Australian Government
Department of Agriculture, Fisheries and Forestry

Oriental melon and rockmelon fruit from Korea: biosecurity import requirements final report

February 2023

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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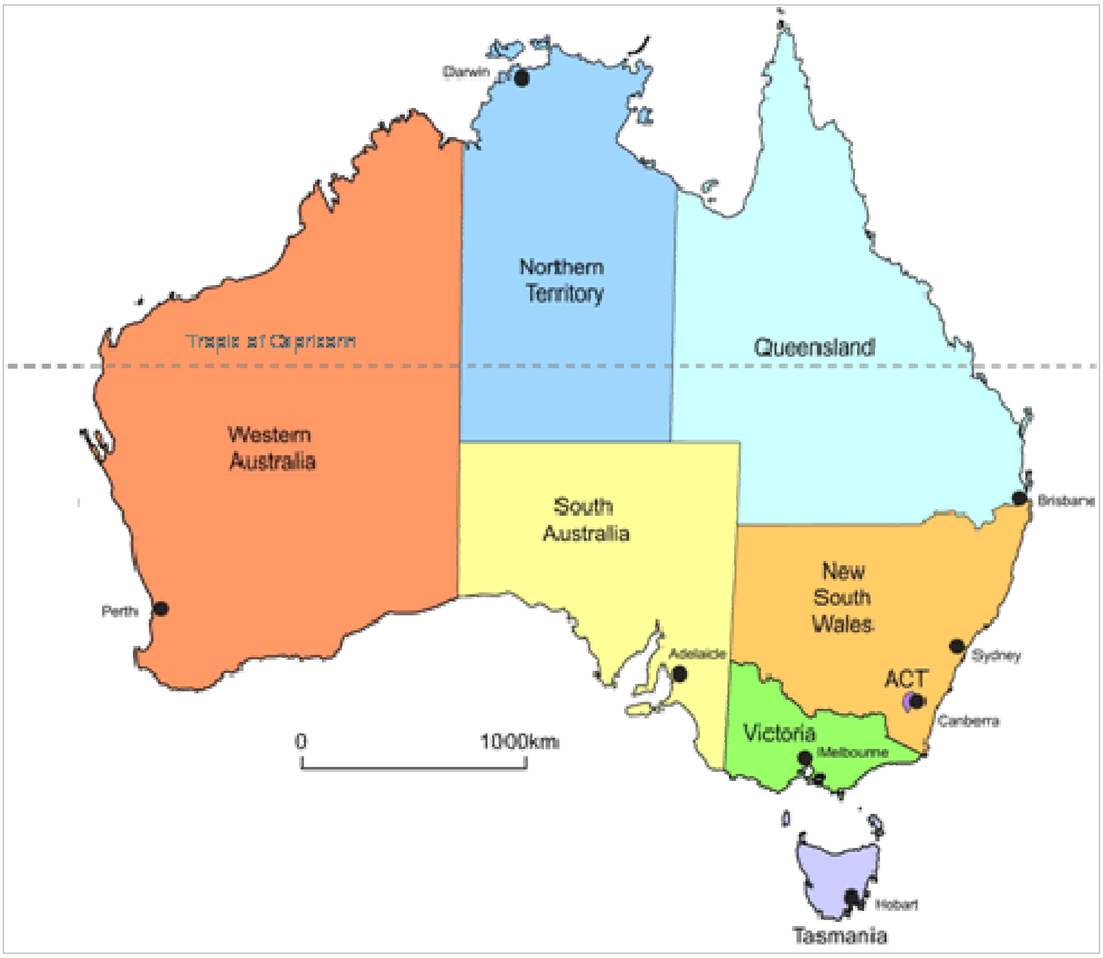

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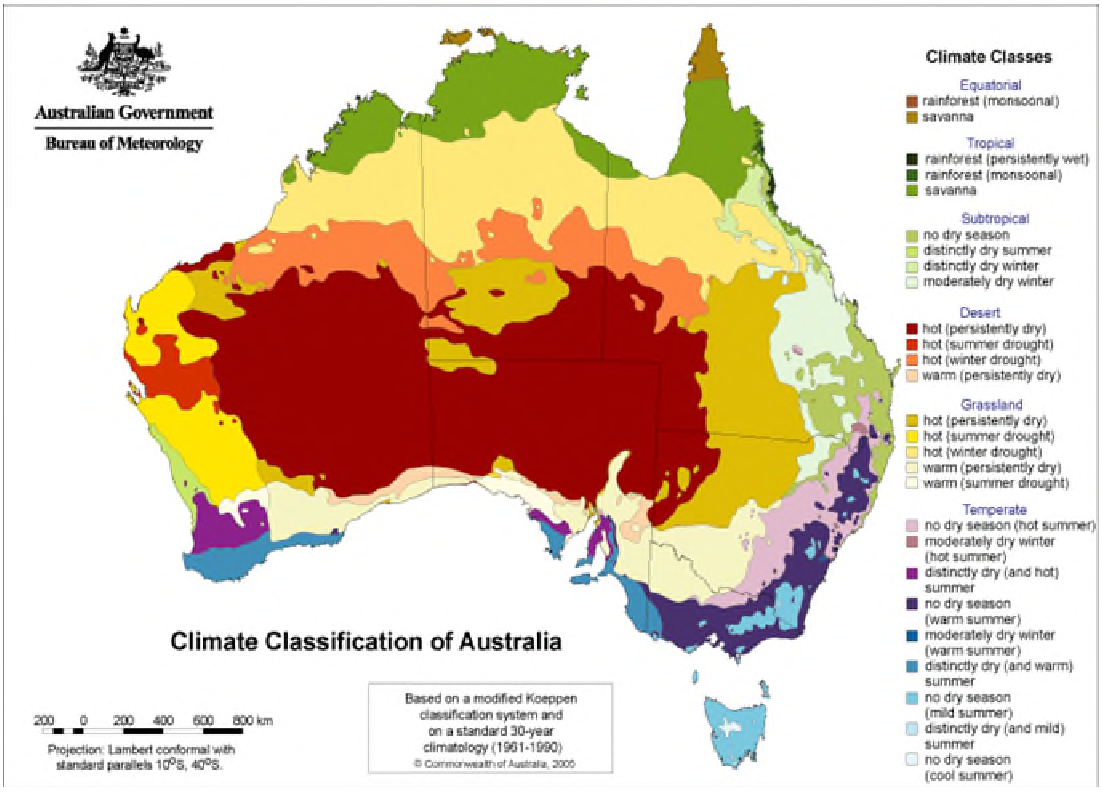


Summary

The Australian Government Department of Agriculture, Fisheries and Forestry (the department) has prepared this final report to assess the proposal by the Republic of Korea (Korea) for market access to Australia for greenhouse-grown fresh oriental melon and rockmelon fruit for human consumption.

Australia currently permits the importation of rockmelon fruit from European countries, New Zealand and the United States of America (except Hawaii) for human consumption, provided Australian biosecurity import conditions are met.

Australia does not currently permit the importation of oriental melon fruit from any country for human consumption.

This final report recommends that the importation of commercially produced greenhouse-grown oriental melon and rockmelon fruit to Australia from all commercial production areas of Korea be permitted, subject to a range of biosecurity requirements.

This final report contains details of plant pests that are of biosecurity concern to Australia and are potentially associated with the importation of greenhouse-grown oriental melon and rockmelon fruit from Korea. Also included are the risk assessments for the identified quarantine pests and regulated articles, and, where required, recommended risk management measures to reduce the biosecurity risk to an acceptable level, that is, to achieve the appropriate level of protection (ALOP) for Australia.

Five quarantine pests have been identified in this risk analysis as requiring risk management measures to reduce the biosecurity risk to an acceptable level. These pests are:

- fruit fly: pumpkin fruit fly (*Zeugodacus depressus*)
- mites: Kanzawa spider mite (*Tetranychus kanzawai*)
- thrips: Eurasian flower thrips (*Frankliniella intonsa*), western flower thrips (*Frankliniella occidentalis*) and melon thrips (*Thrips palmi*).

All 3 thrips species (Eurasian flower thrips, western flower thrips and melon thrips) were also assessed as regulated articles for all of Australia, as they are capable of harbouring and spreading emerging orthotospoviruses that are quarantine pests for Australia.

The identified pests are the same, or of the same pest groups, as those associated with other horticultural commodities that have been analysed previously by the department.

The recommended risk management measures take account of regional differences in pest distribution within Australia. Western flower thrips has been identified as a regional quarantine pest for the Northern Territory, melon thrips has been identified as a regional quarantine pest for South Australia and Western Australia, and Kanzawa spider mite has been identified as a regional quarantine pest for Western Australia. These pests are considered regional quarantine pests as interstate quarantine regulations and enforcement are in place to prevent the introduction and distribution of these pests into the respective jurisdictions.

In this final report the department recommends a range of risk management measures, combined with operational systems, to reduce the risks posed by the 5 identified species to

achieve the ALOP for Australia. The 5 identified species are all quarantine pests, and the 3 thrips are also regulated articles. The recommended measures are:

- for *Zeugodacus depressus* (pumpkin fruit fly):
  - pest free areas, pest free places of production or pest free production sites, or
  - fruit treatment considered to be effective against pumpkin fruit fly
- for thrips species and *Tetranychus kanzawai* (Kanzawa spider mite):
  - pre-export visual inspection and, if found, remedial action.

Written comments on the draft report were received from 4 stakeholders. The department has made changes to the risk analysis following consideration of the stakeholder comments on the draft report and a subsequent review of literature. These changes include:

- minor amendments to Chapter 2 'Commercial production practices for oriental melon and rockmelon fruit in Korea' to enhance clarity on commercial production practices and include additional information obtained during the in-country visit in June 2022.
- amendments to Chapter 3 'Pest risk assessments for quarantine pests'
  - A number of factors considered in the risk assessment for *Z. depressus* (pumpkin fruit fly) have been reviewed and minor amendments made to clarify the technical arguments around the effectiveness of traps to detect pumpkin fruit fly.
  - Additional information is also included in the consequence assessment for *Z. depressus* to provide further clarity and evidence to support the rationale for the consequence risk estimate impact score. However, these changes have not resulted in a change in the unrestricted risk estimate of Low for this pest.
- amendments to section 4.1.2 'Risk management measures for quarantine pests and regulated articles associated with oriental melon and rockmelon fruit from Korea', and elsewhere as appropriate, to clarify the trapping requirements recommended to demonstrate pest free places of production or pest free production sites (during a limited seasonal period) for pumpkin fruit fly.

  In addition, minor amendment to 'Recommended measure 2: fruit treatment' to include consideration of all potential treatment options for pumpkin fruit fly.
- addition of Appendix C 'Stakeholder comments', which summarises the key technical issues raised by stakeholders, and how these issues have been considered by the department in this final report.
- minor corrections, rewording and editorial changes for consistency, accuracy, clarity and web-accessibility.

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, Fisheries and Forestry using technical and scientific experts in relevant fields and involve 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 review 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, Fisheries and Forestry website at agriculture.gov.au/biosecurity-trade/policy/risk-analysis/guidelines.

1.2 This risk analysis

1.2.1 Background

Korea's Animal and Plant Quarantine Agency (APQA) formally requested market access to Australia for greenhouse-grown fresh oriental melon and rockmelon fruit for human consumption in a submission received in December 2018. This submission provided information on the pests associated with oriental melon and rockmelon fruit in Korea, including the plant parts affected. Information was also provided on the standard commercial production practices for greenhouse-grown oriental melon and rockmelon fruit in Korea.

On 15 May 2019, the department notified stakeholders of the decision to progress a request for market access for greenhouse-grown fresh oriental melon and rockmelon fruit from Korea as a review of biosecurity import requirements. This analysis is conducted in accordance with the *Biosecurity Act 2015*.

In March 2020, departmental officers were scheduled to visit major oriental melon and rockmelon fruit production areas in Seongju-county, Gyeongsangbuk-do and other areas in Korea. However, the visit was postponed due to travel restrictions relating to the COVID-19 pandemic. Further information was provided by Korea to supplement their original market access submission, and these submissions formed the basis of the production and processing procedures described in Chapter 2 of the draft report released in June 2022. These procedures were accepted as standard commercial production practices for greenhouse-grown oriental melon and rockmelon fruit in Korea for export. The submission from APQA also proposed that the export of oriental melon and rockmelon fruit will only occur from December to May.

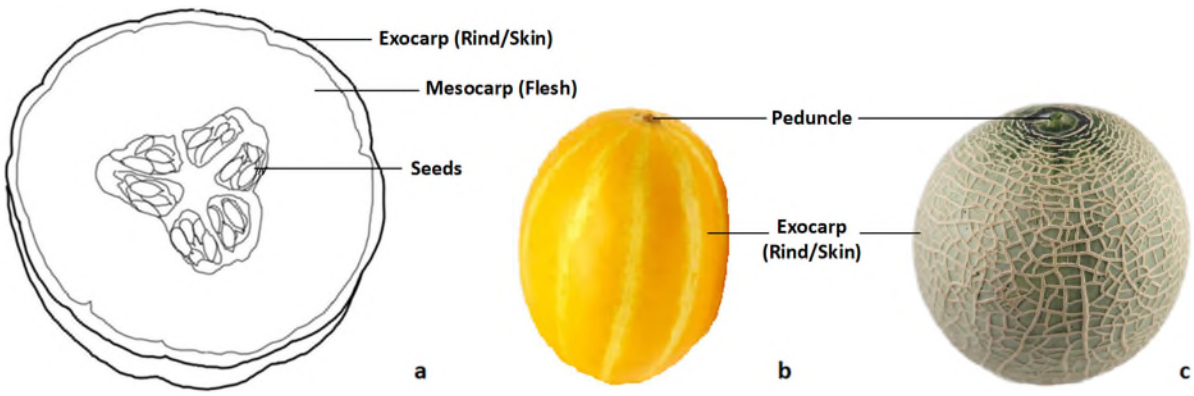
In June 2022, departmental officers visited production areas for oriental melon and rockmelon fruit from Korea. The objective of this visit was to observe commercial production, pest management and other export practices and to verify the standard commercial production practices as described in the draft report.

1.2.2 Scope

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the pathway of imported greenhouse-grown oriental melon (*Cucumis melo* var. *makuwa*) and rockmelon (*Cucumis melo* var. *cantalupo*) fruit from Korea, produced using standard commercial production practices as described in Chapter 2, for human consumption in Australia.

In this risk analysis, oriental melon and rockmelon fruit are defined as the entire fruit comprising skin, flesh and seed, with possibly a very small portion of peduncle attached (Figure 1.1). This risk analysis covers all oriental melon and rockmelon varieties commercially grown in greenhouses in Korea.

Figure 1.1 Diagram and images of oriental melon and rockmelon fruit



a: Cross-section of a melon fruit. **b:** Whole oriental melon fruit. **c:** Whole rockmelon fruit.

1.2.3 Existing policy

International policy

Oriental melon for human consumption has not previously been assessed for import into Australia.

Import policy exists for fresh rockmelon fruit from European countries, New Zealand and the United States of America (except Hawaii). Australia also has import policy for Korean horticultural commodities for Korean pear (AQIS 1999), persimmons (DAFF 2004), capsicums (Biosecurity Australia 2009), strawberry fruit (DAWR 2017c) and table grapes (Biosecurity

Australia 2011b). It was determined that the oriental melon and rockmelon fruit from Korea pathway is comparable to these previously assessed pathways, with the exception of table grapes from Korea. This is due to the structural differences between a single, whole fruit and a bunch of grapes.

The biosecurity import conditions for these commodity pathways can be found on the department's Biosecurity Import Conditions (BICON) system on the department website at bicon.agriculture.gov.au/BiconWeb4.0.

A preliminary assessment has identified that the potential pests of biosecurity concern for oriental melon and rockmelon fruit from Korea are the same, or of the same pest groups, as those associated with these and other horticultural commodities that have been assessed previously by the department, and for which risk management measures are established.

The department has reviewed all the pests and pest groups previously identified in existing policies and, where relevant, the information in those assessments has been considered in this risk analysis. The department has also reviewed the latest scientific literature and other information to ensure that the previous assessments are still valid.

The biosecurity risk posed by thrips and the orthotospoviruses they transmit was previously assessed for all countries in the *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (thrips Group PRA) (DAWR 2017a).

This Group policy is applicable for oriental melon and rockmelon fruit from Korea. The department has determined that the information in that Group policy can be adopted for the species under consideration in this risk analysis.

Domestic arrangements

The Australian Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. 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 Contaminating pests

In addition to the pests of oriental melon and rockmelon fruit from Korea that are assessed in this risk analysis, other organisms may arrive with the imported commodity. These organisms may include pests considered not to be associated with the fruit pathway, pests of other crops, or predators and parasitoids of arthropods. The department considers these organisms to be contaminating pests ('contaminants') that could pose sanitary (to human or animal life or health) or phytosanitary (to plant life or health) risks. These risks are identified and addressed using existing operational procedures that require an inspection of all consignments during processing and preparation for export. Consignments will also undergo a verification process on arrival in Australia. The department will investigate whether any pest identified through import verification processes may be of biosecurity concern to Australia and may thus require remedial action.

1.2.5 Consultation

On 15 May 2019, the department notified stakeholders, in Biosecurity Advice 2019-P07, of the commencement of a review of biosecurity import requirements to assess a proposal by Korea for market access to Australia for greenhouse-grown fresh oriental melon and rockmelon fruit for human consumption.

Prior to, and following the announcement of this decision, the department engaged with the Australian melon industry.

The department has also consulted with the government of Korea and Australian state and territory governments during the preparation of this report.

The draft report was released on 6 June 2022 (Biosecurity Advice 2022-P04) for a stakeholder consultation period of 60 days that concluded on 5 August 2022.

The department received 4 written submissions on the draft report. All submissions received during the consultation period, and issues raised by stakeholders throughout the risk analysis process, were carefully considered and, where relevant, changes were made to the final report. A summary of key technical stakeholder comments and how they were considered is provided in Appendix C.

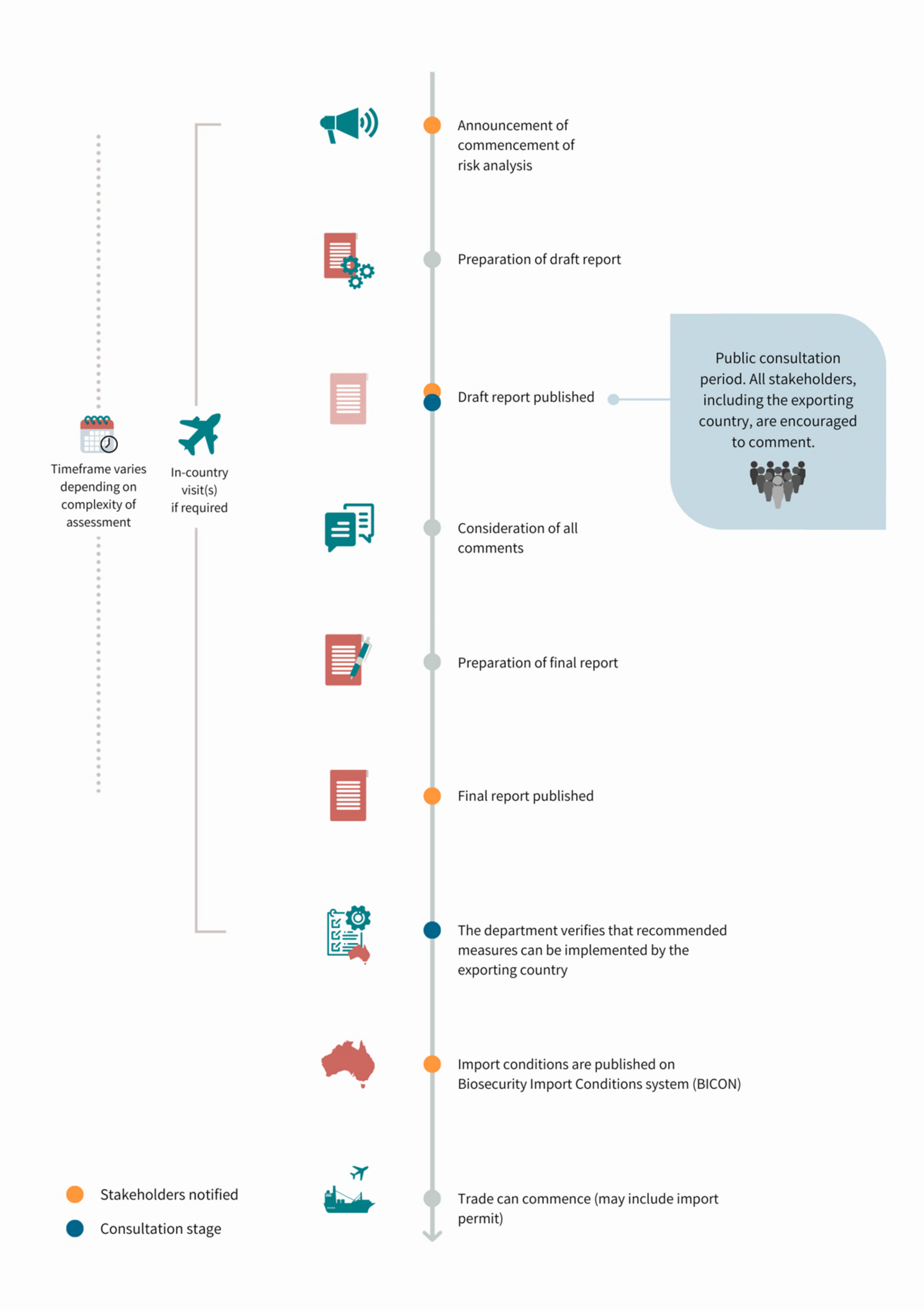
1.2.6 Overview of this pest risk analysis

A pest risk analysis (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 2022). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2022). This definition is also applied in the *Biosecurity Act 2015*.

The department conducted this PRA in accordance with Australia's method for pest risk analysis (Appendix A), which is consistent 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 2019b), and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) (WTO 1995).

A summary of the process used by the department to conduct a risk analysis is provided in Figure 1.2.

Figure 1.2 Process flow diagram for conducting a risk analysis



The PRA was conducted in the following 3 consecutive stages:

1) Initiation—identification of
   - the pathway being assessed in the risk analysis
   - the pest(s) that have potential to be associated with the pathway and are of biosecurity concern and should be considered for analysis in relation to the identified PRA area.
2) Pest risk assessment—this was conducted in 2 sequential steps:

   2.a Pest categorisation: examination of each pest identified in stage 1 to determine whether it is a quarantine pest and requires further pest risk assessment.

   2.b Further pest risk assessment: evaluation of the likelihoods of the introduction (entry and establishment) and spread, and the magnitude of the potential consequences of the quarantine pest. The combination of the likelihoods and consequences gives an overall estimate of the biosecurity risk of the pest, known as the unrestricted risk estimate (URE).
3) Pest risk management—the process of identifying and proposing/recommending required phytosanitary measures to reduce the biosecurity risk to achieve the ALOP for Australia where the URE is determined as not achieving the ALOP for Australia. Restricted risk is estimated with these phytosanitary measure(s) applied.

A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2022).

For further information on the:

- method for PRA: see Appendix A
- terms used in this risk analysis: see Glossary, acronyms and abbreviations at the end of this report
- pathway being assessed in this risk analysis: see section 1.2.2
- initiation and pest categorisation: see Appendix B
- pest risk assessments for pests/pest groups identified in Appendix B as requiring further pest risk assessment: see Chapter 3
- risk management measures for pests/pest groups assessed in Chapter 3 as not achieving the ALOP for Australia: see Chapter 4.

1.2.7 Next steps

The final report will be published on the department website with a notice advising stakeholders of the release. The department will also notify the proposer, the registered stakeholders and the WTO Secretariat about the release of the final report. Publication of the final report represents the end of the risk analysis process.

Before any trade in oriental melon and rockmelon fruit from Korea commences, the department will verify that Korea can implement the required pest risk management measures (as specified in section 4.1), and operational system for the assurance, maintenance and verification of phytosanitary status (as specified in section 4.2). On verification of these requirements, the import conditions for oriental melon and rockmelon fruit from Korea will be published on BICON.

2 Commercial production practices for oriental melon and rockmelon fruit in Korea

This chapter provides information on the pre-harvest, harvest and post-harvest practices considered to be standard practices in Korea for the production of greenhouse-grown oriental melon and rockmelon fruit for export. It also outlines the export capability of Korea.

2.1 Considerations used in estimating unrestricted risk

Korea provided a technical market access submission to Australia that included information on commercial production practices of greenhouse-grown oriental melon and rockmelon fruit in Korea.

In June 2022 the department visited oriental melon and rockmelon producing areas in Seongju and Andong, within Gyeongsangbuk-do province of Korea. The department's observations during this visit, and additional information provided by Korea to supplement their original market access submission, confirmed the production, harvest, processing and packing procedures described in this chapter as standard commercial production practices for oriental melons and rockmelons for export.

The information provided by Korea and gathered by the department during the June 2022 visit has been supplemented with data from published literature and other sources and has been taken into consideration when estimating the unrestricted risks of pests that may be associated with import of this commodity.

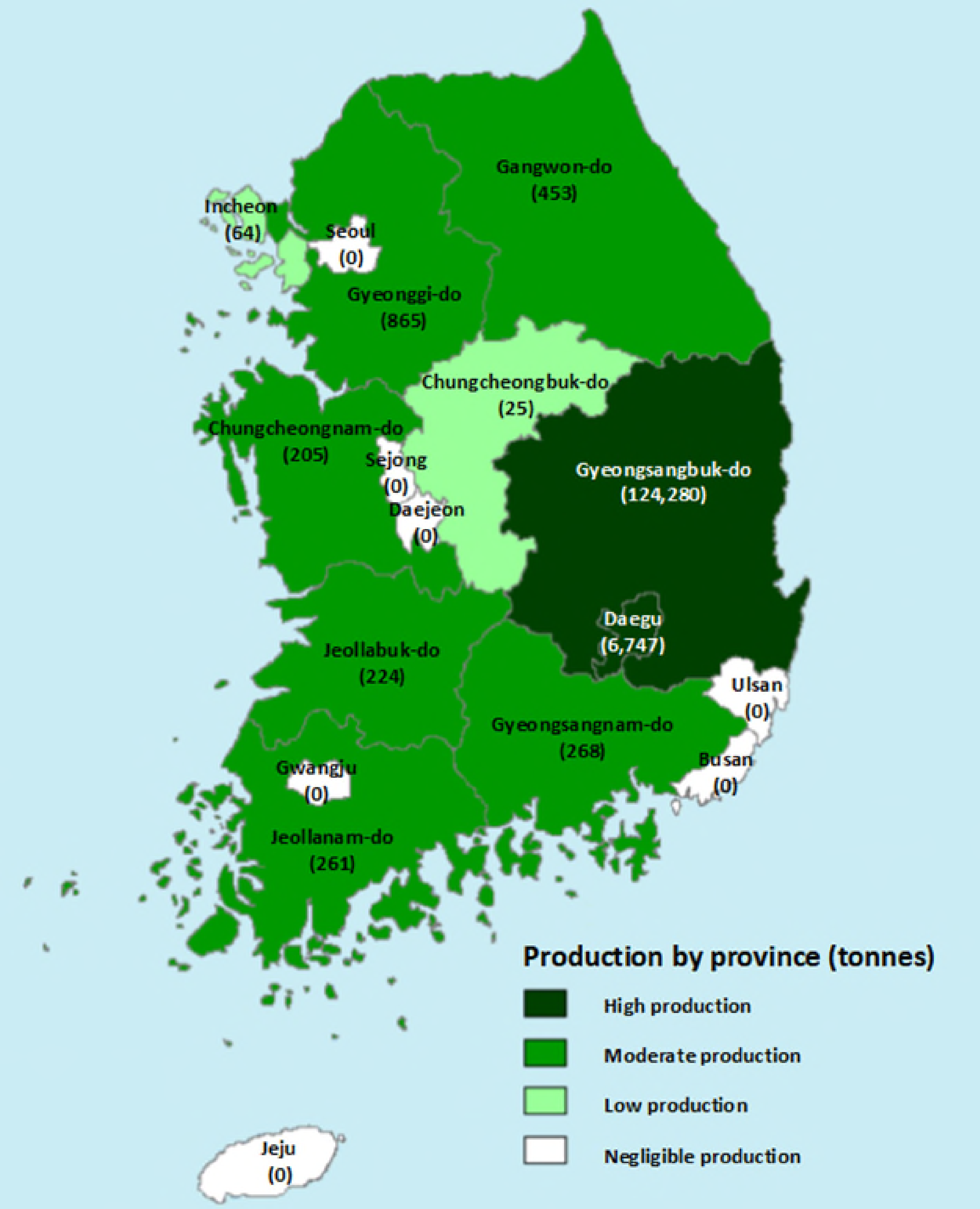
In estimating the likelihood of pest introduction, it was considered that the pre-harvest, harvest and post-harvest production practices for oriental melon and rockmelon fruit, as described in this chapter, are implemented in all greenhouses and packing houses, and for all oriental melon and rockmelon varieties produced for export.

2.2 Production areas of oriental melon and rockmelon fruit

Melons, including oriental melon (*Cucumis melo* var. *makuwa*) and rockmelon (*Cucumis melo* var. *cantalupo*), are the second most common species of the Cucurbitaceae family grown in greenhouses in Korea. Production statistics show that melon production occupied 3,488 hectares of greenhouses across Korea in 2019 and produced 133,393 tonnes of fruit (APQA 2021; KOSIS 2023). Most provinces across Korea grow oriental melon and rockmelon fruit, with the largest volumes produced in the provinces of Gyeongsangbuk-do, Daegu and Gyeonggi-do. The majority of melon production occurs in Gyeongsangbuk-do, with 3,196 hectares of greenhouses producing 124,280 tonnes of melons in 2019 (KOSIS 2023).

The main oriental melon and rockmelon fruit production provinces are identified in Map 3.

Map 3 Production of greenhouse-grown oriental melon and rockmelon fruit by province in Korea

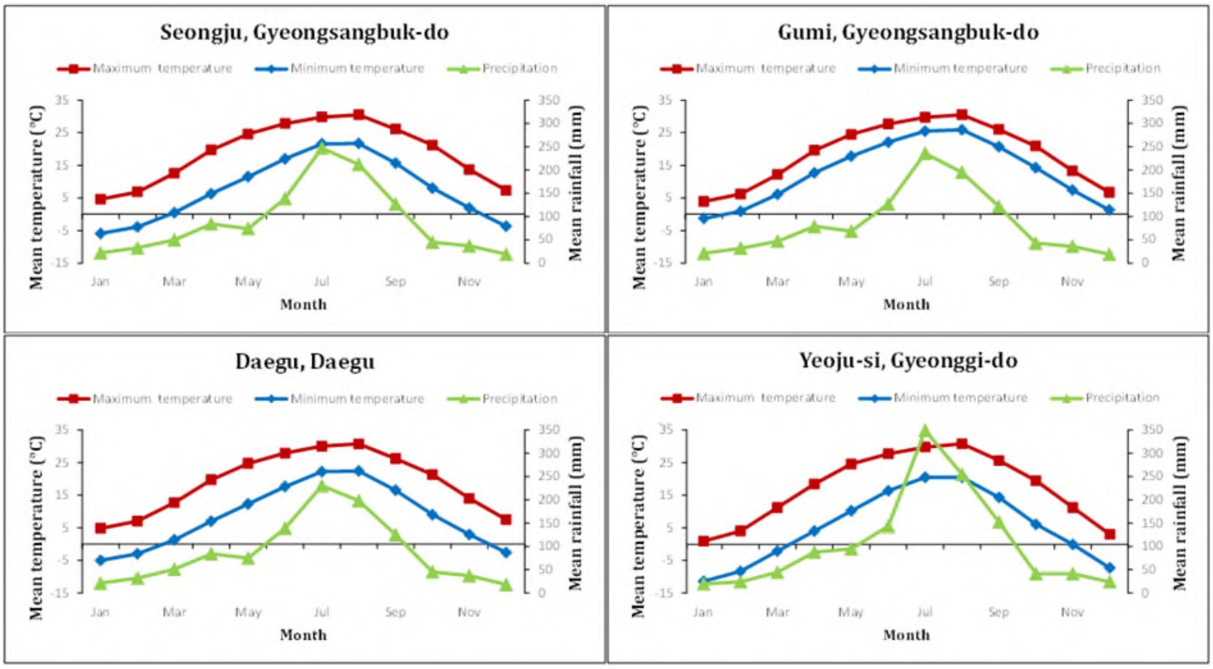


Production of greenhouse-grown oriental melon and rockmelon fruit (in tonnes) for each Province in Korea in 2019. Source: Image modified using data from KOSIS (2023)

2.3 Climate in production areas

Korea is located in the temperate climatic zone and experiences 4 distinct seasons. Winter (December–February) in Korea is typically characterised by snow and low temperatures; spring (March–May) is mild, dry, and clear; summer (June–August) is warm and humid with heavy rainfall and typhoons; and autumn (September–November) is dry and clear, with some heavy rainfall through September (KMA 2011). Melons grown in greenhouses are able to be produced all year round, while low temperatures and snow during winter mean that melons grown in the field can only be produced during warmer seasons. Figure 2.1 shows mean monthly maximum and minimum temperatures, as well as mean monthly rainfall in the cities of major melon-growing provinces of Gyeongsangbuk-do, Daegu and Gyeonggi-do.

Figure 2.1 Mean monthly minimum and maximum temperatures and mean monthly rainfall in the main production areas of oriental melon and rockmelon fruit in Korea



Mean monthly maximum (—■—) and minimum (— ◆ —) temperatures (°C) and mean monthly rainfall (millimetres) (— ▲ —) from climate data collected between 1982 and 2012 in the cities in the major melon-growing provinces of Gyeongsangbuk-do, Daegu and Gyeonggi-do, in Korea. Source: Climate-data.org (2023).

2.4 Pre-harvest

2.4.1 Cultivars

***Cucumis melo* var. *makuwa* (oriental melon)**

The oriental melon vine is a trailing plant with thin stems and large dark green leaves (Figure 2.2.a). The leaves are 8–15 cm across in size and large yellow flowers are produced on a 3–5 cm long peduncle (Lim 2012).

