sm. & Sm.) Leonian [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora cryptogea</i> Pethybr. & Laff. [Peronosporales: Peronosporaceae]	<i>Brassica</i> , <i>Nasturtium</i>	Yes (Zahid et al. 2001a)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora drechsleri</i> Tucker [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Farr & Rossman 2019; Stukely et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora erythroseptica</i> Pethybr. [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora megasperma</i> Drechsler [Peronosporales: Peronosporaceae]	<i>Brassica</i> , <i>Rorippa</i>	Yes (Stukely et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora nicotianae</i> Breda de Haan [Peronosporales: Peronosporaceae] (synonym: <i>Phytophthora parasitica</i> Dastur)	<i>Brassica</i>	Yes (Stukely et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora palmivora</i> (Butler) Butler [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Barber et al. 2013; O'Gara et al. 2004; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phytophthora porri</i> Foister [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Phytophthora undulata</i> (Peterson) Dick [Peronosporales: Peronosporaceae] (synonyms: <i>Elongisporangium undatum</i> (Petersen) Uzuhasi et al.; <i>Pythium undulatum</i> Petersen)	<i>Brassica</i>	Not known to occur	No: <i>Phytophthora undulata</i> has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence <i>Phytophthora undulata</i> is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for <i>Phytophthora undulata</i> .	Assessment not required	Assessment not required	No
<i>Pythium acanthicum</i> Drechs. [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium afertile</i> Kanouse & Humphrey [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium aphanidermatum</i> (Edson) Fitzp. [Peronosporales: Pythiaceae]	<i>Brassica</i> , <i>Lepidium</i> , <i>Raphanus</i>	Yes (Farr & Rossman 2019; Male & Vawdrey 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium brassicum</i> Stangh. et al. [Peronosporales: Pythiaceae]	<i>Brassica</i> , <i>Eruca</i>	Not known to occur	No: <i>Pythium brassicum</i> has been reported naturally occurring on <i>Brassica</i> (Farr & Rossman 2019; Stanghellini et al. 2014) and <i>Eruca</i> species (Michel, Wohler & Käser 2015). To date there is no published evidence that <i>Pythium brassicum</i> is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for <i>Pythium brassicum</i> .	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pythium butleri</i> Subraman. [Peronosporales: Pythiaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Male & Vawdrey 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium coloratum</i> Vaartaja [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (El-Tarabily, Hardy & Sivasithamparan 1997)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium debaryanum</i> Hesse [Peronosporales: Pythiaceae]	<i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i>	Yes (Wong, Barbeti & Sivasithamparan 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium deliense</i> Meurs [Peronosporales: Pythiaceae] (synonym: <i>Pythium indicum</i> Balakr.)	<i>Brassica</i>	Yes (Sampson & Walker 1982). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium dissotocum</i> Drechsler [Peronosporales: Pythiaceae]	<i>Rorippa</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium echinocarpum</i> Ito & Tokun. [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium graminicola</i> Subraman [Peronosporales: Pythiaceae]	<i>Rorippa</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pythium indigoferae</i> Butler [Peronosporales: Pythiaceae] (synonym: <i>Phytophythium indigoferae</i> (Butler) Kirk)	<i>Brassica</i>	Not known to occur	No: <i>Pythium indigoferae</i> has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Yu 1998). To date there is no published evidence that <i>Pythium indigoferae</i> is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for <i>Pythium indigoferae</i> .	Assessment not required	Assessment not required	No
<i>Pythium irregulare</i> Buisman [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium irregulare</i> (Buisman) Uzuhashi et al.)	<i>Brassica</i> , <i>Lepidium</i>	Yes (Sampson & Walker 1982; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium megalacanthum</i> de Bary [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium megalacanthum</i> (de Bary) Uzuhashi et al.)	<i>Brassica</i>	Not known to occur	No: <i>Pythium megalacanthum</i> has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Pennycook 1989). To date there is no published evidence that <i>Pythium megalacanthum</i> is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for <i>Pythium megalacanthum</i> .	Assessment not required	Assessment not required	No
<i>Pythium middletonii</i> Sparrow [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium proliferum</i> (Cornu) Kirk)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium monospermum</i> Pringsh [Peronosporales: Pythiaceae]	<i>Lepidium</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pythium myriotylum</i> Drechsler [Peronosporales: Pythiaceae]	<i>Raphanus</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium oligandrum</i> Drechs. [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium paroecandrum</i> Drechsler [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium peritum</i> Drechsler [Peronosporales: Pythiaceae]	<i>Brassica</i> , <i>Rorippa</i>	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium polymastum</i> Drechsler [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium polymastum</i> (Drechsler) Uzuhashi et al.)	<i>Brassica</i> , <i>Rorippa</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium rostratifyingens</i> de Cock & Levesque [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium rostratifyingens</i> (de Cock & Lévesque) Uzuhashi et al.)	<i>Brassica</i>	Yes (Petkowski et al. 2013)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium rostratum</i> Butler [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium rostratum</i> (Butler) Uzuhashi)	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium splendens</i> Hans Braun [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium splendens</i> (Hans Braun) Uzuhashi et al.)	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium torulosum</i> Coker & Patt. [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythium tracheiphilum</i> Matta [Peronosporales: Pythiaceae]	<i>Brassica</i>	Yes (Kumar et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pythium ultimum</i> Trow [Peronosporales: Pythiaceae] (synonym: <i>Globisporangium ultimum</i> (Trow) Uzuhashi et al.)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
FUNGI						
<i>Acaulospora paulinae</i> Błaszk. [Diversisporales: Acaulosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Acrostalagmus aphidum</i> Oudem. [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Aecidium crambes</i> Moesz [Pucciniales: Incertae sedis]	<i>Crambe</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Crambe</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			not considered to provide a pathway for this fungus.			
<i>Albugo candida</i> (Pers.) Roussel [Albuginales: Albuginaceae] (synonyms: <i>Albugo cruciferarum</i> (DC) Gray; <i>Albugo macrospora</i> (Togashi) Ito; <i>Cystopus candidus</i> (Pers.) Lev.)	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Eruca</i> , <i>Eutrema</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Albugo ipomoeae-panduratae</i> (Schwein.) Swingle [Albuginales: Albuginaceae]	<i>Raphanus</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Albugo lepidii</i> Rao [Albuginales: Albuginaceae]	<i>Lepidium</i>	Yes (Ploch et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Albugo rorippae</i> Choi et al. [Albuginales: Albuginaceae]	<i>Rorippa</i>	Yes (Choi et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria alternata</i> (Fr.) Keissl. [Pleosporales: Pleosporaceae] (synonyms: <i>Alternaria tenuis</i> Nees; <i>Ulocladium consortiale</i> sensu Brook)	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria armoraciae</i> Simmons & Hill [Pleosporales: Pleosporaceae]	<i>Armoracia</i>	Not known to occur	No: This fungus has been reported naturally occurring on the leaves of <i>Armoracia</i> species causing leaf spot (Farr & Rossman 2019; Woudenberg et al. 2013). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Alternaria brassicae</i> (Berk.) Sacc. [Pleosporales: Pleosporaceae] (synonyms: <i>Alternaria herculea</i> (Ellis & Martin) Elliott; <i>Alternaria macrospora</i> (Sacc.) Mussat; <i>Alternaria saccardoi</i> Sawada)	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Crambe</i> , <i>Eruca</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (Sampson & Walker 1982; Shivas 1989)	not considered to provide a pathway for this fungus. Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria brassicae-pekinensis</i> Woudenberg & Crous [Pleosporales: Pleosporaceae] (synonym: <i>Ulocladium brassicae</i> Yong Wang bis & Zhang)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Woudenberg et al. 2013). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Alternaria brassicinae</i> Simmons [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Simmons 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Alternaria brassicicola</i> (Schwein.) Wiltshire [Pleosporales:	<i>Armoracia</i> , <i>Brassica</i> ,	Yes (Persley, Cooke & House	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
Pleosporaceae] (synonyms: <i>Alternaria circinans</i> (Berk. & Curtis) Bolle; <i>Alternaria oleracea</i> Milbrath; <i>Helminthosporium brassicae</i> Henn.; <i>Helminthosporium brassicicola</i> Schwein.)	<i>Crambe</i> , <i>Eruca</i> , <i>Raphanus</i>	2010; Shivas 1989)				
<i>Alternaria broccoli-italicae</i> Simmons [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Farr & Rossman 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria cheiranthi</i> (Lib.) Bolle [Pleosporales: Pleosporaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria dauci</i> (Kühn) Groves & Skolko [Pleosporales: Pleosporaceae] (synonyms: <i>Alternaria carotae</i> (Ellis & Langl.) Stev et al.; <i>Macrosporium carotae</i> Ellis & Langl.)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria japonica</i> Yoshii [Pleosporales: Pleosporaceae] (synonym: <i>Alternaria raphani</i> Groves & Skolko)	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Cunnington 2003). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Alternaria malorum</i> (Ruehle) Braun et al. [Pleosporales: Pleosporaceae] (synonym: <i>Alternaria malorum</i> (Ruehle) Braun et al.)	<i>Raphanus</i>	Not known to occur	Yes: Seeds provide a pathway for this fungus, which has been reported as	Yes: When introduced via the seed pathway, <i>Alternaria malorum</i> could	No: To date there is no evidence of economic consequences	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Chalastospora gossypii</i> (Jacq.) Braun & Crous)			seed-borne in <i>Raphanus sativus</i> (Dugan, Schubert & Braun 2004). This fungus has also been reported on other <i>Raphanus</i> species (Dugan, Schubert & Braun 2004; Farr & Rossman 2019).	establish and spread in Australia. This fungus has established in areas with a wide range of climatic conditions (Farr & Rossman 2019). Spread of this fungus from the seed pathway depends on human mediated transport of infected seeds.	associated with this fungus. Therefore, it is not considered to pose risks of economic significance for Australia.	
<i>Alternaria nepalensis</i> Simmons [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Simmons 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Alternaria tenuissima</i> (Kunze) Wiltshire [Pleosporales: Pleosporaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Giles et al. 2002)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ampelomyces quisqualis</i> Ces. [Pleosporales: Phaeosphaeriaceae] (synonym: <i>Cicinobolus cesatii</i> de Bary)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aphanomyces brassicae</i> Singh & Pavgi [Saprolegniales: Leptolegniaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing root rot disease (Singh & Pavgi 1977). To date there is no available evidence demonstrating that this	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Aphanomyces raphani</i> Kendr. [Saprolegniales: Leptolegniaceae]	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010; Shivas 1989)	fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus. Assessment not required	Assessment not required	Assessment not required	No
<i>Apiospora montagnei</i> Sacc. [Incertae sedis: Apiosporaceae] (synonym: <i>Arthrimum arundinis</i> (Corda) Dyko & Sutton)	<i>Brassica</i>	Yes (Fröhlich, Hyde & Guest 1997)	Assessment not required	Assessment not required	Assessment not required	No
<i>Arnium olerum</i> (Fr.) Lundq. & Krug [Sordariales: Lasiosphaeriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Eriksson 2014; Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Arnium tomentosum</i> (Speq.) Lundg & Krug [Sordariales: Lasiosphaeriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Kruys, Huhndorf & Miller 2014). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Arthrobotrys oligospora</i> Fresen [Orbiliiales: Orbiliaceae]	<i>Rorippa</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ascobolus brassicae</i> Crouan & Crouan [Pezizales: Ascobolaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Eriksson 2014; Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ascochyta armoraciae</i> Cooke [Pleosporales: Didymellaceae]	<i>Armoracia</i> , <i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> and <i>Brassica</i> species (Eriksson 2014; Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ascochyta brassicae</i> Thüm [Pleosporales: Didymellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Ascochyta cheiranthi</i> Bres. 1900 [Pleosporales: Didymellaceae]	<i>Crambe</i> , <i>Brassica</i> , <i>Rorippa</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Crambe</i> , <i>Brassica</i> and <i>Rorippa</i> species (Farr & Rossman 2019; Mel'nik, Braun & Hagedorn 2000). To date there is no available evidence demonstrating that this fungus is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ascochyta crambicola</i> Melnik, 1967 [Pleosporales: Didymellaceae]	<i>Crambe</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Crambe</i> species (Mel'nik, Braun & Hagedorn 2000). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ascochyta oleracea</i> Ellis [Pleosporales: Didymellaceae]	<i>Brassica</i>	Not known to occur	Yes: Seeds provide a pathway for this fungus, which has been reported as seed-borne in <i>Brassica oleracea</i> (Richardson 1990). This fungus has also been reported on <i>Brassica oleracea</i> (Farr & Rossman 2019).	Yes: When introduced via the seed pathway, <i>Ascochyta oleracea</i> could establish and spread in Australia. This fungus has established in areas with a wide range of climatic conditions (Farr & Rossman 2019). Spread of this fungus from the seed pathway depends on human mediated transport of infected seeds.	No: To date there is no evidence of economic consequences associated with this fungus. Therefore, it is not considered to pose risks of economic significance for Australia.	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Aspergillus amstelodami</i> Thom & Church [Eurotiales: Trichocomaceae] (synonym: <i>Eurotium amstelodami</i> Mangin)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus candidus</i> Link [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Hocking 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus chevalieri</i> Thom & Church [Eurotiales: Trichocomaceae] (synonym: <i>Eurotium chevalieri</i> Mangin)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus flavus</i> Link [Eurotiales: Trichocomaceae] (synonym: <i>Aspergillus oryzae</i> (Ahlb) Cohn)	<i>Brassica</i>	Yes (Hocking 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus fumigatus</i> Fresen. [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus glaucus</i> (L.) Link [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus japonicus</i> Saito [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus nidulans</i> (Eidam) Winter [Eurotiales: Trichocomaceae] (synonym: <i>Emericella nidulans</i> (Eidam) Vuill.)	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus niger</i> Tiegh. [Eurotiales: Trichocomaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Midgley et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus ochraceus</i> Wilh. [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Hocking 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus repens</i> (Corda) Sacc. [Eurotiales: Trichocomaceae] (synonym: <i>Eurotium repens</i> de Bary)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus tamarii</i> Kita [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Aspergillus terreus</i> Thom [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Midgley et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus versicolor</i> (Vuill.) Tirab. [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Hocking 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aspergillus violaceus</i> Fennel & Raper [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Athelia rolfsii</i> (Curzi) Tu & Kimbr. [Atheliales: Atheliaceae] (synonyms: <i>Corticium rolfsii</i> Curzi; <i>Pellicularia rolfsii</i> (Sacc.) West; <i>Sclerotium rolfsii</i> Sacc.)	<i>Barbarea</i> , <i>Nasturtium</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aureobasidium pullulans</i> (de Bary & Löwenthal) Arnaud [Dothideales: Saccoteciaceae]	<i>Crambe</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Basipetospora chlamydospora</i> Matsush. [Eurotiales: Monascaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Bipolaris indica</i> Rai et al. [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Bipolaris sorokiniana</i> (Sacc.) Shoemaker [Pleosporales: Pleosporaceae] (synonym: <i>Cochliobolus sativus</i> (Ito & Kurib) Drechsler ex Dastur)	<i>Brassica</i>	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Blakeslea trispora</i> Thaxt. [Mucorales: Choanephoraceae]	<i>Brassica</i>	Yes (Shipton, McCown & Williams 1981)	Assessment not required	Assessment not required	Assessment not required	No
<i>Boeremia exigua</i> (Desm.) Aveskamp et al. [Pleosporales: Didymellaceae] (synonym: <i>Phoma exigua</i> Desm.)	<i>Armoracia</i>	Yes (Li et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
<i>Botrytis cinerea</i> Pers [Helotiales: Sclerotiniaceae] (synonym: <i>Botryotinia fuckeliana</i> (de Bary) Whetzel)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cylindrocladium scoparium</i> Morgan [Hypocreales: Nectriaceae] (synonym: <i>Calonectria morganii</i> Crous et al.; <i>Cylindrocladium scoparium</i> Morg. 1892)	<i>Brassica</i>	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cephalotrichum stemonitis</i> (Pers.) Nees [Microascales: Microascaceae] (synonyms: <i>Echinobotryum atrum</i> Corda; <i>Stysanus stemonitis</i> (Pers.) Corda)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cercospora armoraciae</i> Sacc. [Capnodiales: Mycosphaerellaceae] (synonyms: <i>Cercospora atrogrisea</i> Ellis & Everh.; <i>Cercospora barbareae</i> (Sacc.) Mussat; <i>Cercospora</i> <i>bizzozeriana</i> Sacc. & Berl., <i>Cercospora camarae</i> Curzi; <i>Cercospora lepidii</i> Niessl; <i>Cercospora nasturtii</i> Pass.)	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i>	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cercospora brassicicola</i> Henn. [Capnodiales: Mycosphaerellaceae] (synonym: <i>Cercospora bloxamii</i> Berk. & Broome; <i>Cercospora brassicae-</i> <i>campestris</i> Rangel)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cercospora cruciferarum</i> Ellis & Everh [Capnodiales: Mycosphaerellaceae]	<i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Raphanus</i> species causing leaf spot (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Cercospora kikuchii</i> (Tak., Matsumoto & Tomoy.) Gardner [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i>	Yes (Ryley & Drenth 2000)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetomium cochliodes</i> Palliser [Sordariales: Chaetomiaceae]	<i>Brassica</i>	Not known to occur	Yes: Seeds provide a pathway for this fungus, which has been reported as seed-borne in <i>Brassica rapa</i> (Farr & Rossman 2019; Skolko & Groves 1953). This	Yes: When introduced via the seed pathway, <i>Chaetomium cochliodes</i> could establish and spread in Australia. This fungus has established in areas with a	No: To date there is no evidence of economic consequences associated with this fungus. Therefore, it is not considered to pose	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			fungus has also been reported on other <i>Brassica</i> species (Skolko & Groves 1953; Zhuang 2005).	wide range of climatic conditions (Farr & Rossman 2019). Spread of this fungus from the seed pathway depends on human mediated transport of infected seeds.	risks of economic significance for Australia.	
<i>Chaetomium elatum</i> Kunze [Sordariales: Chaetomiaceae] (synonym: <i>Chaetomium comatum</i> (Tode) Fr.)	<i>Brassica</i>	Yes (ALA 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetomium funicola</i> Cooke [Sordariales: Chaetomiaceae]	<i>Brassica</i>	Yes (Minter 2006)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetomium globosum</i> Kunze ex Fr. [Sordariales: Chaetomiaceae]	<i>Brassica</i>	Yes (Syed et al. 2009)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetomium indicum</i> Corda [Sordariales: Chaetomiaceae]	<i>Brassica</i>	Yes (HerbIMI 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetomium nigricolor</i> Ames [Sordariales: Chaetomiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Srivastava, Singh & Pathak 1981). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Chaetomium piluliferum</i> Daniels [Sordariales: Chaetomiaceae] (synonym: <i>Botryotrichum piluliferum</i> Sacc. & Marchal)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chaetospermum chaetosporum</i> (Pat.) Sm. & Ramsb. [Incertae sedis: Incertae sedis]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Chalara kendrickii</i> Nag Raj [Microascales: Incertae sedis]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Roux & Wingfield 2013). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Choanephora cucurbitarum</i> (Berk. & Ravenel) Thaxt. [Mucorales: Choanephoraceae]	<i>Brassica</i> , <i>Nasturtium</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Chromelosporium fulvum</i> (Link) McGinty et al. [Pezizales: Pezizaceae]	<i>Crambe</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium allicinum</i> (Fr.) Bensch et al. [Capnodiales: Cladosporiaceae] (synonym: <i>Cladosporium bruhnei</i> Linder)	<i>Brassica</i>	Yes (Schubert et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium aphidis</i> Thüm. [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Bensch et al. 2012; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Cladosporium brassicae</i> (Ellis & Barthol.) Ellis [Capnodiales: Cladosporiaceae] (synonym:	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Bensch et al. 2012; Zhang et al. 2003). To date	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cladotrichum brassicae</i> Ellis & Barthol.)			there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Cladosporium brassicicola</i> Sawada [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Dugan, Schubert & Braun 2004; Zhang et al. 2003). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Cladosporium cladosporioides</i> (Fresen.) de Vries [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium herbarum</i> (Pers.) Link [Capnodiales: Cladosporiaceae]	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium macrocarpum</i> Preuss [Capnodiales: Cladosporiaceae] (synonym: <i>Davidiella macrocarpa</i> Crous et al.)	<i>Brassica</i>	Yes (Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium nigrellum</i> Ellis & Everh. [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Zhang et al. 2003). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cladosporium oxysporum</i> Berk. & Curtis [Capnodiales: Cladosporiaceae]	<i>Brassica</i> , <i>Crambe</i>	Yes (Willingham et al. 2002)	considered to provide a pathway for this fungus. Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium sphaerospermum</i> Penz. [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cladosporium tenuissimum</i> Cooke [Capnodiales: Cladosporiaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Clathrospora diplospora</i> (Ellis & Everh.) Sacc. & Traverso [Pleosporales: Diademaceae]	<i>Sinapis</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Sinapis</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Cochliobolus bicolor</i> Paul & Parbery [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Nair 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cochliobolus geniculatus</i> Nelson [Pleosporales: Pleosporaceae] (synonym: <i>Curvularia geniculata</i> (Tracy & Earle) Boedijn)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cochliobolus lunatus</i> Nelson & Haasis [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Manamgoda et al. 2012; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum brassicicola</i> Damm et al. [Incertae sedis: Glomerellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Damm et al. 2012; Vieira et al. 2014). To date	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Colletotrichum capsici</i> (Syd. & Syd.) Butler & Bisby [Incertae sedis: Glomerellaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum dematium</i> (Pers.) Grove [Incertae sedis: Glomerellaceae] (synonyms: <i>Colletotrichum brassicae</i> Schulzer & Sacc; <i>Vermicularia dematium</i> (Pers.) Fr.)	<i>Brassica</i> , <i>Lepidium</i>	Yes (Persley, Cooke & House 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc. [Incertae sedis: Glomerellaceae] (synonym: <i>Glomerella cingulata</i> (Stoneman) Spauld. & Schrenk)	<i>Brassica</i> , <i>Nasturtium</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum higginsianum</i> Sacc. [Incertae sedis: Glomerellaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Not known to occur	Yes: Seeds provide a pathway for this fungus, which has been reported as seed-borne in <i>Brassica rapa</i> (Chinese Vegetable Network 2019; Gaetan, Garbagnoli & Irigoyen 1995) and <i>Raphanus sativus</i> (Richardson 1990; Rimmer, Shattuck & Buchwaldt 2007; Scheffer 1950). This fungus has also been reported on the leaves, stems, roots and fruits of other <i>Armoracia</i> , <i>Eruca</i> , <i>Brassica</i> and <i>Raphanus</i> species (Caesar, Lartey & Caesar-TonThat	Yes: When introduced via the seed pathway <i>Colletotrichum higginsianum</i> could establish and spread in Australia. This fungus has established in areas with a wide range of climatic conditions (Farr & Rossman 2019). Spread of this fungus from the seed pathway depends on human mediated transport of infected seeds.	Yes: <i>Colletotrichum higginsianum</i> is an economically important pathogen of several Brassicaceae crops including cabbage, mustard, pak choi, rutabaga and turnip (Rimmer, Shattuck & Buchwaldt 2007). This fungus is known to cause serious losses in host plants including <i>Brassica rapa</i> in South China where yield losses of 30–40% have been observed (Yuan et al.	Yes