The oriental melon fruit reaches an average length of 10–20 cm. The fruit are smooth-skinned, oval to oblong in shape with blunt, curved ends. The rind (skin) is thin, smooth and waxy with linear white indentations extending the length of the fruit. The most common cultivars are usually bright yellow, but the rind of other varieties show colour variations of ivory and green shades. The flesh is usually white but can range in colours such as orange, green or pink. The flesh is crisp, firm, and watery, encasing cavities filled with small, white, oblong, flattened seeds that are suspended in between white fibres (Lim 2012; Shin et al. 2017; Specialty Produce 2019) (Figure 2.2.b). The most common variety of oriental melon in Korea is known as 'Chamoe'.

Figure 2.2 Oriental melon vine and fruit

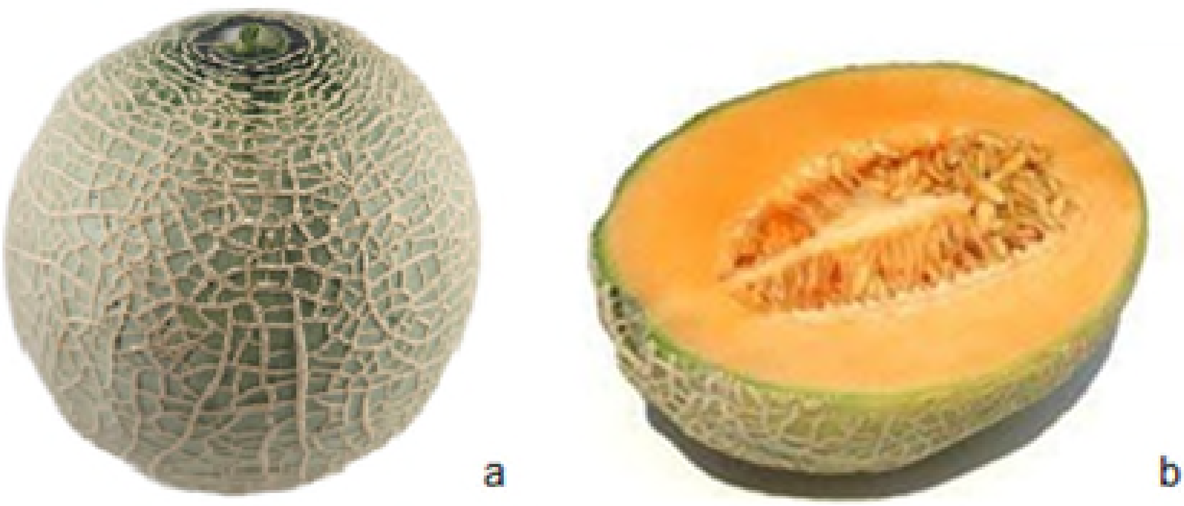
a: Immature oriental melon fruit growing on a vine. **b:** Ripe oriental melon fruit with cut segment showing flesh and seeds. Source: APQA (2021)

Cucumis melo **var.** ***cantalupo*** **(rockmelon)**

Rockmelon plants are tendril-bearing, herbaceous annual vines with large leaves, fibrous roots, and prominent fruits. They produce large yellow flowers which can be female, male or hermaphroditic, all on a single plant (Paris, Tadmor & Schaffer 2017).

Rockmelon fruit are round or oblong shaped, featuring a lightly ribbed, pale green skin with a pale 'netting' of rough exocarp material covering the skin (Figure 2.3.a). Fruit are 11.5–16.5 cm in diameter and generally weigh 450–850 g when ripe. Internally, its flesh colour ranges from orange to salmon. At the fruit's centre, a hollow cavity is filled with small off-white colour seeds encased in a web of mucilaginous netting (Figure 2.3.b) (Mariod, Mirghani & Hussein 2017). Rockmelons that are harvested prematurely do not attain their maximum potential sweetness (Mariod, Mirghani & Hussein 2017; Paris, Tadmor & Schaffer 2017).

Figure 2.3 Rockmelon fruit



a: Rockmelon fruit showing rind. **b:** Segmented rockmelon fruit showing rind, flesh and seeds. Source: APQA (2021, 2022)

2.4.2 Cultivation practices

Seed sourcing and production of seedlings

In Korea, varieties of oriental melon and rockmelon are bred by the National Institute of Horticultural and Herbal Science (NIHHS), the Rural Development Administration (RDA) or private breeders. Seeds are only sourced from providers registered with the APQA, with seed testing and traceback documentation for seed lots used (APQA 2021).

Oriental melon seedlings are grafted onto pumpkin rootstock. Rockmelon is not grafted onto rootstock, but rather the seedlings are planted directly into the greenhouses.

Planting season

The planting season for oriental melon and rockmelon is described in Table 2.1.

Table 2.1 Common planting seasons for oriental melon and rockmelon in Korea

Variety	Sowing	Grafting	Planting	Harvesting
Oriental melon	October-November	November-December	December-January	From March **a**
Rockmelon	Year round **b**	N/A	Year round **b**	Year round **a, b**

a: Korea proposes that fruit for export to Australia will only be harvested from December to May. **b**: Rockmelon production is split into 4 distinct yet overlapping seasons, with different greenhouses producing fruit at different times. Source: APQA (2021, 2022)

In general, oriental melon seedlings are planted in greenhouses approximately 20–25 days after grafting and first fruit set is approximately 40 days after planting. Oriental melon is harvested between 35–45 days after the fruit set when grown during the winter (APQA 2021).

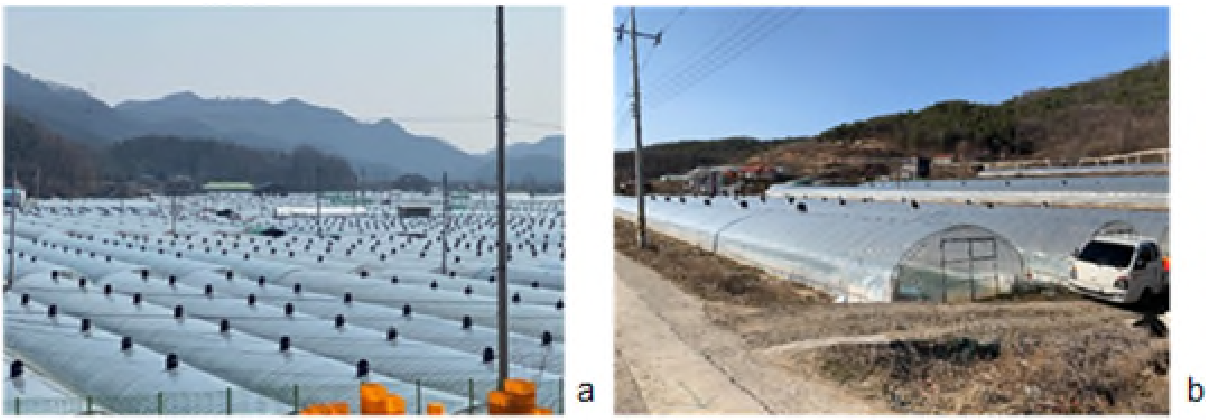
Rockmelon takes approximately 25–35 days from planting the seedling to flowering, and 45–60 days between flowering and harvest. Vines are removed after each harvest and greenhouses are sealed and disinfected before fresh seedlings are planted (APQA 2022).

Greenhouse planning and plantation

Oriental melon and rockmelon fruit are produced in plastic greenhouses or in glasshouses, with the majority of production occurring in plastic greenhouses, as seen in Figure 2.4.

Greenhouses for commercial cultivation of oriental melons are standardised to the dimensions of 5.4 metres wide, 97 metres long and 2.6 metres high. All greenhouses have specialised ventilation ducts on the roof as seen in Figure 2.4.a.

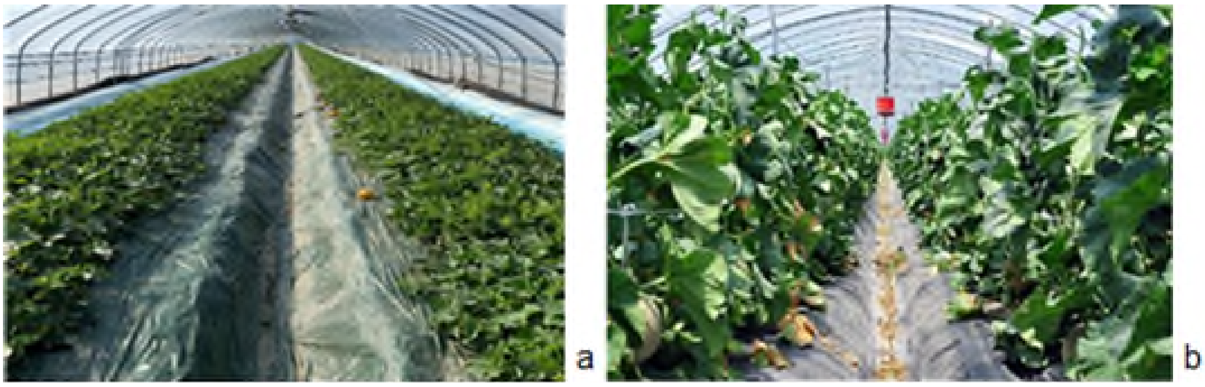
Figure 2.4 Plastic greenhouses used for the production of oriental melon and rockmelon fruit in Korea



a: Plastic greenhouse roofs with ducted air vents visible. **b:** Plastic greenhouses with surrounding roadways and structure visible. Source: APQA (2021)

Currently, oriental melons and rockmelons are grown in soil beds within the greenhouse. However, NIHHS is developing a technology for hydroponic cultivation of rockmelon plants (APQA 2021). Oriental melons are grown in soil beds that are covered with plastic mulch. This ensures that the fruit has no direct contact with the soil, as seen in Figure 2.5.a. Rockmelons are also grown in soil beds. However, their vines are manipulated to grow on trellises and fruit are suspended from the trellises so they do not touch the ground (Figure 2.5.b) of varying configurations (for example, 1 row per ridge, 2 rows per ridge, total of 4 or 5 rows per greenhouse) (APQA 2021, 2022).

Figure 2.5 Oriental melon and rockmelon growing in plastic greenhouses



a: Oriental melon vines growing prostrate in a plastic greenhouse with plastic mulch and irrigation furrow visible.
b: Rockmelon vines growing along a trestle in a plastic greenhouse with plastic mulch and irrigation furrow visible. Source: APQA (2021)

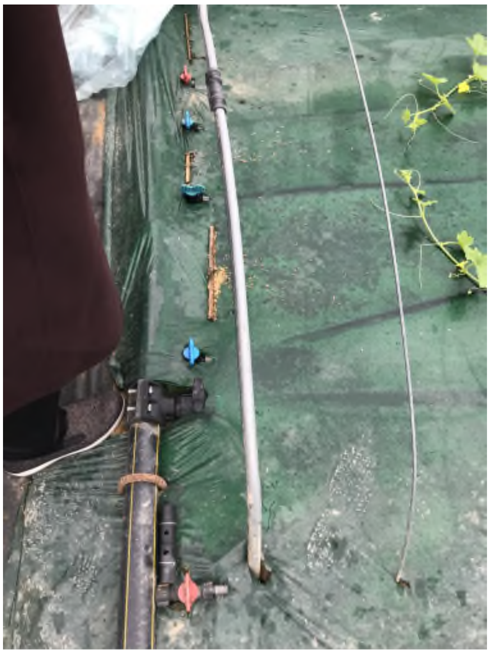
Application of fertiliser

Oriental melon vines require a basic fertiliser application of nitrogen, phosphoric acid, potassium, and dolomitic limestone during seedling period and planting period (when the grafted oriental melon is planted). Rockmelon vines require application of basic fertiliser such as nitrogen, phosphoric acid, potassium, lime, and magnesium for cultivation.

Irrigation

Oriental melon and rockmelon greenhouses utilise various irrigation systems. These systems include drip-irrigation, sprinkler irrigation, and furrow irrigation. Drip irrigation (Figure 2.6) is the most commonly used irrigation system as this reduces the risk of waterborne pathogens being spread from plant to plant.

Figure 2.6 Underground drip irrigation system in the greenhouse



Source: APQA (2021)

2.4.3 Pest management

Seed and seedling testing

Seed companies test for seed-borne pathogens before commercialisation. In addition, all imported cucurbit seeds are tested by APQA laboratories to ensure they are free from any quarantine pests (for example, *Squash mosaic virus*) or regulated non-quarantine pests for Korea (for example, *Cucumber green mottle mosaic virus*).

General pest management practices

Growers manage pests and diseases throughout the production season using various practices, such as integrated pest management, surveillance and monitoring programs, which can include use of sticky traps, protein baits and crop inspections, and use of commercial insecticides, fungicides and miticides. The soil is sterilised by solar heating after each harvest to prevent soil-borne diseases and insects. This is done by removing all plants and trellises from the greenhouse before sealing the greenhouse doors and windows and covering the soil with plastic for an extended period of time (Figure 2.7). During this period, temperatures within the greenhouse can rise to as high as 90°C. Once the solar sterilisation process is completed, the plastic sheeting is removed, and fertiliser is applied to the soil before new seedlings are planted.

Figure 2.7 Soil sterilisation in greenhouse

Source: APQA (2022)

Growers routinely inspect their melon crops for pests and diseases. Any plants showing disease symptoms are removed from the production site and destroyed to minimise the spread of diseases. Sticky traps are commonly used to monitor the presence of insect pests in the greenhouse. Traps containing protein bait are placed inside of each exterior door on a greenhouse to verify that greenhouses are free from the pumpkin fruit fly *Zeugodacus depressus* (Figure 2.8). Table 2.2 provides an example of the pest surveillance and monitoring program followed in Korean greenhouses.

Figure 2.8 Protein bait trap installed in a greenhouse to verify freedom from *Zeugodacus depressus*

a: McPhail trap with monitoring record attached. **b:** Inside of trap, showing protein bait. **c:** Trap mounted within a greenhouse. Source: APQA (2021)

Table 2.2 Example of pest surveillance/monitoring programs used in Korean greenhouses

Time of year	Pest/pathogen	Surveillance/monitoring strategy
November-May	*Zeugodacus depressus*	Traps with protein baits, sticky traps
November-May	*Frankliniella intonsa*	Sticky traps
November-May	*Frankliniella occidentalis*	Sticky traps
November-May	*Thrips palmi*	Sticky traps
November-May	*Tetranychus kanzawai*	Sticky traps
November-May	*Phytophthora melonis*	Crop inspection
November-May	CGMMV	Crop inspection

Source: APQA (2021)

Preventative sprays are applied throughout the year to manage populations of pests if required. Examples of the pest management schedules which may be followed for oriental melon and rockmelon are presented in Table 2.3 and Table 2.4 respectively.

Table 2.3 Pest management schedules for oriental melon production in Korea

Time of year	Pest/pathogen	Management strategy
Late-December	*Fusarium oxysporum* f. sp. *melonis*	Fungicide spray and grafting onto pumpkin rootstock
Late-January	*Sphaerotheca fuliginea*	Fungicide spray
	Aphids (e.g., *Aphis gossypii*)	Insecticide spray
Late-February	*Meloidogyne* spp.	Nematicide spray
Early-March	*Pseudoperonospora cubensis*	Fungicide spray
Early-April	Thrips (e.g., *Frankliniella occidentalis*)	Insecticide spray
Mid-April	Spider mites (e.g., *Tetranychus kanzawai*)	Miticide spray

Source: APQA (2021)

Table 2.4 Pest management schedules for rockmelon production in Korea

Time of year	Pest/pathogen	Management strategy
Early-December	*Sphaerotheca fuliginea*	Fungicide spray
Mid-January	*Didymella bryoniae*	Fungicide spray
Late-March	Mosaic viruses (e.g., CGMMV, KGMMV, MNSV)	Insecticide spray for potential vectors and planting virus free seeds
Late-May	Spider mites (e.g., *Tetranychus kanzawai*)	Miticide spray
Early-July	Thrips (e.g., *Frankliniella occidentalis*)	Insecticide spray

Source: APQA (2021)

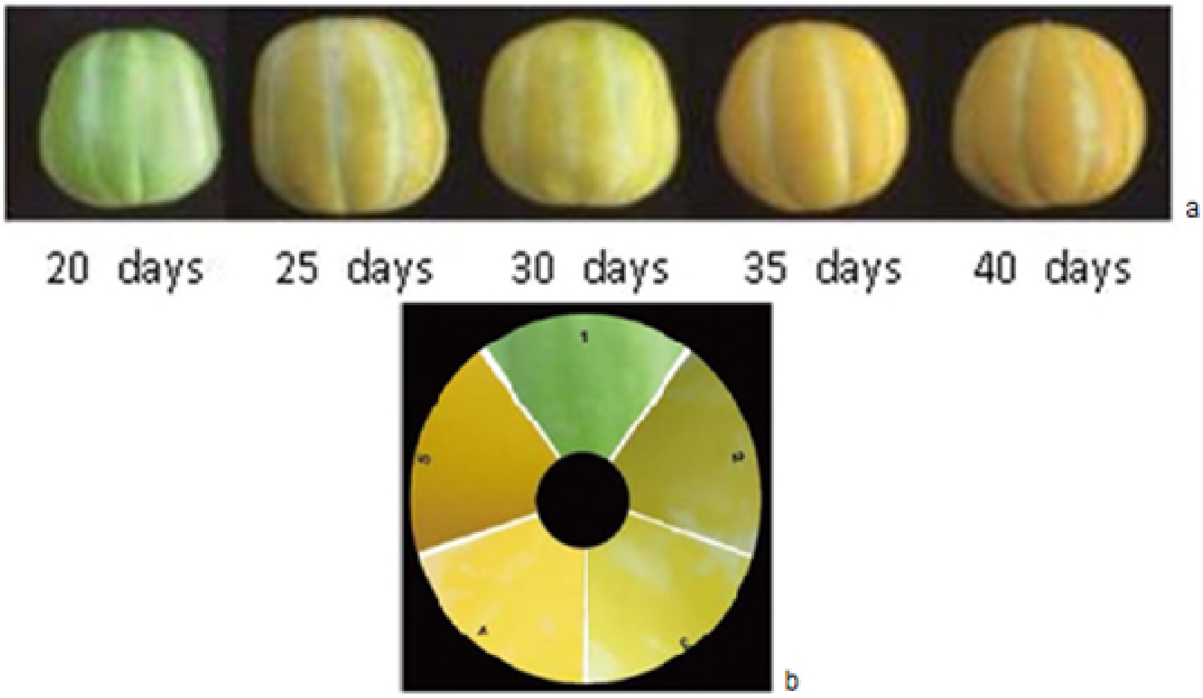
2.5 Harvesting and handling procedures

As part of APQA’s phytosanitary certification system, greenhouses and packing houses intending to export fruit must be registered with APQA. All greenhouse-grown oriental melons and rockmelons produced in Korea are also subject to a system of traceability. Whilst the level of traceability may vary between companies, the ability to trace back at least to the individual greenhouse and packing house for any melon packed for export is required, and is already in place for all export packing houses registered with APQA.

Harvesting of oriental melon

The appropriate harvesting time of oriental melon is determined based on the date after fruit set, which varies depending on temperature. In general, harvesting time during low temperature periods is between 35 and 45 days after fruit set, as explained in Figure 2.9.a. However, harvesting may occur earlier during seasons of high temperature. The appropriate timing of harvesting is guided by a 'colour chart' used to determine when fruit are at the ideal mature stage for harvest (Figure 2.9.b).

Figure 2.9 Determining oriental melon maturity



a: Gradient showing fruit colour and shape by days after planting: at 20 days the fruit is shaped but still green; at 25 days the fruit begins to turn yellow; at 30 days the fruit loses the green colour; at 35 days the fruit is reaching maturity and can be harvested; at 40 days the fruit is ripe and still able to be harvested. **b:** A colour chart, used by greenhouse workers to harvest mature fruit. Source: APQA (2021)

Oriental melon fruit are harvested by hand. Each fruit is held with one hand and the peduncle is cut from the vine using disinfected pruning scissors (Figure 2.10.a). The harvested oriental melon fruit are placed in a clean container inside the greenhouse (Figure 2.10.b) until they are ready to be transported to the packing house.

Figure 2.10 Harvesting method for oriental melon

a: Process of harvesting oriental melon fruit by hand with pruning scissors. **b:** Plastic harvesting container. Source: APQA (2021)

Harvesting of rockmelon

Rockmelon fruit are harvested approximately 50 days post-flowering. The rockmelon fruit are mature and ready to harvest when the leaves attached to the fruit turn yellow and yellow colour appears around the stem and the surrounding area where the stem is attached to the fruit (Figure 2.11).

Figure 2.11 Determining when to harvest rockmelon

Source: APQA (2021)

Rockmelon fruit are harvested by hand. The method used to harvest rockmelon fruit is to support the fruit with one hand and cut the stem using disinfected pruning scissors (Figure 2.12). The harvested melons are placed into clean containers ready for transport to the packing house.

Figure 2.12 Harvesting method for rockmelon

Source: APQA (2021)

Transport of harvested fruit to packing houses

Containers with harvested fruit are loaded onto trucks or utility vehicles (depending on the volume of melons harvested) and covered by a net or tarpaulin for transport to registered packing houses. Each harvest container is labelled so that melons can be traced back to a specific greenhouse.

Figure 2.13 Harvest containers covered with tarpaulin loaded on a vehicle for transport

Source: APQA (2021)

2.6 Post-harvest

2.6.1 Packing house processes

Receival at registered packing house

As part of APQA's phytosanitary certification system, packing houses intending to export fruit must be registered and approved by APQA. The registered packing houses must be insect-proofed with nets and air curtains.

Greenhouse-grown oriental melon and rockmelon fruit are transported in the harvest containers to a loading dock at the packing house. The loading docks are separated from internal sorting and packing facilities by a physical wall.

Fruit are processed in the packing house within 24 hours of harvesting. Fruit harvested in the morning are usually processed on the same day, while fruit harvested in the evening are processed the following morning.

Both oriental melon and rockmelon fruit undergo the same processing procedures of cleaning, sorting, grading, and packing. However, the order of the procedures varies between the 2 types of melon. For example, oriental melon fruit are cleaned before the first sorting, whereas rockmelon fruit are cleaned after the first sorting.

Cleaning

Oriental melon: washing and drying

Oriental melons are submerged in a tank filled with water where the first wash is performed. During this first stage of washing oriental melons are guided by packing house employees towards a conveyor belt at one end of the tank (Figure 2.14.a). Once the oriental melons reach the conveyor belt, they are moved to the second washing stage. This stage may be performed as a rapid water stream in a separate water tank (Figure 2.14.b) or using pressurised water nozzles that spray water over the melons as they pass through the conveyor belt (Figure 2.14.c). After the second washing, oriental melons are dried by a hot air dryer for 20–30 seconds as they pass through a conveyor belt towards the sorting area (Figure 2.14.d).

Figure 2.14 Oriental melon washing and drying within the packhouse

a: First washing step with immersion bath. **b:** Second washing step with high-speed water jets in dump tank. **c:** Alternative second washing step with high-pressure water spray on conveyor belt. **d:** Hot air drying and movement to grading via conveyor belt. Source: APQA (2021)

Rockmelon: high pressure air cleaning

Instead of being washed with water in a tank, rockmelons are placed onto a conveyor belt where packing house workers use pressurised air guns to clean the fruit surface (Figure 2.15).

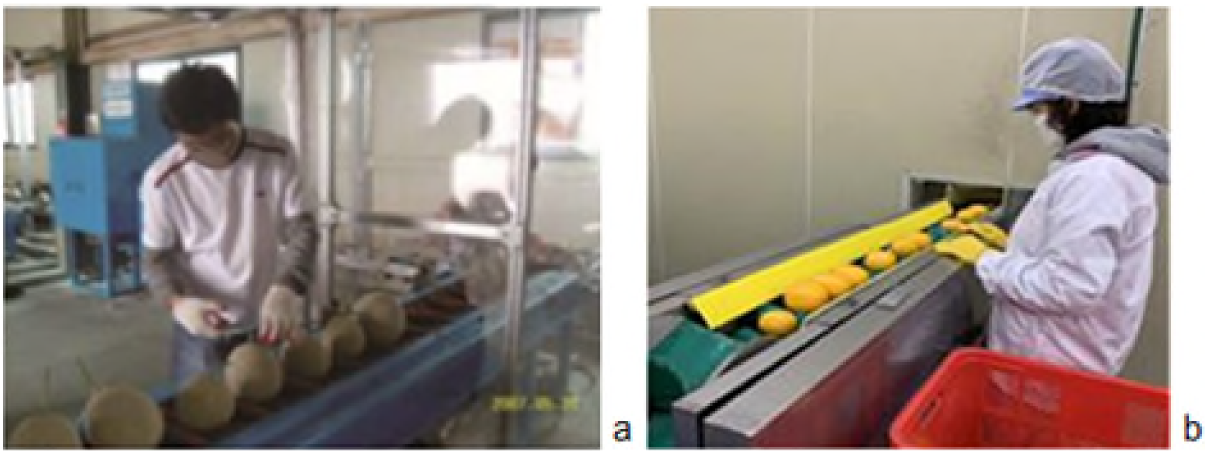
Figure 2.15 Cleaning the surface of rockmelon fruit using pressurised air guns

Note: fruit shown are for sale on the Korean domestic market. Unlike export fruit, these fruit have had foam netting applied before cleaning with pressurised air guns, and retain a large amount of peduncle. Source: APQA (2021)

Sorting and quality inspection

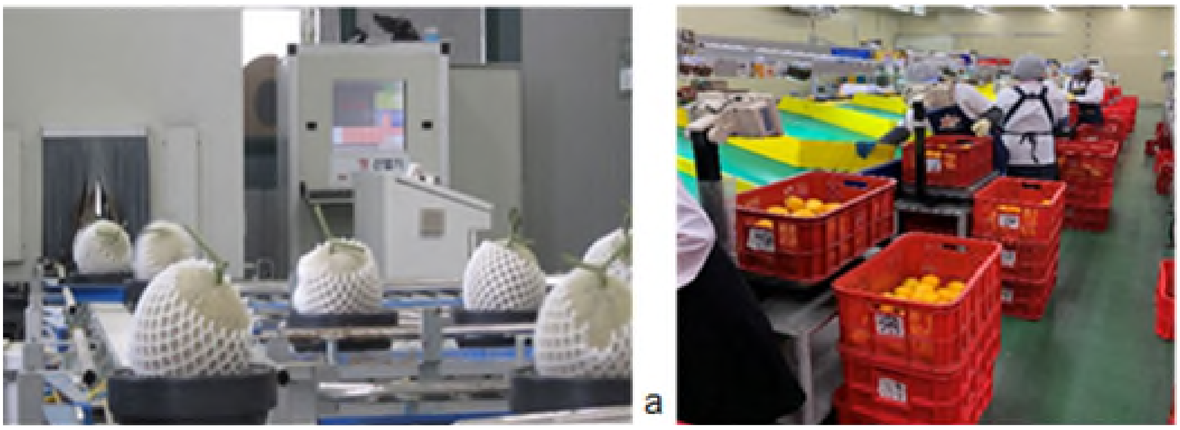
Fruit undergo 2 sorting stages. The first sorting stage involves packing house workers quality-inspecting the fruit to remove any fruit that are misshapen, discoloured, damaged or show disease symptoms (Figure 2.16). The second sorting stage also incorporates a grading stage. During this process fruit are quality inspected further by packing house employees, then graded by machines, using a non-destructive method, according to weight and brix (Figure 2.17).

Figure 2.16 First sorting stage to remove damaged or irregular shaped fruit



a: Packing house worker checking rockmelon fruit for irregularity or damage. **b:** Packing house worker checking oriental melon fruit for irregularity or damage. Source: APQA (2021)

Figure 2.17 Second sorting stage using a non-destructive sorting and grading method



a b

a: Rockmelons on conveyor belt entering automated grading machine. **b:** Oriental melons being sorted and graded by packing house workers and automated grading machines. Source: APQA (2021)

Packing and storage

Oriental melon and rockmelon fruit for export are packed into cardboard cartons. Further quality checks are conducted and the peduncle and any stem material is removed from the fruit before it is packed into the cardboard carton (Figure 2.18.a).

Oriental melon fruit are either packed directly into the cardboard carton or may be individually wrapped in plastic (Figure 2.18.b), depending on exporting market preference. Rockmelon fruit may be packed directly into cardboard carton or may be individually wrapped in foam netting. In the case of rockmelons for export, the netting is applied after the fruit has been cleaned with pressurised air guns. Traceability information is attached to the carboard cartons once packaging is complete.

Figure 2.18 Packing of oriental melon and rockmelon fruit

a b

a: Packing house worker conducting a final inspection of melon fruit before packaging and removal of peduncle material. **b**: An oriental melon in individual plastic packaging. Source: APQA (2021)

Packed melons are palletised and placed in cool rooms, under controlled conditions (Figure 2.19). Oriental melons are stored at 4.5°C to 10°C and at an average relative humidity of 90–95%. Rockmelons are stored at 10°C and at an average relative humidity of 85–90%.

Figure 2.19 Palletised melons stored in a controlled environment

a: Packed and palletised oriental melons. **b:** Packed and palletised rockmelons. Source: APQA (2021)

2.6.2 Phytosanitary inspection

Prior to export, randomly selected samples from each consignment are inspected at the packing house by APQA-approved personnel, as described in section 4.2.6. If the consignment is found to be free of pests and meets the requirements of the importing country, it is issued with a phytosanitary certificate.

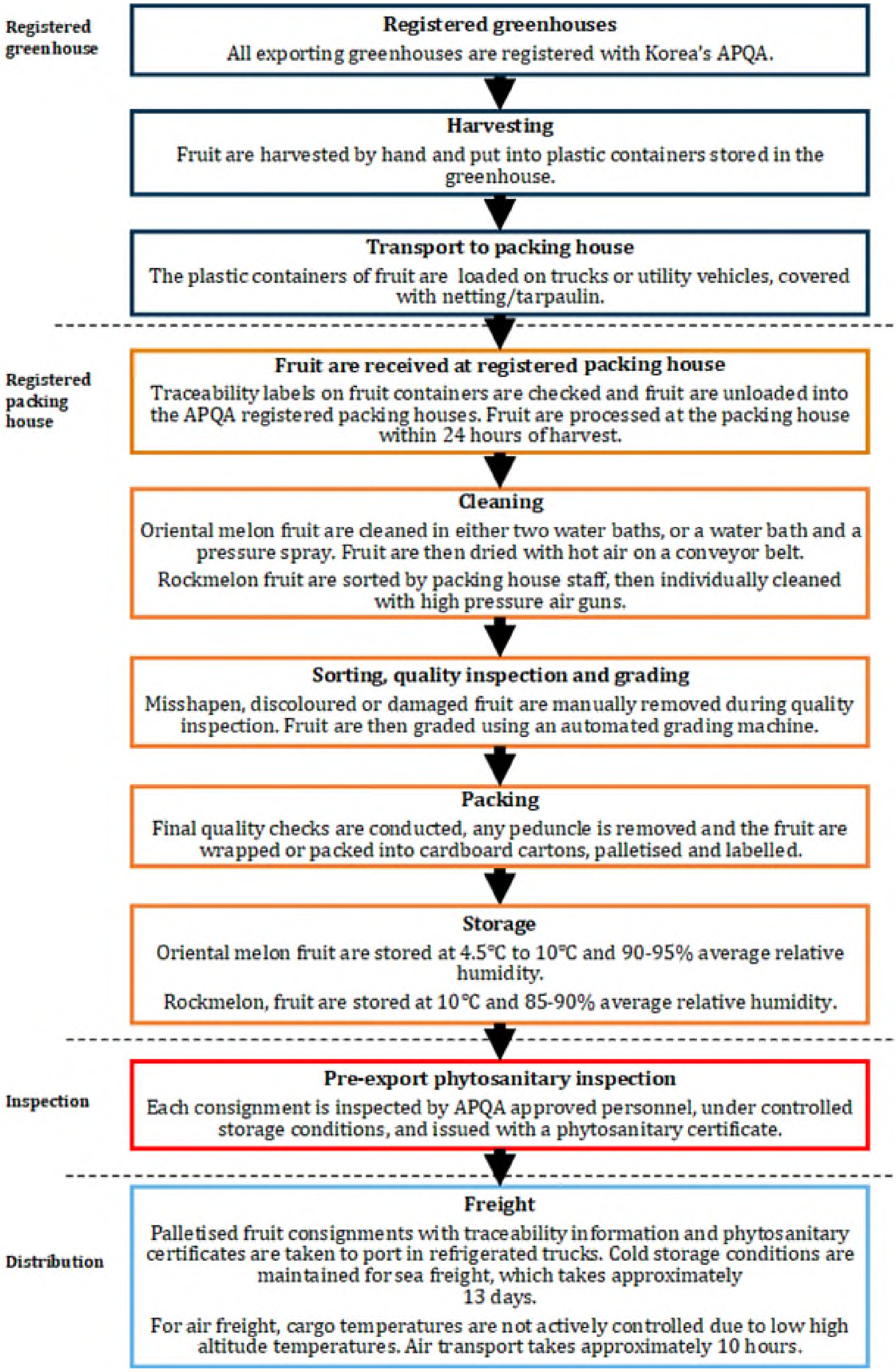
2.6.3 Transport

Consignments issued with a phytosanitary certificate are wrapped in plastic to prevent contamination post-inspection and are kept under controlled conditions at the packing house until they are exported. The truck loading area of a packing house is physically separated from the rest of the facility and refrigerated trucks are used to transport consignments to the port under controlled conditions. Temperatures are measured and recorded before loading, during loading and during transit.

The majority of greenhouse-grown oriental melons and rockmelons are likely to be exported by sea freight, although some may be exported by air freight. Sea freight to Australia takes approximately 13 days, where fruit are kept refrigerated. Air freight to Australia takes approximately 10 hours, and no temperature controls are in place since temperatures in the aircraft cargo hold are naturally low.

A summary of the operational steps for oriental melon and rockmelon fruit grown in Korea is provided in Figure 2.20.