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			2010; Farr & Rossman 2019; Patel, Costa de Novaes & Zhang 2014; Takeuchi, Horie & Shimada 2007; Zhuang 2005).		2016). Therefore, this fungus has the potential for economic consequences in Australia.	
<i>Colletotrichum kahawae</i> Waller & Bridge [Incertae sedis: Glomerellaceae]	<i>Eruca</i>	Yes (Noor & Zakaria 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum lini</i> (Westerd.) Tochinai [Incertae sedis: Glomerellaceae]	<i>Raphanus</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Colletotrichum truncatum</i> (Schwein.) Andrus & W.D. Moore [Incertae sedis: Glomerellaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Coniothyrium olivaceum</i> Bonord. [Pleosporales: Coniothyriaceae]	<i>Lepidium</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Coniothyrium orbicula</i> (Ellis & Everh.) Keissl. [Pleosporales: Coniothyriaceae] (synonym: <i>Phyllosticta orbicula</i> Ellis & Everh.)	<i>Armoracia</i> , <i>Nasturtium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> and <i>Nasturtium</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Corynespora cassiicola</i> (Berk. & Curtis) Wei [Pleosporales: Corynesporascaceae]	<i>Brassica</i>	Yes (Shivas & Alcorn 1996)	Assessment not required	Assessment not required	Assessment not required	No
<i>Curvularia inaequalis</i> (Shear) Boedijn [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cochliobolus eragrostidis</i> (Tsuda & Ueyama) Sivan [Pleosporales: Pleosporaceae] (synonyms: <i>Curvularia eragrostidis</i> (Henn.) Mey; <i>Curvularia maculans</i> (Bancr.) Boedijn; <i>Pseudocochliobolus eragrostidis</i> Tsuda & Ueyama)	<i>Raphanus</i>	Yes (Lenne 1990; Plant Health Australia 2001)	Assessment not required	Assessment not required	Assessment not required	No
<i>Curvularia spicifera</i> (Bainier) Boedijn [Pleosporales: Pleosporaceae] (synonyms: <i>Cochliobolus spicifer</i> Nelson; <i>Bipolaris spicifera</i> (Bain.) Subram.)	<i>Brassica</i>	Yes (Cook & Dubé 1989; Jeon, Nguyen & Lee 2015; Manamgoda et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cytospora ribis</i> Ehrenb [Diaporthales: Valsaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Fotouhifar, Hedjaroude & Leuchtman 2010). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Davidiella variabile</i> Crous et al. [Capnodiales: Davidiellaceae] (synonyms: <i>Cladosporium variabile</i> (Cooke) de Vries; <i>Heterosporium variabile</i> Cooke)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Ginns 1986). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Dendryphion nanum</i> (Nees) Hughes [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Didymella macropodii</i> Petr. [Pleosporales: Didymellaceae]	<i>Brassica</i>	Not known to occur	species (Ginns 1986). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Aveskamp et al. 2010; Pearce et al. 2016). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Didymella glomerata</i> (Corda) Qian Chen & L. Cai [Pleosporales: Didymellaceae] (synonym: <i>Phoma glomerata</i> (Corda) Wollenw. & Hochapfel)	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Diplodiella brassicae</i> (Cooke) Grove [Incertae sedis: Incertae sedis]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Ellis & Ellis 1997). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Drechslera biseptata</i> (Sacc. & Roum.) Richardson & Fraser [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
(synonym: <i>Pyrenophora bisptata</i> (Sacc. & Roum) Crous)						
<i>Epicoccum nigrum</i> Link [Pleosporales: Pleosporaceae] (synonym: <i>Epicoccum purpurascens</i> Ehrenb.)	<i>Brassica</i> , <i>Crambe</i> , <i>Nasturtium</i>	Yes (Fisher, Petrini & Sutton 1993)	Assessment not required	Assessment not required	Assessment not required	No
<i>Erysiphe betae</i> (Vanha) Weltzien [Erysiphales: Erysiphaceae]	<i>Brassica</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Erysiphe cruciferarum</i> Opiz ex Junell [Erysiphales: Erysiphaceae]	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Crambe</i> , <i>Eruca</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (You et al. 2013)	Assessment not required	Assessment not required	Assessment not required	No
<i>Erysiphe polygoni</i> DC. [Erysiphales: Erysiphaceae] (synonym: <i>Ischnochaeta polygoni</i> (DC.) Sawada)	<i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Cook & Dubé 1989; Ryley et al. 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Exophiala mansonii</i> (Castell.) de Hoog [Chaetothyriales: Herpotrichiellaceae] (synonym: <i>Rhinocladiella mansonii</i> (Castell.) Schol-Schwarz)	<i>Brassica</i>	Yes (Sivasithamparan 1975)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium acuminatum</i> Ellis & Everh. [Hypocreales: Nectriaceae] (synonym: <i>Gibberella acuminata</i> Wollenw.)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium avenaceum</i> (Fr.) Sacc. [Hypocreales: Nectriaceae] (synonym: <i>Gibberella avenacea</i> Cook)	<i>Brassica</i> , <i>Crambe</i> , <i>Lepidium</i>	Yes (Summerell et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Fusarium commune</i> Skovg., O'Donnell & Nirenberg [Hypocreales: Nectriaceae]	<i>Armoracia</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia rusticana</i> (Yu & Babadoost 2013). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Fusarium culmorum</i> (Sm.) Sacc. [Hypocreales: Nectriaceae]	<i>Crambe</i>	Yes (Summerell et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium equiseti</i> (Corda) Sacc. [Hypocreales: Nectriaceae]	<i>Brassica</i> , <i>Crambe</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Elmer et al. 1997; Summerell et al. 2010; Wang, Brubaker & Burdon 2004)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium gibbosum</i> Appel & Wollenw. [Hypocreales: Nectriaceae] (synonyms: <i>Fusarium bullatum</i> Sherb.; <i>Gibberella intricans</i> Wollenw.)	<i>Brassica</i> , <i>Crambe</i>	Yes (Lenne 1990; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium heterosporum</i> Nees & Nees [Hypocreales: Nectriaceae] (synonym: <i>Gibberella gordonii</i> Booth)	<i>Brassica</i>	Yes (Lenne 1990; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium incarnatum</i> (Roberge) Sacc. [Hypocreales: Nectriaceae] (synonym: <i>Fusarium semitectum</i> Berk. & Ravenel)	<i>Brassica</i>	Yes (Farr & Rossman 2019; Summerell et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium oxysporum</i> Schltdl. [Hypocreales: Nectriaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Crambe</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Elmer et al. 1997; Persley, Cooke & House 2010; Summerell et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Fusarium oxysporum</i> f. sp. <i>conglutinans</i> (Wollenw.) Snyder & Hansen [Hypocreales: Nectriaceae]	<i>Brassica</i> , <i>Crambe</i>	Yes (Bosland & Williams 1987; Persley, Cooke & House 2010). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium oxysporum</i> f. sp. <i>matthiolae</i> Baker [Hypocreales: Nectriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica rapa</i> (Srinivasan et al. 2012). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Fusarium oxysporum</i> f. sp. <i>rapae</i> Enya et al [Hypocreales: Nectriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica rapa</i> (Enya et al. 2008). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Fusarium oxysporum</i> f. sp. <i>raphani</i> Kendr. & Snyder [Hypocreales: Nectriaceae]	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Not known to occur	considered to provide a pathway for this fungus. Yes: Seeds provide a pathway for this fungus, which has been reported as seed-borne in <i>Eruca sativa</i> and <i>Raphanus sativus</i> (Bomberger 2013; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004). This fungus has also been reported on <i>Brassica</i> species causing Fusarium wilt (Rimmer, Shattuck & Buchwaldt 2007).	Yes: When introduced via the seed pathway <i>Fusarium oxysporum</i> f. sp. <i>raphani</i> could establish and spread in Australia. This fungus has established in areas with a wide range of climatic conditions (Farr & Rossman 2019). Spread of this fungus from the seed pathway depends on human mediated transport of infected seeds.	Yes: <i>Fusarium oxysporum</i> f. sp. <i>raphani</i> is an economically important pathogen of <i>Raphanus sativus</i> (du Toit & Pelter 2003; Rimmer, Shattuck & Buchwaldt 2007). Fusarium wilt of radish is a major soil-borne disease in Japan (Toyota, Yamamoto & Kimura 1994) and can cause significant losses (Rimmer, Shattuck & Buchwaldt 2007). The disease can affect plants at any age and infection of mature plants may result in leaf yellowing, premature leaf drop and stunting, which can affect marketability (Rimmer, Shattuck & Buchwaldt 2007). In Washington, the combination of Fusarium wilt and cabbage maggot injury resulted in a stand loss of about 90% in a radish stock seed crop (du Toit & Pelter 2003). Therefore, this fungus has the potential for economic consequences in Australia.	Yes

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Fusarium pallidoroseum</i> (Cooke) Sacc. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium poae</i> (Peck) Wollenw. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Summerell et al. 2010). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium proliferatum</i> (Matsush.) Nirenberg ex Gerlach & Nirenberg [Hypocreales: Nectriaceae]	<i>Raphanus</i>	Yes (Summerell et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium redolens</i> Wollenweb. [Hypocreales: Nectriaceae] (synonym: <i>Fusarium oxysporum</i> var. <i>redolens</i> (Wollenweb.) Gordon)	<i>Brassica</i>	Yes (Plant Health Australia 2019; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium roseum</i> Link [Hypocreales: Nectriaceae] (synonyms: <i>Fusarium sambucinum</i> Fuckel; <i>Gibberella pulicaris</i> (Kunze) Sacc)	<i>Armoracia</i> , <i>Brassica</i>	Yes (Richardson 1990; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium solani</i> (Mart.) Sacc. [Hypocreales: Nectriaceae] (synonyms: <i>Haematonectria haematococca</i> (Berk. & Broome)	<i>Brassica</i> , <i>Crambe</i>	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
Samuels & Rossman; <i>Nectria haematococca</i> Berk. & Broome)						
<i>Fusarium sporotrichioides</i> Sherb. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Shivas 1989; Summerell et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium subglutinans</i> (Wollenw. & Reinking) Nelson et al. (synonyms: <i>Fusarium moniliforme</i> Sheld.; <i>Gibberella fujikuroi</i> (Sawada) Wollenw.) [Hypocreales: Nectriaceae]	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i>	Yes (Nelson et al. 1991; Petrovic et al. 2009; Summerell et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusarium tricinctum</i> (Corda) Sacc. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Barkat et al. 2016)	Assessment not required	Assessment not required	Assessment not required	No
<i>Galactomyces geotrichum</i> (Butler & Peterson) Redhead & Malloch [Saccharomycetales: Dipodascaceae] (synonyms: <i>Dipodascus geotrichum</i> (Butler & Petersen) Arx; <i>Geotrichum candidum</i> Link)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Gibberella baccata</i> (Wallr.) Sacc. [Hypocreales: Nectriaceae] (synonym: <i>Fusarium lateritium</i> Nees)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Gibberella cyanogena</i> (Desm.) Sacc. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Gibberella zeae</i> (Schwein.) Petch [Hypocreales: Nectriaceae] (synonym: <i>Fusarium graminearum</i> Schwabe)	<i>Brassica</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Glomus caledonium</i> (Nicolson & gerd.) Trappe & Gerd. [Glomerales: Glomeraceae] (synonym: <i>Funneliformis</i>	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>caledonium</i> (Nicolson & Gerd.) Walker & Schubler)						
<i>Glomus macrocarpum</i> Tul. & Tul. [Glomerales: Glomeraceae]	<i>Brassica</i>	Yes (Keane et al. 2000)	Assessment not required	Assessment not required	Assessment not required	No
<i>Golovinomyces cichoracearum</i> (DC) Heluta [Erysiphales: Erysiphaceae] (synonym: <i>Erysiphe cichoracearum</i> DC.)	<i>Brassica</i> , <i>Eruca</i>	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Golovinomyces verbasci</i> (Jacz.) Heluta [Erysiphales: Erysiphaceae] (synonym: <i>Oidium balsamii</i> Mont.)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species and has been associated with powdery mildew disease (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Harzia verrucosa</i> (Tognini) Hol.-Jech. [Melanosporales: Ceratostomataceae] (synonym: <i>Acremoniella verrucosa</i> Tognini)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Helicobasidium mompa</i> Nobuj. Tanaka [Helicobasidiales: Helicobasidiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species and has been associated with root rot (Farr & Rossman 2019; Watson 1971). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Helicobasidium purpureum</i> (Tul.) Pat. [Helicobasidiales: Helicobasidiaceae]	<i>Brassica</i>	Yes (Shivas 1989)	considered to provide a pathway for this fungus. Assessment not required	Assessment not required	Assessment not required	No
<i>Hyaloperonospora brassicae</i> (Gäum.) Göker et al. [Peronosporales: Peronosporaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Sinapis</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> , <i>Brassica</i> and <i>Sinapis</i> species (Coelho et al. 2012; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ilyonectria radicola</i> (Gerlach & Nilsson) Chaverri & Salgado [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (Farr & Rossman 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Itersonilia perplexans</i> Derx (Cystofilobasidiales: Cystofilobasidiaceae)	<i>Brassica</i> , <i>Lepidium</i>	Yes (Aldaoud, Salib & Cunningham 2009)	Assessment not required	Assessment not required	Assessment not required	No
<i>Kabatiella lini</i> (Laff.) Karak. [Dothideales: Dothioraceae] (synonym: <i>Aureobasidium lini</i> (Laff.) Herm.-Nijh)	<i>Barbarea</i>	Yes (Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No
<i>Khuskia oryzae</i> Huds. [Incertae sedis: Incertae sedis] (synonyms: <i>Nigrospora oyzae</i> (berk & Broome) Petch; <i>Nigrospora sphaerica</i> (Sacc.) Mason)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Lagena radicola</i> Vanterp. & Ledingham [Incertae sedis: Lagenaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Lasiodiplodia theobromae</i> (Pat.) Griffon & Maubl. [Botryosphaeriales: Botryosphaeriaceae] (synonym: <i>Botryodiplodia theobromae</i> Pat.)	<i>Brassica</i>	Yes (Burgess et al. 2006; Muller & Burt 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Leptosphaeria australis</i> (Crie) Sacc. [Pleosporales: Leptosphaeriaceae]	<i>Brassica</i>	Yes (Crane & Shearer 1991)	Assessment not required	Assessment not required	Assessment not required	No
<i>Leptosphaeria biglobosa</i> Shoemaker & Brun [Pleosporales: Leptosphaeriaceae] (synonym: <i>Plenodomus biglobosus</i> (Shoemaker & Brun) Gruyter et al.)	<i>Brassica</i> , <i>Raphanus</i>	Yes (van de Wouw et al. 2008)	Assessment not required	Assessment not required	Assessment not required	No
<i>Leptosphaeria maculans</i> (Tul.) Ces. & De Not. [Pleosporales: Leptosphaeriaceae] (synonyms: <i>Phoma lingam</i> (Tode) Desm.; <i>Phoma napobrassicae</i> Rostr.)	<i>Brassica</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Cook & Dubé 1989; Rimmer, Shattuck & Buchwaldt 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Leptosphaeria nigrella</i> (Rabenh.) Sacc. [Pleosporales: Leptosphaeriaceae] (synonym: <i>Pyrenophora peltita</i> (Fr.) Sacc.)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing stem decay and leaf spot (Crane & Shearer 1991; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Leptosphaeria salebrosa</i> Sacc. [Pleosporales: Leptosphaeriaceae]	<i>Brassica</i>	Not known to occur	considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Crane & Shearer 1991). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Leptosphaeria sinapis</i> Hollós [Pleosporales: Leptosphaeriaceae]	<i>Sinapis</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Sinapis</i> species (Crane & Shearer 1991). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Leptosphaeria virginica</i> (Cooke & Ellis) Sacc. [Pleosporales: Leptosphaeriaceae] (synonym: <i>Sphearia virginica</i> Cooke & Ellis)	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Farr & Rossman 2019; Shoemaker & Brun 2001). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Leptosphaerulina australis</i> McAlpine [Pleosporales: Didymellaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Leptosphaerulina brassicae</i> Karan [Pleosporales: Didymellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing leaf spot (Gupta & Paul 2002; Watson 1971). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Leptosphaerulina trifolii</i> (Rostr.) Petr. [Pleosporales: Didymellaceae] (synonym: <i>Pseudoplea trifolii</i> (Rostr.) Petr.)	<i>Brassica</i>	Yes (Shivas 1989; Sivanesan 1999)	Assessment not required	Assessment not required	Assessment not required	No
<i>Leveillula taurica</i> (Lev.) Arnaud [Erysiphales: Erysiphaceae] (synonym: <i>Oidiopsis taurica</i> (Lév.) Salmon)	<i>Brassica</i> , <i>Eruca</i> , <i>Lepidium</i> , <i>Nasturtium</i>	Yes (Cunnington 2003; Glawe et al. 2005; Lenne 1990)	Assessment not required	Assessment not required	Assessment not required	No
<i>Lewia infectoria</i> (Fuckel) Barr & Simmons [Pleosporales: Pleosporaceae] (synonym: <i>Alternaria infectoria</i> Simmons)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Lewia scrophulariae</i> (Desm.) Barr & Simmons [Pleosporales: Pleosporaceae] (synonym: <i>Alternaria scrophulariae</i> (desm.) Rossman & Crous)	<i>Brassica</i> , <i>Eruca</i> , <i>Lepidium</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ligniera pilorum</i> Fron & Gaillat [Plasmodiophorida: Plasmodiophoridae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Ginns 1986). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Lunulospora curvula</i> Ingold [Incertae sedis: Incertae sedis]	<i>Rorippa</i>	Yes (Stewart 1986)	considered to provide a pathway for this fungus. Assessment not required	Assessment not required	Assessment not required	No
<i>Macrophoma lepidii</i> Politis [Botryosphaerales: Botryosphaeriaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Macrophomina phaseolina</i> (Tassi) Goid. [Botryosphaerales: Botryosphaeriaceae] (synonyms: <i>Macrophoma phaseolina</i> Tassi; <i>Macrophomina phaseoli</i> (Maubl.) Ashby)	<i>Brassica</i>	Yes (Fuhlbohmer, Ryley & Aitken 2012)	Assessment not required	Assessment not required	Assessment not required	No
<i>Melanospora breviostris</i> (Fuckel) Hohn. [Melanosporales: Ceratostomataceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Cannon & Hawksworth 1982). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Memnoniella echinata</i> (Rivolta) Galloway [Hypocreales: Incertae sedis]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Metacordyceps chlamydosporia</i> (Evans) Sung et al. [Hypocreales: Incertae sedis]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
Clavicipitaceae] (synonym: <i>Pochonia chlamydosporia</i> (Goddard) Zare & Gams)						
<i>Microascus brevicaulis</i> Abbott [Microascales: Microascaceae] (synonym: <i>Scopulariopsis brevicaulis</i> (Sacc.) Bainier)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mortierella elongata</i> Linnem. [Mortierellales: Mortierellaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor circinelloides</i> Tiegh. [Mucorales: Mucoraceae]	<i>Brassica</i>	Yes (Stewart, Munday & Hawkesford 1999)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor hiemalis</i> Wehmer [Mucorales: Mucoraceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor plumbeus</i> Bonord. [Mucorales: Mucoraceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor pusillus</i> Lindt [Mucorales: Mucoraceae] (synonym: <i>Rhizomucor pusillus</i> (Lindt) Schipper)	<i>Brassica</i>	Yes (ALA 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor racemosus</i> Fresen. [Mucorales: Mucoraceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mycogone rosea</i> Link [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mycosphaerella brassicicola</i> (Duby) Lindau [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mycosphaerella capsellae</i> Inman & Sivan. [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Maxwell & Scott 2008)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Mycosphaerella cruciferarum</i> (Fr.) Lindae [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Mycosphaerella tassiana</i> (De Not.) Johanson [Capnodiales: Mycosphaerellaceae] (synonym: <i>Mycosphaerella tulasnei</i> (Jancz.) Lindau)	<i>Brassica</i>	Yes (Sampson & Walker 1982; Sharma & Heather 1981)	Assessment not required	Assessment not required	Assessment not required	No
<i>Myrothecium roridum</i> Tode [Hypocreales: Incertae sedis]	<i>Brassica</i> , <i>Rorippa</i>	Yes (Cook & Dubé 1989; Lenne 1990)	Assessment not required	Assessment not required	Assessment not required	No
<i>Myrothecium verrucaria</i> (Alb. & Schwein.) Ditmar [Hypocreales: Incertae sedis]	<i>Brassica</i>	Yes (Lenne 1990; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Nectria brassicae</i> Ellis & Sacc. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Nectria inventa</i> Pethybr. [Hypocreales: Nectriaceae]	<i>Brassica</i>	Yes (ALA 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Nectria mammoidea</i> Phillips & Plowr. [Hypocreales: Nectriaceae] (synonym: <i>Thelonectria</i>)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>mammoidea</i> (Phillips & Plowr.) Salgado & Sanchez)			species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Olpidium brassicae</i> (Woronin) Dang. [Olpidiales: Olpidiaceae] (synonyms: <i>Asterocystis radialis</i> de Wild.; <i>Pleotrachelus brassicae</i> (Woronin) Sahtiy)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Paecilomyces variotii</i> Bainier [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium aurantiogriseum</i> Dierckx [Eurotiales: Trichocomaceae] (synonym: <i>Penicillium puberulum</i> Bainier)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium brevicompactum</i> Dierckx [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Lamb & Brown 1970)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium chrysogenum</i> Thom [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium citrinum</i> Thom [Eurotiales: Trichocomaceae] (synonym: <i>Penicillium steckii</i> Zalessky)	<i>Brassica</i> , <i>Eruca</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium corylophilum</i> Dierckx [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium decumbens</i> Thom [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium discolor</i> Frisvad & Samson [Eurotiales: Trichocomaceae]	<i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Raphanus</i> species (Farr & Rossman	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			2019; Mouchacca 2004). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Penicillium glabrum</i> (Wehmer) Westling [Eurotiales: Trichocomaceae] (synonym: <i>Penicillium frequentans</i> Westling)	<i>Brassica</i>	Yes (Fischer & Patel 1993)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium griseofulvum</i> Dierckx [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Ginns 1986). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Penicillium hirsutum</i> Dierckx [Eurotiales: Trichocomaceae]	<i>Armoracia</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> species causing <i>Penicillium</i> blue mould and rot (Farr & Rossman 2019; Horst 2013). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Penicillium restrictum</i> Gilman & Abbott [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019;	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		Yip & Weste 1985)				
<i>Penicillium roquefortii</i> Thom [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium rugulosum</i> Thom [Eurotiales: Trichocomaceae] (synonym: <i>Talaromyces rugulosus</i> (Thom) Samson et al.)	<i>Brassica</i>	Yes (Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium simplicissimum</i> (Oudem.) Thom [Eurotiales: Trichocomaceae] (synonyms: <i>Penicillium janthinellum</i> Biourge; <i>Penicillium piscarium</i> Westling)	<i>Brassica</i>	Yes (Fischer & Patel 1993; Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium spinulosum</i> Thom [Eurotiales: Trichocomaceae] (synonym: <i>Penicillium nigricans</i> Zalesky)	<i>Brassica</i>	Yes (Lamb & Brown 1970; Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium viridicatum</i> Westling [Eurotiales: Trichocomaceae] (synonym: <i>Penicillium aurantiogriseum</i> Dierckx)	<i>Brassica</i>	Yes (Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium waksmanii</i> Zakeski [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (HerbIMI 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Periconia byssoides</i> Pers. [Pleosporales: Incertae sedis]	<i>Brassica</i>	Yes (Chakraborty, Charudattan & De Valerio 1994)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Peronospora alliariae-wasabi</i> Gäum [Peronosporales: Peronosporaceae]	<i>Eutrema</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Eutrema</i> species causing downy mildew (Lo & Wang 2000). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora barbareae</i> Gäum. [Peronosporales: Peronosporaceae] (synonym: <i>Hyaloperonospora barbareae</i> (Gäum.) Göker et al.)	<i>Barbarea</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Barbarea</i> species causing downy mildew (Farr & Rossman 2019; Riethmuller et al. 2002). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora brassicae</i> f. sp. <i>raphani</i> Gäum. [Peronosporales: Peronosporaceae]	<i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Raphanus</i> spp. (Gustavsson 1991; Plant Protection Society 1979). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora brassicae</i> f. sp. <i>sinapidis</i> Gäum.	<i>Sinapsis</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Sinapsis</i> spp. (Gustavsson 1991). To date	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
[Peronosporales: Peronosporaceae]			there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Peronospora cochleariae</i> Gäum. [Peronosporales: Peronosporaceae] (synonym: <i>Hyaloperonospora cochleariae</i> (Gäum.) Göker et al.)	<i>Armoracia</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> species (Constantinescu 1991; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora effusa</i> (Grev.) Rabenh. [Peronosporales: Peronosporaceae] (synonym: <i>Peronospora farinosa</i> (Fr.) Fr.)	<i>Raphanus</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Peronospora lepidii</i> (McAlpine) Wilson [Peronosporales: Peronosporaceae] (synonym: <i>Perofascia lepidii</i> (McAlpine) Constant)	<i>Lepidium</i> , <i>Rorippa</i>	Yes (Farr & Rossman 2019). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Peronospora lepidii-perfoliati</i> Sävul. & Rayss [Peronosporales: Peronosporaceae] (synonym: <i>Hyaloperonospora lepidii-perfoliati</i> (Sävul. & Rayss) Constant.)	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Constantinescu & Fatehi 2002; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora lepidii-sativi</i> Gäum [Peronosporales: Peronosporaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Constantinescu & Fatehi 2002; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora lepidii-virginici</i> Gäum [Peronosporales: Peronosporaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species causing downy mildew (Constantinescu & Fatehi 2002; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Peronospora nasturtii-aquatici</i> Gäum. [Peronosporales: Peronosporaceae] (synonym: <i>Hyaloperonospora nasturtii-aquatici</i> (Gäum.) Voglmayr)	<i>Nasturtium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Nasturtium</i> species (Voglmayr, Choi & Shin 2014). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Peronospora parasitica</i> (Pers.) Fr. [Peronosporales: Peronosporaceae] (synonym: <i>Peronospora parasitica</i> subsp. <i>brassicae</i> Wang)	<i>Armoracia</i> , <i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Peronospora rorippae-islandicae</i> Gäum. [Peronosporales: Peronosporaceae] (synonym: <i>Hyaloperonospora rorippae-islandicae</i> (Gäum.) Göker et al.)	<i>Rorippa</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Rorippa</i> species (Voglmayr, Choi & Shin 2014). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Pestalotia brassicicola</i> Kachroo [Xylariales: Amphispæriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Nag Raj 1993). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pestalotiopsis theae</i> (Sawada) Steyaert [Xylariales: Amphisphaeriaceae] (synonym: <i>Pseudopestalotiopsis theae</i> (Sawada) Maharachch. et al.)	<i>Raphanus</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phoma herbarum</i> Westend. [Pleosporales: Didymellaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phoma lepidii-graminifolii</i> Gonz. Frag [Pleosporales: Didymellaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Phoma macrostoma</i> Mont [Pleosporales: Didymellaceae]	<i>Lepidium</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phoma medicaginis</i> Malbr. & Roum. [Pleosporales: Didymellaceae]	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phoma nigrificans</i> (Karst.) Boerema et al. [Pleosporales: Didymellaceae]	<i>Brassica</i>	Yes (Zahid et al. 2001b)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phomatodes nebulosa</i> (Pers. : Fr.) Qian Chen & Cai [Pleosporales: Didymellaceae] (synonym: <i>Phoma nebulosa</i> (Pers. : Fr.) Berk.)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phomopsis arctii</i> (Lasch) Traverso [Diaporthales: Diaporthaceae] (synonym: <i>Diaportha arctii</i> (Lasch) Nischke)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Phomopsis velata</i> (Sacc.) Traverso [Diaporthales: Diaporthaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