Figure 2.20 Summary of operational steps for oriental melon and rockmelon fruit grown in Korea for export



2.7 Export capability

2.7.1 Production statistics

Total production of greenhouse-grown oriental melon and rockmelon fruit in Korea remained relatively steady between 2013 and 2019, with an average yield per annum of 141,106 tonnes for oriental melon and 40,132 tonnes for rockmelon. Total planted area and production for oriental melon is shown in Table 2.5 and rockmelon in Table 2.6.

Table 2.5 Greenhouse-grown oriental melon production in Korea (2013 to 2019)

Year	Total planted area (hectares)	Total production (tonnes)
2019	3,488	147,040
2018	3,469	127,424
2017	3,454	163,983
2016	4,872	158,828
2015	5,305	158,528
2014	5,358	155,397
2013	5,380	174,097

Source: KOSIS (2023)

Table 2.6 Greenhouse-grown rockmelon production in Korea (2013 to 2019)

Year	Total planted area (hectares)	Total production (tonnes)
2019	1,486	39,551
2018	1,437	35,236
2017	1,456	34,622
2016	1,498	36,937
2015	1,550	41,583
2014	1,486	44,790
2013	1,477	48,256

Source: KOSIS (2023)

Many provinces in Korea produce greenhouse-grown oriental melon and rockmelon fruit commercially, with the largest volumes produced in the provinces of Gyeongsangbuk-do and Daegu, accounting for 98% of total production in 2018 and 97% of total production in 2017. In major growing areas in Korea, peak production for oriental melon fruit occurs from March to June, with the potential to be extended into August. Rockmelon fruit is produced all year round, with variation in planting date. Peak harvest occurs in August and September, coinciding with a traditional festive season in Korea. However, oriental melon and rockmelon fruit grown in Korea for export to Australia will only be sourced during the export season defined in section 2.7.3.

2.7.2 Export statistics

Korea is a relatively small exporter of melons globally. In 2019, Korea exported around 1,113 tonnes of melons to overseas markets, including Taiwan, Hong Kong, Japan, Singapore, Vietnam, Malaysia, minor outlying islands of the United States of America (Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Atoll, Palmyra Atoll, and Wake Island) and Russia (KOSIS 2023). This accounted for just 3.7% of Korea's total greenhouse-grown melon production. A breakdown of Korea's melon export markets and the volumes exported in 2015 to 2019 is provided in Table 2.7.

Korea has indicated they anticipate exporting approximately 100 tonnes of fresh oriental melon and rockmelon fruit to Australia per year. The majority of exports are expected to be oriental melon fruit.

Table 2.7 Export volumes of greenhouse-grown melons from Korea by destination market

Export market	Export volume per year (tonnes)				
	2015	2016	2017	2018	2019
Taiwan	631.5	501.1	293.5	521.4	151.6
Hong Kong	429.6	488.4	365.6	480.0	507.1
Japan	379.7	350.0	22.6	252.4	287.3
Singapore	85.6	138.3	92.8	188.0	146.3
Vietnam	19.6	1.5	9.3	61.3	0.4
Malaysia	31.7	17.5	32.0	47.8	19.2
United States of America (Minor outlying islands)	1.6	0.0	4.1	1.7	0.1
Russia	0.0	4.1	0.0	0.5	1.9
Total	**1579.3**	**1500.9**	**996.9**	**1553.1**	**1113.9**

Source: KOSIS (2023)

2.7.3 Export season

While oriental melon and rockmelon can be produced year-round, Korea has proposed that exports to Australia would only occur from December to May. This proposal is to mitigate the risk of presence of the pumpkin fruit fly (*Zeugodacus depressus*), which was identified in the preliminary assessment stage as being a pest of biosecurity concern to Australia.

3 Pest risk assessments for quarantine pests

3.1 Summary of outcomes of pest initiation and categorisation

The initiation process (Appendix B) identified 174 pests as being associated with oriental melon and rockmelon in Korea.

Of these 174 pests, the pest categorisation process (Appendix B) identified:

- 136 pests as already present in Australia and not under official control, and therefore not requiring further assessment, and
- 28 pests as not having potential to enter on the commercially produced oriental melon and rockmelon fruit from Korea pathway, and therefore not requiring further assessment.

The remaining 10 pests were assessed as having potential to establish, spread and cause consequences in Australia, and therefore as requiring further pest risk assessment.

In applying the thrips Group PRA, 3 quarantine pests for the thrips group were identified on the import pathway and listed in the pest categorisation (Appendix B). However, if any other quarantine thrips or regulated articles not included in this risk analysis and/or in the thrips Group PRA are detected at pre-export or on arrival in Australia, the Group policy will also apply to those thrips species. The application of the Group PRAs to this risk analysis is outlined in Appendix A in section A2.7.

3.2 Pests requiring further pest risk assessment

The 10 pests, potentially associated with commercially produced oriental melon and rockmelon fruit for export from Korea, identified as requiring further pest risk assessment are listed in Table 3.1.

- All of the 10 species are quarantine pests, with 3 being regional quarantine pests as, whilst they have been recorded in some regions of Australia, interstate quarantine regulations are in place and enforced.
- 3 of the 10 quarantine pests are also regulated articles for Australia as they can vector emerging quarantine orthotospoviruses

Table 3.1 Quarantine pests and regulated articles potentially associated with oriental melon and rockmelon fruit from Korea, and requiring further pest risk assessment

Pest/pest group	Scientific name	Common name	Policy status/region
Fruit flies [Diptera: Tephritidae]	*Zeugodacus depressus*	Pumpkin fruit fly	
Thrips [Thysanoptera: Thripidae]	*Frankliniella intonsa* **a**	Eurasian flower thrips	GP
	Frankliniella occidentalis **a**	Western flower thrips	GP, NT
	Thrips palmi **a**	Melon thrips	GP, SA, WA
Spider mites [Trombidiformes: Tetranychidae]	*Tetranychus kanzawai*	Kanzawa spider mite	EP, WA
Late blight [Peronosporales: Peronosporaceae]	*Phytophthora melonis*	Late blight of foot rot	

Pest/pest group	Scientific name	Common name	Policy status/region
Tobamoviruses [Virgaviridae: Tobamovirus]	*Cucumber fruit mottle mosaic virus*	CFMMV	EP
	Cucumber green mottle mosaic virus	CGMMV	EP
	Kyuri green mottle mosaic virus	KGMMV	EP
Gammacarmoviruses [Procedovirinae: Gammacarmovirus]	*Melon necrotic spot virus*	MNSV	EP

a: Thrips species that is also identified as a regulated article for Australia as it vectors emerging quarantine orthotospoviruses. **EP:** Species has been assessed previously and import policy already exists. **GP:** Species has been assessed previously in a Group PRA, and the Group PRA has been applied. **NT**: Regional quarantine pest for the Northern Territory. **SA**: Regional quarantine pest for South Australia. **WA**: Regional quarantine pest for Western Australia.

3.3 Overview of pest risk assessment

This chapter assesses, for each of the pests, or pest groups identified in Table 3.1, the likelihoods of entry, establishment and spread, and the magnitude of the associated potential consequences these species may cause if they were to enter, establish and spread in Australia.

All of the pest groups, and most of the 10 identified quarantine pests in Table 3.1 have been assessed previously by the department. Where appropriate, the outcomes of the previous assessments for these pests have been adopted for this risk analysis, unless new information is available that suggests the risk would be different. The acronym 'EP' is used to identify species assessed previously and for which import policy already exists. The adoption of outcomes from previous assessments is outlined in Appendix A in section A2.6.

The biosecurity risk posed by thrips and the orthotospoviruses they transmit was previously assessed for all countries in the thrips Group PRA (DAWR 2017a), which has been applied to this assessment of oriental melon and rockmelon fruit from Korea.

The acronym 'GP' is used to identify species assessed previously in a Group PRA and for which a Group PRA was applied. The application of the Group PRAs to this risk analysis is outlined in Appendix A in section A2.7. A summary of assessment from the Group PRA is presented for the relevant pests and/or regulated thrips in this chapter for convenience.

A summary of the likelihood, consequence and URE ratings obtained in each pest risk assessment is provided in Table 3.5. An overview of the decision process at the initiation, pest categorisation and pest risk assessment stages of this PRA is presented diagrammatically in Figure 3.2.

3.4 Pumpkin fruit fly

Zeugodacus depressus

The pumpkin fruit fly (*Zeugodacus depressus;* synonym: *Bactrocera depressa*) belongs to the family Tephritidae. Some species of Tephritidae, also known as true fruit flies, are considered among the most damaging pests to horticulture globally (White & Elson-Harris 1992).

This species was previously known as *Bactrocera* (*Zeugodacus*) *depressa* until *Zeugodacus* was elevated to genus level by Virgilio et al. (2015). While this fruit fly has also been listed as *Bactrocera depressa, Dacus depressus*, *Paradacus depressus* and *Zeugodacus depressus* in published literature, this assessment uses the currently accepted name of *Zeugodacus depressus* as per Doorenweerd et al. (2018) and Plant Health Australia (2023).

Zeugodacus depressus has been identified as an agricultural pest of economic importance distributed in Korea, China, Japan and Taiwan (Han, Choi & Ro 2017; Jeong et al. 2017; Mun et al. 2000). Larvae of *Z. depressus* are internal fruit pests of various plants in the family Cucurbitaceae. The main host plants for *Z. depressus* are Chinese cucumber or 'snakegourd' (*Trichosanthes kirilowii*) and pumpkin (*Cucurbita moschata*), where it can cause serious economic damage (Han, Choi & Ro 2017; Mun, Bohonak & Roderick 2003). Potential hosts that are attacked less often include melon (*Cucumis melo*), squash (*Cucurbita pepo*), watermelon (*Citrullus lanatus*), gourd (*Lagenaria siceraria*), African horned cucumber (*Cucumis metuliferus*), cucumber (*Cucumis sativus*), luffa (*Luffa aegyptiaca*) and other varieties of wild gourds (*Trichosanthes multiloba*) (Han, Choi & Ro 2017; Mun et al. 2000). Tomato (*Solanum lycopersicum*) was confirmed as a secondary host in Korea with occasional infestations in the Jeollabuk-do region (Han et al. 1994).

Zeugodacus depressus has 4 life stages: egg, larva, pupa and adult, with the larval stage having 3 instars. Adult flies are predominantly black with yellow markings, and are comparatively large for tephritid flies (Han, Choi & Ro 2017). Adult flies oviposit eggs into the skin of the host fruit, and hatched larvae feed within the fruit before leaving to pupate in the soil under the host plant (Han, Choi & Ro 2017; Han et al. 1994; Kang et al. 2008). Larvae infesting melons generally leave the fruit to pupate when the infested fruit drops from the vine or, if the melon does not drop due to feeding damage, when the fruit begins to rot (Takamatsu 1952).

Zeugodacus depressus is a univoltine species within its distributed range, meaning there is only one generation produced per year (Han, Choi & Ro 2017). *Zeugodacus depressus* adults have been observed as early as mid-May throughout South Korea (Han, Choi & Ro 2017; Han et al. 1994; Kang et al. 2008). However, actual infestations of cucurbit hosts occur only between July and September after a two-month pre-oviposition period before the adults reach sexual maturity (Han, Choi & Ro 2017; Kang et al. 2008). During the pre-oviposition period, both sexes can be found on foliage of non-host trees such as *Quercus* spp. (Common oak) (Han, Choi & Ro 2017; Han et al. 1994; Kang et al. 2008). In the laboratory, *Z. depressus* adults reached sexual maturity about 40 days after emergence from pupation, after which they could show courtship behaviour and copulate (Kim & Jeon 2008).

Adults and pupae are unlikely to be imported with *Cucumis melo* fruit as pupation occurs in the soil, while adults are only occasionally associated with the surface of the fruit and fly away if disturbed.

The risk scenario of biosecurity concern is that *Z. depressus* eggs or larvae may be present within oriental melon or rockmelon fruit imported from Korea.

Several species in the family Tephritidae have previously been assessed by the department and import policies for tephritid fruit flies already exist. However, the species *Z. depressus* has not previously been assessed by the department. The biology and host range of *Z. depressus* are sufficiently different from previously assessed species to warrant a pest risk assessment specific for this species.

3.4.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that *Z. depressus* will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Moderate**.

The likelihood of importation is assessed as Moderate because, while oriental melon and rockmelon are not preferred hosts for *Z. depressus*, this fruit fly is occasionally known to infest these fruits in Korea, causing mild damage when it does. *Zeugodacus depressus* produces one generation per year and infestation of hosts is limited to a short period between July and September. Commercially produced oriental melon fruit is grown almost exclusively during months when *Z. depressus* does not infest fruit, but rockmelon is grown year-round and would be available for infestation when this fly is active. It is possible that early stages of infestation may not show visible symptoms and immature life stages could survive the low temperatures during storage and transport if they are exported to Australia during months when infestation of fruit occurs.

The following information provides supporting evidence for this assessment.

Zeugodacus depressus is present in melon growing areas of Korea.

- *Zeugodacus depressus* has been collected from multiple locations across Korea (Han, Choi & Ro 2017; Han et al. 1994), including regions where melons are grown (KOSIS 2023).
- A nation-wide survey of Korea found that damage to host fruit by *Z. depressus* was most prevalent in regions at 300–399 metre altitude, but some flies were collected from regions at altitudes as low as 200 metres and as high as 850 metres (Han et al. 1994).

Zeugodacus depressus may attack melons grown in Korea, though they are not a preferred host.

- *Zeugodacus depressus* is an internal fruit pest of 9 hosts in the Cucurbitaceae and Solanaceae plant families (Plant Health Australia 2023), and causes serious economic damage to pumpkins in Korea (Han, Choi & Ro 2017).
- *Zeugodacus depressus* is mostly associated with its wild host *Trichosanthes kirilowii* (Chinese cucumber or 'snakegourd') (Mun, Bohonak & Roderick 2003) and pumpkin (*Cucurbita moschata*) (Han, Choi & Ro 2017). However, there are records of *Z. depressus* also occasionally attacking melon (*Cucumis melo*), squash (*Cucurbita pepo*), watermelon (*Citrullus lanatus*), gourd (*Lagenaria siceraria*), African horned cucumber (*Cucumis metuliferus*), cucumber (*Cucumis sativus*), luffa (*Luffa aegyptiaca*) and tomato (*Solanum lycopersicum*) (Han, Choi & Ro 2017).

- During a nationwide survey of Korea from 1991 to 1992, it was found that *Z. depressus* only causes a mild degree of damage (< 10%) in *Cucumis melo* production areas (Han et al. 1994).

Zeugodacus depressus only infests fruit at certain times of the year.

- *Zeugodacus depressus* produces one generation a year in Korea and adults begin emerging from overwintering pupae in mid-May (Han, Choi & Ro 2017; Kang et al. 2008).
  - However, it takes time for the flies to reach sexual maturity and infestation of cucurbit hosts occurs between July and September (Kang et al. 2008).
- Oriental melons planted in Korean greenhouses produce fruit in January to March and harvest occurs 35–45 days after fruit set (APQA 2021) (March to early May). Oriental melon fruit are not available when sexually mature flies are active.
- Rockmelon can be produced in greenhouses in Korea year-round (APQA 2021). Rockmelon produced during warmer periods may therefore be available when sexually mature flies are active.

Zeugodacus depressus eggs are laid inside fruit and larvae feed internally.

- Adult female *Z. depressus* lay eggs into the host fruit, and the larvae develop and feed within the pulp of the host (Han, Choi & Ro 2017; Jeon 2008; Kang et al. 2008).
- Females lay their eggs 4–7 mm deep in the skin of the host (Takamatsu 1952).

Feeding damage on infested melons may not be immediately obvious and infested fruit may remain undetected during harvest and post-harvest procedures.

- Ripe pumpkins have been observed to heal over oviposition wounds from *Z. depressus*, making them difficult to detect (Kang et al. 2008). It is possible that melons will heal in a similar fashion.
  - Similarly, puncture wounds caused by another tephritid species, *Ceratitis capitata*, are not readily visible when eggs are laid into non-citrus fruit hosts (Avidov & Harpaz 1969; Talhouk 1969).
- Directly after hatching, *Z. depressus* larvae are small, and may not be detected by farmers (Kang et al. 2008) or during post-harvest procedures.
- Mun, Bohonak and Roderick (2003) reported that *Z. depressus* has previously been intercepted in crops exported from Korea to Japan, but did not state which commodities these interceptions were on.
- Secondary damage to fruit infested by *Z. depressus* develops over time due to larval feeding, and decay of the fruit, making the infestation more detectable (Kang et al. 2008).

Zeugodacus depressus larvae may be able to survive transport to Australia.

- Larvae feed within the fruit and get adequate nutrition from their host fruit until they emerge to pupate, even if the fruit is removed from the vine (Kang et al. 2008).
- Most melons will be transported to Australia via sea freight, which takes approximately 13 days (APQA 2021).
- Eggs hatch around 10 days after being laid into fruit, and larvae remain within the fruit for a further month (Han et al. 1994).
  - These periods become longer at lower temperatures as egg and larval development slows down (Jeon 2008).

- Oriental melons are stored at 4.5°C to 10°C, and rockmelons are stored at 10°C (APQA 2021).
- While the mortality of *Z. depressus* eggs and larvae increases as temperatures fall below 20°C (Jeon 2008), it is unlikely that the temperatures melons are stored and transported at will lead to 100% mortality.
  - This mortality effect is decreased in second instar larvae, and decreased again in third instar larvae (Jeon 2008). This means that older larvae may survive cold storage, while eggs and younger larvae are less likely to survive.

For the reasons outlined, the likelihood that *Z. depressus* will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Moderate.

Likelihood of distribution

The likelihood that *Z. depressus* will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as: **Moderate**.

The likelihood of distribution is assessed as Moderate because, if *Z. depressus* larvae are imported into Australia in infested melon fruit, there is the potential for them to successfully pupate into adults. The ability of adults to fly, combined with their behaviour of moving between different environments to locate resources, increases the likelihood they will disperse to a suitable host. However, this species has a relatively narrow host range compared to other pest fruit flies, which may reduce the likelihood of this species finding a suitable host compared to highly polyphagous fruit fly species.

The following information provides supporting evidence for this assessment.

Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Infested melon fruit showing signs of infestation are likely to be removed from distribution, but infested fruit without obvious signs could be distributed and sold.

- It is expected that fresh oriental melons and rockmelons from Korea will likely be distributed for retail sale in many areas of the country. The major population centres are likely to receive the majority of the imported melons.
- The intended end use for imported fresh oriental melons and rockmelons is human consumption. Fresh melons without obvious signs of infestation could potentially be distributed via the wholesale and retail trade pathway.
- Feeding by larvae leads to obvious fruit damage and eventual rotting of the fruit (Kang et al. 2008).
- The development of eggs and larvae slows down at low temperatures (Jeon 2008), which could delay fruit showing damage.
  - However, once in retail stores fruit are likely to be kept at room temperature, allowing the rate of development to increase in speed.
- Damaged fruit will likely be discarded into managed waste systems.
  - Mortality of *Z. depressus* eggs and larvae reaches nearly 100% in temperatures above 33°C (Jeon 2008), which are likely to be reached in managed waste systems.

- Fruit that is purchased by consumers before showing damage may be discarded in urban, rural and natural locations, or in domestic compost.

Larvae from fruit discarded in suitable environments may be able to pupate.

- *Zeugodacus depressus* usually pupates in the soil (Han, Choi & Ro 2017; Kang et al. 2008), so fruit discarded near soil may allow larvae to begin pupation.
  - Pupation is also possible without soil, but the pupae are less likely to survive.
- *Zeugodacus depressus* infest fruit during summer and then pupate over winter before developing into adults in the spring (Kang et al. 2008). If any melons potentially infested with *Z. depressus* during Korean summer (June to August) were to be imported into Australia, they would arrive during late winter or spring in Australia, which would be conducive to adult development.
- *Zeugodacus depressus* pupae are able to develop into adults at temperatures ranging from 15°C to 30°C (Kang et al. 2008), which are available in many parts of Australia in spring and summer (Bureau of Meteorology 2023).
- Pupae that form in unsuitable environments, such as areas that are too dry, are unlikely to successfully develop into adults (Jeon 2008).

Zeugodacus depressus can attack and develop in several cultivated fruit species, and some wild species.

- The main commercial host of *Z. depressus* is pumpkin, though watermelon, cucumber, various melons and tomato can also be attacked on occasion (Han, Choi & Ro 2017; Han et al. 1994).
- Production of these host crops occurs in some parts of all mainland states and territories of Australia (Horticulture Innovation Australia 2022a, b).
- *Zeugodacus depressus* is also recorded attacking wild gourds in Korea and Japan (Han, Choi & Ro 2017) and therefore may be able to attack some wild cucurbitaceous species present in Australia.

Adult *Z. depressus* are capable of flying short distances to find mates and hosts.

- In Korea newly emerged *Z. depressus* adults fly to adjacent weedy or forested areas and stay there for up to 2 months before returning to fields to lay eggs into host fruit (Han et al. 1994; Jeon 2008; Seo et al. 2008).
- Female *Z. depressus* are largely attracted towards mates and potential host fruit by smell (Jeon 2008).
- Adults that emerge near suitable host fruit would likely be able to access and infest it once they are sexually mature.

For the reasons outlined, the likelihood that *Z. depressus* will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as Moderate.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules in Table A.2.

The likelihood that *Z. depressus* will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea and be distributed in a viable state to a susceptible part of a host is assessed as: **Low**.

3.4.2 Likelihood of establishment

The likelihood that *Z. depressus* will establish within Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The likelihood of establishment is assessed as Moderate because, while many places in Australia have environments that are unsuitable for the survival of *Z. depressus*, there are some areas where this species could establish, particularly in places where host plants are grown. Existing practices to detect and control fruit fly pests in Australia may not be immediately effective against *Z. depressus*.

The following information provides supporting evidence for this assessment.

Host species of *Z. depressus* are available in Australia.

- Host plants of *Z. depressus* are limited to a small number of wild and cultivated species within the Cucurbitaceae and Solanaceae families (Han, Choi & Ro 2017; Plant Health Australia 2023).
- Cucurbitaceae and Solanaceae species are widely grown commercially in rural area as well as non-commercially in peri-urban areas (ALA 2023). Some of these species are known hosts of *Z. depressus* (Han, Choi & Ro 2017; Plant Health Australia 2023).
- There are some native species of *Cucumis* in Australia (Telford et al. 2011), though it is unknown if these would be suitable hosts for *Z. depressus*.

Parts of Australia's natural environment are unsuitable for the development or survival of *Zeugodacus depressus*.

- Mortality of *Z. depressus* eggs and larvae reaches nearly 100% in temperatures above 33°C (Jeon 2008). During summer, many regions in Australia experience maximum temperatures above 30°C for multiple consecutive days (Bureau of Meteorology 2023).
- In laboratory conditions, *Z. depressus* develops best at humidity values of 65% and pupae are unable to develop into adults if there is not enough moisture in the soil (Jeon 2008).
  - Many parts of Australia have a relatively low humidity when compared to the native range of *Z. depressus* (Bureau of Meteorology 2023; KMA 2011).

Some areas in Australia, particularly gardens and production areas could support the development of *Z. depressus*.

- Most life stages of *Z. depressus* are capable of developing between temperatures of 15°C and 30°C (Jeon 2008; Kang et al. 2008) and pupae have a lower development threshold calculated at 6.8°C (Kang et al. 2008). Temperatures within these ranges are available in parts of Australia (Bureau of Meteorology 2023).
- *Zeugodacus depressus* overwinter as pupae (Han, Choi & Ro 2017; Kang et al. 2008). In the regions of Korea where *Z. depressus* is found winter temperatures can fall to –10°C (Climate-data.org 2023). Winter temperatures are unlikely to fall below this temperature in parts of Australia where potential hosts are grown.

- Irrigated farms and home gardens could provide suitable humidity for the survival of *Z. depressus*.
- *Zeugodacus depressus* is recorded from mountainous regions in its native range, mostly at altitudes above 200 metres (Han et al. 1994). However, there is insufficient information to determine if this species would be unable to survive at lower altitudes with suitable climates if it were introduced into Australia.

Existing pest control practices may be insufficient to prevent this species from establishing.

- Australia maintains a network of parapheromone lure traps to detect and delimit the presence of some fruit fly species. However, *Z. depressus* is not known to respond to any known parapheromone lures (Plant Health Australia 2023) and will not be detected by this surveillance network.
- Traditional control of fruit fly pests in Australia tends to rely on parapheromone lures to trap and kill male flies more than the use of broad-scale insecticides (Stovold et al. 2002; Zamek et al. 2012). As *Z. depressus* is non-responsive to known parapheromone lures, these methods are not expected to be as effective at controlling this species.
- However, there is some existing use of protein baiting and cover sprays in Australia which would be effective against *Z. depressus*, and new traps are being developed for traditionally non-lure responsive fruit fly species including for species in the genus *Zeugodacus*.
- Eggs are laid into fruit and the larvae develop entirely within the host (Han, Choi & Ro 2017; Jeon 2008; Kang et al. 2008).
  - Infestation of fruit may not be immediately obvious and may be overlooked, especially in non-commercial or home gardens.
  - If an adult female successfully lays eggs into fruit, the eggs and larvae will be unaffected by control practices that do not remove the fruit.

For the reasons outlined, the likelihood that *Z. depressus* will establish within Australia is assessed as Moderate.

3.4.3 Likelihood of spread

The likelihood that *Z. depressus* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as: **Moderate**.

The likelihood of spread is assessed as Moderate because hosts for *Z. depressus* are available in many parts of Australia, though the host range is limited in comparison to other fruit fly species. While adults are unlikely to travel long distances naturally, larvae in infested fruit could be carried across the country by travellers.

The following information provides supporting evidence for this assessment.

Host species for *Z. depressus* are grown commercially in Australia and potential hosts are present in the wild.

- Cucurbitaceae and Solanaceae species known to be hosts of *Z. depressus* are grown in parts of every mainland state of Australia (ALA 2023; Horticulture Innovation Australia 2022a, b).
- However, the host range of *Z. depressus* is much narrower than most pest fruit fly species (Plant Health Australia 2023), limiting the areas where suitable hosts will be available.

- There are native Australian plant species that are related to known *Z. depressus* hosts (Telford et al. 2011), although the host status of these species have not been determined.

Natural spread of *Z. depressus* over long distances across Australia will be limited by natural barriers and the short distances these flies tend to travel in their lifetime.

- The large distances between major horticultural production areas in Australia are largely made up of arid regions with few potential hosts for any fruit fly (Dominiak & Daniels 2012), including *Z. depressus*. This would limit the natural spread of this species.
- Most tephritid fruit fly adults travel only a few hundred metres in their lifetime, with very few travelling more than 1.5 km from the point of emergence (Gilchrist & Meats 2012; MacFarlane et al. 1987; Meats & Smallridge 2007).
- While *Z. depressus* adults do fly from areas with hosts to wooded areas and back (Han et al. 1994; Jeon 2008; Seo et al. 2008), they are only reported to travel as far as locations adjacent to farms.

Fruit fly larvae could be carried long distances through the movement of infested fruit by travellers, though legislation exists in some states and territories to limit or prevent this from occurring.

- The transportation of fruit infested with *Z. depressus* larvae would aid in the spread of this species between areas with suitable environments for adults to survive in.
- Some Australian state governments have legislation in place to control the domestic movement of potential fruit fly hosts (DNRE Tasmania 2023; DPIRD 2023; PIRSA 2022).

For the reasons outlined, the likelihood that *Z. depressus* will spread within Australia is assessed as Moderate.

3.4.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the individual likelihoods of entry, establishment and spread using the matrix of rules in Table A.2.

The overall likelihood that *Z. depressus* will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as: **Low.**

3.4.5 Consequences

The potential consequences of the establishment of *Z. depressus* in Australia has been estimated according to the methods described in Figure A.1.

Based on the decision rules described in Table A.3, that is, where the potential consequences of a pest with respect to one or more criteria are 'E', the overall consequences are estimated to be **Moderate.**

Criterion	Estimate and rationale
Direct	
Plant life or health	E – Major significance at the District level *Zeugodacus depressus* has a narrow host range limited mostly to cucurbits (Plant Health Australia 2023). If this fly establishes in parts of Australia, the damage would be limited to these hosts grown in the affected area.

Criterion	Estimate and rationale
	Zeugodacus depressus has been recorded damaging up to 30% of pumpkin crops in Korean farms (Kang et al. 2008). Damage in less preferred hosts, such as melons, has only been observed at less than 10% (Han et al. 1994). There are 8 native Australian species of *Cucumis*, and some foreign species have become naturalised in parts of the country (Telford et al. 2011). However, it is unknown if any of these species would be suitable hosts for *Z. depressus*.
Other aspects of the environment	A – Indiscernible at the Local level There are no currently known direct consequences of *Z. depressus* on any other aspects of the natural environment.
Indirect	
Eradication, control	E –Significant at the Regional level Some of the hosts of *Z. depressus* are not preferred hosts for most other species of fruit fly already present in Australia. A control program would add considerably to the cost of production for pumpkins and melons in areas where fruit flies that attack these commodities have not previously been present. There are no parapheromone-based lures identified for *Z. depressus* (Plant Health Australia 2023). This means any trapping for this species would need to be food based, which is not fully effective when used alone and therefore would need to be employed as part of a system that includes other measures proven to be efficacious. As an exotic species of fruit fly, the preferred response to an incursion of *Z. depressus* would be complete eradication of the introduced population, not just control. Such a program would need to cover the entire distribution of any *Z. depressus* incursion and is likely to incur substantial costs. The eradication of a *Bactrocera papayae* (papaya fruit fly) incursion in 1995 cost almost $35 million for the eradication program alone (Cantrell, Chadwick & Cahill 2002). The limited host range and specific biology of *Z. depressus* may make eradication measures less costly for this species, though the lack of an effective parapheromone lure for this species could complicate eradication efforts.
Domestic trade	E – Major significance at the District level The presence of an exotic fruit fly species in a commercial production area will have a significant effect on domestic trade due to resulting interstate trade restrictions on potential host commodities produced in that area. Phytosanitary measures would likely be required to facilitate interstate movement of host commodities and therefore require industry adjustment at the district level.
International trade	E – Major significance at the District level Fruit flies are regarded as some of the most damaging horticultural pests in the world (Plant Health Australia 2023). The establishment of a new species of fruit fly in parts of Australia is likely to have an impact on trade of host commodities to countries where *Z. depressus* is not present. However, *Z. depressus* is already recorded in a number of major export markets (e.g., Asia). The presence of *Z. depressus* in production areas would limit access to some overseas markets and complicate market access negotiations. This may be especially relevant for this species as there are fewer accepted treatment options for *Z. depressus* than for other, more widespread, fruit fly species.
Non-commercial and environmental	A – Indiscernible at the Local level Although additional pesticide applications or other control activities may be required to control this species on susceptible crops, this increase is unlikely to substantially change the current impact of pesticides on the local environment.

3.4.6 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Zeugodacus depressus*	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The URE for *Z. depressus* on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Low**, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *Z. depressus* on this pathway.

3.5 Thrips

***Frankliniella intonsa* (GP), *Frankliniella occidentalis* (GP, NT) and *Thrips palmi* (GP, SA, WA)**

Three thrips species were identified on the oriental melon and rockmelon fruit from Korea pathway as quarantine pests and/or regulated articles for Australia: *Frankliniella intonsa, F. occidentalis* and *Thrips palmi* (Table 3.2).

Frankliniella occidentalis is not present in the Northern Territory and is assessed as a regional quarantine pest for that territory. *Thrips palmi* is not present in South Australia and is assessed as a regional quarantine pest for that state. *Thrips palmi* is present but not widely distributed in Western Australia, and is assessed as a regional quarantine pest for all areas of Western Australia outside the Ord River Irrigation Area (Shire of Wyndham-East Kimberley).

Frankliniella intonsa, F. occidentalis and *T. palmi* are also identified as regulated articles for Australia because they are capable of harbouring and spreading (vectoring) emerging orthotospoviruses that are quarantine pests for Australia, as detailed in the thrips Group PRA (DAWR 2017a). A regulated article is defined by the IPPC as '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 2022). For simplicity, thrips identified as a regulated article are also referred to as 'regulated thrips'.

The indicative likelihood of entry for all quarantine and regulated thrips is assessed as Moderate in the thrips Group PRA (DAWR 2017a). *Frankliniella intonsa, F. occidentalis* and *T. palmi* are reported from Korea and are associated with oriental melon and rockmelon fruit (APQA 2019; CABI 2023; Childers 1997; Kumar et al. 2014; Mainali & Lim 2010; Yeon et al. 2011). Standard packing house procedures and transportation are not expected to eliminate these thrips from the pathway. After assessment of relevant pathway-specific factors (sections A2.6 and A2.7) for oriental melon and rockmelon fruit from Korea, the likelihoods of entry of Moderate were verified as appropriate for these thrips species on this pathway (Table 3.2).

Table 3.2 Quarantine and regulated thrips species for oriental melon and rockmelon fruit from Korea

Pest	In thrips Group PRA	Quarantine pest	Regulated thrips	On oriental melon and rockmelon fruit pathway	Likelihood of entry
Frankliniella intonsa	Yes	Yes	Yes	Yes	Moderate
Frankliniella occidentalis	Yes	Yes (NT)	Yes	Yes	Moderate
Thrips palmi	Yes	Yes (SA, WA)	Yes	Yes	Moderate

NT: Regional quarantine pest for the Northern Territory. **SA:** Regional quarantine pest for South Australia. **WA:** Regional quarantine pest for Western Australia.

A summary of the risk assessment for quarantine thrips is presented in Table 3.3 for convenience.

Table 3.3 Risk estimates for quarantine thrips

Risk component	Rating for quarantine thrips
Likelihood of entry (importation x distribution)	Moderate (High x Moderate)

Likelihood of establishment	High
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	**Low**

As assessed in the thrips Group PRA, the indicative URE for thrips is Low (Table 3.3) which does not achieve the ALOP for Australia. This indicative URE is considered to be applicable for the quarantine thrips species present on the oriental melon and rockmelon fruit from Korea pathway. Therefore, specific risk management measures are required for the quarantine thrips on this pathway.

As the thrips species *F. intonsa, F. occidentalis* and *T. palmi* vector orthotospoviruses that are quarantine pests for Australia, a summary of the risk assessment for quarantine orthotospoviruses transmitted by thrips is presented in Table 3.4 for convenience.

Table 3.4 Risk estimates for emerging quarantine orthotospoviruses vectored by regulated thrips

Risk component	**Rating for emerging quarantine orthotospoviruses** (a)
Likelihood of entry (importation x distribution)	Low (Moderate x Moderate)
Likelihood of establishment	Moderate
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	**Low**

a: Risk estimates for orthotospoviruses adopted from the thrips Group PRA (DAWR 2017a).

As assessed in the thrips Group PRA, the URE for emerging quarantine orthotospoviruses transmitted by regulated thrips is Low (Table 3.4), which does not achieve the ALOP for Australia.

This URE is considered to be applicable for the emerging orthotospoviruses known to be vectored by the thrips species present on the oriental melon and rockmelon fruit from Korea pathway. Therefore, specific risk management measures are required for the regulated thrips to mitigate the risks posed by emerging quarantine orthotospoviruses in order to achieve the ALOP for Australia.

This risk assessment, which is based on the thrips Group PRA, applies to all phytophagous quarantine thrips and regulated thrips on the oriental melon and rockmelon fruit from Korea pathway, irrespective of their specific identification in this document. This is explained in section A2.7.

3.6 Kanzawa spider mite

Tetranychus kanzawai (EP, WA)

Tetranychus kanzawai (Kanzawa spider mite) belongs to the Tetranychidae or 'spider mite' family. It is an agricultural pest native to east Asia (CABI 2023; Ozawa et al. 2017). *Tetranychus kanzawai* is highly polyphagous, feeding on over 100 species of plants such as pear (*Pyrus* spp.), tea (*Camellia sinensis*), pawpaw (*Carica papaya*), strawberry (*Fragaria ananassa*), apple (*Malus* spp.), grapes (*Vitis* spp.) and melon (*Cucumis melo*) (CABI 2023).

Tetranychus kanzawai has been recorded in New South Wales and Queensland (Gutierrez & Schicha 1983; Seeman & Beard 2011), but it is not present in Western Australia and is a regional quarantine pest for that state.

Tetranychus kanzawai has been assessed previously in the existing policies for table grapes from Korea (Biosecurity Australia 2011b), table grapes from China (Biosecurity Australia 2011a), table grapes from Japan (Department of Agriculture 2014), table grapes from India (DAWR 2016b) and strawberries from Korea (DAWR 2017c). In those policies, the unrestricted risk estimate for *T. kanzawai* was assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *T. kanzawai* on those pathways.

However, there are differences in the fruit texture and structure, climatic conditions, pest prevalence and commercial production practices between the previously assessed commodity/country pathways, and oriental melon and rockmelon from Korea. These potential differences make it necessary to re-assess the likelihood that *T. kanzawai* will be imported into Australia on the oriental melon and rockmelon fruit from Korea pathway.

The assessment of *T. kanzawai* on the table grapes from China (Biosecurity Australia 2011a), table grapes from Korea (Biosecurity Australia 2011b), table grapes from Japan (Department of Agriculture 2014), table grapes from India (DAWR 2016b) and strawberries from Korea (DAWR 2017c) pathways rated the likelihood of distribution as Moderate. Oriental melon and rockmelon fruit from Korea are expected to be distributed in WA in a similar way to the previously assessed commodity/country pathways. Most fruit waste is disposed of via municipal waste facilities, but some may be discarded in the environment. Any *T. kanzawai* present on the waste may disperse to hosts in Australia if discarded in close proximity, as spider mites are mobile and can crawl short distances. *Tetranychus kanzawai* has a wide host range and host material is present all year round in WA, therefore, the time of year when importation occurs will not affect the likelihood of distribution for this pest. On this basis, the rating of Moderate for the previously assessed import pathways has been adopted for the oriental melon and rockmelon fruit from Korea pathway.

The likelihoods of establishment and spread of *T. kanzawai* in WA from the oriental melon and rockmelon fruit from Korea pathway have been assessed as similar to those of the previous assessments of High and Moderate, respectively for the table grapes from China pathway, which was adopted for subsequent import pathway assessments. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of the entry, establishment and spread of *T. kanzawai* in WA are also independent of the import pathway and have been assessed as similar to those previous risk assessments of Moderate. The existing ratings for the likelihoods of establishment and spread, and the rating for the overall consequences of *T. kanzawai* in previous assessments have been adopted for the oriental melon and rockmelon from Korea pathway.

In addition, the department has reviewed the latest literature—for example, Islam et al. (2017), Jin et al. (2018), Ozawa et al. (2017) and Sepahvandian et al. (2019). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for *T. kanzawai* in the existing policies.

The risk scenario of biosecurity concern is that *T. kanzawai* eggs, juveniles or adults may be present on the surface of oriental melon or rockmelon fruit imported from Korea.

3.6.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that *T. kanzawai* will arrive in WA in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Low**.

The likelihood of importation is assessed as Low because *T. kanzawai* is considered a pest of minor importance in melon production in Korea. While it is mainly associated with foliage, *T. kanzawai* may be present on melon fruit at harvest if infestation levels are high. Due to pest management practices implemented in Korea, high infestation is very unlikely to occur. Packing house processes are likely to reduce any infestation on the fruit even further. If *T. kanzawai* is present on packed fruit, it may survive cold storage and transport to Australia.

The following information provides supporting evidence for this assessment.

Tetranychus kanzawai is considered a pest of minor importance in melon production in Korea.

- *Tetranychus kanzawai* is widely distributed in Korea, including in the melon production areas of Gyeongsangbuk-do (Kawashima, Chung & Jung 2008).
- Although *T. kanzawai* is associated with melon production in Korea (Ehara 1999), it is considered a pest of minor importance (Goh, Kim & Kim 2003).

Tetranychus kanzawai may be present on melon fruit at harvest, but only if infestation levels are high. Pest management practices are likely to reduce infestation levels in greenhouses and any infestation on the fruit.

- *Tetranychus kanzawai* has 5 life stages: egg, larva, protonymph, deutonymph and adult (CABI 2023). It has a short lifecycle and goes through many generations in a year (Gotoh & Gomi 2000). Development time depends on temperature and is slower in cooler conditions. At temperatures from 30°C to 15°C, egg development takes 2–15 days, and juveniles take 3.5–19.5 days to develop to adulthood (Vacante 2016). Therefore, all life stages have the potential to be present on melon fruit at harvest.
- *Tetranychus kanzawai* is found primarily on the leaves of host plants, where it feeds and lays eggs (Vacante 2016). Some other *Tetranychus* species are known to infest fruit when populations are high (Seeman & Beard 2005). However, no literature was found to suggest *T. kanzawai* had any association with melon fruit.

- High infestation levels of *T. kanzawai* lead to noticeable damage to the plant as well as silk webbing on the infested areas, which may contain eggs (Jeppson, Keifer & Baker 1975; Kennedy & Smitley 1985; Zhang 2008).
- Standard commercial pest management practices, such as surveillance and monitoring programs with sticky traps and preventative sprays used in Korea, are likely to reduce infestation levels.
- Low populations of *T. kanzawai* due to pest management practices implemented in Korea means that it is unlikely that the pest will be present on the fruit.
- Spider mites are very small, with adult females measuring 0.3–0.5mm in length and adult males, juveniles and eggs being even smaller (Zhang 2008), making detection difficult if present on the fruit.

Packing house processes in Korea and melon fruit morphology significantly reduce the risk of *T. kanzawai* being associated with the fruit. Therefore, the risk of *T. kanzawai* being associated with export quality fruit is very unlikely.

- Oriental melon fruit undergo 2 washing stages in the packing house in Korea. One of these stages includes a high-pressure water wash. Rockmelons are cleaned with pressurised air gun to remove any dust and invertebrates that may be present. All fruit are then inspected prior to packing. If *T. kanzawai* life stages are present on the fruit at this time, the washing and inspection are likely to reduce any infestation.
- Due to the morphology of oriental melon and rockmelon fruit, and the absence of any prominent calyx material, *T. kanzawai* is considerably less likely to be concealed on melon fruit than on the previously assessed table grapes and strawberries.
- Melon fruit are picked and packed individually. Therefore, heavily infested fruit are very likely to be detected and removed during standard commercial grading and packing processes.

Tetranychus kanzawai may survive storage and transport to Australia.

- Transport of melon fruit to Australia would be either by air freight or by sea freight, and would result in fruit being in transit for a minimum of 1–3 days for air freight and a minimum of 13 days for sea freight.
- Transport and storage of melons take place under controlled conditions, with an average temperature of 4.5°C to 10°C and average relative humidity of 90–95% for oriental melons, and 10°C with an average relative humidity of 85–90% for rockmelons (APQA 2021). *Tetranychus kanzawai* has been found to survive temperatures of –5°C for 10 days (Yang, Cao & Chen 1991), suggesting it can survive cold storage and transport.
- *Tetranychus kanzawai* can enter diapause when under stress and can survive for long periods at low temperatures, and even develop a tolerance for low oxygen levels (Suzuki et al. 2015). These conditions may be experienced during air freight.
- Female spider mites and eggs may overwinter, and can survive sub-zero temperatures (Jeppson, Keifer & Baker 1975). This suggests that cold storage alone may not be sufficient to control spider mites, although it is likely to reduce mobility, feeding and reproduction.
- *Tetranychus* species are regularly intercepted alive on horticultural commodities at the Australian border (Brake, Crowe & Russell 2003).
- *Tetranychus* species have been intercepted numerous times on fruit from New Zealand (MAF Biosecurity New Zealand 2009). While the time in transit from Korea is likely to be

longer than from New Zealand, the interception data demonstrate that spider mites can survive in-transit cold storage.

For the reasons outlined, the likelihood that *T. kanzawai* will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Low.

Likelihood of distribution

The likelihood that *T. kanzawai* will be distributed within WA in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is likely to be similar to *T. kanzawai* on previously assessed commodity/country pathways. Therefore, the same rating of **Moderate** for the likelihood of distribution for *T. kanzawai* on previously assessed pathways is also adopted for *T. kanzawai* assessed for oriental melon and rockmelon fruit from Korea.

Overall likelihood of entry

The overall likelihood of entry is determined as **Low** by combining the re-assessed likelihood of importation of Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table A.2.

3.6.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for *T. kanzawai* are independent of the import pathway and are considered similar to those in previously assessed pathways.

Based on the existing import policies for table grapes from Japan (Department of Agriculture 2014), table grapes from Korea (Biosecurity Australia 2011b), table grapes from China (Biosecurity Australia 2011a), table grapes from India (DAWR 2016b) and strawberries from Korea (DAWR 2017c), the likelihoods of establishment and spread are assessed as **High** and **Moderate**, respectively.

3.6.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules in Table A.2.

The overall likelihood that *T. kanzawai* will enter WA as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in WA and subsequently spread within WA is assessed as **Low**.

3.6.4 Consequences

The potential consequences of the entry, establishment and spread of *T. kanzawai* in WA are similar to those in the previous assessments of *T. kanzawai* for table grapes from Japan (Department of Agriculture 2014), table grapes from Korea (Biosecurity Australia 2011b), table grapes from China (Biosecurity Australia 2011a), table grapes from India (DAWR 2016b) and strawberries from Korea (DAWR 2017c). The overall consequences in the previous assessments were assessed as Moderate. The overall consequences for *T. kanzawai* on the oriental melon and rockmelon fruit from Korea pathway are also assessed as **Moderate**.

3.6.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Tetranychus kanzawai*	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The URE for *T. kanzawai* on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Low**, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *T. kanzawai* on this pathway.

3.7 Late blight or foot rot

Phytophthora melonis

Phytophthora melonis (synonym: *P. sinensis*) is an important soil-borne pathogen of cucurbits, and can cause heavy damage to crops (Guharoy et al. 2006; Mirtalebi & Banihashemi 2019; Sangeetha et al. 2016). It was first described in 1976 as a causal agent of foot rot of cucumber in Japan, but due to errors in the original description by Katsura, the species was redescribed by Ho, Gallegly and Hong (2007). *Phytophthora melonis* was previously thought to be conspecific with both *P. drechsleri* and *P. sinensis* based on morphological and cultural similarities (Ho 1986; Ho, Gallegly & Hong 2007). However, while molecular data support the synonymy of *P. sinensis* with *P. melonis*, *P. drechsleri* is regarded as a separate species (Cooke et al. 2000; Mirabolfathy et al. 2001; Mostowfizadeh-Ghalamfarsa & Banihashemi 2015).

The main hosts of *P. melonis* are cucurbits, particularly cucumber (*Cucumis sativa*) and melon (*C. melo*) (Ho, Gallegly & Hong 2007; Mills, Förster & Coffey 1991) but also watermelon (*Citrullus lanatus*), pumpkin (*Cucurbita moschata*) (Chehri et al. 2010) and pointed gourd (*Trichosanthes dioica*) (Sangeetha et al. 2016). It has also been isolated from diverse hosts such as pistachio (*Pistacia vera*) (Mirabolfathy et al. 2001; Mirsoleimani & Mostowfizadeh-Ghalamfarsa 2013), juniper (*Juniperus phoenicea*) (Scanu et al. 2015) and cassava (*Manihot esculenta*) (de Oliveira et al. 2016).

While *P. melonis* is recorded from several continents, its recognised distribution is scattered. *Phytophthora melonis* has been recorded from cucurbits in Korea (APQA 2019; Kim & Koo 2009), China, Taiwan, Japan (Mills, Förster & Coffey 1991), Iran (Mirabolfathy et al. 2001; Mostowfizadeh-Ghalamfarsa & Banihashemi 2015), India (Guharoy et al. 2006), Egypt and Turkey (Ho, Gallegly & Hong 2007). On other hosts, it has been recorded in Iran (on pistachio) (Mirabolfathy et al. 2001; Mostowfizadeh-Ghalamfarsa & Banihashemi 2015), Italy (on juniper) (Scanu et al. 2015), and Brazil (on cassava) (de Oliveira et al. 2016). Iran is the only country where *P. melonis* has been recorded on more than one host family (Cucurbitaceae and Anacardiaceae).

Life cycle of *Phytophthora melonis*

Phytophthora species can produce 5 different life stages: mycelium (hyphae), sporangia, zoospores, oospores and, in some species, chlamydospores (Erwin & Ribeiro 1996).

Mycelium, consisting of a collection of filamentous hyphae, is the vegetative stage growing inside and on the surface of the host, acquiring nutrients from the plant tissues (Abad et al. 2023; Hardham 2007). *Phytophthora* does not survive well in dead tissue, so as the disease starts to kill the host, sporangia attached to the mycelium produce spores that can disperse to colonise a new host (Judelson & Blanco 2005).

As illustrated in Figure 3.1, mature sporangia can produce either mycelium or zoospores (Erwin & Ribeiro 1996; Hardham 2007). Depending on the species, sporangia are either retained on the mycelium (non-caducous) or are shed and dispersed in wind or rain (caducous). Caducous species generally infect aerial plant parts (Yakabe et al. 2009). *Phytophthora melonis* is a non-caducous species (Cooke et al. 2000; Erwin & Ribeiro 1996; Ho, Lu & Gong 1984). As the sporangia in this species are not adapted for aerial dispersal, the primary means of dispersal is zoospores, which are soil-borne and generally infect roots (Erwin & Ribeiro 1996; Yakabe et al. 2009).

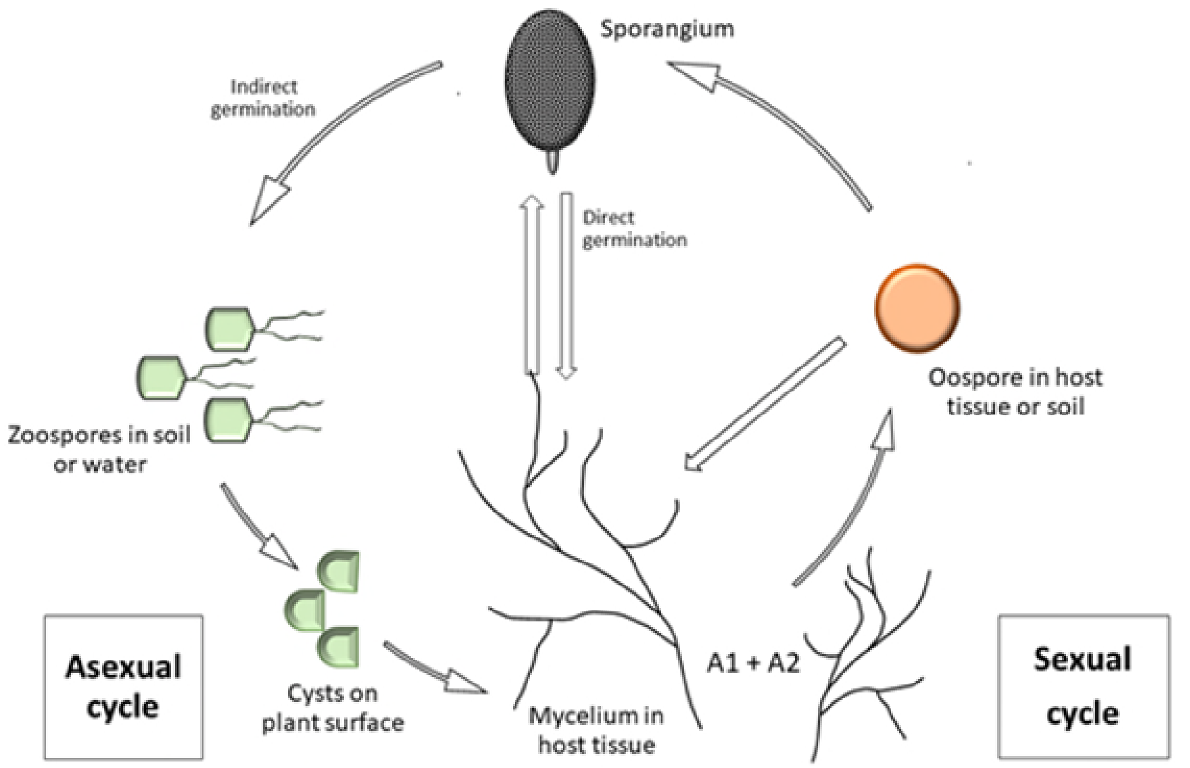
Zoospores are flagellate motile spores considered to be the major type of infectious propagule in *Phytophthora*. They disperse through water or water films in soil and are attracted to chemicals released by roots. Zoospores encyst permanently on contact with any solid object (Erwin & Ribeiro 1996; Hardham 2007). If they make contact with a suitable host, they germinate, producing mycelium that colonises the host tissue (Figure 3.1).

If able to move unobstructed, zoospores can potentially remain motile for hours or sometimes days, but they have limited energy reserves to sustain them (Judelson & Blanco 2005). Further, zoospores lack cell walls and are highly sensitive to dehydration and solar radiation (Erwin & Ribeiro 1996; Hardham 2007; Judelson & Blanco 2005).

Chlamydospores are asexual resting spores formed in host tissues from the mycelium. They are not present in all *Phytophthora* species (Judelson & Blanco 2005), and are not thought to occur in *P. melonis* (Ho, Gallegly & Hong 2007).

Oospores are sexually produced resting spores that are released into the plant tissue or into the soil as the plant breaks down (Hardham 2007; Judelson & Blanco 2005) (Figure 3.1). They are resistant to desiccation, and are able to remain dormant in soil for extended periods (Erwin & Ribeiro 1996; Hardham 2007; Judelson & Blanco 2005). While oospores may be readily produced under laboratory conditions, they are relatively uncommon in the natural environment (Abad et al. 2023). Depending on the species, they may be produced by self-fertilisation (homothallic species) or by cross-fertilisation (heterothallic species). The latter species, which include *Phytophthora melonis*, require the meeting of 2 mating types to produce oospores (Erwin & Ribeiro 1996; Judelson & Blanco 2005). Both mating types do not necessarily occur within the same geographical area (Ann, Kao & Ko 1986; Drenth, Turkensteen & Govers 1993; Judelson & Blanco 2005; Zentmyer et al. 1973). Oospores may produce sporangia or hyphae (Erwin & Ribeiro 1996) (Figure 3.1).

Figure 3.1 ***Phytophthora melonis*** **lifecycle**



Phytophthora melonis is a heterothallic species, therefore 2 opposite mating types (A1 and A2) must be present in the same growing medium in order to produce oospores.

Phytophthora melonis spreads through soil, irrigation water, rain splash or human-assisted movement (Erwin & Ribeiro 1996; Judelson & Blanco 2005; Zitter, Hopkins & Thomas 1996). Irrigation water and heavy rain facilitate rapid spreading of the pathogen among crop plants within and between fields (Lin & Wu 1985).

Phytophthora melonis can infect any part of the host plant at any growth stage (Ho, Gallegly & Hong 2007). Infection occurs in wet conditions and usually begins at the stem collar of the host plant when water pooling around the stem allows the pathogen to invade the host tissue (Erwin & Ribeiro 1996). The stem becomes discoloured and softens, and the plant eventually collapses and dies (Erwin & Ribeiro 1996; Ho, Gallegly & Hong 2007). In fruit, infection appears as dark green, water-soaked lesions and eventually develops into soft rot of the fruit. If the environment remains moist, white mycelial growth and powdery sporangia become visible on the fruit surface (Erwin & Ribeiro 1996; Guharoy et al. 2006; Ristaino 2023; Zitter, Hopkins & Thomas 1996).

The risk scenario of biosecurity concern is that oriental melon and rockmelon fruit from Korea may be infected with *P. melonis*.

3.7.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that *P. melonis* will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Low**.

The likelihood of importation is assessed as Low because, while *P. melonis* is present in Korea on *Cucumis melo*, standard commercial production practices, such as soil treatment, cleaning and sanitization of the greenhouses, would greatly reduce the likelihood of melon fruit infected with *P. melonis* being exported to Australia. Symptoms on mature fruit are visible, and symptomatic fruit are unlikely to be harvested or would likely be removed during standard commercial packing house practices. However, not all infected fruit may be removed. The pathogen could survive refrigerated storage and transport from Korea to Australia.

The following information provides supporting evidence for this assessment.

Phytophthora melonis is known to be associated with melon fruit in Korea.

- *Phytophthora melonis* has been recorded infecting fruit of *Cucumis melo* in Korea (APQA 2019; Kim & Koo 2009).

Oriental melon and rockmelon fruit infected with *P. melonis* are likely to be removed during standard commercial production and packing practices.

- Standard production practices such as crop inspections, control of humidity, disinfecting tools, and annual cleaning and heat sanitising of the greenhouses reduce the likelihood of *Phytophthora* occurring on greenhouse-grown melon fruit (APQA 2018, 2021; NPQS 2007).
- Standard commercial pest management practices used in Korean greenhouses, such as surveillance and monitoring programs with crop inspection (APQA 2021), are likely to reduce incidence of this disease.
  - Visible symptoms on plants include discolouration and softening of the stem which can eventually lead to the collapse and death of the plant (Erwin & Ribeiro 1996; Ho, Gallegly & Hong 2007).
  - In fruit, infection generally appears as dark green, water-soaked lesions and eventually soft rot of the fruit. If the environment remains moist, white mycelial growth and powdery sporangia become visible on the fruit surface (Erwin & Ribeiro 1996; Guharoy et al. 2006; Ristaino 2023; Zitter, Hopkins & Thomas 1996).
- Any fruit showing visible signs of infection would be readily identified and excluded at harvest or during the packing house processes of quality inspection, sorting and grading (APQA 2018; NPQS 2007).

The pathogen is unlikely to be present on the fruit surface, as there is no direct contact between the fruit and soil, and if spores or hyphae were present on the fruit surface they would likely be removed during processing.

- Rockmelons are grown on trellises, and the fruit do not touch the ground, whereas oriental melons are grown on the ground, with plastic sheeting used to prevent direct contact between fruit and the soil (APQA 2021). This reduces the likelihood of *Phytophthora* coming into contact with the fruit if the pathogen is present in the soil.
- However, the pathogen could come into contact with the fruit through contaminated water that has washed over exposed soil around infected plant stems.

- Spores situated externally on the fruit are likely to be removed during standard post-harvest procedures, which include washing or cleaning with a pressurised air gun (APQA 2021).

Some fruit may not exhibit symptoms at the time of harvest, and infected fruit could escape detection.

- *Phytophthora melonis* can infect a plant at any growth stage (Ho, Gallegly & Hong 2007). Therefore, mature fruit infected shortly before harvest may not show symptoms at harvest.
- Some *P. melonis* spores on the surface of harvested fruit may survive standard commercial packing house processes and remain with the fruit.

Phytophthora melonis could survive post-harvest storage and transport from Korea to Australia.

- Melons are transported and stored under controlled conditions, with an average temperature of 4.5°C to 10°C and an average relative humidity of 90–95% for oriental melons, and at 10°C with an average relative humidity of 85–90% for rockmelons (APQA 2021).
- The growth rate of *P. melonis* slows at lower temperatures (Mills, Förster & Coffey 1991) and it does not grow at temperatures below 9°C (Erwin & Ribeiro 1996). This suggests that the pathogen could survive during refrigerated storage and transport.
- Mills, Förster and Coffey (1991) noted that *P. melonis* isolates 'did not survive long-term storage at 5°C' but did not state the period of storage.

For the reasons outlined, the likelihood that *P. melonis* will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Low.

Likelihood of distribution

The likelihood that *P. melonis* will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as: **Very Low**.

The likelihood of distribution is assessed as Very Low because most melon waste will be disposed of in managed waste systems, though some might be discarded into the environment. Spores may be carried from the discarded fruit waste in moving water or by human-assisted movement. While known host plants of *P. melonis* are present in Australia and it is possible there may also be unidentified hosts of *P. melonis* present in Australia, it is unlikely that *P. melonis* spores would reach any host plant before dying or encysting on an unsuitable surface.

The following information provides supporting evidence for this assessment.

Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Infected fruit showing symptoms of *P. melonis* infection are likely to be removed from distribution, but some asymptomatic fruit, and fruit with mild symptoms, may be distributed and sold.

- Imported melon fruit will likely be distributed throughout Australia via the wholesale and retail trade for sale for human consumption. The major population centres are likely to receive most of the imported fruit.
- Packed melon fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of *P. melonis* infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of

imported melon fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.

- However, some melon fruit infected with *P. melonis* may not show symptoms and therefore may be sold to consumers.

Some melon waste infected with *P. melonis* may be discarded into the environment near a suitable host.

- Melon fruit from Korea are intended for human consumption and most fruit, other than the rind and seeds of the fruit, will be consumed. Any fruit waste, including rind, seeds and rotten fruit, is likely to be discarded into managed waste systems. Potential exposure to suitable host plants from waste discarded in this way is likely to be negligible.
- However, individual consumers may discard small quantities of melon fruit waste in a variety of urban, rural and natural environments, including in domestic compost. Some of this waste could be discarded near suitable host plants, including household or wild host plants.
- Wild-growing populations of commercially grown cultivars of *C. melo* sometimes occur around picnic areas (Telford et al. 2011).

Phytophthora melonis is unlikely to survive on discarded fruit waste, but in certain conditions it may sporulate.

- *Phytophthora* does not survive for long on dead plant material, where it lacks nutrients to grow and is unable to compete with microorganisms that exploit damaged or decaying organic matter (Erwin & Ribeiro 1996).
- However, in wet conditions, death of host material can induce sporulation, giving rise to zoospores that could allow the pathogen to move to new hosts (Erwin & Ribeiro 1996; Judelson & Blanco 2005).

However, spores are very unlikely to transfer successfully from discarded melon waste to a suitable host plant, as *P. melonis* has a limited host range, and spores will generally not move far or survive for long in the environment.

- The known host range of *P. melonis* is mainly restricted to Cucurbitaceae (Chehri et al. 2010; Ho, Gallegly & Hong 2007).
- Outside Asia, *P. melonis* has only been isolated from a small number of hosts, but these hosts represent a very diverse group of families (de Oliveira et al. 2016; Mirabolfathy et al. 2001; Scanu et al. 2015), making it difficult to assess how many potential hosts may be present in Australia. However, records of *P. melonis* on non-cucurbitaceous hosts are rare and isolated (de Oliveira et al. 2016; Scanu et al. 2015), with the possible exception of pistachios in Iran where *P. melonis* is one of the principal causes of pistachio gummosis (Mirabolfathy et al. 2001).
- *Phytophthora* spores can be carried for long distances in flooded ground, water runoff or human-assisted movement, or be dispersed short distances (up to 50cm) through active movement of zoospores (Erwin & Ribeiro 1996; Lin & Wu 1985). These dispersal mechanisms could assist further movement from discarded waste towards suitable host plants.
- Soil- and water-borne zoospores are the primary means of dispersal in *P. melonis*. They have limited energy reserves and are vulnerable to desiccation and solar radiation, rarely surviving more than a few days (Judelson & Blanco 2005).

- Zoospores can move autonomously towards plant roots, but permanently encyst on contact with non-host material, which they will be unable to colonise successfully.
  - Zoospores can propel themselves through water or wet soil for up to 35–50cm, depending on the soil type. Chemical and electrical stimuli guide them towards plant tissue, but the range for unimpeded autonomous movement is limited, particularly through soil (Erwin & Ribeiro 1996; Irwin, Cahill & Drenth 1995; Judelson & Blanco 2005).
  - Upon contacting a solid object, the zoospores adhere to the surface and lose their flagella, forming a cyst (Erwin & Ribeiro 1996; Hardham 2007). This means that, unless the soil is sufficiently porous, a zoospore is likely to encyst prematurely and will be unable to reach a susceptible part of a host (Erwin & Ribeiro 1996). This would end the life cycle of the pathogen.
- While *P. melonis* sporangia are generally retained on the hyphae and do not readily detach (Cooke et al. 2000; Erwin & Ribeiro 1996; Ho, Lu & Gong 1984), in some circumstances, such as in heavy rain, the sporangia could conceivably be forcibly broken off and carried from the infected host material in moving water. However, it is not certain how likely this is to occur in the natural environment.
  - In dispersal tests on inoculated cucumbers by Lin and Wu (1985), sporangia were not detached by air currents in the field or laboratory, and none were detected in contaminated waste irrigation water in contact with diseased plants, but sporangia were recovered from water beneath infected cucumber fruit left in heavy rain for an hour.
- Even in the event of mature sporangia becoming detached from the mycelium, it is unlikely that they would be carried within close proximity of suitable host plants from discarded melon waste.

For the reasons outlined, the likelihood that *P. melonis* will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as Very Low.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules in Table A.2.

The likelihood that *P. melonis* will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea and be distributed in a viable state to a susceptible host is assessed as: **Very Low**.

3.7.2 Likelihood of establishment

The likelihood that *P. melonis* will establish within Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The likelihood of establishment is assessed as Moderate because hosts are available in Australia, though populations of these host plants outside of commercial growing areas are often transient, and therefore could not support a permanent population of *P. melonis*. *Phytophthora melonis* requires a warm, wet environment to establish. Suitable environments occur in tropical areas of Australia. *Phytophthora melonis* is not self-fertile and under natural conditions does not readily produce the desiccation-resistant oospores. Other structures and life stages of *P. melonis* are highly vulnerable to desiccation and antagonistic microorganisms.

The following information provides supporting evidence for this assessment.

Host plants are present in the Australian environment which could sustain a population of *P. melonis*. However, these host plants are often transient outside of commercial growing areas and thus unlikely to support a permanent population of *P. melonis*.

- The known host range of *P. melonis* is mainly restricted to Cucurbitaceae (Chehri et al. 2010; Ho, Gallegly & Hong 2007). These host plants are present in commercial plantings, home gardens and natural environments in Australia.
- Melons are commercially produced in every mainland state of Australia, with the majority of *C. melo* production occurring in Queensland and New South Wales (Horticulture Innovation Australia 2022a).
- Endemic *Cucumis* and *Trichosanthes* species occur in Australia (CSIRO 2020; Telford et al. 2011) which are potential hosts of *P. melonis*, as members of these genera are known hosts in other countries. Other cucurbit species such as *Citrullus lanatus* (wild watermelon variant) and *Cucumis myriocarpus* (paddy melon) are common and widespread weeds throughout Australia (ALA 2023; DEEDI 2016).
- Naturalised or endemic populations of *C. melo* subsp. *agrestis* occur throughout tropical and subtropical Australia in a variety of habitats (ALA 2023; Telford et al. 2011). It is unknown whether this subspecies is susceptible to *P. melonis*.
- Host plants grown in domestic gardens or wild melon plants arising from discarded waste, such as those that occur around picnic areas, are unlikely to be available for longer than a single growing season (Telford et al. 2011). Therefore, these host populations could not support a permanent population of *P. melonis*.

Establishment of *P. melonis* in Australia would be limited to areas with suitably warm and wet climatic conditions.

- *Phytophthora melonis* requires warm temperatures and high humidity for disease development (Lin & Wu 1985). These conditions occur in tropical regions in Australia.
  - Optimum growth occurs at 28°C to 32°C, with a minimum growth temperature of 9°C and a maximum of 37°C (Erwin & Ribeiro 1996; Ristaino 2023).
  - Infection is often initiated soon after heavy rain and the disease progresses under moist conditions (Erwin & Ribeiro 1996).
- Native and naturalised cucurbitaceous populations occur in Australia, mainly in tropical areas (Telford et al. 2011). Areas where these populations occur are likely to have suitably warm and wet climatic conditions for *P. melonis* to establish.
- Soil moisture is also an important factor affecting the survival of the pathogen. In a study by Lin and Wu (1985), the pathogen was not detected in flooded soil (30% water content) 4 weeks after inoculation, possibly due to the paucity of oxygen. In soils with 20% water content, it persisted for 5 weeks, and in soil with 6% water content for up to 20 weeks (Lin & Wu 1985).

Active stages of *Phytophthora* are vulnerable to the environment outside host plant tissue and to antagonistic microorganisms. Desiccation-resistant oospores are more robust and longer-lived, but are unlikely to be produced by *P. melonis* under natural conditions.