(synonym: <i>Diaporthe eres</i> Nitschke)						
<i>Phyllosticta brassicae-oleraceae</i> Sawada [Botryosphaerales: Phyllostictaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Phyllosticta decidua</i> Ellis & Kellerm. [Botryosphaerales: Phyllostictaceae]	<i>Armoracia</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> species as a secondary leaf spot (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Phyllosticta raphani</i> Brezhnev [Botryosphaerales: Phyllostictaceae]	<i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Raphanus</i> species (Watson 1971). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Phymatotrichum omnivorum</i> Duggar [Helotiales: Sclerotiniaceae] (synonym:)	<i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> and	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Phymatotrichopsis omnivora</i> (Duggar) Hennebert)			<i>Raphanus</i> species causing root rot (Farr & Rossman 2019; Williams 1993). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Pithomyces maydicus</i> (Sacc.) Ellis [Pleosporales: Didymellaceae]	<i>Brassica</i>	Yes (Farr & Rossman 2019; Taylor & Hyde 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Plasmodiophora brassicae</i> Woronin [Plasmodiophorida: Plasmodiophoridae]	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Eruca</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pleospora aurea</i> Ellis & Everh. [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Pleospora herbarum</i> (Pers.) Rabenh. [Pleosporales: Pleosporaceae]	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Lepidium</i> ,	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
	<i>Raphanus</i> , <i>Sinapis</i>					
<i>Pleospora oleraceae</i> Tehon & Stout [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Pleospora tarda</i> Simmons [Pleosporales: Pleosporaceae] (synonym: <i>Stemphylium botryosum</i> Wallr.)	<i>Brassica</i>	Yes (Cunnington 2003; Hall et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Podosphaera fuliginea</i> (Schltld.) Braun & Takam [Erysiphales: Erysiphaceae] (synonym: <i>Oidium erysipeloides</i> (Fr.) Subram.)	<i>Brassica</i>	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Podosphaera macularis</i> (Wallr.) Braun & Takam. [Erysiphales: Erysiphaceae] (synonym: <i>Sphaerotheca macularis</i> (Wallr.) Magnus)	<i>Brassica</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudocercospora capsellae</i> (Ellis & Everh.) Deighton [Capnodiales: Mycosphaerellaceae] (synonyms: <i>Cercospora albomaculans</i> Ellis & Everh.; <i>Pseudocercospora capsellae</i> (Ellis & Everh.) Morris & Crous)	<i>Brassica</i> , <i>Crambe</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudocochliobolus pallescens</i> Tsuda & Ueyama [Pleosporales: Pleosporaceae] (synonym:	<i>Brassica</i>	Yes (Sivanesan 1987)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cochliobolus pallescens</i> (Tsuda & Ueyama) Sivan.)						
<i>Pseudocochliobolus verruculosus</i> Tsuda & Ueyama [Pleosporales: Pleosporaceae] (synonym: <i>Cochliobolus verruculosus</i> (Tsuda & Ueyama) Sivan.)	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudogymnoascus pannorum</i> (Link) Minnis & Lindner [Incertae sedis: Myxotrichaceae] (synonym: <i>Geomyces pannorum</i> (Link) Sigler & Carmich)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudombrophila deerrata</i> (Karst.) Seaver [Pezizales: Pyronemataceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Pseudoperonospora cubensis</i> (Berk. & Curtis) Rostovzev [Peronosporales: Peronosporaceae]	<i>Brassica</i>	Yes (Persley, Cooke & House 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Puccinia aristidae</i> Tracy [Pucciniales: Pucciniaceae]	<i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i>	Not known to occur	No: This fungus has been reported naturally occurring on leaves of <i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> and <i>Rorippa</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Puccinia holboellii</i> (Hornem.) Rostr. [Pucciniales: Pucciniaceae]	<i>Lepidium</i>	Not known to occur	considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Puccinia isiacae</i> (Thüm.) Winter [Pucciniales: Pucciniaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Bahcecioglu & Kabaktepe 2012; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Puccinia monoica</i> Arthur [Pucciniales: Pucciniaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Puccinia subnitens</i> Dietel [Pucciniales: Pucciniaceae]	<i>Lepidium</i> , <i>Nasturtium</i> , <i>Rorippa</i>	Yes (Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pyrenochaeta terrestris</i> (Hansen) Gorenz et al. [Incertae sedis: Incertae sedis]	<i>Lepidium</i>	Yes (Hall et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pyrenopeziza brassicae</i> Sutton & Rawl. [Helotiales: Dermateaceae] (synonym: <i>Cylindrosporium concentricum</i> Grev.)	<i>Brassica</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pyrenophora graminea</i> Ito & Kurib. [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pythiogeton ramosum</i> Minden [Peronosporales: Pythiogetonaceae]	<i>Brassica</i>	Yes (Le, Smith & Aitken 2014)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ramichloridium indicum</i> (Subram.) de Hoog [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ramichloridium verrucosum</i> (Geeson) Sutton [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing black lesions (Farr & Rossman 2019; Jones & Baker 2007). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Ramularia armoraciae</i> Fuckel [Capnodiales: Mycosphaerellaceae] (synonym: <i>Entylomella armoraciae</i> (Fuckel) Cif.)	<i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Raphanus</i> , <i>Rorippa</i>	Not known to occur	No: This fungus has been reported naturally occurring on leaves of <i>Armoracia</i> , <i>Barbarea</i> , <i>Brassica</i> , <i>Raphanus</i> and <i>Rorippa</i> species causing leaf spot (Braun 1998; Braun & Hill 2004; Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ramularia barbareae</i> Peck [Capnodiales: Mycosphaerellaceae]	<i>Barbarea</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Barbarea</i> species (Farr & Rossman 2019; Horst 2008). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Retroconis fusiformis</i> (Reddy & Bilgrami) de Hoog & Bat. Vegte [Incertae sedis: Incertae sedis]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (WCSP 2016). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Rhizoctonia dauci</i> Rabenh. [Cantharellales: Ceratobasidiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Rhizoctonia ferruginea</i> Matz. [Cantharellales: Ceratobasidiaceae]	<i>Brassica</i>	Not known to occur	species (Farr & Rossman 2019; Roberts 1999). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no published evidence that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Rhizoctonia solani</i> Kühn [Cantharellales: Ceratobasidiaceae] (synonyms: <i>Corticium sasakii</i> (Shirai) Matsumoto; <i>Corticium solani</i> (Prill. & Delacr.) Bourdot & Galzin; <i>Pellicularia filamentosa</i> (Pat.) Rogers; <i>Thanatephorus cucumeris</i> (Frank) Donk)	<i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (Anderson et al. 2004; Neate & Warcup 1985; Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Rhizoctonia zeae</i> Voorhees [Cantharellales: Ceratobasidiaceae] (synonym: <i>Waitea circinata</i> Warcup & Talbot)	<i>Raphanus</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Rhizophlyctis rosea</i> (de Bary & Woronin) Fisch [Rhizophlyctidales: Rhizophlyctidaceae]	<i>Rorippa</i>	Yes (Marano et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Rhizopus arrhizus</i> Fisch [Mucorales: Rhizopodaceae] (synonyms: <i>Rhizopus oryzae</i> Went & Prins. Geerl.)	<i>Brassica</i> , <i>Eruca</i>	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
<i>Rhizopus stolonifer</i> (Ehrenb.) Vuill. [Mucorales: Rhizopodaceae] (synonym: <i>Rhizopus nigricans</i> Ehrenb.)	<i>Brassica</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Rhodotorula glutinis</i> (Fresen.) Harrison [Sporidiobolales: Incertae sedis]	<i>Brassica</i>	Yes (Lamb & Brown 1970)	Assessment not required	Assessment not required	Assessment not required	No
<i>Sclerotinia minor</i> Jagger [Helotiales: Sclerotiniaceae]	<i>Brassica</i>	Yes (Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No
<i>Sclerotinia sclerotiorum</i> (Lib.) de Bary [Helotiales: Sclerotiniaceae] (synonym: <i>Sclerotinia libertiana</i> Fuckel)	<i>Armoracia</i> , <i>Brassica</i> , <i>Crambe</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i> , <i>Sinapis</i>	Yes (Horne, de Boer & Crawford 2002; Li et al. 2006)	Assessment not required	Assessment not required	Assessment not required	No
<i>Scopulariopsis fusca</i> Zach [Microascales: Microascaceae]	<i>Brassica</i>	Not known to occur	No: This fungus which has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Ginns 1986). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Septomyxa affinis</i> Wollenw. [Diaporthales: Gnomoniaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Septoria armoraciae</i> Oudem. [Capnodiales: Mycosphaerellaceae]	<i>Armoracia</i>	Not known to occur	species causing leaf spot (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Armoracia</i> species (Farr & Rossman 2019; Priest 2006). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Septoria lepidii</i> Desm [Capnodiales: Mycosphaerellaceae]	<i>Lepidium</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Septoria matthiolae</i> (Oudem.) Cooper (Synonyms: <i>Ascochyta matthiolae</i> Oudem., <i>Ascochyta rusticana</i> Kabát & Bubák) [Pleosporales: Didymellaceae]	<i>Armoracia</i>	Yes (Farr & Rossman 2019; Priest 2006)	Assessment not required	Assessment not required	Assessment not required	No
<i>Septoria radiculae</i> Dearn [Capnodiales: Mycosphaerellaceae]	<i>Rorippa</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Rorippa</i> species causing leaf spot (Farr & Rossman 2019). To date there is no available evidence demonstrating	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Septoria selenophomoides</i> Cash & Watson [Capnodiales: Mycosphaerellaceae]	<i>Brassica</i>	Yes (Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Septoria sisymbrii</i> Niessl [Capnodiales: Mycosphaerellaceae] (synonyms: <i>Septoria brassicae</i> Ellis & Everh.; <i>Septoria lepidicola</i> Ellis & Martin)	<i>Brassica</i> , <i>Lepidium</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Rorippa</i>	Yes (Priest 2006)	Assessment not required	Assessment not required	Assessment not required	No
<i>Spongospora nasturtii</i> Dick [Plasmodiophorida: Plasmodiophoridae]	<i>Nasturtium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Nasturtium</i> species (Koike, Gladders & Paulus 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Spongospora subterranea</i> (Wallr.) Lagerh [Plasmodiophorida: Plasmodiophoridae]	<i>Nasturtium</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Sporidesmium mucosum</i> var. <i>pluriseptatum</i> Karst. & Har [Incertae sedis: Incertae sedis] (synonym: <i>Alternaria pluriseptata</i> (Karst & Har) Jørst)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Sporidesmium folliculatum</i> (Corda) Mason & Hughes [Incertae sedis: Incertae sedis] (synonym: <i>Helminthosporium folliculatum</i> Corda)	<i>Brassica</i>	Not known to occur	not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Cho & Shin 2004; Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Sporormia brassicae</i> Grove [Pleosporales: Sporormiaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Stagonosporopsis caricae</i> (Syd. & Syd.) Aveskamp et al. [Pleosporales: Incertae sedis]	<i>Brassica</i>	Yes (Snowden 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Stemphylium nabarii</i> Sarwar [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Stemphylium turritiforme</i> Zhang & Zhang [Pleosporales: Pleosporaceae]	<i>Brassica</i>	Not known to occur	not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Stemphylium vesicarium</i> (Wallr.) Simmons [Pleosporales: Pleosporaceae] (synonym: <i>Stemphylium brassicicola</i> Pei & Zhang)	<i>Brassica</i> , <i>Raphanus</i>	Yes (Cunnington 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Stephanonectria keithii</i> (Berk. & Broome) Schroers & Samuels [Hypocreales: Bionectriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Schroers, Samuels & Gams 1999). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Stilbella annulata</i> (Berk. & Curtis) Seifer [Hypocreales: Incertae sedis] (synonym: <i>Acrostalagmus annulatus</i> (Berk. & Curtis) Seifert)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Seifert 1985). To date there is no available evidence demonstrating	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Synchytrium aureum</i> Schröt [Chytridiales: Synchytriaceae]	<i>Rorippa</i>	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Synchytrium lepidii</i> Cook [Chytridiales: Synchytriaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species causing leaf gall (Farr & Rossman 2019; Karling 1964). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Synchytrium macrosporum</i> Karling [Chytridiales: Synchytriaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Talaromyces flavus</i> (Klocker) Stolk & Samson [Eurotiales: Trichocomaceae]	<i>Brassica</i>	Yes (Fravel & Adams 1986)	Assessment not required	Assessment not required	Assessment not required	No
<i>Talaromyces thermophilus</i> Stolk [Eurotiales: Trichocomaceae] (synonym: <i>Thermomyces thermophiles</i> (Stolk) Kirk)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Thanatephorus microsclerotium</i> (Matz) Boidin et al. [Cantharellales: Ceratobasidiaceae] (synonym: <i>Corticium microsclerotium</i> (Matz) Weber)	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	2019; Ginns 1986). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus. No: This fungus has been reported naturally occurring on <i>Brassica</i> and <i>Raphanus</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Thielavia octospora</i> (Natarajan) Arx [Sordariales: Chaetomiaceae] (synonym: <i>Achaetomium globosum</i> Rai & Tewari)	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Thielaviopsis basicola</i> (Berk. & Broome) Ferraris [Microascales: Ceratocystidaceae] (synonym: <i>Chalara elegans</i> Nag Raj & Kendr.)	<i>Brassica</i>	Yes (Persley, Cooke & House 2010; Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Trichoderma harzianum</i> Rifai [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Yes (Fisher, Petrini & Sutton 1993)	Assessment not required	Assessment not required	Assessment not required	No
<i>Trichoderma koningii</i> Oudem. [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Trichoderma pseudokoningii</i> Rifai [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Yes (Turner et al. 1997)	Assessment not required	Assessment not required	Assessment not required	No
<i>Trichoderma viride</i> Pers.: Fr. [Hypocreales: Hypocreaceae]	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Trichothecium roseum</i> (Pers.) Link [Hypocreales: Incertae sedis]	<i>Brassica</i> , <i>Crambe</i> , <i>Lepidium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Persley, Cooke & House 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Typhula umbrina</i> Remsberg [Agaricales: Typhulaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species (Farr & Rossman 2019; Ginns 1986). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Ulocladium chartarum</i> (Preuss) Simmons [Pleosporales: Pleosporaceae] (synonym: <i>Alternaria chartarum</i> Preuss)	<i>Raphanus</i>	Yes (Maxwell & Scott 2008)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ulocladium consortiale</i> (Thüm.) Simmons [Pleosporales: Pleosporaceae] (synonyms: <i>Sverticillium</i> <i>emphylium</i> <i>consortiale</i>)	<i>Brassica</i> , <i>Raphanus</i>	Yes (David 1995a)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
(Thüm.) Groves & Skolko; <i>Stemphylium ilicis</i> Tengwall)						
<i>Umbelopsis isabellina</i> (Oudem.) Gams [Mucorales: Umbelopsidaceae] (synonym: <i>Mortierella isabellina</i> Oudem.)	<i>Brassica</i>	Yes (Meyer & Gams 2003; Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Urocystis brassicae</i> Mundk. [Urocystidales: Urocystidaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing smut disease (Farr & Rossman 2019; Vanky 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Urocystis coralloides</i> Rostr. [Urocystidales: Urocystidaceae]	<i>Lepidium</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Lepidium</i> species causing smut disease (Farr & Rossman 2019; Vanky 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Urocystis yunnanensis</i> Guo [Urocystidales Urocystidaceae]	<i>Brassica</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Brassica</i> species causing smut disease (Farr & Rossman	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Valsaria insitiva</i> (Tode: Fr.) Ces. & De Not [Valsariales: Valsariaceae]	<i>Brassica</i>	Yes (Yuan 1996). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	2019; Guo 2013). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Verticillium albo-atrum sensu lato</i> Reinke & Berthold [Incertae sedis: Plectosphaerellaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Raphanus</i>	Yes (David 1995b)	Assessment not required	Assessment not required	Assessment not required	No
<i>Verticillium dahliae</i> Kleb [Incertae sedis: Plectosphaerellaceae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Lepidium</i> , <i>Sinapis</i>	Yes (Cook & Dubé 1989; Sampson & Walker 1982; Shivas 1989).	Assessment not required	Assessment not required	Assessment not required	No
<i>Verticillium longisporum</i> (Stark) Karapapa et al. [Incertae sedis: Plectosphaerellaceae] (synonym: <i>Verticillium dahliae</i> var. <i>longisporum</i> Stark)	<i>Armoracia</i> , <i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Armoracia</i> , <i>Brassica</i> and <i>Raphanus</i> species causing <i>Verticillium</i>	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			wilt (Karapapa, Bainbridge & Heale 1997; Rimmer, Shattuck & Buchwaldt 2007). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.			
<i>Verticillium nigrescens</i> Pethybr. [Incertae sedis: Plectosphaerellaceae] (synonym: <i>Gibellulopsis nigrescens</i> (Pethybr.) Zare et al.)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Verticillium tricorpus</i> Isaac [Incertae sedis: Plectosphaerellaceae]	<i>Brassica</i>	Yes (Nair et al. 2015)	Assessment not required	Assessment not required	Assessment not required	No
<i>Viennotidia raphani</i> (Malloch) Cannon & Hawskw. [Microascales: Plectosphaerellaceae] (synonym: <i>Viennotidia raphani</i> Negru & Verona)	<i>Raphanus</i>	Not known to occur	No: This fungus has been reported naturally occurring on <i>Raphanus</i> species (Farr & Rossman 2019). To date there is no available evidence demonstrating that this fungus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this fungus.	Assessment not required	Assessment not required	No
<i>Xepicula leucotricha</i> (Peck) Nag Raj [Incertae sedis: Incertae sedis] (synonym: <i>Myrothecium leucotrichum</i> (Peck) Tulloch)	<i>Brassica</i>	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
NEMATODES						