- *Phytophthora* zoospores and sporangia are short-lived and vulnerable to desiccation and solar radiation (Judelson & Blanco 2005).
- Oospores are longer-lived than zoospores, but are produced uncommonly in nature (Abad et al. 2023). For heterothallic species such as *P. melonis*, hyphae of 2 opposite mating types must be present on the same growing medium for oospores to be produced (Erwin & Ribeiro 1996; Judelson & Blanco 2005).
- *Phytophthora* is highly vulnerable to antagonistic microorganisms, which can proliferate more rapidly and suppress growth directly and indirectly through parasitism, production of antibiotic substances, and competition (Drenth & Sendall 2001; Erwin & Ribeiro 1996).

For the reasons outlined, the likelihood that *P. melonis* will establish within Australia is assessed as Moderate.

3.7.3 Likelihood of spread

The likelihood that *P. melonis* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as: **Moderate**.

The likelihood of spread is assessed as Moderate because *P. melonis* can spread by natural means, such as via water, or by human-assisted movement of infected plants or contaminated material. However, the unfavourable climatic conditions in many parts of Australia are limiting factors in the potential spread of this disease.

The following information provides supporting evidence for this assessment.

Phytophthora melonis can be spread naturally and by movement of humans.

- *Phytophthora* can be spread naturally by water, for example in irrigation water, rain or flooding, and by animal agents, such as herbivorous vertebrates or insects (Erwin & Ribeiro 1996).
- *Phytophthora* can be carried longer distances through the movement of contaminated soil, clothing, equipment or plant material by humans (Erwin & Ribeiro 1996).
- Movement of any part of an infected plant or surrounding soil could spread the pathogen to other regions.

Spread of *P. melonis* would be limited to areas where climatic conditions are suitable for growth.

- The current distribution and optimal growth conditions of *P. melonis* indicate that it is unlikely to spread into parts of the country that experience cool to cold winters and low rainfall. However, there are regions, particularly in the north of Australia, where climatic conditions may be suitable for the spread of this pathogen (high temperatures, humidity and rainfall).

Host plants are available in areas that are climatically favourable for *P. melonis*.

- The majority of Australian melons are produced in the northern parts of Australia (Horticulture Innovation Australia 2022a) where climatic conditions are suitable for the growth of *P. melonis*.

- Host plants are also available throughout Australia in domestic gardens, and endemic and naturalised cucurbitaceous species present in the environment may facilitate spread of the pathogen. However, these populations are often transient (Telford et al. 2011) and the susceptibility of these species to *P. melonis* is unknown.

For the reasons outlined, the likelihood that *P. melonis* will spread within Australia is assessed as Moderate.

3.7.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the individual likelihoods of entry, establishment and spread using the matrix of rules in Table A.2.

The overall likelihood that *P. melonis* will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as: **Very Low.**

3.7.5 Consequences

The potential consequences of the establishment of *P. melonis* in Australia has been estimated according to the methods described in Figure A.1.

Based on the decision rules described in Table A.3, that is, where the potential consequences of a pest with respect to one or more criteria are 'D', the overall consequences are estimated to be **Low.**

Criterion	Estimate and rationale
Direct	
Plant life or health	D—Significant at the District level *Phytophthora melonis* is known to infect several commercial cucurbit crop species, including melons and cucumbers, causing rapid wilting and death of whole plants (Ho, Gallegly & Hong 2007; Ho, Lu & Gong 1984). It is one of the most severe diseases on wax gourd and cucumber plants, especially during the rainy season (Wu et al. 2016). In 2020–21, Australia produced 182,572 tonnes of melons valued at $149 million (which included 67,598 tonnes of muskmelons valued at $84.1 million and 114,975 tonnes of watermelons valued at $64.79) and 90,998 tonnes of cucumbers valued at $172.7 million (Horticulture Innovation Australia 2022a). Native and naturalised species of Cucurbitaceae, including *Cucumis melo*, occur in Australia in climatic conditions (high temperatures and heavy rainfall) that may be favourable for growth and spread of *P. melonis*. However, this pathogen is recorded almost exclusively from plants on farms and there is only one record of *P. melonis* being associated with a host in the wild (Scanu et al. 2015).
Other aspects of the environment	A—Indiscernible at the Local level There are currently no known direct consequences of *P. melonis* on other aspects of the natural environment.
Indirect	
Eradication, control	D—Significant at the District level Eradication of *P. melonis* could incur substantial costs to government and industry and may not always be considered feasible. Eradication of *Phytophthora* is difficult due to the potential longevity of spores in the soil, and its ability to spread via contaminated equipment, soil, infected plant material, and water. Any programs to eradicate or contain *P. melonis* are likely to require application of fungicide, removal of diseased or potentially diseased plants and replanting with resistant cultivars or non-susceptible host species for a period of time (Chen et al. 2012; Lin & Wu 1985).

Criterion	Estimate and rationale
	There are a number of fungicides registered in Australia for use on horticultural commodities for *Phytophthora* (APVMA 2023). Several other *Phytophthora* species associated with cucurbits are already present in Australia such as *P. nicotianae, P. drechsleri, P. cryptogea, P. cactorum, P. capsici* and *P. citrophthora* (APPD 2023; Cook & Dubé 1989; Cunnington 2003; Persley, Cooke & House 2010; Shivas 1989; Stukely et al. 2007; Weinert et al. 1998). The cultural practices applied in Australia to manage these species would also be likely to manage *P. melonis*; for instance, ensuring good drainage, avoiding excessive irrigation, mulching, removing dead or diseased plant material and crop rotation (Drenth & Guest 2004; Zitter, Hopkins & Thomas 1996).
Domestic trade	C—Minor significance at the District level Australian states and territories have their own domestic biosecurity restrictions for pests of concern for their jurisdictions. When an exotic pest is detected and its distribution is limited in area, the Subcommittee on Domestic Quarantine and Market Access (SDQMA) can restrict intra- and/or inter-state movement of affected commodities to prevent the pest's spread (SDQMA 2014). Such a restriction would clearly impact on domestic trade.
International trade	C—Minor significance at the District level *Phytophthora melonis* is not recorded in most of Australia's major export market countries for muskmelons (such as Singapore, New Zealand, United Arab Emirates and Hong Kong (Horticulture Innovation Australia 2022a)). *Phytophthora melonis* is listed as a regulated quarantine pest in New Zealand; however, there are no phytosanitary measures required for this pathogen on the melon fruit pathway. While fruit is not considered a pathway by New Zealand, other countries may require measures.
Non-commercial and environmental	A—Indiscernible at the Local level Fungicides are commonly applied in agriculture throughout Australia. While the introduction of *P. melonis* to Australia may result in an increased application of fungicides, this increase is unlikely to substantially change the current impact of fungicides on the local environment.

3.7.6 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Phytophthora melonis*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

The URE for *P. melonis* on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Negligible**, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *P. melonis* on this pathway.

3.8 CFMMV and KGMMV

***Cucumber fruit mottle mosaic virus* (EP) and *Kyuri green mottle mosaic virus* (EP)**

Cucumber fruit mottle mosaic virus (CFMMV) and *Kyuri green mottle mosaic virus* (KGMMV) belong to the genus *Tobamovirus* in the family Virgaviridae (Adams, Antoniw & Kreuze 2009). Tobamoviruses are generally considered to be seed-borne, and can be transmitted by mechanical contact. The viral particles of tobamoviruses are extremely stable, and their infectivity can be preserved for months to years in plant debris, contaminated soil and clay (Dombrovsky & Smith 2017). These viruses have been grouped together in this assessment as they have common biological characteristics and are considered to pose similar risk.

***Cucumber fruit mottle mosaic virus* (CFMMV)**

CFMMV was first isolated in greenhouse-grown cucumbers (*Cucumis sativus*) in central Israel in 1992 (Antignus et al. 2001). Subsequently, this virus was reported to infect several cucurbit crops in Korea (Rhee, Hong & Lee 2014). More recently, CFMMV was isolated from a wild cucurbit species (*Coccinia grandis*) in Sudan. Its high sequence divergence from isolates from Israel and Korea suggests that the presence of CFMMV in Sudan is not related to recent exchanges of contaminated material (Desbiez et al. 2021).

The host range of CFMMV is limited to the Cucurbitaceae family. It has been reported naturally infecting several cucurbit crops, including *Cucumis sativus* (cucumber), *Cucumis melo* (melon), *Cucurbita pepo* (zucchini) and *Luffa acutangular* (angled luffa) (Antignus et al. 2005; Antignus et al. 2001; Rhee, Hong & Lee 2014; Rhee, Jang & Lee 2016). Until the CGMMV epidemic in 2007, CFMMV was considered the predominant tobamovirus infecting cucumber crops (Dombrovsky, Tran-Nguyen & Jones 2017).

Symptoms on fruit may vary between cultivars, but generally include bright mottling or mosaic, rendering the fruits unmarketable (Antignus et al. 2001). The symptoms on leaves include severe mosaic, vein-banding, and yellow mottling. In some cases, fully developed plants show severe wilting leading to plant collapse (Antignus et al. 2005; Antignus et al. 2001). Under favourable conditions, the disease incidence may reach up to 100%, leading to significant economic losses in cucumber crops (Antignus et al. 2005).

***Kyuri green mottle mosaic virus* (KGMMV)**

Prior to its characterisation, KGMMV was considered to be a strain of *Cucumber green mottle mosaic virus* (CGMMV). In 1967, KGMMV was first reported as CGMMV cucumber strain (CGMMV-C) in Japan (Inouye et al. 1967). Subsequently, CGMMV Yodo strain (CGMMV-Y) was isolated from cucumbers in Japan in 1969 (Antignus et al. 2001; Varveri, Vassilakos & Bem 2002). Francki, Hu and Palukaitis (1986) indicated that the CGMMV cucumber strain was taxonomically different from CGMMV watermelon strain, based on serological analysis and RNA-cDNA hybridisation. Consequently, the cucumber strains (CGMMV-C and CGMMV-Y) were re-examined and named KGMMV as a distinct species in the genus *Tobamovirus* (Antignus et al. 2001; Tan et al. 2000).

Since its first detection in Japan, KGMMV has been reported to occur in Korea (Lee et al. 2000), Indonesia (Daryono, Somowiyarjo & Natsuaki 2005a) and Thailand (Daryono & Natsuaki 2012). The host range of KGMMV is limited to the Cucurbitaceae family. It is known to infect *Citrullus* *lanatus* (watermelon), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucumis metuliferus* (African horned cucumber), *Cucurbita pepo* (zucchini) and *Luffa acutangula* (angled luffa) (Daryono & Natsuaki 2012; Daryono, Somowiyarjo & Natsuaki 2003, 2005a; Kim, Lee & Natsuaki 2009; Kwon et al. 2014; Lecoq & Katis 2014).

The severity of symptoms on fruit varies between cucurbit cultivars, but generally includes fruit distortion and mottle mosaic symptoms (Daryono, Somowiyarjo & Natsuaki 2005a; Yoon et al. 2001). In Japan, KGMMV is considered a major pest, causing severe yield reduction in cucumber (Fukuta et al. 2012).

Pest risk assessment of CFMMV and KGMMV

CFMMV and KGMMV have been assessed previously in the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020). In that review, the unrestricted risk estimate for CFMMV and KGMMV was assessed as Moderate, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for CFMMV and KGMMV on that pathway.

However, differences in commodity, pest prevalence, end use and commercial production practices between the cucurbitaceous vegetable seeds for sowing pathway and the oriental melon and rockmelon fruit from Korea pathway make it necessary to re-assess the likelihood of importation and distribution of CFMMV and KGMMV associated with the oriental melon and rockmelon fruit for human consumption from Korea pathway. As there is limited information on the biology and epidemiology of these viruses, particularly CFMMV, relevant publications on the genus *Tobamovirus*, or on closely related species (for example, CGMMV), will be used in this risk assessment.

The likelihoods of establishment and spread of CFMMV and KGMMV in Australia from the oriental melon and rockmelon fruit from Korea pathway have been assessed as similar to those of the previous assessments of High and Moderate respectively for the cucurbitaceous vegetable seeds for sowing pathway. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread of CFMMV and KGMMV in Australia are also independent of the import pathway and have been assessed as being similar between the pest risk assessments, and rated as Moderate.

In addition, the department has reviewed the latest literature—for example, Desbiez et al. (2021), Gullino, Albajes and Nicot (2020) and Maksimov et al. (2020). No new information has been identified that would significantly change the risk ratings for establishment, spread and consequences as set out for CFMMV and KGMMV in the existing policy.

The risk scenario of biosecurity concern is that oriental melon and rockmelon fruit from Korea may be infected with CFMMV or KGMMV.

3.8.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that CFMMV and KGMMV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Low**.

The likelihood of importation is assessed as Low because, while CFMMV and KGMMV are present in the major melon production areas of Korea, use of tested seed and seedling grafting material along with standard commercial production and packing practices are likely to reduce the melon fruit infected with CFMMV or KGMMV being exported to Australia. In the unlikely event of contamination of CFMMV or KGMMV in greenhouses in Korea, asymptomatic infected fruit may be packed for export. The virus is likely to survive cool storage and transport from Korea to Australia.

The following information provides supporting evidence for this assessment.

CFMMV and KGMMV are known to be associated with oriental melon and rockmelon fruit and are present in Korea.

- CFMMV and KGMMV have been reported to naturally infect several crops within Cucurbitaceae family, including melon (*Cucumis melo*) (Daryono & Natsuaki 2012; Daryono, Somowiyarjo & Natsuaki 2003; Kim, Lee & Natsuaki 2009; Rhee, Hong & Lee 2014; Rhee, Jang & Lee 2016).
- As members of the genus Tobamovirus, CFMMV and KGMMV infect their cucurbit hosts systemically (Kim, Lee & Natsuaki 2009; Rhee, Hong & Lee 2014). Thus, all plant tissues, including fruit and seeds, may contain the virus.
- CFMMV and KGMMV are known to be present in oriental melon and rockmelon production areas of Korea (Kim, Lee & Natsuaki 2009; Kwon et al. 2014; Rhee, Hong & Lee 2014).
  - In epidemiological surveys for tobamoviruses in various cucurbit species cultivated in Korea, 3 CFMMV variants (CFMMV-Cm, CFMMV-Cu, and CFMMV-Pump) were identified from melon, cucumber, and pumpkin plants, respectively (Rhee, Hong & Lee 2014).
  - A study conducted by Kim, Lee and Natsuaki (2009) characterised an isolate of KGMMV from an oriental melon collected in Seongju County, Korea. This was the first report of KGMMV infecting oriental melon in Korea.

Standard commercial production and packing practices would greatly reduce the likelihood of oriental melon and rockmelon fruit infected with CFMMV or KGMMV being exported to Australia.

- CFMMV and KGMMV are regulated non-quarantine pests in Korea. Seed testing to verify freedom from these viruses is required for all imported Cucurbitaceae seeds into Korea (APQA 2021).
- Standard pre-planting and production practices for Korean melon fruit, such as the use of greenhouse hygiene, sterile soil, tested seed and clean seedling material for grafting (APQA 2018, 2021), would greatly reduce the risk of CFMMV and KGMMV occurring in the greenhouses, and thus reduce the likelihood of both viruses occurring on greenhouse-grown melon fruit for export.
- Rockmelons are grown on trellises, and the fruit do not touch the ground, whereas oriental melons are grown on the ground, with plastic sheeting used to prevent direct contact between fruit and the soil (APQA 2021). This reduces the likelihood of CFMMV and KGMMV coming into contact with the fruit if the pathogen is present in the soil.

- Grafting is a common practice used for oriental melon in Korea. Grafting on resistant rootstocks has proved to be very efficient for protecting melon from soil-borne viruses, such as tobamoviruses (Lecoq & Katis 2014).
- Fruit symptoms caused by CFMMV may vary between cultivars, but generally include bright mottling or mosaic rendering the fruits unmarketable (Antignus et al. 2001). KGMMV causes fruit deformation and mosaic symptoms in melon (Daryono, Somowiyarjo & Natsuaki 2005a). Any fruit showing visible signs of infection would be excluded at harvest or during the grading and packing process.
- Integrated disease management strategies used to control tobamoviruses mainly consist of diverse hygiene measures, but can also include cultural, biological and host resistance measures (Dombrovsky, Tran-Nguyen & Jones 2017). Practices implemented in Korea include the use of CFMMV/KGMMV-free seeds, disinfection of equipment and clothes, and strict control on the movement of potentially infected material from affected greenhouses (APQA 2021).

If CFMMV or KGMMV is present in the greenhouse, it is possible that asymptomatic infected fruit could escape detection during standard commercial harvesting and packing practices and be packed for export.

- Latent infection of CFMMV and KGMMV has been reported on melon and some other cucurbit species (Antignus et al. 2001; Kim, Lee & Natsuaki 2009). Therefore, it is possible that plants infected at later growth stages may not show any symptoms.
- Like other *Tobamovirus* species (for example, CGMMV), infected fruit do not always show symptoms (ASTA 2014; Crespo et al. 2017). In some cases, fruit may be internally discoloured or necrotic but show no external symptoms.

CFMMV and KGMMV could survive cool storage and transport.

- Transport and storage of melons is done under controlled conditions with an average temperature of 4.5°C to 10°C and average relative humidity of 90–95% for oriental melons, and 10°C with an average relative humidity of 85–90% for rockmelons (APQA 2021). These conditions are not expected to affect the viability of either CFMMV or KGMMV.
- Tobamoviruses, including CFMMV and KGMMV, are characterized by high stability and long persistence (Antignus et al. 2005; Daryono, Somowiyarjo & Natsuaki 2005b; Lecoq & Katis 2014). Therefore, it is likely that they could survive during cool storage and transport.

For the reasons outlined, the likelihood that CFMMV or KGMMV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Low.

Likelihood of distribution

The likelihood that CFMMV and KGMMV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as: **Very Low**.

The likelihood of distribution is assessed as Very Low because oriental melon and rockmelon fruit from Korea are intended for human consumption and most fruit, other than the rind and seeds of the fruit, will be consumed. Fruit waste, including rind and rotten fruit, is likely to be discarded into managed waste systems. Small quantities of melon fruit waste may be discarded in a variety of urban, rural and natural environments, including in domestic compost. Due to the limited range of known hosts, the end use, absence of any known vector, and more importantly, lack of seed-borne or seed transmission evidence in melon fruit, there will be very limited opportunity for CFMMV or KGMMV to be transmitted to a susceptible part of a host in Australia.

The following information provides supporting evidence for this assessment.

Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Infected melon fruit showing symptoms of CFMMV and/or KGMMV infection are likely to be removed from distribution, but some asymptomatic fruit and fruit with mild symptoms may be distributed and sold.

- Imported melon fruit will likely be distributed throughout Australia via the wholesale and retail trade for sale for human consumption. The major population centres are likely to receive most of the imported fruit.
- Packed melon fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of CFMMV or KGMMV infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported melon fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some melon fruit infected with CFMMV or KGMMV may not show symptoms, and therefore may be sold to consumers.

Some oriental melon and rockmelon fruit waste infected with CFMMV or KGMMV may be discarded into the environment near suitable host plants.

- Oriental melon and rockmelon fruit from Korea are intended for human consumption and most of the fruit, other than the rind and seeds, will be consumed. Any waste, including rind, seeds and rotten fruit, is likely to be discarded into managed waste systems. Potential exposure to suitable host plants from waste discarded in this way is likely to be negligible.
- However, individual consumers might discard small quantities of melon fruit waste in a variety of environments, mainly home gardens. Some of this waste could be discarded near suitable host plants, including household plants.
- To date, the host range of CFMMV and KGMMV has been limited to several species within the Cucurbitaceae family.
    - CFMMV has been reported naturally infecting angled luffa (*Luffa acutangula*), cucumber (*Cucumis sativus*), melon (*Cucumis melo*) and zucchini (*Cucurbita pepo*) (Antignus et al. 2005; Antignus et al. 2001; Desbiez et al. 2021; Rhee, Hong & Lee 2014; Rhee, Jang & Lee 2016). Recently, a wild cucurbit species (*Coccinia grandis*) has also been identified as a natural host (Desbiez et al. 2021).
    - KGMMV is known to infect angled luffa (*Luffa acutangula*), cucumber (*Cucumis sativus*), melon (*Cucumis melo*), watermelon (*Citrullus lanatus*), zucchini (*Cucurbita pepo*) and African horned cucumber (*Cucumis metuliferus*) (Daryono & Natsuaki 2012; Daryono, Somowiyarjo & Natsuaki 2003, 2005a; Kim, Lee & Natsuaki 2009; Kwon et al. 2014; Lecoq & Katis 2014).

It is unlikely that CFMMV and KGMMV could be transmitted to plants germinating from infected seeds discarded with oriental melon and rockmelon fruit waste.

- Tobamoviruses are generally considered to be seed-borne (Dombrovsky & Smith 2017). However, there are no records of CFMMV or KGMMV being seed-borne or seed transmitted in melon.

  - CFMMV has only been demonstrated to be seed-borne in zucchini (Kwon et al. 2014).
  - KGMMV has been demonstrated to be seed-borne in watermelon (Kwon et al. 2014), cucumber (Lecoq & Katis 2014) and zucchini (Kwon et al. 2014; Lee et al. 2000).
- Seeds from fruit waste disposed of in residential gardens may germinate and grow as volunteer plants. These volunteer plants would become the new hosts. However, even if seed transmission does occur, as with CGMMV, a number of other factors would greatly reduce the likelihood of CFMMV and KGMMV being transmitted this way:
  - Not all seeds in infected melon fruit waste would contain or be contaminated with the virus (Reingold et al. 2016; Wu et al. 2011).
  - Seeds from fruit waste disposed of in residential gardens may germinate and grow as volunteer plants. These volunteer plants would become the new hosts. However, several factors affect the germination of melon seeds, one being temperature; melon seeds require high temperatures for successful germination, the optimum range being 25°C to 30°C. Melon germination can sharply decline from almost 100% to zero when the temperatures are below the optimum (Edelstein & Nerson 2005).
  - Survival of infected seedlings is expected to be limited.

It could be possible for CFMMV and KGMMV to be transmitted to a new host from infected melon fruit mechanically.

- Tobamoviruses, including CFMMV and KGMMV, are characterized by high stability and long persistence (Antignus et al. 2005; Daryono, Somowiyarjo & Natsuaki 2005b; Lecoq & Katis 2014). The virus is likely to remain viable for a significant period in/on melon fruit.
- CFMMV and KGMMV, like other *Tobamovirus* species (for example, CGMMV), can be effectively transmitted by mechanical means such as hands, clothing and tools (in commercial production with intensive handling) (Daryono, Somowiyarjo & Natsuaki 2005b; Dombrovsky, Tran-Nguyen & Jones 2017).
- Hands, clothing or equipment may be contaminated by contact with infected fruit. If these then touch host plants in residential gardens, there is a small chance that the plants could become infected.
- CFMMV and KGMMV, like other *Tobamovirus* species, can spread locally through physical contact with infected plant material or debris (Broadbent & Fletcher 1963; Choi 2001; Reingold et al. 2015). However, transfer of the virus via physical contact between melon fruit waste and host plants is very unlikely.
- Transmission of CFMMV or KGMMV by insects feeding on discarded melon fruit waste and moving to susceptible host plants is very unlikely. To date, no insect vector has been reported to be associated with the transmission of CFMMV or KGMMV.

It could be possible for CFMMV and KGMMV to be transmitted to a host plant through the use of contaminated compost.

- Melon fruit waste can be composted as commercially composted food waste (from municipal green waste bins) or as domestic garden compost. If infected compost is applied around a suitable host plant, there is a small chance that the plant could become infected.
- While there is no specific study demonstrating the temperature effect on the survival of KGMMV or CFMMV in compost, similar studies have been carried out on other closely related tobamoviruses. High temperature (72°C for 3 days) has been shown to eliminate/inactivate CGMMV in a compost pile (Avgelis & Manios 1992; Mandal et al. 2008).

- Commercially composted food waste is expected to reach temperatures which would inactivate the virus. Thus, potential exposure to suitable host plants from commercially composted food waste is likely to be negligible.
- Compost produced in residential gardens may not reach the appropriate temperature to inactivate CFMMV or KGMMV. However, the composting process is likely to reduce the level of virus contamination.

For the reasons outlined, the likelihood that CFMMV or KGMMV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as Very Low.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules in Table A.2.

The likelihood that CFMMV and KGMMV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea and be distributed in a viable state to a susceptible part of a host is assessed as: **Very Low**.

3.8.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for CFMMV and KGMMV are independent of the import pathway and are considered similar to those in previously assessed import pathways.

Based on the existing review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020), the likelihoods of establishment and spread are assessed as **High** and **Moderate**, respectively.

3.8.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules in Table A.2.

The overall likelihood that CFMMV and KGMMV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as **Very Low**.

3.8.4 Consequences

The potential consequences of the entry, establishment and spread of CFMMV and KGMMV in Australia are similar to those in the previous assessments of CFMMV and KGMMV for cucurbitaceous vegetable seeds for sowing (DAWE 2020). The overall consequences in the previous assessments were assessed as Moderate. The overall consequences for CFMMV and KGMMV on the oriental melon and rockmelon fruit from Korea pathway is also assessed as **Moderate**.

3.8.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Cucumber fruit mottle mosaic virus* and *Kyuri green mottle mosaic virus*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The URE for CFMMV and KGMMV on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Very Low**, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for CFMMV and KGMMV on this pathway.

3.9 CGMMV

Cucumber green mottle mosaic virus (EP)

Cucumber green mottle mosaic virus (CGMMV) was detected in September 2014 in the Northern Territory, Australia, and declared a quarantine pest. Delimiting surveys were initiated for all cucurbit growing areas in the Northern Territory. In October 2014, Australia introduced emergency measures to mitigate the risk of any further introductions of CGMMV into Australia. Although there have been several subsequent incidents of CGMMV in Australia, including detections in Queensland (Business Queensland 2019; Department of Agriculture 2019; Dombrovsky, Tran-Nguyen & Jones 2017), in New South Wales (NSW DPI 2020a, b), in Western Australia (DAWR 2016a; DPIRD 2017; Kehoe et al. 2022) and in South Australia (Meffin 2020; PIRSA 2019), substantial resources are being invested in its eradication, containment and management, as appropriate. Therefore, CGMMV is considered under official control and continues to be a quarantine pest for Australia.

CGMMV belongs to the genus *Tobamovirus* in the family Virgaviridae (Adams, Antoniw & Kreuze 2009). The virus was first described in the 1930s in cucumber and was named Cucumber virus 3 and Cucumber virus 4 (Ainsworth 1935; Ugaki et al. 1991). CGMMV is a rod-shaped virus and contains a single-stranded RNA genome (Hollings, Komuro & Tochihara 1975; Lecoq & Desbiez 2012).

Many strains and isolates of CGMMV have been reported in the literature. Different authors have described CGMMV strains based on geographic distribution, host range, symptoms on natural host plants, serological and molecular methods, or by differential responses on indicator plants such as *Chenopodium amaranticolor* and *Datura stramonium* (Antignus et al. 2001; Boubourakas et al. 2004; Hollings, Komuro & Tochihara 1975). Some isolates formerly classified as strains of CGMMV are now accepted as being separate virus species. For instance, Yodo strain (CGMMV-Y) and Cucumber strain (CGMMV-C or CGMMV-Cu) were both previously considered to be strains of CGMMV, but are now considered to be strains of *Kyuri green mottle mosaic virus* (KGMMV) (Antignus et al. 2001; Varveri, Vassilakos & Bem 2002).

CGMMV was first reported in the United Kingdom in the 1930s (Ainsworth 1935; Ugaki et al. 1991). Since then, CGMMV has spread among cucurbit crops worldwide (Reingold et al. 2015) and is now reported to occur on most continents and in over 30 countries (CABI 2023).

The host range of CGMMV includes many species within the Cucurbitaceae family including hosts of economic importance such as watermelon (*Citrullus lanatus*), melon (*Cucumis melo*), cucumber (*Cucumis sativus*), pumpkin (*Cucurbita maxima* and *Cucurbita moschata*) and zucchini (*Cucurbita pepo*) (Dombrovsky, Tran-Nguyen & Jones 2017; Hollings, Komuro & Tochihara 1975). Weed species within the Cucurbitaceae, Apiaceae, Boraginaceae, Lamiaceae, Solanaceae, Amaranthaceae, Chenopodiaceae, Portulacaceae and Euphorbiaceae families have also been identified as natural hosts of CGMMV (Dombrovsky, Tran-Nguyen & Jones 2017).

CGMMV can cause a range of symptoms in host plants but may also infect plants asymptomatically. In cucurbits, CGMMV symptoms typically include leaf mottling, mosaic symptoms on the leaves and fruit mottling or distortion (Reingold et al. 2015). The virus may also symptomatically infect some non-cucurbit crops. For instance, *Heracleum moellendorfii* (Apiaceae) plants naturally infected with CGMMV have shown leaf mottling and mosaic symptoms (Cho, Kim & Jeon 2015). CGMMV symptoms may vary with host tissue type, growth stage, virus isolate, strain, season, host and environmental conditions (ASTA 2014).

CGMMV has been assessed previously in the pest risk analysis for CGMMV (DAWR 2017b) and the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020). In those policies, the unrestricted risk estimate for CGMMV was assessed as Moderate, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for CGMMV on the cucurbitaceous seeds for sowing pathway.

However, differences in the commodity, pest prevalence, end use and commercial production practices between the pathways assessed previously and the fresh oriental melon and rockmelon fruit from Korea pathway make it necessary to reassess the likelihoods of importation and distribution of CGMMV associated with the oriental melon and rockmelon fruit for human consumption from Korea pathway.

The likelihoods of establishment and spread of CGMMV in Australia from the oriental melon and rockmelon fruit from Korea pathway have been assessed as similar to those of the previous assessments of High and Moderate respectively for the cucurbitaceous vegetable seeds for sowing pathway. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread of CGMMV in Australia are also independent of the import pathway and have been assessed as being similar to the previous assessment of Moderate. Therefore, the existing ratings for the likelihoods of establishment, spread and the rating for the overall consequence of CGMMV on previous import pathway have been adopted for the oriental melon and rockmelon fruit from Korea pathway.

In addition, the department has reviewed the latest literature—for example, Asad et al. (2022), Gullino, Albajes and Nicot (2020), Plotnikov et al. (2019) and Wang et al. (2019). No new information has been identified that would significantly change the risk ratings for establishment, spread and consequences as set out for CGMMV in the existing policy.

The risk scenario of biosecurity concern is that oriental melon and rockmelon fruit from Korea may be infected with CGMMV.

3.9.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that CGMMV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Low**.

The likelihood of importation is assessed as Low because, while CGMMV is present in Korea including in the major melon production areas, use of tested seed and seedling grafting material along with standard commercial production and packing practices would reduce the likelihood of melon fruit infected with CGMMV being exported to Australia. However, if CGMMV is present in greenhouses, asymptomatic infected fruit may be packed for export. The virus is likely to survive cool storage and transport from Korea to Australia.

The following information provides supporting evidence for this assessment.

CGMMV is known to be associated with oriental melon and rockmelon fruit and is present in Korea.

- CGMMV has been reported to naturally infect many species within the Cucurbitaceae family, including oriental melon and rockmelon (*Cucumis melo*) (CABI 2023; DAWR 2017b; Li et al. 2015; Liu et al. 2020; Park et al. 2017a; Park et al. 2011).
- CGMMV infects its cucurbit hosts systemically (Dombrovsky, Tran-Nguyen & Jones 2017). Thus, all plant tissues, including fruit and seeds, may contain the virus.
- CGMMV is known to be present in melon production areas of Korea (Park et al. 2017a; Park et al. 2011).
  - A study of virus diseases of oriental melon in the Seongju area of Korea indicated that CGMMV was the most prevalent virus in the region (Park et al. 2011).
  - More recently, CGMMV has been isolated from leaf samples of symptomatic melon plants in Seongju-gun and Chilgok-gun (Gyeongsangbuk-do, Korea) (Park et al. 2017a).
  - Positive CGMMV results from Gyeongsangbuk-do, Korea, where over 90% of melon production occurs, suggests that CGMMV may be associated with melons exported to Australia.

Standard commercial production and packing practices would greatly reduce the likelihood of melon fruit infected with CGMMV being exported to Australia.

- CGMMV is a regulated non-quarantine pest in Korea. Seed testing to verify freedom from this virus is required for all imported Cucurbitaceae seeds (APQA 2021).
- Standard pre-planting and production practices for Korean oriental melon and rockmelon fruit such as the use of greenhouse hygiene, sterile soil, tested seed and clean seedling material for grafting (APQA 2018, 2021), would greatly reduce the risk of CGMMV in the greenhouses and thus reduce the likelihood of CGMMV occurring on greenhouse-grown fruit for export.
- Grafting is a common practice used for oriental melon in Korea. Grafting on resistant rootstocks has proved to be very efficient for protecting melon from soil-borne viruses, such as CGMMV (Lecoq & Katis 2014).
- Melon fruit infected with CGMMV develop different degrees of malformation, mottling and surface netting (Dombrovsky, Tran-Nguyen & Jones 2017). Any fruit showing visible signs of infection would be excluded at harvest or during the grading and packing process.
- Integrated disease management strategies used to control CGMMV mainly consist of diverse hygiene measures, but can also include cultural, biological and host resistance measures (Dombrovsky, Tran-Nguyen & Jones 2017). Practices implemented in Korea include the use of CGMMV-free seeds, disinfection of equipment, tools and clothes, and strict control on the movement of potentially infected material from affected greenhouses (APQA 2021).

If CGMMV were to contaminate a greenhouse in Korea, it is possible that asymptomatic infected fruit could escape detection during standard commercial harvesting and packing practices and be packed for export.

- Symptom development in CGMMV-infected cucurbit plants is affected by environmental conditions, plant growth stage at time of infection and viral strain. Infection at early growth stages induces more severe disease symptoms. It is possible that plants infected at later stages may not show any symptoms (Dombrovsky, Tran-Nguyen & Jones 2017).

- Infected fruit do not always show symptoms (ASTA 2014; Crespo et al. 2017). In some cases, fruit may be internally discoloured or necrotic but show no external symptoms.

CGMMV could survive cool storage and transport.