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Aglenchus agricola</i> (de Man 1884) Meyl 1961 [Panagrolaimida: Tylenchidae]	<i>Crambe</i>	Yes (McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Aphelenchoides fragariae</i> (Ritzema Bos 1891) Christie 1932 [Panagrolaimida: Aphelenchoididae]	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994; Suatmadji & Marks 1983)	Assessment not required	Assessment not required	Assessment not required	No
<i>Belonolaimus longicaudatus</i> Rau 1958 [Panagrolaimida: Belonolaimidae]	<i>Brassica</i>	Yes (Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Ditylenchus destructor</i> Thorne 1945 [Panagrolaimida: Anguinidae]	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> and <i>Raphanus</i> species (CABI 2019; EFSA 2014a). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No
<i>Ditylenchus dipsaci</i> (Kühn 1857) Filipjev 1936 [Panagrolaimida: Anguinidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes: (McLeod, Reay & Smyth 1994; Ophel-Keller et al. 2008). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		WA did not provide any regulatory action in support of area freedom.				
<i>Dolichodorus heterocephalus</i> Cobb 1914 [Panagrolaimida: Dolichodoridae]	<i>Brassica</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> species (Crow & Brammer 2015). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No
<i>Helicotylenchus dihystra</i> (Cobb 1893) Sher 1961 [Panagrolaimida: Hoplolaimidae]	<i>Brassica</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Helicotylenchus microlobus</i> Perry 1959 [Panagrolaimida: Hoplolaimidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Khair 1986)	Assessment not required	Assessment not required	Assessment not required	No
<i>Helicotylenchus multicinctus</i> (Cobb 1893) Golden 1956 [Panagrolaimida: Hoplolaimidae]	<i>Brassica</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Hemicycliophora similis</i> Thorne 1955 [Panagrolaimida: Hemicycliophoridae]	<i>Brassica</i> , <i>Raphanus</i> , <i>Sinapis</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> , <i>Raphanus</i> and <i>Sinapis</i> species (Chitambar & Subbotin 2014; Klinkenberg 1963). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			are not considered to provide a pathway for this nematode.			
<i>Heterodera cruciferae</i> (Franklin 1945) Skarbilovich 1959 [Panagrolaimida: Heteroderidae]	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994; Nobbs 2003). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Heterodera schachtii</i> Schmidt 1871 [Panagrolaimida: Heteroderidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Hoplolaimus indicus</i> Sher 1963 [Panagrolaimida: Hoplolaimidae]	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> (Keshari & Gupta 2016) and <i>Raphanus</i> species (Ravichandra 2014). To date there is no available evidence demonstrating that this nematode is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Hoplolaimus seinhorsti</i> Luc 1958 [Panagrolaimida: Hoplolaimidae]	<i>Brassica</i>	Yes (Khair 1986; Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Meloidogyne arenaria</i> (Neal 1889) Chitwood 1949 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Hay & Pethybridge 2005)	Assessment not required	Assessment not required	Assessment not required	No
<i>Meloidogyne artiellia</i> Franklin 1961 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> species (Greco et al. 1992). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No
<i>Meloidogyne hapla</i> Chitwood 1949 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Pullman & Berg 2010; Quader, Riley & Walker 2001)	Assessment not required	Assessment not required	Assessment not required	No
<i>Meloidogyne incognita</i> (Kofoid & White 1919) Chitwood 1949 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Quader, Riley & Walker 2001; Stirling & Ciriaco 1984)	Assessment not required	Assessment not required	Assessment not required	No
<i>Meloidogyne izalcoensis</i> Carneiro et al. 2005 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i>	Not known to occur	No: This nematode has been reported naturally occurring on the roots of <i>Brassica oleracea</i> var. <i>capitata</i> (Jorge et al. 2016). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Meloidogyne javanica</i> (Treub 1885) Chitwood 1949 [Panagrolaimida: Meloidogynidae]	<i>Armoracia</i> , <i>Brassica</i> , <i>Raphanus</i>	Yes (Hay & Pethybridge 2005)	Assessment not required	Assessment not required	Assessment not required	No
<i>Meloidogyne thamesi</i> Chitwood 1952 [Panagrolaimida: Meloidogynidae]	<i>Brassica</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Merlinius brevidens</i> (Allen 1955) Siddiqi 1970 [Panagrolaimida: Telotylenchidae]	<i>Brassica</i>	Yes (Hay & Pethybridge 2005)	Assessment not required	Assessment not required	Assessment not required	No
<i>Nacobbus aberrans</i> (Thorne 1935) Thorne & Allen 1944 [Panagrolaimida: Pratylenchidae] (synonym: <i>Nacobbus batatiformis</i> Thorne & Schuster 1959)	<i>Brassica</i> , <i>Raphanus</i> , <i>Sinapis</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> , <i>Raphanus</i> and <i>Sinapis</i> species (Whitehead 1997). To date there is no available evidence demonstrating that this nematode is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No
<i>Paralongidorus maximus</i> (Bütschli 1874) Siddiqi 1964 [Dorylaimida: Longidoridae] (synonym: <i>Longidorus maximus</i> (Bütschli 1874) Thorne & Swanger 1936)	<i>Brassica</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> species (Heyns 1975). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No
<i>Paratrachodorus minor</i> (Colbran 1956) Siddiqi 1974 [Triplonchida: Trichodoridae] (synonyms: <i>Nanidorus minor</i> (Colbran 1956) Siddiqi 1974; <i>Paratrachodorus</i>	<i>Brassica</i> , <i>Raphanus</i>	Yes (McLeod, Reay & Smyth 1994; Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>christiei</i> (Allen 1957) Siddiqi 1974)						
<i>Paratrichodorus porosus</i> Allen 1957 [Triplonchida: Trichodoridae]	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994; Sheedy et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Paratylenchus projectus</i> Jenkins 1956 [Panagrolaimida: Paratylenchidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (McLeod, Reay & Smyth 1994; Plant Health Australia 2019)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus brachyurus</i> (Godfrey 1929) Filipjev & Schuurmans-Stekhoven 1941 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i>	Yes (Broadley 1981; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus coffeae</i> (Zimmerman 1898) Filipjev & Schuurmans-Stekhoven 1941 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus neglectus</i> (Rensch 1924) Filipjev & Schuurmans-Stekhoven 1941 [Panagrolaimida: Pratylenchidae] (synonym: <i>Pratylenchus minyus</i> Sher & Allen 1953)	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994; Riley & Kelly 2002)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus penetrans</i> (Cobb 1917) Filipjev & Schuurmans-Stekhoven 1941 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Riley & Kelly 2002)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus pratensis</i> (de Man 1880) Filipjev 1936 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i>	Yes (McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pratylenchus teres</i> Khan & Singh 1974 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i>	Yes (Riley & Wouts 2001)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Pratylenchus thornei</i> Sher & Allen 1953 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i>	Yes (Riley & Kelly 2002)	Assessment not required	Assessment not required	Assessment not required	No
<i>Radopholus similis</i> (Cobb 1893) Thorne 1949 [Panagrolaimida: Pratylenchidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994; Stirling & Stanton 1997). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Rotylenchulus reniformis</i> Linford & Oliveira 1940 [Panagrolaimida: Rotylenchulidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Khair 1986; McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tylenchorhynchus brassicae</i> Siddiqi 1961 [Panagrolaimida: Telotylenchidae]	<i>Brassica</i>	Not known to occur	No: This nematode has been reported naturally occurring on <i>Brassica</i> species (Whitehead 1997). To date there is no available evidence demonstrating that this nematode is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this nematode.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Tylenchorhynchus claytoni</i> Steiner 1937 [Panagrolaimida: Telotylenchidae]	<i>Brassica</i> , <i>Raphanus</i>	Yes (McLeod, Reay & Smyth 1994)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tylenchorhynchus latus</i> Allen 1955 [Panagrolaimida: Telotylenchidae]	<i>Brassica</i>	Yes (Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tylenchus agricola</i> de Man 1884 [Panagrolaimida: Tylenchidae] (synonym: <i>Aglenchus agricola</i> (de Man 1884) Meyl 1961)	<i>Brassica</i>	Yes (Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tylenchus bryophilus</i> Steiner 1914 [Panagrolaimida: Tylenchidae] (synonym: <i>Malenchus bryophilus</i> (Steiner 1914) Steiner 1914)	<i>Brassica</i>	Yes (Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tylenchus costatus</i> de Man 1921 [Panagrolaimida: Tylenchidae] (synonym: <i>Coslenchus costatus</i> (de Man 1921) Siddiqi 1978)	<i>Brassica</i>	Yes (Nobbs 2003)	Assessment not required	Assessment not required	Assessment not required	No
PHYTOPLASMAS						
' <i>Candidatus</i> Phytoplasma asteris' subgroup 16SrI –B [Aster yellows group] [Acholeplasmatales: Acholeplasmataceae] **(Kale phyllody, broccoli phyllody, cabbage proliferation, Italian cabbage yellows strains not known to occur in Australia)	<i>Brassica</i> , <i>Rorippa</i>	Not known to occur	No: This phytoplasma has been reported naturally associated with shoot proliferation, flower virescence and malformation of <i>Brassica</i> and <i>Rorippa</i> species in Europe and the USA (Kaminska, Berniak & Kaminski 2012; Lee et al. 2004). To date there is no available evidence demonstrating that this phytoplasma is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this phytoplasma.	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
Iranian cabbage yellows phytoplasma, subgroup 16SrVI-A [Clover Proliferation Group] [Acholeplasmatales: Acholeplasmataceae]	<i>Brassica</i>	Not known to occur	No: This phytoplasma has been reported naturally occurring on <i>Brassica</i> species in Iran (Salehi, Izadpanah & Siampour 2007). Symptoms of the disease (Iranian cabbage yellows) include yellowing, stunting and proliferation of the bud (Salehi, Izadpanah & Siampour 2007). To date there is no available evidence demonstrating that this phytoplasma is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this phytoplasma.	Assessment not required	Assessment not required	No
Stolbur phytoplasma, subgroup 16SrXII-A] (Stolbur Group) [Acholeplasmatales: Acholeplasmataceae]	<i>Brassica</i>	Not known to occur	No: This phytoplasma has been reported naturally occurring on <i>Brassica</i> species causing symptoms of petiole reddening and stunting (Trkulja et al. 2011). To date there is no available evidence demonstrating that this phytoplasma is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this phytoplasma.	Assessment not required	Assessment not required	No
VIROIDS						
<i>Citrus exocortis viroid</i> (CEVd) [Pospiviroidae: Pospiviroid]	<i>Brassica</i>	Yes (Hardt, Donovan & Barkley 2008;	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		van Brunschot et al. 2014). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.				
<i>Watercress chlorotic leaf spot viroid</i> (WCLVd)	<i>Nasturtium</i>	Not known to occur	No: This viroid has been reported naturally occurring on <i>Nasturtium</i> species causing bright yellow or golden spots on leaves (Koike, Gladders & Paulus 2007). To date there is no available evidence demonstrating that this viroid is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this viroid.	Assessment not required	Assessment not required	No
VIRUSES						
<i>Alfalfa mosaic virus</i> (AMV) [Bromoviridae: Alfamovirus]	<i>Brassica</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Jones et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
<i>Arabis mosaic virus</i> (ArMV) [Secoviridae: Nepovirus]	<i>Armoracia</i> , <i>Brassica</i>	Yes (Sharkey, Hepworth & Whattam 1996).	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.				
<i>Beet curly top virus</i> (BCTV) [Geminiviridae: Curtovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species (Wintermantel et al. 2003). Symptoms of the disease include stunting, cluttered and misshapen leaflets, necrosis, degeneration, and death of the periderm and phloem cells (Harveson 2015; Jones et al. 2009). BCTV is moved locally by its insect vectors and to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Beet western yellows virus</i> (BWYV) [Luteoviridae: Polerovirus]	<i>Brassica</i> , <i>Crambe</i> ,	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
	<i>Raphanus</i> , <i>Sinapis</i>					
<i>Beet western yellows ST9-associated RNA virus</i> (ST9BWYV) [Unassigned: Unassigned]	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> and <i>Raphanus</i> species (Brunt et al. 1996). This virus is transmitted by an insect vector and to date there is no available evidence demonstrating that this virus is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Bidens mottle virus</i> (BiMoV) [Potyviridae: Potyvirus]	<i>Lepidium</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Lepidium</i> species (Purcifull & Zitter 1971). This virus is aphid transmitted and to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Brassica rapa cryptic virus 1</i> (BrCV1) [Partitiviridae: Unassigned]	<i>Brassica</i>	Not known to occur	Yes: Seeds provide a pathway for this virus, which has been reported naturally occurring as seed-borne in <i>Brassica</i> species in China (Li et al. 2016).	Yes: When introduced via the seed pathway BrCV1 could establish and spread in Australia. This virus has established in areas with a wide range of climatic conditions (Li et al. 2016). Spread of this virus from the seed pathway depends on	No: To date there is no evidence of economic consequences associated with this virus. Therefore, it is not considered to pose risks of economic significance for Australia.	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Brassica yellows virus</i> (BrYV) [Luteoviridae: Polerovirus]	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> and <i>Raphanus</i> species (Zhang et al. 2016; Zhang et al. 2014). BrYV is aphid transmitted (Zhang et al. 2016) and to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	human mediated transport of infected seeds. Assessment not required	Assessment not required	No
<i>Broad bean wilt virus</i> (BBWV) [Secoviridae: Fabavirus]	<i>Brassica</i> , <i>Nasturtium</i>	Yes (Brunt et al. 1996; Shukla & Gough 1983). Western Australia's BAM Act 2007 prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Broccoli necrotic yellows virus</i> (BNYV) [Rhabdoviridae: Cytorhabdovirus]	<i>Brassica</i>	Yes (Brunt et al. 1996; Garrett & O'Loughlin 1977). Western	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.				
<i>Cabbage leaf curl Jamaica virus</i> (CabLCJV) [Geminiviridae: Begomovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species (Smith 2005). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Cabbage leaf curl virus</i> (CaLuV) [Geminiviridae: Begomovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species causing yellow spots, vein clearing, mosaic, curling and puckering symptoms on leaves (Mandal et al. 2001). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			provide a pathway for this virus.			
<i>Cardamine chlorotic fleck virus</i> (CCFV) [Tombusviridae: Betacarmovirus]	<i>Brassica</i> , <i>Sinapis</i>	Yes (Skotnicki et al. 1992)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cauliflower mosaic virus</i> (CMV) [Caulimoviridae: Caulimovirus]	<i>Brassica</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Hertel, Schwinghamer & Bambach 2004)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cole latent virus</i> (CoLV) [Betaflexiviridae: Carlavirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species in Brazil (Brunt et al. 1996). CoLV is transmitted by an insect vector, <i>Myzus persicae</i> (Brunt et al. 1996) and to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Croton yellow vein mosaic virus</i> (CYVMV) [Geminiviridae: Begomovirus]	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species (Roy et al. 2013) and <i>Raphanus</i> species (Brunt et al. 1996). CYVMV is transmitted by an insect vector, the whitefly <i>Bemisia tabaci</i> (Roy et al. 2013) and to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Cucumber mosaic virus</i> (CMV) [Bromoviridae: Cucumovirus]	<i>Brassica</i> , <i>Raphanus</i>	Yes (Persley, Cooke & House 2010)	provide a pathway for this virus. Assessment not required	Assessment not required	Assessment not required	No
<i>Erysimum latent virus</i> (ELV) [Tymoviridae: Tymovirus]	<i>Barbarea</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Barbarea</i> species (Shukla & Gough 1980). ELV is transmitted by flea-beetles in the genus <i>Phyllotreta</i> , but to date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Horseradish curly top virus</i> (HrCTV) [Geminiviridae: Curtovirus]	<i>Armoracia</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Armoracia</i> species in California (Nischwitz & Olsen 2010). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Horseradish latent virus</i> [Caulimoviridae: Caulimovirus]	<i>Armoracia</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Armoracia</i> species in Europe (Richins & Shepherd 1986). To date there is no available	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.			
<i>Lettuce mosaic virus</i> [Potyviridae: Potyvirus]	<i>Sinapis</i>	Yes (Stubbs & O'Loughlin 1961)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pedilanthus leaf curl virus</i> [Geminiviridae: Begomovirus]	<i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Raphanus sativus</i> , causing upward leaf curling, stunted growth and vein yellowing (Ismail et al. 2017), and on <i>Brassica rapa</i> , causing leaf crumpling and reduced leaf size (Munir et al. 2018). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Pepper mild mottle virus</i> (PMMoV) [Virgaviridae: Tobamovirus]	<i>Rorippa</i>	Yes (Brunt et al. 1996)	Assessment not required	Assessment not required	Assessment not required	No
<i>Potato virus X</i> (PVX) [Alphaflexiviridae: Potexvirus]	<i>Brassica</i>	Yes (Holmes & Teakle 1980; Kirkwood 2009)	Assessment not required	Assessment not required	Assessment not required	No
<i>Radish leaf curl virus</i> (RLCV) [Geminiviridae: Begomovirus]	<i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Raphanus</i> species causing typical upward and downward leaf curling, leaf distortion, reduction of leaf area and	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Radish mosaic virus</i> (RaMV) [Secoviridae: Comovirus]	<i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i> , <i>Sinapis</i>	Not known to occur	conspicuous enations on the underside of the leaves (Singh et al. 2007). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus. No: This virus has been reported naturally occurring on <i>Brassica</i> , <i>Eruca</i> , <i>Raphanus</i> and <i>Sinapis</i> species (Dikova 1995; Rimmer, Shattuck & Buchwaldt 2007). RaMV is reported to induce severe mosaic and leaf deformations in radish (Dikova 1995). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Radish yellow edge virus</i> (RYEV) [Partitiviridae: Unassigned]	<i>Raphanus</i>	Yes (Brunt et al. 1996; Muthaiyan 2009; Nutsuaki 1985)	Assessment not required	Assessment not required	Assessment not required	No
<i>Raphanus sativa virus 1</i> (RsV1) [Partitiviridae: Unassigned]	<i>Raphanus</i>	Not known to occur	Yes: Seeds provide a pathway for these viruses, which have been reported	Yes: When introduced via the seed pathway these viruses could establish and spread in Australia. These	No: To date there is no evidence of economic consequences associated with these	No
<i>Raphanus sativa virus 2</i> (RsV1) [Partitiviridae: Unassigned]	<i>Raphanus</i>	Not known to occur				No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Raphanus sativa virus 3</i> (RsV1) [Partitiviridae: Unassigned]	<i>Raphanus</i>	Not known to occur	as seed-borne in <i>Raphanus sativus</i> (Li et al. 2016).	viruses have established in areas with a wide range of climatic conditions (Li et al. 2016). Spread of these virus from the seed pathway depends on human mediated transport of infected seeds.	viruses. Therefore, they are not considered to pose risks of economic significance for Australia.	No
<i>Ribgrass mosaic virus</i> (RMV) [Virgaviridae: Tobamovirus]	<i>Brassica</i> , <i>Eutrema</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> and <i>Eutrema</i> species (Kim et al. 2010). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Sinapis alba cryptic virus 1</i> (SaCV1) [Partitiviridae: Unassigned]	<i>Sinapis</i>	Not known to occur	Yes: Seeds provide a pathway for this virus, which has been reported as seed-borne in <i>Sinapis alba</i> with no conspicuous symptoms (Li et al. 2016).	Yes: When introduced via the seed pathway <i>Sinapis alba cryptic virus 1</i> could establish and spread in Australia. This virus has established in areas with a wide range of climatic conditions (Li et al. 2016). Spread of this virus from the seed pathway depends on human mediated transport of infected seeds.	No: To date there is no evidence of economic consequences associated with this virus. Therefore, it is not considered to pose risks of economic significance for Australia.	No
<i>Tobacco necrosis virus</i> (TNV) [Tombusviridae: Necrovirus]	<i>Brassica</i>	Yes: (Findlay & Teakle 1969; Teakle 1988), it is not known if the species or strains that infect	No: This virus has been reported naturally occurring on <i>Brassica</i> species causing spotting, mottling and necrotic symptoms (Zitikaite & Staniulis 2009). To date	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
		brassicaceous crops are present in Australia.	there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.			
<i>Tobacco ringspot virus</i> (TRSV) [Comoviridae: Nepovirus]	<i>Armoracia</i>	Yes (Reynolds & Teakle 1976)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tobacco streak virus</i> (TSV) [Bromoviridae: Ilarvirus]	<i>Brassica</i>	Yes (Sharman, Persley & Thomas 2009; Sharman, Thomas & Persley 2015). Western Australia's <i>BAM Act 2007</i> prohibits this pest (Government of Western Australia 2018). It is not considered as WA did not provide any regulatory action in support of area freedom.	Assessment not required	Assessment not required	Assessment not required	No
<i>Tomato black ring virus</i> (TBRV) [Comoviridae: Nepovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species (EPPO 1990). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore,	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>Tomato chlorosis virus</i> (ToCV) [Closteroviridae: Crinivirus]	<i>Eruca</i>	Not known to occur	seeds are not considered to provide a pathway for this virus. No: This virus has been reported naturally occurring on <i>Eruca</i> species (Boiteux et al. 2016). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Tomato spotted wilt virus</i> (ToSWV) [Bunyaviridae: Orthotospovirus]	<i>Brassica</i>	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No
<i>Turnip crinkle virus</i> (TCV) [Tombusviridae: Betacarmovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species inducing stunting, leaf crinkling and vein clearing (Li & Simon 1990). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Turnip mosaic virus</i> (TuMV) [Potyviridae: Potyvirus] (synonyms: <i>Brussel sprouts mosaic</i> ; <i>Cabbage A virus mosaic</i> ; <i>Cabbage black ring spot virus</i> ; <i>Mustard mosaic virus</i> ; <i>Rutabaga</i>)	<i>Armoracia</i> , <i>Brassica</i> , <i>Nasturtium</i> , <i>Raphanus</i> , <i>Sinapis</i>	Yes (Persley, Cooke & House 2010; Schwinghamer et al. 2014)	Assessment not required	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
<i>mosaic virus; Horseradish mosaic virus; Watercress mosaic virus</i>						
<i>Turnip rosette virus</i> (TRoV) [Unassigned: Sobemovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species causing vein necrosis, leaf distortion and stunting (Brunt et al. 1996). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Turnip-vein clearing virus</i> (TVCV) [Virgaviridae: Tobamovirus]	<i>Brassica</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> species causing vein clearing (Lartey, Lane & Melcher 1994). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Turnip yellow mosaic virus</i> (TYMV) [Tymoviridae: Tymovirus]	<i>Brassica</i>	Yes (Blok et al. 1987; Brunt et al. 1996)	Assessment not required	Assessment not required	Assessment not required	No
<i>Turnip yellows virus</i> (TuYV) [Luteoviridae: Polerovirus]	<i>Brassica</i>	Yes (Hauser et al. 2000)	Assessment not required	Assessment not required	Assessment not required	No
<i>Wasabi mottle virus</i> (WMoV) [Virgaviridae: Tobamovirus]	<i>Eutrema</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Eutrema</i> species causing vein-	Assessment not required	Assessment not required	No