- Transport and storage of melons is done under controlled conditions, with an average temperature of 4.5°C to 10°C and an average relative humidity of 90–95% for oriental melons, and 10°C with an average relative humidity of 85–90% for rockmelons (APQA 2021). These conditions are not expected to affect the viability of CGMMV.
- CGMMV is likely to survive during cool storage and transport, since CGMMV particles are very stable (Dombrovsky, Tran-Nguyen & Jones 2017). Hollings, Komuro and Tochihara (1975) reported that CGMMV can retain nearly all serological activity at 2°C for at least 6 years.

For the reasons outlined, the likelihood that CGMMV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Low.

Likelihood of distribution

The likelihood that CGMMV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as: **Low**.

The likelihood of distribution is assessed as Low because melon fruit from Korea are intended for human consumption and most fruit, other than the rind and seeds of the fruit, will be consumed. Fruit waste, including rind, seeds and rotten fruit, is likely to be discarded into managed waste systems. Small quantities of melon fruit waste may be discarded in a variety of urban, rural and natural environments, including in domestic compost. Due to the range of known hosts, the end use and the seed transmission rates there will be limited opportunity for CGMMV to be transmitted to a new host in Australia.

The following information provides supporting evidence for this assessment.

Oriental melon and rockmelon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Infected melon fruit showing symptoms of CGMMV infection are likely to be removed from distribution, but some asymptomatic fruit and fruit with mild symptoms may be distributed and sold.

- Imported melon fruit will likely be distributed throughout Australia via the wholesale and retail trade for sale for human consumption. The major population centres are likely to receive most of the imported fruit.
- Packed oriental melon and rockmelon fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of CGMMV infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported melon fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some fruit infected with CGMMV may not show obvious symptoms and therefore may be sold to consumers.

Some oriental melon and rockmelon fruit waste, including seeds, infected with CGMMV may be discarded into the environment near suitable host plants or in areas where melon seeds could germinate, and the virus could be transmitted to plants germinating from these seeds.

- Melon fruit from Korea are intended for human consumption and most fruit, other than the rind and seeds of the fruit, will be consumed. Any fruit waste, including rind, seeds and rotten fruit, is likely to be discarded into managed waste systems. Potential exposure to suitable host plants or germination of infected seeds from waste discarded in this way is likely to be negligible.
- However, individual consumers might discard small quantities of oriental melon and rockmelon fruit waste in a variety of environments, mainly home gardens. Some of this waste could be discarded near suitable host plants, including household or wild host plants or in areas where melon seeds could germinate.
- The host range of CGMMV includes many species within the Cucurbitaceae family including hosts of economic importance such as watermelon (*Citrullus lanatus*), melon (*Cucumis melo*), cucumber (*Cucumis sativus*), pumpkin (*Cucurbita maxima* and *Cucurbita moschata*), and zucchini (*Cucurbita pepo*) which are widely grown across Australia (Dombrovsky, Tran-Nguyen & Jones 2017; Hollings, Komuro & Tochihara 1975). Many weed species have also been identified as natural hosts (Boubourakas et al. 2004; Cho, Kim & Jeon 2015; Dombrovsky, Tran-Nguyen & Jones 2017).

CGMMV could be transmitted to plants germinating from infected seeds discarded with melon fruit waste.

- Seeds from fruit waste disposed of in residential gardens may germinate and grow as volunteer plants. These volunteer plants would become the new hosts. However, several factors affect the germination of melon seeds, one being temperature; melon seeds require high temperatures for successful germination, the optimum range being 25°C to 30°C. Melon germination can sharply decline from almost 100% to zero when the temperatures are below the optimum (Edelstein & Nerson 2005).
- CGMMV has been reported to be seed-borne in melon, but the seed-to-seedling transmission rate is likely to be very low (Dombrovsky, Tran-Nguyen & Jones 2017). Transmission rates from 0.1–2.83% have been reported (Dombrovsky, Tran-Nguyen & Jones 2017; Reingold et al. 2015; Reingold et al. 2016; Wang et al. 2019).
- In addition, a number of other factors would significantly reduce the likelihood of the virus being transmitted this way:
  - Not all seeds in infected melon fruit waste would contain or be contaminated with CGMMV (Reingold et al. 2016; Wu et al. 2011).
  - Only a small number of contaminated seeds from discarded melon fruit waste is expected to germinate and produce seedlings.
  - Furthermore, survival of infected seedlings is expected to be limited. If infected plants do emerge from melon fruit waste, they are likely to be unthrifty, and unlikely to initiate further virus transmission. It is thus considered unlikely that infection could be sustained over multiple seasons from such a source.

CGMMV could be transmitted from infected melon fruit to a new host mechanically.

- CGMMV is highly stable and can remain infectious on contaminated surfaces for long periods (Dombrovsky, Tran-Nguyen & Jones 2017). The virus is likely to remain viable for a significant period of time in/on melon fruit.

- CGMMV can be effectively transmitted by mechanical means such as hands, clothing and tools (in commercial production with intensive handling) (Dombrovsky, Tran-Nguyen & Jones 2017).
- Handling of infected fruit could contaminate hands, clothing or equipment with the virus. If these were then to come into contact with host plants in residential gardens, there is a small chance that the plants could become infected.
- Transmission of CGMMV can occur through physical contact with infected plant material or debris (Broadbent & Fletcher 1963; Choi 2001; Reingold et al. 2015). However, transfer of the virus via physical contact between oriental melon and rockmelon fruit waste and CGMMV host plants is very unlikely.
- Transmission of CGMMV by insects feeding on discarded melon fruit waste and moving to susceptible host plants is very unlikely.
  - Rao and Varma (1984) reported that cucumber leaf beetles (*Raphidopalpa foveicollis*) are potential vectors of CGMMV; in their transmission studies, cucumber leaf beetles transmitted CGMMV directly to 10% of tested plants.
  - No CGMMV transmission was observed in trials using aphids (*Aphis gossypii* and *Myzus persicae*) and the cucumber leaf beetle (*Aulacophora femoralis*) as candidate vectors (Hollings, Komuro & Tochihara 1975).
  - Invertebrates feeding on discarded melon fruit waste will mostly be detritivores and are unlikely to move onto live plants.

It is unlikely that CGMMV could be transmitted to a host plant through the use of compost contaminated with CGMMV.

- Melon fruit waste can be composted as commercially composted food waste (municipal green waste bins) or as domestic garden compost. If infected compost is moved to a suitable host plant, there is a small chance that the plant could become infected.
- High temperature (72°C for 3 days) in the compost pile has been shown to eliminate/inactivate CGMMV (Avgelis & Manios 1992; Mandal et al. 2008).
- Commercially composted food waste is expected to reach temperatures which would inactivate the virus. Thus, potential exposure to suitable host plants from commercially composted food waste is likely to be negligible.
- Compost produced in residential gardens may not reach the appropriate temperature to inactivate CGMMV. However, the composting process is likely to reduce the level of virus contamination.

For the reasons outlined, the likelihood that CGMMV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as Low.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules in Table A.2.

The likelihood that CGMMV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea and be distributed in a viable state to a susceptible host is assessed as: **Very Low**.

3.9.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for CGMMV are independent of the import pathway and are considered similar to those in previously assessed commodities.

Based on the existing pest risk analysis for CGMMV (DAWR 2017b) and the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020), the likelihoods of establishment and spread are assessed as **High** and **Moderate**, respectively.

3.9.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the individual likelihoods of entry, establishment and spread using the matrix of rules in Table A.2.

The overall likelihood that CGMMV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as: **Very Low**.

3.9.4 Consequences

The potential consequences of the entry, establishment and spread of CGMMV in Australia are similar to those in the pest risk analysis for CGMMV (DAWR 2017b) and the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020). The overall consequences in the previous assessments were assessed as Moderate. The overall consequences for CGMMV on the oriental melon and rockmelon fruit from Korea pathway is also assessed as **Moderate**.

3.9.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Cucumber green mottle mosaic virus*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The URE for CGMMV on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Very Low**, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for CGMMV on this pathway.

3.10 MNSV

***Melon necrotic spot virus* (EP)**

Melon necrotic spot virus (MNSV) has been detected sporadically in Australia, with outbreaks in New South Wales in 2012, Victoria in 2016 and Queensland in 2018 (Business Queensland 2021b; IPPC 2016). Unlike detections in other parts of the world, MNSV infection has not persisted after detection in Australia (Business Queensland 2021b). Given the isolated occurrences of the virus and the continuing measures to prevent its spread, MNSV remains under official control and is considered to be a quarantine pest for Australia.

MNSV is a soil- and water-borne seed-transmitted virus in the genus *Gammacarmovirus*. MNSV infects members of the Cucurbitaceae family, and has been reported in melon (*Cucumis melo*), cucumber (*C. sativa*), summer squash (*Cucurbita pepo*), watermelon (*Citrullus lanatus*), fluted gourd (*Telfairia occidentalis*) and calabash (*Lagenaria siceraria*) (Ayo-John et al. 2014; Kishi 1966; Koç, Fidan & Baloğlu 2014; Lecoq & Desbiez 2012; Tomlinson & Thomas 1986). It is considered to be a vector-assisted seed transmissible (VAST) virus, as it is generally transmitted by a fungal vector, *Olpidium bornovanus* (previously *Olpidium radicale*), but may sometimes cause low rates of infection in the vector's absence (Campbell, Wipf-Scheibel & Lecoq 1996; Lecoq & Desbiez 2012). MNSV may remain infective in seeds or in plant debris in the soil (Lecoq & Desbiez 2012) and can spread through movement of soil, water, or infected plant material.

MNSV mainly occurs in greenhouses, but may also occur in field crops (Hibi & Furuki 1985; Stanghellini, Mathews & Misaghi 2010). It was first recorded in Japan on muskmelon plants with necrotic lesions on the leaves (Kishi 1966) and is now reported in Europe, USA, Latin America, Africa and Asia (Avgelis 1989; Gonzalez-Garza et al. 1979; Herrera, Cebrián & Jordá 2006; Kwak et al. 2015; Ruiz et al. 2016; Yakoubi et al. 2008). In Korea, it was first reported in 2001 on muskmelons grown on rockwool under cover in plastic housing (Choi, Kim & Kim 2003). Within 5 to 6 years of the first report in Korea, it had spread throughout all the major melon-cultivating regions of the country (Kwak et al. 2015).

MNSV infection is generally systemic in *C. melo,* but this is not true for all hosts (Gonzalez-Garza et al. 1979; Hibi & Furuki 1985). Symptoms and susceptibility to systemic infection depend on the strain of virus and the host species, cultivar or breeding line (Gonzalez-Garza et al. 1979; Hibi & Furuki 1985; Kubo et al. 2005). Symptom expression also depends on temperature and is more prevalent in cool conditions (Kido et al. 2008; Lecoq & Desbiez 2012).

MNSV is characterised by necrotic spots and streaks on the leaves, stems and fruit, sometimes leading to the collapse and death of the plant (Choi, Kim & Kim 2003; Kishi 1966; Kwak et al. 2015; Lecoq & Desbiez 2012; Ruiz et al. 2016). Where the plants survive, there is severe reduction in yield (Hibi & Furuki 1985). Infected fruit may be small and misshapen with spotted rind, and may have reduced sugar content (Hibi & Furuki 1985; Lecoq & Desbiez 2012).

The virus can be present in any plant part, including the fruit (Hibi & Furuki 1985). Transmission may be by seed, usually facilitated by the soil-borne fungal vector *Olpidium bornovanus,* or by mechanical means, for instance through human activities such as pruning or grafting. The virus particles can be transported along with vector fungal spores through soil or water flowing between plants (Gosalvez et al. 2003). It is uncertain whether surface contact between leaves can spread the disease (Choi, Kim & Kim 2003; Lecoq & Desbiez 2012).

The vector, *O. bornovanus,* is a soil- or water-borne fungus that inhabits the roots of plants (Gosalvez et al. 2003; Hibi & Furuki 1985; Ohki et al. 2008; Stanghellini, Mathews & Misaghi 2010). It infects cucurbits, with different fungal strains associated with particular groups within the Cucurbitaceae, such as melon, cucumber and squash (Stanghellini, Mathews & Misaghi 2010). Transmission by seed occurs when seeds produced by plants infected with the virus come into contact with soil or other substrate (for example rockwool) where the zoospores of the fungal vector are present (Campbell, Wipf-Scheibel & Lecoq 1996). The virus particles are released from the seed coat and bind to the surface of the motile fungal zoospores. When the zoospore penetrates the plant root tissue the virus is transmitted to the plant (Lecoq & Desbiez 2012), starting a new cycle of infection.

Once a plant acquires MNSV, the virus remains for the duration of the plant's life. If a plant systemically infected with MNSV bears fruit, the seeds may carry the virus. The virus is usually on the outer surface of the seed, but it can also be carried within the seedcoat (Campbell, Wipf-Scheibel & Lecoq 1996). Symptoms of seed transmitted infection may take at least 60 days to appear (Coudriet, Kishaba & Carroll 1979; Gonzalez-Garza et al. 1979).

MNSV can be retained in a viable state in the resting spores of *O. bornovanus* which may persist for several years in soil or in dried root debris (Lecoq & Desbiez 2012; Tomlinson & Thomas 1986).

MNSV has been assessed previously in the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020). In that review, the unrestricted risk estimate for MNSV was assessed as Moderate, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for MNSV on that pathway.

However, differences in commodity, pest prevalence, end use and commercial production practices between the cucurbitaceous vegetable seeds for sowing pathway and the Oriental melon and rockmelon fruit from Korea pathway make it necessary to re-assess the likelihood of importation and distribution of MNSV associated with the oriental melon and rockmelon fruit from Korea pathway.

The likelihoods of establishment and spread of MNSV in Australia from the oriental melon and rockmelon fruit from Korea pathway have been assessed as similar to those of the previous assessments of High and Moderate respectively for the cucurbitaceous vegetable seeds for sowing pathway. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread of MNSV in Australia are also independent of the import pathway and have been assessed as being similar to the previous assessments of Moderate. Therefore, the existing ratings for the likelihoods of establishment and spread, and the rating for the overall consequence of MNSV on previous import pathways have been adopted for the oriental and rockmelon fruit from Korea pathway.

In addition, the department has reviewed the latest literature—for example, Gullino, Albajes and Nicot (2020), Mackie et al. (2020) and Yu et al. (2016). No new information has been identified that would significantly change the risk ratings for establishment, spread and consequences as set out for MNSV in the existing policy.

The risk scenario of biosecurity concern is that oriental melon and rockmelon fruit from Korea may be infected with MNSV.

3.10.1 Likelihood of entry

The likelihood of entry is considered in 2 parts: the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that MNSV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as: **Low**.

The likelihood of importation is assessed as Low because, while MNSV is present in all the major melon-cultivating regions in Korea, standard commercial production and packing practices such as using sterile soil, tested seeds and resistant root stock would greatly reduce the likelihood of melon fruit infected with MNSV being exported to Australia. Although very unlikely, if a plant is infected by the virus, infected fruit may be packed for export as the virus can be present in the plant for some time before visible symptoms appear. The virus is likely to survive refrigerated storage and transport from Korea to Australia.

The following information provides supporting evidence for this assessment.

MNSV is associated with oriental melon and rockmelon fruit and is widespread in Korea.

- MNSV infects members of the Cucurbitaceae family, including oriental melon and rockmelon (Choi, Kim & Kim 2003; Gonzalez-Garza et al. 1979; Kishi 1966; Lecoq & Desbiez 2012).
- In oriental melon and rockmelon, the infection is generally systemic and may be present in fruit (Gonzalez-Garza et al. 1979; Hibi & Furuki 1985; Lecoq & Desbiez 2012).
- MNSV has been recorded in all the major melon-cultivating regions in Korea (Choi, Kim & Kim 2003; Kwak et al. 2015).

Standard commercial production and packing practices would greatly reduce the likelihood of melon fruit infected with MNSV being exported to Australia.

- Standard pre-planting and production practices for melon fruit in Korea, such as the use of sterile soil and tested seed (APQA 2021; NPQS 2007), would greatly reduce the likelihood of MNSV occurring on greenhouse-grown melon fruit for export (APQA 2018).
- Grafting is a common practice used for oriental melon in Korea (APQA 2021). Grafting on resistant rootstock (such as *Lagenaria siceraria* or various *Cucurbita* species, including interspecific crosses between *C. moschata* and *C. maxima* and resistant melons) is commonly used to prevent soil-borne infection by MNSV (Lecoq & Katis 2014).
- Rockmelons are grown on trellises, and the fruit do not touch the ground, whereas oriental melons are grown on the ground, with plastic sheeting used to prevent direct contact between fruit and the soil (APQA 2021). This reduces the likelihood of MNSV coming into contact with the fruit if the pathogen is present in the soil.
- Infection is usually evident first on leaves and stems before visible symptoms appear on the fruit or the plant collapses (Avgelis 1989; Choi, Kim & Kim 2003; Kwak et al. 2015). Therefore, the infection is likely to be detected through surveillance/monitoring programs used in Korean greenhouses prior to harvesting stage.

- Systemically infected plants often produce no or low-quality fruit (Kido et al. 2008). Any fruit showing visible signs of infection such as necrosis, malformation or stunted growth would be excluded at harvest or during the grading and packing process (APQA 2018; NPQS 2007).

If MNSV were to contaminate a greenhouse in Korea, it is possible that asymptomatic infected fruit could escape detection during standard commercial harvesting and packing practices and be packed for export.

- Symptom development in MNSV-infected oriental melon and rockmelon can be affected by temperature (Kido et al. 2008), breeding line or cultivar, and age of the plant. Symptoms are more likely to be visible in older plants and at cooler temperatures (Gonzalez-Garza et al. 1979; Lecoq & Desbiez 2012). It is possible that infected plants under certain conditions may not show any symptoms.
- In laboratory conditions, plants infected with MNSV by seed transmission can take 25–60 days to show symptoms (Campbell, Wipf-Scheibel & Lecoq 1996; Coudriet, Kishaba & Carroll 1979). Fruit infected shortly prior to harvesting may not have developed visible symptoms. Therefore, fruit carrying latent infections may not be detected during harvest or packing practices.

MNSV could survive cool storage and transport.

- Melons are transported and stored under controlled conditions, with an average temperature of 4.5°C to 10°C and an average relative humidity of 90–95% for oriental melons, and 10°C with an average relative humidity of 85–90% for rockmelons (APQA 2021). These conditions are not expected to affect the viability of MNSV.
- MNSV particles are very stable, and they can remain infective in the sap of *C. melo* plants for up to 32 days at room temperature and for 131 days at 4°C (Herrera-Vásquez et al. 2009; Hibi & Furuki 1985).

For the reasons outlined, the likelihood that MNSV will arrive in Australia in a viable state with the importation of oriental melon and rockmelon fruit from Korea is assessed as Low.

Likelihood of distribution

The likelihood that MNSV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as: **Very Low**.

The likelihood of distribution is assessed as Very Low because, while infected melon seeds discarded into the environment with melon fruit waste by consumers could germinate and give rise to new infected host plants, seed transmission is relatively unlikely in the absence of the fungal vector. However, the distribution of the fungal vector in Australia is not well understood. When the fungal vector is present, it would likely occur in areas where potential cucurbit host plants are, or have been, grown. Mechanical transmission from infected fruit waste to a potential host plant through direct contact, contaminated hands, clothing or equipment, or feeding insects, is very unlikely.

The following information provides supporting evidence for this assessment.

Oriental melon and rockmelon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Infected fruit showing symptoms of MNSV infection are likely to be removed from distribution, but some asymptomatic fruit may be distributed and sold.

- Imported melon fruit will likely be distributed throughout Australia via the wholesale and retail trade for sale for human consumption. The major population centres are likely to receive most of the imported fruit.
- Packed oriental melon and rockmelon fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of MNSV infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported melon fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some melon fruit infected with MNSV may not show symptoms and therefore may be sold to consumers.

Some melon fruit waste, including seeds, infected with MNSV may be discarded into the environment near suitable host plants or in areas where melon seeds could germinate.

- Melon fruit from Korea are intended for human consumption and most fruit, other than the rind and seeds of the fruit, will be consumed. Any fruit waste, including rind, seeds and rotten fruit, is likely to be discarded into managed waste systems. Potential exposure to suitable host plants or germination of infected seeds from waste discarded in this way is likely to be negligible.
- However, individual consumers may discard small quantities of melon fruit waste in a variety of urban environments, mainly home gardens. Some of this waste could be discarded near suitable host plants, including household or wild host plants or in areas where melon seeds could germinate.

It is unlikely that MNSV will be transmitted to plants germinating from infected seeds discarded with oriental melon and rockmelon fruit waste.

- Seeds from fruit waste disposed of in residential gardens may germinate and grow as volunteer plants. These volunteer plants would become the new hosts. However, several factors affect the germination of melon seeds, one being temperature; melon seeds require high temperatures for successful germination, the optimum range being 25°C to 30°C. Melon germination can sharply decline from almost 100% to zero when the temperatures are below the optimum (Edelstein & Nerson 2005).
- Seeds from fruit waste disposed of in residential gardens may germinate and grow as volunteer plants. These volunteer plants would potentially become the new hosts.
- Transmission of MNSV from infected seeds to plants germinating from these seeds is relatively unlikely if the fungal vector is not present in the soil.
  - The fungal vector is associated with the root tissue of cucurbit plants and would therefore not be imported with the melon fruit (Gosalvez et al. 2003; Hibi & Furuki 1985; Ohki et al. 2008; Stanghellini, Mathews & Misaghi 2010).
  - The distribution and prevalence of the fungal vector in Australia are unknown. However, if present in Australia, the fungal vector is only expected to be present in soil where cucurbits are/have been grown.
  - Seed-to-seedling transmission rates of MNSV are very low in the absence of the fungal vector even under experimental conditions. Seeds derived from systemically infected

melon plants were sown in 360 containers (10 seeds per container) and half of the containers were inoculated with *O. bornovanus* zoospores. When the seedling roots were tested 16–17 days after planting, the virus was detected in 37% of pots containing *O. bornovanus* zoospores, but in fewer than 2% of the vector-free containers (Campbell, Wipf-Scheibel & Lecoq 1996).

- The distribution and prevalence of *O. bornovanus* in Australia are not well understood.
  - Its presence was suspected at the MNSV incursion site in Victoria (Agriculture Victoria 2018), and has been recently confirmed from soil sampled from MNSV-contaminated sites in Australia (Mackie et al. 2020). There are no other published records of the fungus occurring in Australia. As it is an obligatory, root-inhabiting parasite that is only associated with the Cucurbitaceae family (Stanghellini, Mathews & Misaghi 2010) it is not likely to be widely present in the soil unless potential cucurbit hosts have previously grown in the area.
- In addition, a number of other factors would significantly reduce the likelihood of the virus being transmitted this way:
  - Not all seeds in infected melon fruit waste would be contaminated with MNSV.
  - Only a small number of contaminated seeds from discarded melon fruit waste is expected to germinate and produce seedlings.

It is unlikely that MNSV will be mechanically transmitted from infected oriental melon and rockmelon fruit to a new host.

- The virus may remain viable for a significant period of time in or on melon fruit. It can remain infectious in melon sap for 9–32 days at room temperature, and 131 days at 4°C (Hibi & Furuki 1985).
- MNSV may be transmitted to a new host via hands, clothing or tools contaminated by the virus after contact with infected fruit (Lecoq & Desbiez 2012).
- Transmission of MNSV via direct contact between infected fruit waste and MNSV host plants is very unlikely.
- Transmission of MSNV by insects feeding on discarded melon fruit waste and moving to a susceptible part of a host is very unlikely.
  - A laboratory study by Coudriet, Kishaba and Carroll (1979) demonstrated that a small percentage of the cucumber beetles *Diabrotica undecimpunctata undecimpunctata* and *D. balteata* (8% and 13%, respectively) transmitted the virus successfully between casaba melon seedlings (*Cucumis melo* var. *inodorus*). These beetles are not present in Australia, but other insects with similar feeding habits may be potential vectors. However, no other invertebrates have been recorded as potential vectors of MNSV to date. Thrips and the melon aphid *Aphis gossypii* have been tested as potential vectors of MNSV but have not been found to transmit the virus (Coudriet, Kishaba & Carroll 1979; Kishi 1966).
- Invertebrates feeding on discarded melon fruit waste will mostly be detritivores, and are unlikely to move from fruit waste onto live cucurbit plants.

It is unlikely that MNSV will be transmitted to a host plant through the use of compost contaminated with the virus.

- Melon fruit waste can be composted as commercially composted food waste (municipal green waste bins) or as domestic garden compost. If infected compost is moved to a suitable host plant, there is a small chance that the plant could become infected.

- Commercially composted food waste is expected to reach temperatures which would inactivate the virus.
  - MNSV is no longer infective after 10 minutes at 65°C (Gonzalez-Garza et al. 1979; Kishi 1966). Composting in a heap that reached maximum temperatures of 61.9°C to 73.8°C killed both MNSV and *Olpidium bornovanus* in infected melon root residues (Aguilar et al. 2010). Thus, potential exposure to suitable host plants from commercially composted food waste is likely to be negligible.
- Compost produced in residential gardens may not reach the appropriate temperature to inactivate MNSV. However, the composting process is likely to reduce the level of virus contamination.

For the reasons outlined, the likelihood that MNSV will be distributed within Australia in a viable state as a result of processing, sale or disposal of oriental melon and rockmelon fruit from Korea, and subsequently transfer to a susceptible part of a host is assessed as Very Low.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules in Table A.2.

The likelihood that MNSV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea and be distributed in a viable state to a susceptible part of a host is assessed as: **Very Low**.

3.10.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for MNSV are independent of the import pathway and are considered similar to those in previously assessed commodities.

Based on the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020), the likelihoods of establishment and spread are assessed as **High** and **Moderate**, respectively.

3.10.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the individual likelihoods of entry, establishment and spread using the matrix of rules in Table A.2.

The overall likelihood that MNSV will enter Australia as a result of trade in oriental melon and rockmelon fruit from Korea, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as: **Very Low.**

3.10.4 Consequences

The potential consequences of the entry, establishment and spread of MNSV in Australia are similar to those in the previous assessments of MNSV in the review of import conditions for cucurbitaceous vegetable seeds for sowing (DAWE 2020). The overall consequences in the previous assessments were assessed as Moderate. The overall consequences for MNSV on the oriental melon and rockmelon fruit from Korea pathway is also assessed as **Moderate**.

3.10.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the overall likelihood of entry, establishment and spread with the outcome of overall consequences. The likelihood and consequences are combined using the risk estimation matrix shown in Table A.4.

Unrestricted risk estimate for *Melon necrotic spot virus*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The URE for MNSV on the oriental melon and rockmelon fruit from Korea pathway is assessed as **Very Low**, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for MNSV on this pathway.

3.11 Pest risk assessment conclusions

Likelihood ratings and the consequences estimate for individual quarantine pests and regulated articles are set out in Table 3.5.

Of the 10 quarantine pests and regulated articles for which a further pest risk assessment was conducted:

- The URE for 5 pests were assessed as not achieving the ALOP for Australia, and thus specific risk management measures are required for these pests on this pathway. These pests are:
  - pumpkin fruit fly (*Zeugodacus depressus*)
  - Eurasian flower thrips (*Frankliniella intonsa*)
  - western flower thrips (*Frankliniella occidentalis*)
  - melon thrips (*Thrips palmi*)
  - Kanzawa spider mite (*Tetranychus kanzawai*)
- The 3 quarantine thrips species (*F. intonsa*, *F. occidentalis* and *T. palmi*) were also identified as regulated articles for Australia due to their potential to introduce emerging quarantine orthotospoviruses into Australia. The URE for quarantine orthotospoviruses transmitted by thrips was assessed in the thrips Group PRA (DAWR 2017a) as not achieving the ALOP for Australia, and thus specific risk management measures are required for these regulated articles on this pathway.

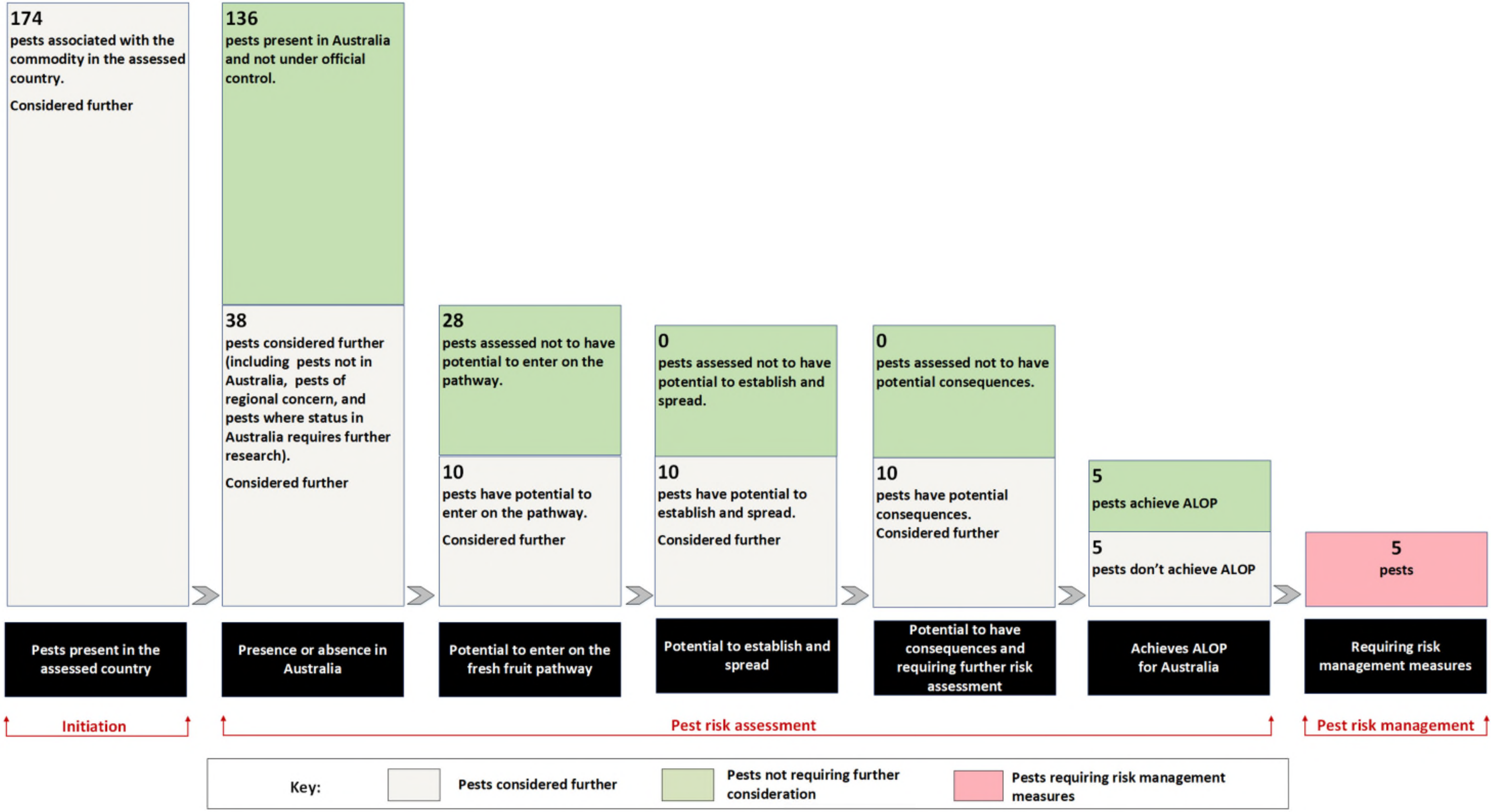
An overview of the decision process at the initiation, pest categorisation and pest risk assessment stages of the pest risk analysis for oriental melon and rockmelon fruit from Korea is presented in Figure 3.2.

Table 3.5 Pest risk assessment conclusions for pests, and pest groups, associated with the pathway of oriental melon and rockmelon fruit from Korea

Pest name	Likelihood of						Consequences	URE
	Entry			Establishment	Spread	EES		
	Importation	Distribution	**Overall**					
Fruit flies [Diptera: Tephritidae]								
Zeugodacus depressus	Moderate	Moderate	**Low**	Moderate	Moderate	Low	Moderate	**Low**
Thrips [Thysanoptera: Thripidae]								
Frankliniella intonsa (GP) **a**	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Frankliniella occidentalis (GP, NT) **a**	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Thrips palmi (GP, SA, WA) **a**	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Spider mites [Trombidiformes: Tetranychidae]								
Tetranychus kanzawai (EP, WA)	Low	Moderate	**Low**	High	Moderate	Low	Moderate	**Low**
Late blight [Peronosporales: Peronosporaceae]								
Phytophthora melonis	Low	Very Low	**Very Low**	Moderate	Moderate	Very Low	Low	**Negligible**
Tobamoviruses [Virgaviridae: Tobamovirus]								
Cucumber fruit mottle mosaic virus (EP)	Low	Very Low	**Very Low**	High	Moderate	Very Low	Moderate	**Very Low**
Cucumber green mottle mosaic virus (EP)	Low	Low	**Very Low**	High	Moderate	Very Low	Moderate	**Very Low**
Kyuri green mottle mosaic virus (EP)	Low	Very Low	**Very Low**	High	Moderate	Very Low	Moderate	**Very Low**
Gammacarmoviruses [Procedovirinae: Gammacarmovirus]								
Melon necrotic spot virus (EP)	Low	Very Low	**Very Low**	High	Moderate	Very Low	Moderate	**Very Low**
Orthotospoviruses [Bunyavirales: Tospoviridae] vectored by *Frankliniella intonsa*, *Frankliniella occidentalis* and *Thrips palmi* a								
Listed in the thrips group PRA (GP)	Moderate	Moderate	**Low**	Moderate	High	Low	Moderate	**Low**

a: Thrips species that is also identified as a regulated article for Australia as it vectors emerging quarantine orthotospoviruses. This table also presents the risk estimates for these viruses from the thrips Group PRA (DAWR 2017a). **EP:** Species has been assessed previously and import policy already exists. **GP:** Species has been assessed previously in a Group PRA (thrips Group PRA) and the Group PRA has been applied. **WA:** Regional quarantine pest for Western Australia. **SA:** Regional quarantine pest for SA. **NT:** Regional quarantine pest for the Northern Territory. **EES:** Overall likelihood of entry, establishment and spread. **URE:** Unrestricted risk estimate.

Figure 3.2 Overview of the PRA decision process for oriental melon and rockmelon fruit from Korea



4 Pest risk management

Pest risk management evaluates and selects options for measures for quarantine pests and regulated articles identified in Chapter 3 as having a URE that does not achieve the ALOP for Australia. This chapter recommends specific risk management measures for those quarantine pests and regulated articles (section 4.1). It also recommends an operational system for the assurance, maintenance and verification of phytosanitary status (section 4.2). Both specific risk management measures (section 4.1) and the operational system (section 4.2) are required to reduce the risk of introduction of these quarantine pests and regulated articles to achieve the ALOP for Australia. These measures are in addition to existing commercial production practices for oriental melon and rockmelon fruit in Korea, as described in Chapter 2, as these practices have been considered in assessing the URE.

4.1 Pest risk management measures and phytosanitary procedures

This section describes the recommended risk management measures for the 5 quarantine pests (3 of which are also regulated articles) assessed, in Chapter 3, as having a URE that does not achieve the ALOP for Australia.

Historical trade and pest interception data of other similar pathways, as described in section 4.1.1, have been considered in determining the appropriate risk management measures for the importation of oriental melon and rockmelon fruit from Korea.

4.1.1 Analysis of pest interception data

Australia currently allows imports of rockmelon fruit from European countries, New Zealand and the United States of America (except Hawaii). However, there have been no imports of rockmelon fruit from these countries to date. There has been one consignment (14 tonnes) of a similar melon variety, honeydew melon (*Cucumis melo* (Inodorus group)), from the USA. No pests were detected in this consignment.

Korea has access to the Australian market for imported fresh fruit that present a similar risk pathway to melon fruit, including strawberries, capsicums, persimmons and pears.

Since import conditions for strawberries from Korea were published in January 2018, 1.3 tonnes have been imported. Of the 5 consignments of strawberries imported from Korea, only one required remedial action, due to the interception of a spider mite from an unidentified species in the genus *Tetranychus*. All other consignments were cleared at the Australian border.

Between 2013 and 2016, Korea exported 3.2 tonnes of capsicums to Australia. One consignment required remedial action following the interception of a fungal pathogen of the genus *Botrytis*. All other consignments were cleared at the Australian border.

Between 2013 and 2020 Korea exported 1,133.2 tonnes of pears to Australia. No pest species of biosecurity concern have been detected at the border in consignments of pears from Korea.

4.1.2 Risk management measures for quarantine pests and regulated articles associated with oriental melon and rockmelon fruit from Korea

Recommended specific risk management measures for the 5 quarantine pests (3 of which are also regulated articles) associated with Oriental melon and rockmelon fruit from Korea are listed in Table 4.1.

Table 4.1 Recommended risk management measures for quarantine pests and regulated articles potentially associated with oriental melon and rockmelon fruit from Korea.

Pest/pest group	Scientific name	Common name	Measures
Fruit flies [Diptera: Tephritidae]	*Zeugodacus depressus*	Pumpkin fruit fly	PFA, PFPP or PFPS **a** OR Fruit treatment considered to be effective against *Z. depressus*
Thrips [Thysanoptera: Thripidae]	*Frankliniella intonsa* (GP) **c**	Eurasian flower thrips	Pre-export visual inspection and, if found, remedial action **b**
	Frankliniella occidentalis (GP, NT) **c**	Western flower thrips	
	Thrips palmi (GP, SA, WA), **c**	Melon thrips	
Spider mites [Trombidiformes: Tetranychidae]	*Tetranychus kanzawai* (EP, WA)	Kanzawa spider mite	Pre-export visual inspection and, if found, remedial action **b**

a: PFA is pest free areas, PFPP is pest free places of production and PFPS is pest free production sites. This can include pest free place of production or pest free production sites during a limited seasonal period. **b:** Remedial action may include treatment of the consignment to ensure that the pest is no longer viable or withdrawal of the consignment from export to Australia. **c:** Thrips species that is also identified as a regulated article for Australia as it vectors emerging quarantine orthotospoviruses, assessed in the thrips Group PRA (DAWR 2017a) as posing an unrestricted risk that does not achieve the ALOP for Australia. **EP:** Species has been assessed previously and import policy already exists. **GP:** Species has been assessed previously in a Group PRA, and the Group PRA has been applied. **NT:** Regional quarantine pest for the Northern Territory. **SA**: Regional quarantine pest for South Australia. **WA:** Regional quarantine pest for Western Australia.

The Australian Government Department of Agriculture, Fisheries and Forestry (the department) recommends the following specific risk management measures for the identified quarantine pest and regulated articles:

- for *Zeugodacus depressus* (pumpkin fruit fly)
  - pest free areas, pest free places of production or pest free production sites, or
  - fruit treatment considered to be effective against pumpkin fruit fly
- for thrips species and *Tetranychus kanzawai* (Kanzawa spider mite)
  - pre-export visual inspection and, if found, remedial action.

Measures for *Zeugodacus depressus*

For *Z. depressus*, the department recommends the options of pest free areas, pest free places of production, pest free production sites or fruit treatment considered to be effective against all life stages associated with export melons, such as irradiation. The objective of each recommended measure is to reduce the risk associated with *Z. depressus* to achieve the ALOP for Australia when applied in combination with the operational system outlined in section 4.2.

Recommended measure 1: Pest free areas, pest free places of production or pest free production sites

The requirements for establishing and maintaining pest free areas are set out in ISPM 4: *Requirements for the establishment of pest free areas* (FAO 2017) and, more specifically, ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)* (FAO 2018). The requirements for establishing and maintaining pest free places of production and pest free production sites are set out in ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2016a).

1) Pest free places of production or pest free production sites (during a limited seasonal period)

The department recommends pest free places of production and pest free production sites as a suitable measure to manage *Z. depressus* during a limited seasonal period in winter and spring. A pest free place of production refers to a premises, or collection of fields/greenhouses that are operated as a single production unit (FAO 2016a), where the entire place of production is maintained as pest free. A pest free production site refers to a defined portion of a place of production, that is managed as a separate unit for phytosanitary purposes (FAO 2016a), such as one or more greenhouses within a farm that are maintained as pest free.

This assessment of acceptability of production place/site freedom is supported by biological information presented in section 3.4. This information is consistent with the principles of ISPM 10, Section 2.1.1, where factors such as a pest having a low natural spread and low rate of reproduction during a specified period (for example, seasonal absence) are taken to support production place/site freedom. The biological information is supported by extensive surveillance undertaken by APQA to confirm seasonal absence of *Z. depressus* during the production of oriental melon and rockmelon in the months proposed by Korea for export (December to May).

It is recommended that melons produced in a pest free place of production or pest free production site must be harvested, packed and exported between 1 December and 31 May, when sexually active adult *Z. depressus* activity is known to be absent.

Korea would need to verify the pest freedom of places of production and production sites consistent with ISPM 10. It is recommended that APQA (or suitably qualified personnel authorised by APQA) verify the absence of *Z. depressus* at the start of each season through the inspection of suitable traps that attract adults (for example, protein-based traps) at regular intervals (e.g., fortnightly) during the export harvest season. Traps would need to be placed inside and immediately outside the production site. The placement, design and inspection rate of traps will need to follow parameters set out and documented by APQA. Any damaged melons in a greenhouse must also be inspected for fruit fly eggs or larvae. These trapping parameters and inspection records must be made available to the department before commencement of each export season.

Sampling must occur weekly for at least 4 inspections prior to export harvest season (i.e., November) to verify freedom from *Z. depressus*, and regular inspections (e.g., fortnightly) must continue for one month after the end of the export harvest season (i.e., June). If this surveillance outside the proposed winter season continues to demonstrate the absence of sexually active adult *Z. depressus* over a sufficient number of years it may inform whether November and June could be included in the seasonal absence proposal.

APQA is required to notify the department immediately if *Z. depressus* are detected in an export pest free place of production or pest free production site prior to export harvest (November) and during the entire export production period (December to May). APQA is to take immediate action, such as suspension of certification of this pathway, pending further investigation. Exports may still be permitted under an approved treatment.

If *Z. depressus* was detected during pre-export certification inspection or on-arrival inspection, trade under the pest free place of production or pest free production site (seasonal absence) arrangement would be suspended immediately, pending the outcome of an investigation. Detection of *Z. depressus* during the export production period (December to May) would result in a review of the recognition of pest free place of production and pest free production site (seasonal absence) arrangement.

2) Pest free areas

Should Korea wish to use pest free areas as a management measure for *Z. depressus*, APQA would need to provide a detailed submission to the department. The submission must fulfil requirements as set out in ISPM 4 (FAO 2017) and ISPM 26 (FAO 2018). The submission is subject to approval by the department.

3) Pest free places of production or pest free production sites (all year round)

Should Korea wish to use secure production sites to meet the requirements for a pest free place of production or pest free production site, as a management measure for *Z. depressus* anytime throughout the year, APQA would need to provide a detailed submission to the department. The submission would need to demonstrate how the pest free place of production or pest free production site meets the requirements set out in ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2016a). The submission is subject to approval by the department.

In the event of a detection of *Z. depressus* at any given time in a pest free place of production or pest free production site, APQA would be required to notify the department immediately. Detection of *Z. depressus* in a recognised pest free place of production or pest free production site during fruit production would result in the recognition of pest freedom being suspended. Exports may still be permitted under an approved treatment.

If *Z. depressus* was detected during pre-export certification inspection or on-arrival inspection, trade under pest free area, pest free place of production or pest free production site would be suspended immediately, pending the outcome of an investigation.

Any packing house handling fruit as part of a pest free area, pest free places of production or pest free production site arrangement would require a monitoring and trapping program to verify pest absence to manage any possible post-harvest infestation. These trapping records must be made available to the department upon request.

Recommended measure 2: Fruit treatment considered to be effective against Zeugodacus depressus

Fruit treatment considered to be effective against *Z. depressus*, applied prior to export, may be used as a phytosanitary measure for *Z. depressus*.

The department considers irradiation to be an effective treatment for *Z. depressus* on the oriental melon and rockmelon fruit pathway. The requirements for using irradiation as a phytosanitary measure are set out in ISPM 18: *Guidelines for the use of irradiation as a phytosanitary measure* (FAO 2019c). Irradiation is recognised as an effective method for pest risk management when performed in approved facilities and at specific dose rates recognised as effective for target pest groups. Irradiation dose rates up to a maximum of 1000 Gy are permitted for quarantine purposes for fresh fruit and vegetables, including oriental melon and rockmelon fruit, by Food Standards Australia New Zealand (FSANZ 2017, 2021).

The department recommends a treatment schedule of 150 Gy minimum absorbed dose, consistent with ISPM 28 Annex 07: *Irradiation treatment for fruit flies of the family Tephritidae (generic)* (FAO 2021) for *Z. depressus*.

The use of irradiation as a phytosanitary measure is subject to the department's approval of the irradiation facilities identified by APQA. Should Korea wish to use irradiation as a phytosanitary measure, APQA would need to provide a submission to the department. The submission must fulfil requirements as set out in ISPM 18 (FAO 2019c).

The department recognises other treatments, such as cold, heat (e.g., vapour heat treatment) or fumigation, may also be effective treatments against *Z. depressus* on the oriental melon and rockmelon fruit pathway. The use of any such treatment option is subject to its approval by the department as an efficacious measure against *Z. depressus*. Should Korea wish to propose a treatment option, APQA would need to provide a submission, which includes suitable information to support the claimed efficacy of the treatment to manage *Z. depressus* on the oriental melon and rockmelon fruit pathway, for consideration by the department.

Measures for thrips and *Tetranychus kanzawai*

For *Frankliniella intonsa*, *F. occidentalis*, *Thrips palmi* and *Tetranychus kanzawai*, the department recommends the option of pre-export visual inspection and, if found, remedial action. The method used for visual inspection must be able to detect all life stages of these pests, for example by using visual aids such as hand lens, where necessary. The inspection should be consistent with ISPM 23: *Guidelines for inspection* (FAO 2019d) and ISPM 31: *Methodologies for sampling of consignments* (FAO 2016b) and provide a 95% level of confidence that infestation greater than 0.5% will be detected. The objective of this recommended measure is to reduce the risk associated with these pests to achieve the ALOP for Australia when applied in combination with the operational system outlined in section 4.2.

Recommended measure: Pre-export visual inspection and, if found, remedial action

All oriental melon and rockmelon fruit consignments for export to Australia must be inspected by APQA in accordance with ISPM 23 (FAO 2019d) and ISPM 31 (FAO 2016b). The inspection technique must be capable of detecting all life stages of these pests. Each consignment must be found free of thrips and *T. kanzawai*. Export consignments found to contain any of these pests must be subjected to remedial action. Remedial action may include withdrawing the consignment from export to Australia, or application of an approved treatment to ensure that the pest is no longer viable.

4.1.3 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019b), the department will consider any alternative measure recommended by APQA. Alternative measures must demonstrably manage the target pests to achieve the ALOP for Australia. Evaluation of any such measure will require a technical submission from APQA that details the recommended measure, including suitable information to support the claimed efficacy, for consideration by the department.

4.2 Operational system for the assurance, maintenance and verification of phytosanitary status

A system of operational procedures is necessary to ensure recommended specific risk management measures (section 4.1) are effectively applied, the phytosanitary status of oriental melon and rockmelon fruit from Korea is maintained, and that these can be verified.

4.2.1 A system of traceability to source production sites

The objectives of this recommended procedure are to ensure that:

- oriental melon and rockmelon fruit are sourced only from registered production sites producing commercial quality fruit
- production sites from which oriental melon and rockmelon fruit are sourced can be identified, so that any investigation and corrective action can be targeted in the event that pests of biosecurity concern to Australia are intercepted
- where oriental melon and rockmelon fruit is grown/produced in an approved PFA, PFPP or PFPS, it can be verified that all fruit was sourced from the approved area, place or site and produced and exported under the conditions for that pathway.

APQA must establish a system to enable traceability to where oriental melon and rockmelon fruit for export to Australia are sourced. APQA must ensure that growers of oriental melon and rockmelon fruit for export are aware of pests of biosecurity concern for Australia and have systems in place to produce export quality fruit that meet Australia's requirements.

Where a pest risk management measure involving pest monitoring and controls during production and at harvest (such as PFA, PFPP or PFPS) is used, export production sites must be registered with APQA before commencement of each harvest season. Records of registered production sites and APQA audits must be kept by APQA and must be made available to the department upon request.

4.2.2 Registration of packing houses and treatment providers, and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- commercial quality oriental melon and rockmelon fruit are sourced only from packing houses that are approved by APQA
- where applicable, treatment providers are approved by APQA and capable of applying a treatment that suitably manages the target pests.

Oriental melon and rockmelon fruit export packing houses are registered with APQA before the commencement of each harvest season. APQA is required to ensure that the registered packing houses are suitably equipped and have a system in place to carry out the specified phytosanitary activities. The list of registered packing houses and records of APQA audits must be kept by APQA and must be made available to the department upon request.

In circumstances where oriental melon and rockmelon fruit undergo pre-export treatment, this process must be undertaken by treatment providers that have been registered with and audited by APQA for that purpose. Records of APQA registration requirements and audits must be made available to the department upon request.

The approval of treatment providers by APQA must include verification that suitable systems are in place to ensure compliance with treatment requirements. This may include:

- documented procedures to ensure oriental melon and rockmelon fruit are appropriately treated and safeguarded post treatment
- staff training to ensure compliance with procedures
- record-keeping procedures
- suitability of facilities and equipment
- APQA's system of oversight of treatment application.

The department provides final approval of facilities, following review of regulatory oversight provided by APQA and the capability demonstrated by the facility. Site visits may be required for the department to have assurance that treatment can be applied accurately and consistently.

4.2.3 Packaging, labelling and containers

The objectives of this recommended procedure are to ensure that:

- oriental melon and rockmelon fruit intended for export to Australia, and associated packaging, are not contaminated by quarantine pests or regulated articles (as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2022))
- unprocessed packaging material is not imported with oriental melon and rockmelon fruit from Korea. Unprocessed packaging material is not permitted, as it may vector pests identified as not being on the pathway, or pests not known to be associated with oriental melon and rockmelon fruit
- all wood material associated with the consignment used in packaging and transport of oriental melon and rockmelon fruit complies with the department's import requirements, as published on BICON
- secure packaging is used for export of oriental melon and rockmelon fruit from Korea to Australia, to prevent re-infestation during storage and transport and prevent escape of pests during clearance procedures on arrival in Australia. Packaging must meet Australia's secure packing options published on BICON
- consignments are made insect proof and secure, by using at least one of the following secure consignment options:
  - **integral cartons**: produce may be packed in integral (fully enclosed) cartons (packages) with boxes having no ventilation holes and lids tightly fixed to the bases
  - **ventilation holes of cartons covered:** cartons (packages) with ventilation holes must have the holes covered/sealed with a mesh/screen of no more than 1.6mm pore size

and not less than 0.16mm strand thickness. Alternatively, the vent holes may be taped over

- **polythene liners:** vented cartons (packages) with sealed polythene liners/bags within are acceptable (folded polythene bags are acceptable).
- **meshed or shrink-wrapped pallets or Unit Load Devices (ULDs):** ULDs transporting cartons with open ventilation holes/gaps, or palletised cartons with ventilation holes/gaps must be fully covered or wrapped with polyethylene/plastic/foil sheet or mesh/screen of no more than 1.6mm diameter pore size and not less than 0.16mm strand thickness
- **produce transported in fully enclosed containers:** cartons (packages) with holes as loose boxes or on pallets may be transported in fully enclosed containers. Enclosed containers include 6-sided containers with solid sides, or ULDs with tarpaulin sides that have no holes or gaps. The container must be transported to the inspection point intact.

- packaged oriental melon and rockmelon fruit from Korea must be labelled with sufficient identification for the purposes of traceability. This may include:
  - for treated product: the treatment facility name/number and treatment identification reference/number
  - for oriental melon and rockmelon fruit where the measures include pre-harvest controls/production site freedom: the production site reference number
  - for oriental melon and rockmelon fruit where phytosanitary measures are applied at the packing house: the packing house reference/number.
- where applicable, packaged oriental melon and rockmelon fruit that has undergone irradiation treatment is labelled with a statement that the fruit has been treated with ionising radiation.

Export packing houses and treatment providers (where applicable) must ensure packaging and labelling are suitable to maintain phytosanitary status of the export consignments.

4.2.4 Specific conditions for storage and movement

The objective of this recommended procedure is to ensure that the quarantine integrity of the oriental melon and rockmelon fruit is maintained during storage and movement.

Treated and/or inspected oriental melon and rockmelon fruit for export to Australia must be kept secure and segregated at all times from any fruit for domestic or other markets, and from untreated/un-inspected product, to prevent mixing or cross-contamination. The area set aside for goods to Australia must be clearly identified with signage.

4.2.5 Freedom from trash

The objective of this recommended procedure is to ensure that oriental melon and rockmelon fruit for export are free from trash (for example, loose stem and leaf material, seeds, soil, animal matter/parts or other extraneous material) and foreign matter.

Freedom from trash will be confirmed by the inspection procedures. Export lots or consignments found to contain trash or foreign matter must be withdrawn from export unless approved remedial action, such as reconditioning, is available and applied to the export consignment and then re-inspected.

4.2.6 Pre-export phytosanitary inspection and certification by APQA

The objective of this recommended procedure is to ensure that Australia's import conditions have been met. All consignments of oriental melon and rockmelon fruit from Korea for export to Australia must be inspected by APQA and found free of pests of biosecurity concern for Australia. Pre-export visual inspection must be undertaken by APQA in accordance with ISPM 23: *Guidelines for inspection* (FAO 2019d) and consistent with the principles of ISPM 31: *Methodologies for sampling of consignments* (FAO 2016b). The inspection technique must be capable of detecting all life stages of these pests. Any netting or artificial wrapping material must be removed during the inspection.

All consignments must be inspected prior to export in accordance with official procedures for all visually-detectable quarantine pests and regulated articles (including trash). Sampling and inspection methods should be consistent with ISPM 23 (FAO 2019d) and ISPM 31 (FAO 2016b) and provide a 95% level of confidence that infestation greater than 0.5% will be detected. For a consignment equal to or greater than 1,000 units (one unit being a single oriental melon or rockmelon fruit), this is equivalent to a 600 unit sample randomly selected across the consignment. The inspection technique must be capable of detecting all life stages of these pests. Any netting or artificial wrapping material must be removed during the inspection.

A phytosanitary certificate must be issued for each consignment upon completion of pre-export inspection and treatment to verify that the required risk management measures have been undertaken prior to export and that the consignment meets Australia's import requirements.

Each phytosanitary certificate must include:

– a description of the consignment (including traceability information)
– details of disinfestation treatments (if required) which includes approved facility name and address, date of treatment and, where irradiation is used, absorbed dose (target and measured)
– additional declarations that may be required such as identification of the consignment as being sourced from a recognised pest free area, pest free place of production or pest free production site.

Some treatments (such as irradiation) may also require treatment certificates that accompany the phytosanitary certificate. BICON will describe where treatment certificates are required.

4.2.7 Phytosanitary inspection by the Department of Agriculture, Fisheries and Forestry

The objectives of this recommended procedure are to ensure that:

- consignments comply with Australian import requirements
- consignments are as described on the phytosanitary certificate
- quarantine integrity has been maintained.

On arrival in Australia, the department will:

– assess documentation to verify that the consignment is as described on the phytosanitary certificate, that required phytosanitary actions have been undertaken, and that product security has been maintained

- verify that the biosecurity status of consignments of oriental melon and rockmelon fruit from Korea meet Australia's import requirements. When inspecting consignments, the department will use random samples of 600 units, or equivalent per phytosanitary certificate and an inspection method suitable for the commodity.

4.2.8 Remedial action(s) for non-compliance

The objectives of remedial action(s) for non-compliance are to ensure that:

- any quarantine pest or regulated article, including trash, is addressed by remedial action, as appropriate
- non-compliance with import requirements is addressed, as appropriate.

Any consignment that fails to meet Australia's import requirements will be subject to suitable remedial treatment where an effective treatment is available for the identified biosecurity risks. Where an effective treatment is not available, the imported consignment will be exported or destroyed.

Other actions, including partial or complete suspension of the import pathway, may be taken depending on the identity and/or importance of the pest intercepted, for example, fruit flies of economic importance or pests for which PFAs, PFPPs or PFPSs are established.

In the event that consignments of oriental melon and rockmelon fruit from Korea are repeatedly non-compliant, the department may require enhanced risk management measures, including mandatory phytosanitary treatment. The department reserves the right to suspend imports (either all imports, or imports from specific pathways) and to conduct an audit of the risk management systems. Imports will be allowed to recommence only when the department is satisfied that appropriate corrective action has been undertaken.

4.3 Uncategorised pests

If an organism that has not been categorised, including a contaminant pest, is detected on oriental melon and rockmelon fruit on arrival in Australia, it will require assessment by the department to determine its quarantine status and whether phytosanitary action is required.

Assessment is also required if the detected species was categorised as not having the potential to be on the import pathway. If the detected species was categorised as being on the pathway but assessed as having an unrestricted risk that achieves the ALOP for Australia, then it may require reassessment. The detection of any pests of biosecurity concern not already identified in the analysis may result in remedial action and/or temporary suspension of trade while a review is conducted to ensure that existing measures continue to provide the ALOP for Australia.

4.4 Review of processes

4.4.1 Verification of protocol

Prior to or during the first season of trade, the department will verify the implementation of the required import requirements including registration, operational procedures and treatment providers, where applicable. This may involve representatives from the department visiting areas in Korea that produce oriental melon and rockmelon fruit for export to Australia.

4.4.2 Review of policy

The department will review the import policy after a suitable volume of trade has been achieved to ensure import requirements continue to be appropriate to manage the biosecurity risk of the pathway. In addition, the department reserves the right to review the import policy as deemed necessary. This may include if there is reason to believe that the pest or phytosanitary status in Korea has changed, or where alternative risk management or compliance-based intervention options become available.

APQA must inform the department immediately on the detection of any new pests of oriental melon and rockmelon fruit in Korea that might be of potential biosecurity concern to Australia.

4.5 Meeting Australia's food laws

In addition to meeting Australia's biosecurity laws, imported food for human consumption must comply with the requirements of the *Imported Food Control Act 1992*, as well as Australian state and territory food laws. Among other things, these laws require all food, including imported food, to meet the standards set out in the Australia New Zealand Food Standards Code (the Code).

Food Standards Australia New Zealand (FSANZ) is responsible for developing and maintaining the Code. The Code is available at foodstandards.gov.au/code/Pages/default.aspx.

The department administers the *Imported Food Control Act 1992* which supports the inspection and testing of imported food to verify its safety and compliance with Australia's food standards, including the Code. This is undertaken through a risk-based border inspection program, the Imported Food Inspection Scheme. More information about this scheme is available at agriculture.gov.au/biosecurity-trade/import/goods/food/inspection-testing/ifis.

Standards 1.1.1, 1.1.2 and 1.4.4 of the Code specify that a food for sale must not consist of, or have as an ingredient or a component, a prohibited or restricted plant or fungus, unless expressly permitted by the Code. The prohibited and restricted plants and fungi are listed in Schedules 23 and 24 of the Code, respectively.

Standard 1.4.2 and Schedules 20, 21 and 22 of the Code set out the maximum residue limits and extraneous residue limits for agricultural or veterinary chemicals that are permitted in foods for sale, including imported food. Standard 1.1.1 of the Code specifies that a food must not have, as an ingredient or a component, a detectable amount of an agvet chemical, or a metabolite or a degradation product of the agvet chemical; unless expressly permitted by the Code.

Certain imported food, including some minimally processed horticulture products, must be covered by a food safety management certificate to be imported into Australia. The certificate provides evidence that a food has been produced through a food safety management system. This system must have appropriate controls in place to manage food safety hazards. More information about the foods that require a food safety management certificate and how to comply is available at agriculture.gov.au/biosecurity-trade/import/goods/food/lodge/safety-management-certificates.

5 Conclusion

This final risk analysis report was conducted to assess the proposal by the Republic of Korea (Korea) for market access to Australia for greenhouse-grown fresh oriental melon and rockmelon fruit for human consumption.

The risk analysis was conducted in accordance with Australia's method for pest risk analysis (Appendix A), which is consistent 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 2019b), and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).

In conclusion, this final report recommends that the importation of commercially produced greenhouse-grown fresh oriental melon and rockmelon fruit to Australia from all commercial production areas of Korea be permitted, subject to a range of biosecurity requirements outlined in Chapter 4.

The findings of this final report are based on a comprehensive analysis of scientific literature and other relevant information.

The Department of Agriculture, Fisheries and Forestry considers that the risk management measures recommended in this report will provide an appropriate level of protection against the quarantine pests and regulated articles identified as associated with the trade of fresh, greenhouse-grown oriental melon and rockmelon fruit from Korea.

All fresh fruit, including oriental melons and rockmelon fruit from Korea, have been determined by the Director of Biosecurity to be conditionally non-prohibited goods under s174 of the *Biosecurity Act 2015*. Conditionally non-prohibited goods cannot be brought or imported into Australia unless they meet specific import conditions.

This report, upon its finalisation, provides the basis for import conditions for greenhouse-grown fresh oriental melon and rockmelon fruit from Korea for human consumption. The import conditions will be communicated on BICON. The publication of import conditions on BICON is subject to Korea being able to demonstrate that processes and procedures are in place to implement the required risk management measures.

Appendix A: Method for pest risk analysis

This section sets out the method for the pest risk analysis (PRA) used by the Department of Agriculture, Fisheries and Forestry (the department). This method is consistent 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 2019b) and the WTO 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 2022). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products' (FAO 2022). 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 2022).

Biosecurity risk consists of 2 major components: the likelihood of a pest entering, establishing and spreading in Australia for a defined import pathway; and the consequences should this happen. These 2 components are combined to give an overall estimate of the pest risk for the defined import pathway.

Unrestricted risk is estimated taking into account, where applicable, the existing commercial production practices of the exporting country and procedures that occur on arrival in Australia. These procedures include verification by the department 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 or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2022).

A PRA is conducted in 3 consecutive stages: initiation (A1), pest risk assessment (A2) and pest risk management (A3).

A1 Stage 1: Initiation

Initiation identifies the pest(s) and pathway(s) that are of biosecurity concern and should be considered for risk analysis in relation to the identified PRA area.

A pathway is 'any means that allows the entry or spread of a pest' (FAO 2022). For this risk analysis, the 'pathway' being assessed is defined in Chapter 1 (section 1.2.2).

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 based on 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.

According to ISPM 11 (FAO 2019b), the PRA process may be initiated as a result of:

- the identification of a pathway that presents a potential pest hazard. For example, international trade is requested for a commodity not previously imported into the country or a commodity from a new area or new country of origin
- the identification of a pest that may require phytosanitary measures. For example, a new pest risk is identified by scientific research, a pest is repeatedly intercepted, a request is made to import an organism, or an organism is identified as a vector of other pests
- the review or revision of a policy. For example, a country's decision is taken to review phytosanitary regulations, requirements or operations or a new treatment or loss of a treatment system, a new process, or new information impacts on an earlier decision.

The basis for the initiation of this risk analysis is defined in Chapter 1 (section 1.2.1).

The primary elements considered in the initiation stage are:

- identity of the pests
- potential association with the pathway being assessed for each of the pests.

The identity of the pests is presented at species level by the species' scientific name in most instances, but a lower taxonomic level may be used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting country's National Plant Protection Organisation (NPPO) or where the cited literature used a different scientific name.

The potential association of each pest with the pathway being assessed considers information on:

  - association of the pest with the host plant/commodity and
  - the presence or absence of the pest in the exporting country/region relevant to the pathway being assessed.

A2 Stage 2: Pest risk assessment

The process for pest risk assessment includes 2 sequential steps:

- pest categorisation (A2.1)
- further pest risk assessment, which includes evaluation of the likelihood of the introduction (entry and establishment) and spread of a pest (A2.2) and evaluation of the magnitude of the associated potential consequences (A2.3).

A2.1 Pest categorisation

Pest categorisation examines the pests identified in the initiation stage (A1) to determine which of these pests meet the definition of a quarantine pest and require further pest risk assessment.

ISPM 11 (FAO 2019b) states that '*The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorisation process. An advantage of pest categorisation is that it can be done with relatively little information; however information should be sufficient to adequately carry out the categorisation*'. In line with ISPM 11, the department utilises the pest categorisation step to screen out some pests from further consideration where appropriate. For each pest that is not present in Australia, or is present but under official control, the department assesses its potential to enter (importation and distribution) on the pathway being assessed and, if having potential to enter, its potential to establish and spread in the PRA area. For a pest to cause economic consequences, the pest will need to enter, establish and spread in the PRA area. Therefore, pests that do not have potential to enter on the pathway being assessed, or have potential to enter but do not have potential to establish and spread in the PRA area, are not considered further. The potential for economic consequences is then assessed for pests that have potential to enter, establish and spread in the PRA area. Further pest risk assessments are then undertaken for pests that have potential to cause economic consequences, i.e., pests that meet the criteria for a quarantine pest.

Pest categorisation uses the following primary elements to identify the quarantine pests and to screen out some pests from further consideration where appropriate for the pathway being assessed:

- presence or absence and regulatory status in the PRA area
- potential for entry, establishment and spread in the PRA area
- potential for economic consequences in the PRA area.

A2.2 Assessment of the likelihood of entry, establishment and spread

ISPM 11 (FAO 2019b) provides details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest. The SPS Agreement (WTO 1995) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' as the descriptor. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

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

A2.2.1 Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia when a given commodity is imported, be distributed in a viable state in the PRA area and subsequently be transferred to a host.

For the purpose of considering the likelihood of entry, the department divides this step into 2 components:

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia in a viable state when a given commodity is imported
- **Likelihood of distribution**— the likelihood that the pest will be distributed in a viable state, 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.

Factors to be considered in the likelihood of importation may include:

- likelihood of the pest being associated with the pathway at origin
  - prevalence of the pest in the source area
  - occurrence of the pest in a life-stage that would be associated with the commodity
  - mode of trade (for example, bulk, packed)
  - volume and frequency of movement along each pathway

- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin (for example, application of plant protection products, handling, culling, and grading)

- likelihood of survival of the pest during transport or storage
  - speed and conditions of transport and duration and conditions of storage compared with the duration of the life cycle of the pest
  - vulnerability of the life-stages of the pest during transport or storage
  - prevalence of the pest likely to be associated with a consignment
  - commercial procedures (for example, refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia
- likelihood of pest surviving existing pest management procedures.

Factors to be considered in the likelihood of distribution may include:

- commercial procedures (for example, refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a suitable host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to suitable hosts
- time of year at which import takes place
- intended use of the commodity (for example, for planting, processing or consumption)
- risks from by-products and waste.

A2.2.2 Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2022). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, 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.

Factors to be considered in the likelihood of establishment in the PRA area may include:

- availability of suitable hosts, alternate hosts and vectors in the PRA areas
  - prevalence of hosts and alternate hosts in the PRA area
  - whether hosts and alternate hosts occur within sufficient geographic proximity to allow the pest to complete its life cycle
  - whether there are other plant species, which could prove to be suitable hosts in the absence of usual host species
  - whether a vector, if needed for dispersal of the pest, is already present in the PRA area or likely to be introduced
- suitability of environment in the PRA area

  - factors in the environment in the PRA area (for example, suitability of climate, soil, pest and host competition) that are critical to the development of the pest, its host and if applicable its vector, and to their ability to survive periods of climatic stress and complete their life cycles
- cultural practices and control measures in the PRA area that may influence the ability of the pest to establish
- other characteristics of the pest
  - reproductive strategy of the pest and method of pest survival
  - potential for adaptation of the pest
  - minimum population needed for establishment.

A2.2.3 Likelihood of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2022). 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.