Scientific name(s)	Host genera	Present in Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest
			clearing and ringspots (Macdonald et al. 2018; Pasin et al. 2018). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.			
<i>Watercress yellow spot virus</i> (WYSV) [Tombusviridae: Unassigned]	<i>Nasturtium</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Nasturtium</i> species causing chlorotic spotting and blotching (Brunt et al. 1996; Koike, Gladders & Paulus 2007). To date there is no available evidence demonstrating that this virus is seed-borne in this host. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No
<i>Youcai mosaic virus</i> (YoMV) [Virgaviridae: Tobamovirus] (synonyms: <i>Chinese rape mosaic virus</i> ; <i>oilseed rape mosaic virus</i>)	<i>Brassica</i> , <i>Raphanus</i>	Not known to occur	No: This virus has been reported naturally occurring on <i>Brassica</i> and <i>Raphanus</i> species causing stunting and mild mosaic of leaves (Choi et al. 2017; Gibbs et al. 1982; Ju et al. 2019). To date there is no available evidence that this virus is seed-borne in these hosts. Therefore, seeds are not considered to provide a pathway for this virus.	Assessment not required	Assessment not required	No

Appendix 2: Issues raised on the draft review and responses

The Department of Agriculture circulated the 'Draft review of import conditions for brassicaceous crop seeds for sowing into Australia' in February 2018 for stakeholder consultation'. A WTO SPS notification G/SPS/N/AUS/445 was also issued at this time.

Comments were received on the draft review from stakeholders, including from industry representatives, trading partners and state and territory governments. The department undertook a comprehensive review of all comments received from stakeholders. A summary of the key issues they raised, and the department's responses, are provided.

Pathway association

Stakeholders suggested that further evidence was required to support assessments that *Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp. *raphani* (*F. o. f. sp. raphani*) are seed-borne in brassicaceous hosts.

Colletotrichum higginsianum—three references (Chinese Vegetable Network 2019; Richardson 1990; Rimmer, Shattuck & Buchwaldt 2007) were cited in the draft report in support of *Colletotrichum higginsianum* being seed-borne. Daly & Tomkins (1997), Damicone (2017), Li (1989) and Scheffer (1950) are also added to the final report as additional evidence that *Colletotrichum higginsianum* is seed-borne in radish and turnip.

The Chinese Vegetable Network (2019) stated that *Colletotrichum higginsianum* overwinters in plant debris and seed, and the pathogen can be spread through infected seeds of *Brassica oleracea*, *Brassica rapa* and *Raphanus sativus*. The quality of this reference was questioned. A translation of the relevant details can be provided on request.

The *Annotated List of Seed-borne Diseases* provided authority that *Colletotrichum higginsianum* is seed-borne in *Raphanus sativus* (Richardson 1990). This handbook (4th Edition) is published by the International Seed Testing Association. The quality of this reference was challenged on the basis that some primary references are not accessible. It is acknowledged that some older references may not be accessible from the website. However, all information contained in this edition has been placed into a data-bank for improved access and to bring this book up to date.

Rimmer, Shattuck and Buchwaldt (2007) was used to support the seed-borne association for *Colletotrichum higginsianum*. Rimmer, Shattuck and Buchwaldt (2007) stated that '*Colletotrichum higginsianum* has been found in seeds of radish and may be disseminated with seeds of other hosts.' The quality of the original references to support this statement was questioned. The department notes that this publication is a joint effort of fifty-nine international plant disease experts and has been subject to peer review.

Additional evidence that *Colletotrichum higginsianum* is seed-borne was added in the final report. Scheffer (1950), concluded that *Colletotrichum higginsianum* is seed-borne on *Raphanus sativus*. Scheffer (1950) isolated *Colletotrichum higginsianum* from 16% of infected radish seeds and confirmed its seed to seedling transmission. Furthermore, numerous other peer reviewed references cite *Colletotrichum higginsianum* as a seed-borne pathogen of radish (Agarwal & Sinclair 1996; George 2009; George 2011; Kidane 1993). *Colletotrichum higginsianum* is also seed-borne in *Brassica rapa* (Daly & Tomkins 1997; Damicone 2017; Holliday 1995). Infected seed was considered to be the most important pathway for the long-distance transmission of *Colletotrichum higginsianum* in *Brassica rapa* (Li 1989).

It is concluded that there is sufficient evidence that *Colletotrichum higginsianum* is seed-borne in radish (*Raphanus sativus*) and turnip (*Brassica rapa*) to justify measures to prevent it from entry into Australia.

Stakeholders suggested that the evidence provided in the draft report for *Colletotrichum higginsianum* being seed-borne in *Brassica oleracea* was not robust. In the preparation of this final report, the department has further reviewed available evidence to support the seed-borne status of the two identified quarantine pests. Consequently, in contrast to the action proposed in the draft report, *Brassica oleracea* has been removed from this final report on the basis of insufficiency of evidence for *Colletotrichum higginsianum* as a seed-borne pest in this host.

- *Brassica oleracea* is a well-studied host, but the body of available evidence for seed association with *Colletotrichum higginsianum* is limited to only one reference (Chinese Vegetable Network 2019)
- The single reference presents a statement to support the association of *Colletotrichum higginsianum* with *Brassica oleracea* seeds without providing underpinning evidence.

Three other references (Caesar, Lartey & Caesar-TonThat 2010; Farr & Rossman 2019; Zhuang 2005) provide evidence that *Colletotrichum higginsianum* can naturally infect *Armoracia*, *Brassica* and *Raphanus* species. Reference to work by Takeuchi, Horie and Shimada (2007) has been added to the final report to support *Eruca vesicaria* (cultivated rocket) as a natural host. These references were not used to support a seed pathway association in the review.

***Fusarium oxysporum* f. sp. *raphani* (F. o. f. sp. *raphani*)**—*Fusarium oxysporum* forms a complex of cosmopolitan fungi (the *Fusarium oxysporum* species complex, FOSC) (Edel-Hermann & Lecomte 2018). Collectively, members of the complex can infect a broad range of hosts, but each *Fusarium oxysporum* forma *specialis* (f. sp.) usually has one or a few closely related hosts (Edel-Hermann & Lecomte 2018).

Of the more than 200 ff. spp. of *Fusarium oxysporum* described so far, *F. o. f. sp. raphani* has been described as the causal agent of fusarium wilt of radish (*Raphanus sativus*) (also known as radish yellows) (du Toit & Pelter 2003; Kim et al. 2017; Toyota, Yamamoto & Kimura 1994) and wilt of wild (*Diplotaxis muralis*) and cultivated (*Eruca vesicaria*) rocket (Catti et al. 2007; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004; Gullino, Gilardi & Garibaldi 2014b; Srinivasan et al. 2012). Kim et al. (2017) verified *F. o. f. sp. raphani* as the causal agent of fusarium wilt on radish by polymerase chain reaction techniques and pathogenicity assays.

Three references (Bomberger 2013; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004) were cited in the draft review to support *F. o. f. sp. raphani* being seed-borne in *Raphanus sativus* and *Eruca sativa*. Rimmer, Shattuck and Buchwaldt (2007) was cited as evidence that *F. o. f. sp. raphani* can naturally infect *Brassica* species causing Fusarium wilt, not to prove seed pathway association.

Bomberger (2013) recovered *Fusarium oxysporum* from samples of commercial stock seed of radish and daughter seed collected from wilted parent plants. Bomberger (2013) also reported the association of *Fusarium oxysporum* with red radish (*Raphanus sativus*) in the field, and confirmed that *Fusarium oxysporum* isolates obtained from affected radish plants were pathogenic on radish, consistent with the causative agent being *F. o. f. sp. raphani*. However, extended host range tests of these isolates were not undertaken, meaning that the possible involvement of other f. sp. of *Fusarium oxysporum* could not be technically excluded.

Nevertheless, and despite elements of inconsistency in the scientific literature (Bosland, Williams & Morrison 1988; du Toit & Pelter 2003), it is considered reasonable to conclude that *Fusarium oxysporum* isolated from red radish seeds by Bomberger (2013) was *F. o. f. sp. raphani*. Consequently, it is also considered that there is sufficient evidence to conclude that radish seeds are a potential source of inoculum for *F. o. f. sp. raphani*.

Garibaldi et al. (2004) and Garibaldi, Gilardi and Gullino (2006) were cited to support the seed pathway association of *F. o. f. sp. raphani* on cultivated rocket seeds. Garibaldi et al. (2004) and Garibaldi, Gilardi and Gullino (2006) claimed that seed transmission on wild and cultivated rocket seeds contributed to the sudden appearance and rapid spread of the disease in Italy. Garibaldi et al. (2004) isolated the *F. o.* from commercial rocket seeds, carried out pathogenicity tests of the isolates, and confirmed some of the isolates were pathogenic on wild and cultivated rocket. Garibaldi, Gilardi and Gullino (2006) later used isolates from infected stem tissue of rocket to conducted pathogenicity studies and concluded *F. o. f. sp. raphani* to be the causal agent of fusarium wilt of both cultivated and wild rocket in Italy as reported in 2004. Before the publication of this paper, it was not clear which *f. sp.* caused wilt of rocket.

Catti et al. (2007) and Srinivasan Srinivasan et al. (2012) also concluded *F. o. f. sp. raphani* as the causal agent of fusarium wilt of rocket. Movement of the pathogen via seed appears to be the only credible explanation for the sudden appearance and rapid spread of the disease in Italy (Catti et al. 2007; Garibaldi, Gilardi & Gullino 2006; Garibaldi et al. 2004). Srinivasan et al. (2012) reported that low levels of genetic variations among highly virulent strains of *F. o. f. sp. raphani* infecting cultivated rocket in Italy is due to a recent introduction of the pathogen into Italy, probably with a contaminated seed lot. Gullino, Gilardi and Garibaldi (2014b) in their review, reiterate that seed transmission contributed to the spread of the Fusarium wilt of rocket in Italy. Consequently, it is considered that there is sufficient evidence to conclude that cultivated rocket seeds are a potential source of inoculum for *F. o. f. sp. raphani*.

Stakeholders suggested that although contaminated seed might introduce *F. o. f. sp. raphani* into the soil, it may not establish and spread in Australia, as there is no information demonstrating survival of the pathogen in soil and subsequent potential infection of a host. It is known that *F. o. f. sp. raphani* can colonize plant debris, persist in soil as chlamydospores, is wind disseminated and likely to survive dispersal and spread into new areas (du Toit & Pelter 2003; Toyota, Yamamoto & Kimura 1994). In many locations, the pathogen has established as a soil inhabitant and caused significant losses (du Toit & Pelter 2003).

Recent outbreaks of several seed-borne diseases have highlighted the risk of seed as a potential pathway for pathogens and the need for appropriate phytosanitary regulation. For example, by the time it was recognised that basil seeds provided a pathway for *F. o. f. sp. basilici*, the fungus had spread to many countries, including Australia (Martini & Gullino 1991; Vannacci et al. 1999). Demand for basil production in North America led to seed imports and in the 1990s the disease emerged in the USA (Wick & Haviland 1992). Similarities exist between *F. o. f. sp. basilici* and *F. o. f. sp. raphani* in their mode of transmission, and both pathogens infest the seed coat with no visual symptoms.

Based on the weight of evidence, it is concluded that *F. o. f. sp. raphani* is seed-borne and could enter Australia through infected radish and rocket seeds.

Economic consequences

Stakeholders suggested that the economic consequences for *Alternaria malorum* (syn. *Cladosporium malorum*) and *Raphanus sativa virus* (1, 2, and 3) should be considered further in the pest categorisation process.

Alternaria malorum (syn. *Cladosporium malorum*)—Goetz and Dugan (2006) was cited in support of a claim that this pest has potential for economic consequences. The reference stated *A. malorum* has been reported on the seeds of several hosts. However, no information about losses caused by this fungus was provided. The fungus was reported as pathogenic on ripe apple and cherry fruits, but this resulted from artificial inoculation (Goetz & Dugan 2006). Therefore, this reference does not support the claim.

Raphanus sativa virus (1, 2 and 3)—Schmelzer (1976) was cited in support of a claim that these viruses have potential for economic consequences. The reference was about a mosaic disease in garden radish (*Raphanus sativus* L. var. *sativus*) that had spread quickly to cause substantial crop losses. Several viruses were isolated from the diseased plants, including *Cauliflower mosaic*, *Cabbage black ring*, *Turnip yellow mosaic*, *Turnip crinkle*, *Turnip rosette* and *Radish mosaic viruses* (Schmelzer 1976). However, no isolate was confirmed as *Raphanus sativa virus* 1, 2 or 3. Therefore, this reference does not support the claim.

Genus level regulation

Stakeholders suggested that all pathogens in a genus should be considered to be seed-borne on all hosts if one or more pathogen species within that genus is seed-borne in any of their hosts. These genera include *Alternaria*, *Cercospora* and *Cladosporium*.

It is acknowledged that some species in the genera *Alternaria*, *Cercospora* and *Cladosporium* are seed-borne in several hosts. However, for most species in these genera there is no scientific evidence that they are seed-borne in any brassicaceous vegetable species under review. Additionally, several species in these genera are not quarantine pests for Australia as they are present in Australia and are not under official control.

The WTO SPS Agreement (WTO 1995) requires members to set the least trade restrictive phytosanitary measures possible to achieve an appropriate level of protection. ISPM 11 states that the taxonomic unit for a pest is generally the species (FAO 2019c). In addition, the use of a higher or lower taxonomic level (such as a genus listing) should be supported by scientifically sound rationale (FAO 2019c).

These three pathogen genera are well studied; however, there is no evidence indicating that they are seed-borne in the genera of brassicaceous vegetables covered by this review. The body of available evidence for species in these pathogen genera being seed-borne is also limited.

Based on the weight of available evidence, it is considered that regulating the entire genera of *Alternaria*, *Cercospora* and *Cladosporium* is not technically justified. Consistent with ISPM 11 (FAO 2019c) and the SPS Agreement (WTO 1995), these pathogens were not considered at the genus level.

Regional pest status

Stakeholders suggested that *Alternaria japonica* and *Ditylenchus dipsaci* are present in Australia's eastern states, but not recorded in Western Australia, and that their entry is

restricted or prohibited under Western Australia's legislation, the *Biosecurity and Agriculture Management Act 2007* (Government of Western Australia 2018).

However, *Alternaria japonica* and *Ditylenchus dipsaci* have been recorded from Western Australia (Goss 1964; Nobbs 2003; Plant Health Australia 2019). Therefore, these pathogens must be under 'official control' to justify phytosanitary regulations.

To meet the definition of 'official control', two major requirements need to be satisfied: active enforcement of mandatory phytosanitary regulations (official rules such as state/territory legislation) and the application of mandatory phytosanitary procedures (officially prescribed methods for implementing phytosanitary regulations) with the objective of pest eradication or containment. At a minimum, official control programs must demonstrate program evaluation and pest surveillance to determine the need for, and effect of, control.

The department was not provided with evidence that demonstrates controls are in place to prevent movement of host material of these pathogens, or to prevent the spread of these pathogens from known infested areas to other areas in the state. Consequently, these pathogens are not considered to be under official control in Western Australia.

It was also suggested that *Alternaria cheiranthi*, *Arabis mosaic virus*, *Broad bean wilt virus*, *Cercospora brassicicola*, *Fusarium poae*, *F. o. f. sp. conglutinans*, *Peronospora lepidii*, *Pseudomonas syringae* pv. *alisalensis*, *Pyrenopeziza brassicae*, *Rhodococcus fascians*, *Tobacco streak virus*, *Xanthomonas campestris* pv. *aberrans*, *Xanthomonas campestris* pv. *armoraciae* and *Xanthomonas campestris* pv. *raphani*, are not recorded from Western Australia, are associated with seeds, and require further risk reassessment.

The department adheres to the internationally accepted guidelines for a 'pest free area' (PFA). For recognition of a PFA, a submission demonstrating area freedom is required, as outlined in ISPM 4 (FAO 2017b).

In accordance with ISPM 11 (FAO 2019c), to assess the probability of entry, an association of the pest with the import pathway is required. In this case, the pathogens must be recorded as seed-borne in one or more of the brassicaceous vegetables under review. However, the references provided by the stakeholder do not provide evidence to support the pathway association of these pathogens with seeds of brassicaceous vegetable species under review. Therefore, these pathogens are not considered further in the pest categorisation process.

The organic status of fungicide treated seeds

Stakeholders suggested that a mandatory fungicidal treatment proposed in the draft report would impact the organic status of imported seeds. Several potential alternative options to the mandatory fungicidal treatment were proposed for consideration.

As advised by the Australian organics sector, the majority of seeds used by organic growers are conventionally produced and follow the same import process as for conventional seeds. Therefore, the majority of imported seeds used by the Australian organic growers may not be strictly organic because seed produced conventionally is unlikely to meet Australia's National Standard for Organic and Bio-Dynamic Produce (NSOBP) (DAWR 2016). It is also likely that these seeds may have been exposed to fungicides.

This review has identified two fungal pathogens (*Colletotrichum higginsianum* and *F. o. f. sp. raphani*) of biosecurity concern that are associated with brassicaceous vegetable seeds for

sowing. The economic consequences that would result from the introduction of these pathogens to Australia would impact both the organic and non-organic production sectors.

Alternative options are provided for both organic and non-organic production sectors to achieve the appropriate level of protection for Australia (Section 4.4). Supplementary details of the potential range of options raised by stakeholders and their consideration are provided in Appendix 3.

Fungicidal seed treatment

Stakeholders suggested that more details of the recommended fungicidal treatment, including specific details of the required fungicide, be provided in the report.

ISPM 38 '*International movement of seeds*' recommends that phytosanitary import requirements do not specify chemical products, active ingredients or exact protocols (FAO 2017a). Therefore, consistent with ISPM 38, the department did not prescribe the names of fungicides for seed treatment. Fungicidal seed treatment is an integral part of the modern seed production system. Fungicidal seed treatments protect seedlings from both seed-borne and soil-borne pathogens. Vegetable seeds are generally treated with a broad spectrum fungicide such as Thiram, Carboxin plus Thiram or another product with equivalent chemical ingredients.

Thiram is registered as a seed treatment fungicide worldwide on a variety of crops including brassicaceous vegetables such as broccoli, Brussels sprouts, cabbage, cauliflower, kale, radish, rape seed, swede and turnip (Anon 2018). It has been used to control a broad range of seed-borne pathogens, including *Colletotrichum* spp. (Thomas & Sweetingham 2003) and *Fusarium oxysporum* (Falloon 1982, 1987). Soaking seeds in 0.2 % suspension of thiram has been shown to eradicate 11 out of 13 tested seed-borne fungal pathogens (Maude, Vizor & Shuring 1969).

Historically, Australia has been importing brassicaceous vegetable seeds treated with a broad spectrum fungicide such as Thiram, and neither *Colletotrichum higginsianum* nor *Fusarium oxysporum* f. sp. *raphani* is reported in Australian brassicaceous vegetables. This empirical evidence supports an assessment that fungicidal treatment is effective in managing the risk posed by these fungal pathogens.

Polymerase Chain Reaction (PCR) testing of seeds

It was suggested that seed testing by PCR to verify freedom from the identified pathogens may be an appropriate measure.

Seed testing by PCR to verify freedom from identified seed-borne pathogens is regularly used as an effective and least trade restrictive measures against other pathogens.

Colletotrichum higginsianum—currently, there is no PCR test protocol suitable for the detection of *Colletotrichum higginsianum* on commercially traded seeds. However, if one were to become available, it is likely that this could provide an alternative measure.

Fusarium oxysporum* f. sp. *raphani—the PCR test protocol described by (Kim et al. 2017) is reported to be effective for the detection of *F. o. f. sp. raphani*. This PCR testing protocol is in the process of validation. When validated, the department's Biosecurity Import Conditions (BICON) database will be amended and testing (on-shore or off-shore) can commence.

Heat treatment of seeds

It was suggested that heat treatment could provide an alternative measure to the proposed fungicidal treatment.

Dry heat treatment—dry heat treatment (DHT) has been applied to various vegetable seeds to mitigate the risk of seed-borne pathogens (Bang et al. 2011; Kubota, Hagiwara & Shirakawa 2012; Schmitt et al. 2009). Nakamura (1982) stated that DHT of vegetable seeds was routinely used by seed companies on watermelon, bottle gourd and tomato in Japan. Lecoq and Desbiez (2012) also noted that many of the commercial cucurbit seeds produced in the Mediterranean region are heat treated.

Specifically, DHT has been successfully used to eradicate *Colletotrichum* species from seeds.

- *Colletotrichum orbiculare* was eradicated from four vegetable crop seeds by DHT at 70°C for 90 minutes (Meng 2014).
- DHT at 70°C for 90 minutes was optimal for the eradication of *Colletotrichum orbiculare* from cucumber seeds (Shi et al. 2016).

Consequently, DHT at 70°C for 90 minutes is recommended for control of *Colletotrichum higginsianum*.

There is no known scientific evidence that DHT is efficacious for the eradication of any *Fusarium oxysporum* species from seeds. For example, Bennett and Colyer (2010) incubated cotton seeds infected with *Fusarium oxysporum* f. sp. *vasinfectum* in dry heat at 60, 70, and 80°C for 2 to 14 days. None of these treatments were efficacious at eliminating this pathogen from cotton seeds.

Consequently, DHT is not recommended for control of *F. o. f. sp. raphani*.

Hot water treatment—Nega et al. (2003) demonstrated that hot water treatment (HWT) is an efficacious treatment to control seed-borne pathogens.

Zhou et al. (2002) investigated the effects of HWT on the growth, sporulation and conidial germination of *Colletotrichum higginsianum*. Their results showed that the lethal temperatures for conidia were 53°C for 10 min or 55°C for 5 min. HWT has also been shown to be efficacious in eradicating other *Colletotrichum* species from seeds of other hosts.

- Babadoost (1992) recommended HWT of seeds of cabbage, broccoli, Brussels sprouts, cauliflower, collards, kale, kohlrabi, mustard, radish and turnip at 50°C for 20 – 25 minutes as efficacious against several pathogens including anthracnose (*Colletotrichum* spp.).
- Siang et al. (1956) demonstrated that complete control of anthracnose of kenaf (*Colletotrichum hibisci*) could be achieved by treating the seed at 50°C for 15 – 20 minutes after presoaking at 20°C for 24 hours.

Consequently, HWT at 53°C for 10 minutes or 50°C for 20 minutes is recommended for the treatment of *Colletotrichum higginsianum*.

However, there is no scientific evidence that HWT can eradicate any *F. o. formae speciales* from seeds without a significant reduction of seed germination.

- Doan and Davis (2015) tested a series of seed treatments using hot water at various temperatures (55 to 90°C) for various lengths of time (105s to 20 min) on cotton seed infected by *Fusarium oxysporum* f. sp. *vasinfectum*. The pathogen was completely eliminated

by treating the seed at 80°C for 20 min. However, seed germination was reduced by 95% and vigour was reduced by 98%.

Consequently, HWT is not recommended for *F. o. f. sp. raphani*.

Organic treatments described by Meena et al. (2013)

It was suggested that further consideration be given to non-fungicidal treatments as considered by Meena et al. (2013) to minimise potential impacts to the organic sector.

Meena et al. (2013) reported the use of various treatments to reduce overall pest incidence in field trials in India. However, the targeted pests and treatments were not explicitly defined in the paper. In addition, neither individual treatments nor the combinations of seed treatments were demonstrated to be efficacious to manage seed-borne pathogens. Therefore, this review does not provide sufficient information to inform the selection of appropriate measures.

Other potential organic treatments for seeds

It was suggested that other organic seeds treatments may be appropriate as measures to mitigate the risk of *Colletotrichum higginsianum* and *F. o. sp. raphani*. These included biocontrol agents, biopesticides, essential oils/thyme oil, or chitosan.

These organic seeds treatments were carefully considered as potential alternative options. The details of potential options and their consideration are provided in Appendix 3 of this report.

Limitations of alternative measures (e.g. hot water treatment)

It was indicated that the organic sector was concerned that commercial practicalities and excessive costs will rule out many potential alternatives (e.g. hot water treatment) to mandatory fungicidal treatment.

It is acknowledged that not all risk management options will be suitable for, or acceptable to all members of the vegetable seed industry. Therefore, all potential alternative options proposed by stakeholders were considered (see Appendix 3). Based on available scientific evidence, very few alternatives to fungicidal treatment are considered suitable as risk management measures, with the exceptions of PCR testing and heat treatment.

The limitations of hot water treatment, both practically and scientifically, are also acknowledged. Therefore, it is recommended that stakeholders undertake pilot heat tolerance studies on seeds prior to using the recommended temperature and time combinations on large batches. Miller and Lewis Ivey (2018) provided a range of recommended hot water temperature and exposure times required for various brassicaceous vegetable seeds to eradicate bacterial pathogens in organic production systems. These included treatment at 50°C for 20 minutes for broccoli, cauliflower, collard, kale, kohlrabi, rutabaga and turnip seed, and for 15 minutes for mustard, cress and radish seed.

Nega et al. (2003) also demonstrated that HWT can be an alternative treatment method to control seed-borne pathogens in organic farming. According to Nega et al. (2003), seed-borne pathogens could be reduced without significant losses of germination by using HWT at 50°C for 20 to 30 minutes, and up to 53°C for 10 to 30 minutes. At higher temperature, however, treatment time needed to be lowered to avoid reduced germination of sensitive seeds.

Underpinning supporting evidence and references

It was suggested that there was over-reliance on citing the fungal database of Farr and Rossman (2019) rather than the underpinning supporting references.

In principle, it is acknowledged that primary references should be cited in preference throughout risk assessments. However, Farr and Rossman (2019) was cited in the pest categorisation process only to support the association of a pest with the genera under review, or the geographic distribution of that pest. Original references were cited in support of specific pathway associations (i.e. seed-borne associations) and economic consequences. This ensured that all potential pests associated with brassicaceous vegetables were included in the initial step of the risk analysis.

Farr and Rossman (2019) is a reputable United States of America (US) national fungus-host database, which is managed by the US Department of Agriculture. It is one of the most comprehensive collections of fungal pathogen data in the world, and a respected source of evidence to initiate the pest categorisation process. However, references cited by the database often cannot not be accessed easily. For reasons of transparency, the database is cited as it is easily publically accessible.

Most importantly, primary references were always used for the later steps of risk analysis, such as the assessments of risk and economic consequences, and for supporting the determination of the risk ratings.

Sprouting and micro-greens for human consumption

It was noted that sprouting and micro-greens producers are also reliant on imported seeds, and suggested that an exemption should be considered where seeds are imported for human consumption. It was also stated that sprouts produced for therapeutic use may not be able to meet required residue limits.

Under existing import conditions, brassicaceous vegetable seeds imported for sprouting or micro-greens are subject to standard seeds for sowing conditions. Therefore, any changes of import requirements for brassicaceous vegetable seeds for sowing will have potential to affect seeds imported for sprouting and micro-greens.

It is acknowledged that fungicidal treatment may not be a viable option for sprouting and micro-greens for human consumption. After consultation with stakeholders, alternative options have been recommended in this final report, such as PCR testing or heat treatment that do not involve use of any chemicals. In addition, seeds for sprouting and micro-greens production will be exempt from the additional measures if imported directly to be germinated at a production facility operated under an approved arrangement.

Potential impacts of fungicide on the environment

It was suggested that the draft review did not fully consider the environmental impacts of imported seeds being treated with a broad spectrum fungicide.

It is acknowledged that it has been suggested (White & Hoppin 2004) that farmers may be exposed to residual fungicide treatments on seeds during seed handling practices.

Fungicidal seed treatment is routinely applied in Australian primary industries. The consideration and approval of agricultural chemicals are the responsibility of the Australian Pesticides and Veterinary Medicines Authority (APVMA). All safety directions concerning the use of fungicides authorised by the APVMA should be followed.

Potential impacts of some plant pests on human health

It was suggested that the potential impacts of some plant pests on human health are not adequately considered in the pest risk assessments, as illustrated by the genus *Chaetomium*.

The department is aware of the potential for impacts of some plant pathogens on human health, and where this may occur it is considered in the PRA under 'Indirect pest effects' (Chapter 2). One of the most common ways in which plant pathogens can affect humans is through the secretion of toxic metabolites, such as of 'mycotoxins' by fungi infecting plant products (Al-Sadi 2017). Additionally, airborne fungi have been reported to play a role in causing allergy and infections in susceptible people (Hung et al. 2011).

ISPM 11 provides guidelines for determination of quarantine pest status, and for conducting a PRA. According to ISPM 11, in the case of pest effects (direct and indirect effects), specific evidence is needed (FAO 2019c). It is acknowledged that *Chaetomium*-like fungi can cause opportunistic infections in humans. However, there is no evidence that any of the *Chaetomium* species listed in the pest categorisation (Appendix 1) cause infections in humans. Therefore, human impacts were not addressed in the pest categorisation for the identified *Chaetomium* species.

Acknowledging the potential for some plant pathogens to cause human health issues, such as toxicity or allergenicity, the department will continue to review the literature in the future and address any human impacts where specific evidence becomes available.

Potential long term impacts of fungicide

Stakeholders suggested that the draft review did not fully consider the long-term efficiency of the proposed seed treatment with a broad spectrum fungicide. Stakeholders suggested that over time the effectiveness of fungicides may decline due to resistance development.

Fungicidal seed treatments are an integral part of the modern seed production system, and they have been used in Australia over many decades. Potential long term impacts from fungicides such as Thiram, which has multiple modes of action, is low (Hahn 2014; Wyenandt et al. 2016). In addition, of all brassicaceous vegetable species, only three are recommended for additional measures, of which fungicidal treatment is one option. According to CropLife Australia (2018), there is no indication that *Fusarium* or *Colletotrichum* spp. has developed resistance to fungicides.

Permissibility of removing fungicides prior to planting

Stakeholders requested clarification of whether treated seeds could be washed to remove the fungicide, and advised that this may be a common practice in the organics sector.

A broad spectrum fungicidal treatment is recommended as an option to mitigate the risks posed by the identified quarantine pests (*Colletotrichum higginsianum* and *Fusarium oxysporum* f. sp.

raphani) to a level that achieves the ALOP for Australia. As removing the fungicide from the seed prior to planting interferes with the treatment efficacy, this is not permitted by the department. However, other options, such as heat treatment or PCR testing that do not involve use of any fungicides have also been recommended in this final report. Therefore, if the organic status of seeds is a concern, stakeholders can source seeds imported under heat treatment or PCR testing, or source seeds produced domestically.

Establishment of an Australian seed bank

Stakeholders suggested that establishing an Australian seed bank is a potential alternative to heavy reliance on imported vegetable seeds and organic derogations.

Australian vegetable growers (organic or conventional) have the choice to import seed, use their own, or purchase locally produced seeds. Establishment of a seed bank is beyond the scope of this review.

Appendix 3: Consideration of potential risk mitigation options

Introduction

The purpose of this section is to provide supplementary details of potential risk mitigation options proposed by stakeholders, and describe their consideration by the department.

After the release of the *'Draft review of import conditions for brassicaceous crop seeds for sowing into Australia'*, the department received 21 responses from stakeholders, particularly from the organic sector, suggesting potential alternative risk mitigation measures to the proposed mandatory fungicidal treatment.

Australia recognises the principle of equivalence, namely, *'the situation where, for a specified pest risk, different phytosanitary measures achieve a contracting party's appropriate level of protection'* (FAO 2019b). ISPM 24 (FAO 2017c) provides the principles and requirements that apply for the determination and recognition of equivalence of phytosanitary measures.

There is a substantial distinction between an acceptable seed treatment for use in a primary production setting compared to that required to be efficacious as a phytosanitary measure. For example, a pest management objective may be to suppress or reduce pest prevalence in the field to achieve an economically acceptable pest impact threshold. However, this standard of efficacy would be unlikely to be acceptable as a measure that would achieve the appropriate level of protection (ALOP) for Australia.

Seed testing

Diagnostic protocols are described in ISPM 27 (*Diagnostic protocols for regulated pests*) and adopted protocols are provided as annexes to ISPM 27 (FAO 2016b). Australia accepts validated on-shore or off-shore test protocols.

The Polymerase Chain Reaction (PCR) test described by Kim et al. (2017) is effective for the detection of *Fusarium oxysporum* f. sp. *raphani* (*F. o. f. sp. raphani*) and recommended as a measure in this final report (see Chapter 4 and Appendix 2).

Seed heat treatments

Heat treatments, including hot water treatment and dry heat treatment have been applied to various seeds to mitigate the risk of seed-borne pathogens (Bang et al. 2011; Godefroid et al. 2017; Kubota, Hagiwara & Shirakawa 2012; McGrath, Wyenandt & Holmstrom 2016; Nega et al. 2003; Schmitt et al. 2009; Toporek & Hudelson 2017).

Hot water treatment (HWT)—HWT is effective against seed-contaminating pests which are associated with the seed coat, but less effective against embryo-borne pathogens (Godefroid et al. 2017; McGrath, Wyenandt & Holmstrom 2016; Toporek & Hudelson 2017). Precise control of the intensity and duration of the treatment is required. Seed lots can differ in sensitivity to HWT, depending on the cultivar, maturity of the seed, water content, or the seed storage period, even within batches of the same cultivar (Miller & Lewis Ivey 2018; Spadaro, Herforth-Rahmé & van der Wolf 2017; Toporek & Hudelson 2017).

HWT also has some practical constraints, including the requirements for treating and re-drying large seed volumes (Borgen 2004) and has potential to impact germination and post-treatment maturation (Borgen 2004; McGrath, Wyenandt & Holmstrom 2016; Nega et al. 2003). However, as discussed elsewhere in this report (Chapter 4), this may provide a viable option in some circumstances.

Dry heat treatment (DHT)—DHT has been applied to various vegetable seeds (Bang et al. 2011; Godefroid et al. 2017; Kubota, Hagiwara & Shirakawa 2012; Schmitt et al. 2009; Spadaro, Herforth-Rahmé & van der Wolf 2017). Much of the cucurbit seed commercially produced in the Mediterranean region is heat treated (Lecoq & Desbiez 2012). DHT of vegetable seeds (spinach, watermelon, cucumber, bottle gourd, lettuce, Chinese cabbage, carrot and tomato) is routinely used by seed companies in Japan (Nakamura 1982). Specifically, DHT has been successfully used to eradicate seed-borne *Colletotrichum* spp. (Meng 2014; Shi et al. 2016).

Heat transfer in air is less efficient than in water, and DHT treated seeds may require rehydration before sowing (Spadaro, Herforth-Rahmé & van der Wolf 2017). Longer exposure periods or higher temperatures are likely to be required than for HWT in order to eliminate seed-borne pathogens, which may impact seed viability and vigour. Longer exposure periods at high temperatures (above 75°C) during DHT have also been shown to reduce seed viability and seedling vigour (Kubota, Hagiwara & Shirakawa 2012; Nakamura 1982; Shi et al. 2016).

DHT and HWT have been successfully used to eradicate *Colletotrichum* species (Babadoost 1992; Meng 2014; Shi et al. 2016; Siang et al. 1956; Zhou et al. 2002) from seeds, and these treatments are recommended as measures for *Colletotrichum higginsianum* (Chapter 4 and Appendix 2).

However, there is no known scientific evidence that either DHT or HWT is efficacious for the eradication of any *Fusarium oxysporum* species from seeds. Therefore, these treatments are not recommended for *F. o. f. sp. raphani*.

Other potential seed treatments raised by stakeholders

Several potential seed treatments were suggested by stakeholders for consideration. However, none of these were supported with efficacy data appropriate for phytosanitary measures. If formal recognition of their equivalence is required, a technical submission with relevant evidence of efficacy of the proposed measure would be required for consideration on a case-by-case basis. In addition, some of the proposed options do not meet Australia's National Standard for Organic and Bio-Dynamic Produce (NSOBP) (DAWR 2016).

Bleach or organic acids—Seed disinfectants have been used to manage some seed-borne infections or contamination of spores and other forms of disease organism on seeds. Disinfection may take place during various steps of seed production process (Mancini & Romanazzi 2014). Seed disinfection with sodium hypochlorite (bleach) is used in both conventional and organic agricultural production.

Bleach may be effective against some saprophytic fungi but is not generally effective in eliminating potentially internal seed-borne pathogens such as *Fusarium* spp. (Garibaldi et al. 2004; Gracia-Garza et al. 1999; Menzies & Jarvis 1994), and may be phytotoxic and/or impact germination (Cantliffe & Watkins 1983; Moutia & Dookun 1999; Sauer & Burroughs 1986).

Other disinfectants, such as acetic acid (CH₃COOH), hydrochloric acid (HCl) and hydrogen peroxide (H₂O₂) have been used to reduce bacteria on cabbage seed without affecting seed germination (Groot et al. 2004; van der Wolf et al. 2008).

However, these disinfectants rarely eliminate all of the microorganisms present, and there is no efficacy data to support the use of these substances as seed disinfectants against the specific fungal pathogens identified in this report.

Gaseous treatments—Ozone and ClO₂ gases are strong oxidizing agents, with a broad antimicrobial spectrum, therefore are used to decontaminate various fruits and vegetables, reduce produce decay and extend storage shelf life (Trinetta et al. 2011). To date these gases have been used mostly to inactivate food-borne pathogens on fruits, vegetables, sprouts and seeds intended for direct consumption (Gómez-López et al. 2009; Jin & Lee 2007; Paylan et al. 2014; Sharma et al. 2002). However information on the application of these gases on seeds for sowing is limited. Trinetta et al. (2011) reported that ozone and ClO₂ gas treatments were able to significantly reduce the pathogenic bacteria contamination of tomato and lettuce seeds, but not eliminate the bacteria. However, there is no efficacy data to support the use of these gas treatments against the specific fungal pathogens identified in this report.

Biopesticides—Specific biopesticides including lecithin, copper (in various forms), lime, sulphur, calcium hydroxide and phosphates have been used to control a range of plant pathogens (EEC 1991). However, their application as seed treatments are rare (Spadaro, Herforth-Rahmé & van der Wolf 2017). In addition, there is no efficacy data to support the use of biopesticides against the specific fungal pathogens identified in this report.

Biocontrol agents—Several microbial formulations are commercially available for the control of seed-borne pathogens, which include strains of *Bacillus subtilis* (Kodiak), *Streptomyces grieseoviridis* (Mycostop), *S. lydicus* (Actinovate), *Gliocladium virens* (SoilGard), *Trichoderma harzianum* (T-22 Planter Box) (Gatch 2016). For example, *B. subtilis* (Kodiak, Companion), has been used for many years to suppress plant pathogens with varying degrees of success (Araújo, Henning & Hungria 2005; Asaka & Shoda 1996; Turner & Backman 1991; Utkhede & Rahe 1983). Efficacy data on these formulations is limited and inconsistent (Gatch 2016). In addition, seed treatments with biocontrol agents have been shown to be less effective and the protection effect is often inconsistent in comparison to those achieved with chemical treatments (Gullino, Gilardi & Garibaldi 2014a). It is considered that there is insufficient data to support the use of biocontrol agents against the specific fungal pathogens identified in this report.

Essential oils—Thyme oil has commonly been tested for its ability to control seed-borne pathogens of several crops (Groot et al. 2004; Schmitt et al. 2009; Tinivella et al. 2009; van der Wolf et al. 2008). Thyme oil contains thymol and other antifungal compounds, which provide general antimicrobial activity against seed-borne pathogens. Van der Wolf et al. (2008) reported a significant reduction from 70% to less than 10% in seeds contaminated with two fungi. Batista de Lima et al. (2016) also reported essential oils extracted from orange peel reduced the incidence of *Alternaria alternata* and *A. dauci* in carrot seeds. Similarly, Schmitt et al. (2009) demonstrated a reduction in infection of *Phoma valerianellae*, but not its eradication from lamb's lettuce seeds. However, there is insufficient efficacy data to support the use of essential oils against the specific fungal pathogens identified in this report.

In-field visual inspection

In-field visual inspection of crops may be an appropriate phytosanitary measure to detect some pests where they produce characteristic visible symptoms during the production cycle. However, in most cases it is impossible to discern a specific pest on the basis of generic symptoms. For this reason, in-field visual inspection alone is not generally recommended as an appropriate phytosanitary measure for the detection of seed-borne pathogens.

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2019b).
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Appropriate level of protection (ALOP) for Australia	The <i>Biosecurity Act 2015</i> defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2019b).
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity measures	The <i>Biosecurity Act 2015</i> defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity import risk analysis (BIRA)	The <i>Biosecurity Act 2015</i> defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation.
Biosecurity risk	The <i>Biosecurity Act 2015</i> refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Consignment	A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2019b).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2019b).
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2019b).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2019b).
Equivalence (of phytosanitary terms)	The situation where, for a specified pest, different phytosanitary measures achieve a contracting party's appropriate level of protection (FAO 2019b).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2019b).
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Goods	The <i>Biosecurity Act 2015</i> defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property).
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.

Term or abbreviation	Definition
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2019b).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2019b).
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2019b).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (FAO 2019b).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2019b).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2019b).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on Phytosanitary Measures or the Commission on Phytosanitary Measures, established under the IPPC (FAO 2019b).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2019b).
National Plant Protection Organization	Official service established by a government to discharge the functions specified by the IPPC (FAO 2019b).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Department of Agriculture and Water Resources 2016).
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2019b).
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2019b).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2019b).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2019b).
Pest free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2019b).
Pest free place of production	Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2019b).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2019b).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2019b).

Term or abbreviation	Definition
Pest risk assessment (for regulated non-quarantine pests)	Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact (FAO 2019b).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2019b).
Pest risk management (for regulated non-quarantine pests)	Evaluation and selection of options to reduce the risk that a pest in plants for planting causes an economically unacceptable impact on the intended use of those plants (FAO 2019b).
Pest status (in an area)	Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgement on the basis of current and historical pest records and other information (FAO 2019b).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2019b).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2019b).
Phytosanitary measure	Phytosanitary relates to the health of plants. Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2019b). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2019b).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2019b).
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2019b).
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2019b).
Quarantine pest	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 (FAO 2019b).
Regional pest	A pest of quarantine concern for a specified area, such as Western Australia.
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2019b).
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 (FAO 2019b).
Restricted risk	Restricted risk is the risk estimate when risk management measures are applied.
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	Conditions that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.

Term or abbreviation	Definition
Soil	The loose surface material of the earth in which plants grow, in most cases consisting of disintegrated rock with an admixture of organic material (NAPPO 2003).
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2019b).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Surveillance	An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures (FAO 2019b).
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests.
Trash	Soil, splinters, twigs, leaves and other plant material, other than fruit as defined in the scope of this risk analysis. For example, stem and leaf material, seeds, soil, animal matter/parts or other extraneous material.
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2019b).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

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