Factors to be considered in the likelihood of spread may include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

A2.2.4 Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six qualitative likelihood descriptors are used: High; Moderate; Low; Very Low; Extremely Low; and Negligible. Definitions for these descriptors and their indicative ranges are given in Table A.1. The indicative ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table A.1 Nomenclature of likelihoods

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

A2.2.5 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 A.2). 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 a descriptor of Low is assigned for the likelihood of importation, Moderate for the likelihood of distribution, High for the likelihood of establishment and Very Low for the likelihood of spread, then the likelihood of importation of Low and the likelihood of distribution of Moderate 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 A.2 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. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account. The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may take many years.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on the department's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this risk analysis, the department assumed that a substantial volume of trade will occur.

A2.3 Assessment of potential consequences

In estimating the potential consequences of a pest if the pest were to enter, establish and spread in Australia, the department uses a 2-step process. In the first step, a qualitative descriptor of the impact is assigned to each of the direct and indirect criteria in terms of the *level of impact* and the *magnitude of impact*. The second step involves combining the impacts for each of the criteria to obtain an 'overall consequences' estimation.

Step 1: Assessing direct and indirect impacts

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

- the life or health of plants and plant products

  This may include pest impacts on the life or health of the plants or production effects (yield or quality) either at harvest or during storage.

  - Where applicable, pest impacts on the life or health of humans or of animals and animal products may also be considered
- Other aspects of the environment.

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

- eradication and control

  This may include pest impacts on new or modified eradication, control, surveillance or monitoring and compensation strategies or programs.
- domestic trade

  This may include pest impacts on domestic trade or industry, including changes in domestic consumer demand for a product resulting from quality changes and effects on other industries supplying inputs to, or using outputs from, directly affected industries.
- international trade

  This may include pest impacts on international trade, including loss of markets, meeting new technical requirements to enter or maintain markets and changes in international consumer demand for a product resulting from quality changes.
- non-commercial and environment

  This may include pest impacts on the community and environment, including reduced tourism, reduced rural and regional economic viability, loss of social amenity, and any 'side effects' of control measures.

For each of these direct and indirect criteria, the level of impact is estimated over 4 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).

For each criterion, the magnitude of impact at each of these geographic levels is described using 4 categories, defined as:

- **Unlikely to be discernible**–pest impact is not usually distinguishable from normal day-to-day variation in the criterion
- **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

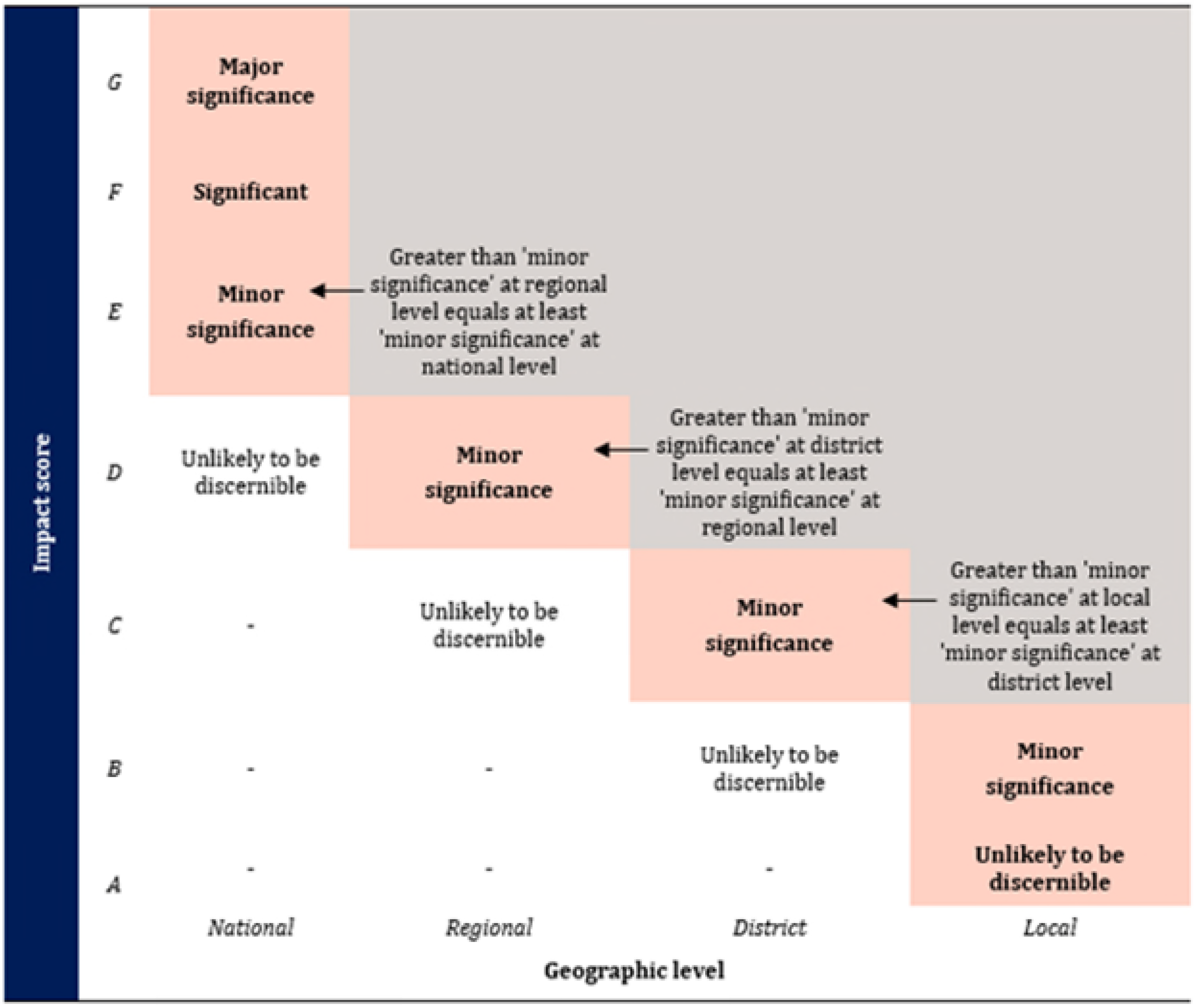
- **Significant**–expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible
- **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.

Each individual direct or indirect impact is given an impact score (A–G) using the decision rules outlined in Figure A.1. This is done by determining which of the shaded cells with bold font in Figure A.1 correspond to the level and magnitude of the particular impact.

The following are considered during this process:

- At each geographic level below 'National', an impact more serious than 'Minor significance' is considered at least 'Minor significance' at the level above. For example, a 'Significant' impact at the state or territory level is considered equivalent to at least a 'Minor significance' impact at the national level.
- If the impact of a pest at a given level is in multiple states or territories, districts or regions or local areas, it is considered to represent at least the same magnitude of impact at the next highest geographic level. For example, a 'Minor significance' impact in multiple states or territories represents a 'Minor significance' impact at the national level.
- The geographic distribution of an impact does not necessarily determine the impact. For example, an outbreak could occur on one orchard/farm, but the impact could potentially still be considered at a state or national level.

Figure A.1 Decision rules for determining the impact score for each direct and indirect criterion, based on the *level of impact* and the *magnitude of impact*



For each criterion:

- the *level of impact* is estimated over 4 geographic levels: local, district, regional and national
- the *magnitude of impact* at each of the 4 geographic levels is described using 4 categories: unlikely to be discernible, minor significance, significant and major significance
- an impact score (A-G) is assigned by determining which of the shaded cells with bold font correspond to the level and magnitude of impact.

Step2: Combining direct and indirect impacts

The overall consequence for each pest or each group of pests is achieved by combining the impact scores (A–G) for each direct and indirect criterion using the decision rules in Table A.3. These rules are mutually exclusive, and are assessed in numerical order until one applies. For example, if the first rule does not apply, the second rule is considered, and so on.

Table A.3 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'; or all criteria have an impact of 'A'.	Negligible

A2.4 Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread and for potential consequences are completed, the unrestricted risk can be determined for each pest or each group of pests. This is determined by using a risk estimation matrix (Table A.4) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread.

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 give a Low rating.

Table A.4 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

A2.5 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 reflects community expectations through government policy, is currently expressed as providing 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 A.4 marked 'Very Low risk' represents the ALOP for Australia.

A2.6 Adoption of outcomes from previous assessments

Outcomes of previous risk assessments have been adopted in this assessment for pests for which the risk profile is assessed as comparable to previously assessed situations.

The prospective adoption of previous risk assessment ratings for the likelihood of importation and the likelihood of distribution is considered on a case-by-case basis by comparing factors relevant to the current commodity/country pathway with those assessed previously. For assessment of the likelihood of importation, factors considered/compared include the commodity type, the prevalence of the pest and commercial production practices in the exporting country/region. For assessment of the likelihood of distribution of a pest the factors considered/compared include the commodity type, the ways the imported produce will be distributed within Australia as a result of the processing, sale or disposal of the imported produce, and the time of year when importation occurs, and the availability and susceptibility of hosts at that time. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihoods for the pathway being assessed to be comparable to those assigned in the previous assessment(s), and there is no new information to suggest that the ratings assigned in the previous assessment(s) have changed.

The likelihoods of establishment and of spread of a pest species in the PRA area will be comparable between risk assessments, regardless of the import pathway through which the pest has entered the PRA area. This is because these likelihoods relate specifically to conditions and events that occur in the PRA area, and are independent of the import pathway. Similarly, the estimate of potential consequences associated with a pest species is also independent of the import pathway. Therefore, the likelihoods of establishment and of spread of a pest, and the estimate of potential consequences, are directly comparable between assessments. If there is no new information available that would significantly change the ratings for establishment or spread or the consequences the pests may cause, the ratings assigned in the previous assessments for these components may be adopted with confidence.

A2.7 Application of Group PRAs to this risk analysis

The Group PRAs that were applied to this risk analysis are:

- the *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (thrips Group PRA) (DAWR 2017a).

- the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (mealybugs Group PRA) (DAWR 2019).
- the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (scales Group PRA) (DAWE 2021).

The Group PRA approach is consistent with relevant international standards and requirements– including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2019a), ISPM 11: *Pest Risk Analysis for Quarantine Pests* (FAO 2019b) and the SPS Agreement (WTO 1995). ISPM 2 states that 'Specific organisms may … be analysed individually, or in groups where individual species share common biological characteristics.'

Risk estimates derived from a Group PRA are 'indicative' in character. This is because the likelihood of entry (the combined likelihoods of importation and distribution) can be influenced by a range of pathway-specific factors, as explained in section A2.6. Therefore, the indicative likelihood of entry from a Group PRA needs to be verified on a case-by-case basis.

In contrast, and as noted in section A2.6, the risk factors considered in the likelihoods of establishment and spread, and the potential consequences associated with a pest species are not pathway-specific, and are therefore comparable across all import pathways within the scope of the Group PRA. This is because at these latter stages of the risk analysis the pest is assumed to have already found a host within Australia at or beyond its point of entry. Therefore, unless there is specific evidence to suggest otherwise, a Group PRA assessment can be applied as the default outcome for any pest species on a plant import pathway once the previously assigned likelihood of entry has been verified.

In a scenario where the likelihood of entry for a pest species on a commodity is assessed as different to the indicative estimate, the Group PRA-derived likelihoods of establishment and spread and the estimate of consequences can still be used, but the overall risk rating (the URE) may change.

Application of Group policy involves identification of up to 3 species of each relevant group associated with the commodity pathway. However, if any other quarantine pests or regulated articles not included in this risk analysis and/or in the relevant group policies are detected at pre-export or on arrival in Australia, the relevant Group policy will also apply.

A3 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 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 proposed/recommended phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure the restricted risk for the relevant pest or pests achieves the ALOP for Australia.

ISPM 11 (FAO 2019b) 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 given of measures commonly applied to traded commodities include:

- options for consignments—for example, inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity
- options preventing or reducing infestation in the crop—for example, treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme
- options ensuring that the area, place or site of production or crop is free from the pest—for example, pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways—for example, consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country—for example, surveillance and eradication programs
- prohibition of commodities—if no satisfactory measure can be found.

Appendix B: Initiation and categorisation for pests of oriental melon and rockmelon from Korea

The pest categorisation table does not represent a comprehensive list of all the pests associated with the entire oriental melon or rockmelon plant grown in Korea. Reference to soil-borne nematodes, soil-borne pathogens, wood-borer pests, root pests or pathogens, and secondary pests has not been made, as they are not directly related to the export pathway of oriental melon and rockmelon fruit and would be addressed by Australia's current approach to contaminating pests.

The steps in the initiation and categorisation processes are considered sequentially, with the assessment terminating at 'Yes' for column 3 (except for pests that are present, but under official control and/or pests of regional concern), or at the first 'No' for columns 4, 5, 6 or 7. In the final column of the table (column 8) the acronyms 'EP', 'GP', 'NT', 'SA' and 'WA' are used. The acronym 'EP' (existing policy) is used for pests that have been assessed by Australia and for which a policy exists. The acronym 'GP' (Group policy) is used for pests that have been assessed by Australia in a Group policy. The acronym 'RA' (regulated article) is used for pests that are known to vector pathogens of biosecurity concern and are therefore regulated articles. The acronym for the state or territory for which regional pest status is considered, such as 'NT' (Northern Territory), 'SA' (South Australia) or 'WA' (Western Australia), is used to identify organisms that have been recorded in some regions of Australia, and due to interstate quarantine regulations are considered regional quarantine pests.

The *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2017a), the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2019) and the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (DAWE 2021) have been applied in this risk analysis. Application of Group policy involves identification of up to 3 species of each relevant group associated with the commodity pathway. However, if any other quarantine pests or regulated articles not included in this risk analysis and/or in the relevant Group policies are detected at pre-export or on-arrival in Australia, the relevant Group policy will also apply.

The department is aware of the recent changes in fungal nomenclature which ended the separate naming of different states of fungi with a pleomorphic life cycle. However, as the nomenclature for these fungi is in a phase of transition and many priorities of names are still to be resolved, this report uses the generally accepted names and provides alternatively used names as synonyms, where required. The department is also aware of the changes in nomenclature of arthropod species based on the latest morphological and molecular reviews. As official lists of accepted fungus and arthropod names become available, these accepted names will be adopted.

A detailed description of the method used for a pest risk analysis is provided in Appendix A.

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
ARTHROPODS							
Coleoptera							
Aulacophora indica (Gmelin, 1790) [Chrysomelidae] Pumpkin beetle	Yes (APQA 2019; Aston 2009).	No records found.	No. *Aulacophora indica* adults feed on the leaves and sometimes flowers of cucurbits hosts, including oriental melon and rockmelon (Abe & Matsuda 2005). Eggs are laid in the soil, and the soil-dwelling larvae feed on the roots and lower parts of the stem of host plants (CABI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	No
Epilachna vigintioctomaculata (Motschulsky, 1857) Synonym: *Henosepilachna vigintioctomaculata* (Motschulsky, 1857) [Coccinellidae] Large 28-spotted lady beetle	Yes (APQA 2019; CABI 2023; Fasulati 2015).	No records found.	No. All life stages of this species live and feed on the leaves of plant (Matsishina et al. 2019).	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Epilachna vigintioctopunctata (Fabricius, 1775) Synonym: *Henosepilachna vigintioctopunctata* (Fabricius, 1775) [Coccinellidae] Hadda beetle	Yes (APQA 2019; CABI 2023).	Yes. NSW, NT, Qld, Tas., WA (APPD 2023; CABI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Collembola							
Bourletiella hortensis (Johannsen, 1912) [Bourletiellidae] Garden springtail	Yes (APQA 2019; Lim et al. 2012).	Yes. SA, Tas., Vic., WA (Greenslade & Ireson 1986; Ireson 1993).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Diptera							
Bradysia impatiens (Johannsen, 1912) Synonyms: *Bradysia difformis* Frey, 1948; *Bradysia agrestis* Sasakawa, 1978 [Sciaridae] Black fungus gnat	Yes (APQA 2019; Park et al. 2017b).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (ABRS 2023; Broadley, Kauschke & Mohrig 2018).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Delia platura (Meigen, 1826) [Anthomyiidae] Bean seed fly	Yes (APQA 2018; Paik et al. 2007).	Yes. NSW, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Drosophila suzukii (Matsumura, 1931) [Drosophilidae] Spotted wing drosophila	Yes (Daane et al. 2016).	No records found.	No. The department conducted a pest risk assessment for *Drosophila suzukii,* and cucurbits were not considered a host (DAFF 2013). *Drosophila suzukii* infests overripe or damaged host fruits and does not infest undamaged, ripe, thicker-skinned fruit (Harris, Hamby & Zalom 2014), such as melons.	Assessment not required.	Assessment not required.	Assessment not required.	No
Liriomyza bryoniae (Kaltenbach, 1858) [Agromyzidae] Tomato leafminer	Yes (APQA 2019; Maharjan, Oh & Jung 2014).	No records found.	No. *Liriomyza bryoniae* is a leaf miner, primarily associated with the leaves of host plants. Adult females in this genus feed on, and oviposit into, the leaves of host plants, and the larvae feed within mines excavated in the leaf tissue (Parrella 1987).	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Liriomyza trifolii (Burgess, 1880) [Agromyzidae] American serpentine leafminer	Yes (APQA 2019; Han et al. 1996).	Yes. Under official control (National) (IPPC 2021a). Present with restricted distribution in Qld (Business Queensland 2021a) and WA (DPIRD 2021).	No. *Liriomyza trifolii* is a leaf miner, primarily associated with the leaves of host plants. Adult females feed on, and oviposit into, the leaves of host plants and the larvae feed within mines excavated in the leaf tissue (Capinera 2017; Dogimont et al. 1999; Parrella 1987).	Assessment not required.	Assessment not required.	Assessment not required.	No
Phytomyza horticola Gourea, 1851 Synonym: *Chromatomyia horticola* (Goureau, 1851) [Agromyzidae] Pea leaf miner	Yes (APQA 2019).	No records found.	No. *Phytomyza horticola* is a leaf miner, primarily associated with leaves of host plants. Adult females oviposit in the leaves of host plants (Yoshida & Sasakawa 1975). The larvae feed within mines excavated in leaf tissue (Pitkin et al. 2019).	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Zeugodacus depressus (Shiraki, 1933) Synonym: *Bactrocera depressa* (Shiraki, 1933) [Tephritidae] Pumpkin fruit fly	Yes (APQA 2019; Han, Choi & Ro 2017).	No records found.	Yes. *Zeugodacus depressus* is an agricultural pest infesting pulp of cucurbitaceous fruits including *C. melo* (Han, Choi & Ro 2017). Adult females lay eggs inside fruits, and the larvae feed on the fruit pulp (Jeong et al. 2017).	Yes. Fresh melons without obvious signs of infestation could potentially be distributed via the wholesale and retail trade pathway. Pupating flies in the fruit could emerge and disperse to new hosts available in Australia.	Yes. *Zeugodacus depressus* has the potential to establish and spread in Australia, as suitable hosts and environments are available. Its host range is restricted to members of Cucurbitaceae and Solanaceae, and it is found in parts of Asia (Norrbom 2023). Its host range and geographic distribution suggest it could establish and spread in Australia.	Yes. *Zeugodacus depressus* has the potential for economic consequences in Australia. It is an internal fruit pest of various plants in the Cucurbitaceae family, inflicting economic damage especially to pumpkins. There are also records of *Z. depressus* affecting watermelon, melon, cucumber and tomato (Han, Choi & Ro 2017), which are commercial crops of economic importance in Australia.	Yes

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Hemiptera							
Aphis gossypii Glover, 1877 [Aphididae] Melon aphid	Yes (APQA 2019; Vuong, Kim & Song 2001).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023). Because *A. gossypii* is a persistent vector of Cucurbit aphid-borne yellows virus (CABYV) (which is absent from Australia but is present in Korea) (Choi & Choi 2016), the potential to enter on the pathway needs to be assessed.	No. *Aphis gossypii* feed on the underside of leaves or growing tips of vines by sucking plant sap (Capinera 2018). It is not considered to feed directly on mature reproductive structures (fruits, berries, nuts) or roots even if infestation levels are high (CABI 2023). Any individuals occurring incidentally on fruit are likely to be removed during harvest and packing house processes.	Assessment not required.	Assessment not required.	Assessment not required.	No
Aulacorthum solani (Kaltenbach, 1843) [Aphididae] Foxglove aphid	Yes (APQA 2019; Lee, Kim & Lee 2008).	Yes. NSW, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Bemisia tabaci (Gennadius, 1889) complex [Aleyrodidae] Silverleaf whitefly	Yes. Putative species MED, MEAM1 and JpL are present in Korea (APQA 2018; Lee et al. 2010; Park et al. 2012a).	Yes, but only some members of the complex (AUS1, AUS II and MEAM 1) are known to be present in Australia. Other species in the complex remain absent from Australia. The *B. tabaci* complex is a known vector for begomoviruses, several of which are quarantine pests of concern for Australia (Fiallo-Olivé et al. 2020). Therefore, the *B. tabaci* complex, including those species known to be present in Australia, are regulated articles for Australia.	No. This pest is not known to be associated with melon fruit. *Bemisia tabaci* eggs are laid on the underside of the leaves (CABI 2023), and nymphs and adults feed on the leaf sap (McAuslane 2009). On *C. melo* they infest leaves and stems, and heavy infestations lead to distorted chlorotic leaves and premature leaf drop (Alegbejo & Banwo 2005).	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Dolycoris baccarum (Linnaeus, 1758) [Pentatomidae] Sloe bug	Yes (APQA 2019; Kim et al. 2006).	No records found.	No. This pest is not known to be associated with melon fruit. *Dolycoris baccarum* is listed in Korea's technical market access submission as associated with the leaves of *C. melo* (APQA 2019). Little information is available on the biology of this species, however pentatomid bugs generally lay their eggs on the underside of leaves of their hosts (Esselbaugh 1946; McPherson 2018).	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Megymenum gracilicorne Dallas, 1851 [Dinidoridae] Cucurbit shield bug	Yes (APQA 2019; Lim & Park 2009).	No records found.	No. Members of this family feed on the sap of host plants (ALA 2023). *Megymenum gracilicorne* is listed in Korea's technical market access submission as being associated with leaves of *C. melo* (APQA 2019). It is not known to be associated with melon fruit.	Assessment not required.	Assessment not required.	Assessment not required.	No
Myzus persicae (Sulzer, 1776) [Aphididae] Green peach aphid	Yes (APQA 2019; Vuong, Kim & Song 2001).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Trialeurodes vaporariorum (Westwood, 1856) [Aleyrodidae] Greenhouse white fly	Yes (APQA 2019; Choi et al. 2003).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Tropidothorax cruciger (Motschulsky, 1860) [Lygaeidae] Lygaeid bug	Yes (APQA 2019; Byun et al. 2009; Kim et al. 2000).	No records found.	No. This species feeds on sap from buds and leaves of host plants (Kim et al. 2001).	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lepidoptera							
Agrotis ipsilon (Hufnagel, 1766) [Noctuidae] Black cutworm	Yes (APQA 2019; Carter 1984).	Yes. NSW, NT, Qld, SA, Tas., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Agrotis segetum (Denis & Schiffermüller, 1775) [Noctuidae] Turnip moth	Yes (APQA 2018; CABI 2023; Choo et al. 1998).	No records found.	No. Eggs sometimes occur on the underside of leaves of host seedlings, but are most commonly laid in the soil (Esbjerg & Lauritzen 2010; Moir et al. 2007). Larvae feed on roots, stems, growing tips, flower buds and leaves (Moir et al. 2007).	Assessment not required.	Assessment not required.	Assessment not required.	No
Anadevidia peponis (Fabricius, 1775) [Noctuidae] Snake gourd semilooper	Yes (APQA 2019; Han, Jin & Park 2005).	Yes. Under official control (Regional) for WA (Government of Western Australia 2023). Present in NSW, Qld (APPD 2023; Common 1990).	No. *Anadevidia peponis* females oviposit on the underside of leaves of cucurbit hosts (Herbison-Evans & Crossley 2023). Larvae in this subfamily generally feed on foliage, and occasionally flowers (Common 1990).	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Calyptra thalictri (Borkhausen, 1790) Synonym: *Calpe thalictri* (Borkhausen, 1790) [Erebidae] Fruit-piercing moth	Yes (APQA 2019; Yoon & Lee 1974).	No records found.	No. *Calyptra thalictri* larvae feed on the leaves of host plants at night and often drop to the ground if disturbed (Hattori 1969). In Korea, adult moths feed during summer and autumn on ripe fruits. They feed primarily on soft-skinned and thick-skinned fruits such as grapes and citrus (Zaspel 2008). This pest is not known to be associated with oriental melon or rockmelon fruit.	Assessment not required.	Assessment not required.	Assessment not required.	No
Chrysodeixis eriosoma (Doubleday, 1843) [Noctuidae] Green garden looper	Yes (APQA 2019; CABI 2023; Yang et al. 2006).	Yes, NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; CABI 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ctenoplusia agnata (Staudinger, 1892) Synonyms: *Acanthoplusia agnata* (Staudinger, 1892); *Chrysodeixis agnata* (Staudinger, 1892) [Noctuidae] Three-spotted plusia	Yes (APQA 2019; Li et al. 2014).	No records found.	No. *Ctenoplusia agnata* is listed in Korea's technical market access submission as feeding on the leaves of *C. melo* (APQA 2019). This pest is not known to be associated with melon fruit.	Assessment not required.	Assessment not required.	Assessment not required.	No
Diaphania indica (Saunders, 1851) [Crambidae] Cotton caterpillar	Yes (APQA 2019; CABI 2023).	Yes. NSW, NT, Qld, WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Helicoverpa armigera (Hübner, 1808) [Noctuidae] Cotton bollworm	Yes (APQA 2019; CABI 2023).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Helicoverpa assulta (Guenée, 1852) [Noctuidae] Oriental tobacco budworm	Yes (APQA 2019; CABI 2023).	Yes. NSW, NT, Qld, WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	**Potential for distribution**			
Peridroma saucia (Hübner, 1808) [Noctuidae] Variegated cutworm	Yes (APQA 2019; Choi et al. 2009).	No records found.	No. *Peridroma saucia* eggs are laid on twigs and stems of host plants. Larvae feed on flowers, leaves and developing fruits, often cutting plant stems off at the base (CABI 2023; Mau & Martin Kessing 2007). This pest is not known to be associated with mature melon fruit.	Assessment not required.	Assessment not required.	Assessment not required.	No
Scopula superior (Butler, 1878) [Geometridae] Yellow rippled white looper moth	Yes (APQA 2019; Choi & Kim 2016).	No records found.	No. This species is associated with leaves of *C. melo* (APQA 2018).	Assessment not required.	Assessment not required.	Assessment not required.	No
Spodoptera exigua (Hübner, 1808) [Noctuidae] Lesser armyworm	Yes (APQA 2019; Jung, Park & Boo 2003).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA, (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Spodoptera frugiperda (Smith, 1797) [Noctuidae] Fall armyworm	Yes (CABI 2023).	Yes. NSW, NT, Qld, Tas., Vic., WA (CABI 2023; Government of Western Australia 2023; IPPC 2021b).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Spodoptera litura (Fabricius, 1775) [Noctuidae] Cluster caterpillar, taro caterpillar	Yes (APQA 2019; Kim et al. 1998).	Yes. NSW, NT, Qld, Tas., WA (ABRS 2023; APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Spoladea recurvalis (Fabricius, 1775) [Crambidae] Hawaiian beet webworm	Yes (APQA 2019; CABI 2023; Lee et al. 2013).	Yes. NSW, Qld, NT, WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Trichoplusia ni (Hübner, 1802) [Noctuidae] Cabbage looper	Yes (APQA 2019; CABI 2023).	No records found.	No. Eggs are laid on leaves of host plants and larvae feed on foliage (Capinera 2020).	Assessment not required.	Assessment not required.	Assessment not required.	No
Orthoptera							
Atractomorpha lata (Motschulsky, 1866) [Pyrgomorphidae] Smaller long-headed locust	Yes (APQA 2019; Kim et al. 2006).	No records found.	No. *Atractomorpha lata* is a leaf feeder (APQA 2018; Ohgushi 2008).	Assessment not required	Assessment not required	Assessment not required	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Gryllotalpa orientalis Burmeister, 1838 [Gryllotalpidae] Oriental mole cricket	Yes (APQA 2019; Toepfer et al. 2014).	No records found.	No. *Gryllotalpa orientalis* mainly occurs underground, feeding generally on roots and tubers of plants, and occasionally on other invertebrates (Ullah et al. 2017).	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Thysanoptera							
Frankliniella intonsa (Trybom, 1895) [Thripidae] Intonsa flower thrips	Yes (APQA 2019; Mintu & Reyes 2018).	No records found.	Yes. *Frankliniella intonsa* oviposits and feeds on fruit, flowers and leaves of hosts (CABI 2023) and has been associated with damage to oriental melon fruit grown in greenhouses in Korea (Yeon et al. 2011). *Frankliniella* spp. are routinely intercepted on horticultural products at the Australian border (DAWR 2017a).	Yes. *Frankliniella intonsa* has a wide host range including crop plants and ornamentals (Miyazaki & Kudo 1988), and many hosts are available in Australia. Imported melons will likely be distributed throughout Australia via the wholesale and retail trade pathway. Thrips present on discarded melon fruit waste could potentially disperse to a new host within close proximity.	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes (GP)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Frankliniella occidentalis (Pergande, 1895) [Thripidae] Western flower thrips	Yes (APQA 2019; Mainali & Lim 2010).	Yes. Under official control (Regional) for NT (DPIR 2018). Present in NSW, Qld, Tas., Vic., WA (APPD 2023).	Yes. *Frankliniella occidentalis* occurs on flowers, fruits, stems and leaves of host plants, often hiding under the calyx on the fruit or in places of contact between fruit and stems or leaves (Demirozer et al. 2012). *Frankliniella occidentalis* has been associated with damage to oriental melon fruit grown in greenhouses in Korea (Yeon et al. 2011). *Frankliniella* spp. are routinely intercepted on horticultural products at the Australian border (DAWR 2017a).	Yes. *Frankliniella occidentalis* has a wide host range including crop plants and ornamentals (CABI 2023), and many hosts are available in Australia. Imported melons will likely be distributed throughout Australia via the wholesale and retail trade pathway. Thrips present on discarded melon fruit waste could potentially disperse to a new host within close proximity.	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes (GP)

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Thrips palmi Karny, 1925 [Thripidae] Melon thrips	Yes (APQA 2019; Cho, Kang & Lee 2000).	Yes. Under official control (Regional) for SA (PIRSA 2022) and WA (Government of Western Australia 2023). Present in NSW, NT, Qld, WA (APPD 2023; Government of Western Australia 2023).	Yes. *Thrips palmi* feeds primarily on leaves but also on stems, flowers and fruits of *C. melo* (Childers 1997). Feeding on leaves and stems occurs at or near regions of new growth. *Thrips palmi* can also occur amongst the petals and developing ovaries in flowers and on the surface of fruit (CABI 2023). Members of this genus are frequently intercepted on horticultural products at the Australian border (DAWR 2017a).	Yes. *Thrips palmi* is a polyphagous species that attacks many hosts in Cucurbitaceae, Solanaceae, and Fabaceae (CABI 2023; Young & Zhang 1998), and many hosts are available in Australia. Imported melons will likely be distributed throughout Australia via the wholesale and retail trade pathway. Thrips present on discarded melon fruit waste could potentially disperse to a new host within close proximity.	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes. Assessed in the thrips Group PRA (DAWR 2017a).	Yes (GP)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Trombidiformes							
Petrobia latens (Müller, 1776) [Tetranychidae] Brown wheat mite	Yes (APQA 2018; CABI 2023).	Yes. NSW, Qld, Tas., WA (APPD 2023; CABI 2023; Halliday 1998; Poole 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Polyphagotarsonemus latus (Banks, 1904) [Tarsonemidae] Broad mite	Yes (APQA 2018; Choi et al. 2013).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Tarsonemus bilobatus Suski, 1965 [Tarsonemidae] Tarsonemid mite	Yes (APQA 2018; Feres, Lofego & Oliveira 2005; Zhang 2003).	No records found.	No. This pest is not known to be associated with melon fruit. *Tarsonemus bilobatus* is generally found on leaves, as well as in the soil and litter around host plants (Vacante 2016). This species may occur on greenhouse grown seedlings including melons, but is primarily fungivorous (Nucifora & Vacante 2004; Zhang 2003).	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Tetranychus kanzawai Kishida, 1927 [Tetranychidae] Kanzawa spider mite	Yes (APQA 2019; Vacante 2016; Zhang 2003).	Yes. Under official control (Regional) for WA (Government of Western Australia 2023). Present in NSW, Qld (Gutierrez & Schicha 1983; Seeman & Beard 2011).	Yes. *Tetranychus kanzawai* infests the leaves, stems and fruit of several species of host plants, which include *C. melo* (Vacante 2016). While principally found on the leaves of host plants, spider mites may spread to other plant parts including fruit, particularly if population densities are high (Jeppson, Keifer & Baker 1975).	Yes. *Tetranychus kanzawai* has a host range of around 190 wild and cultivated plant species (Migeon & Dorkeld 2023; Yano, Kanaya & Takafuji 2003), and many hosts are available in Australia. Imported melons will likely be distributed throughout WA via the wholesale and retail trade pathway. Spider mites present on discarded melon fruit waste could potentially disperse to a new host within close proximity. *Tetranychus kanzawai* generally disperse by crawling, but some may be dispersed in wind (Kennedy & Smitley 1985;	Yes. Hosts of *T. kanzawai* are widely available in WA. *Tetranychus kanzawai* has been recorded from at least 25 countries (Migeon & Dorkeld 2023). It has successfully established in Qld and NSW (Gutierrez & Schicha 1983). Environments with climates similar to these regions exist in various parts of WA, suggesting that *T. kanzawai* has the potential to establish and spread in WA.	Yes. *Tetranychus kanzawai* is a significant polyphagous pest subject to quarantine measures in many parts of the world (Navajas et al. 2001). It is considered a pest of economic concern in Japan, Korea, Taiwan and China, where it can cause serious damage to several agricultural crops (Kondo 2004; Takafuji et al. 2000) particularly when infestation levels are high (Ho 2000). Heavy damage from feeding leads to wilting, defoliation, and reduced growth (Cheng 2007).	Yes (EP, WA)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
				Yano, Kanaya & Takafuji 2003).			
Tetranychus urticae Koch, 1835 [Tetranychidae] Two-spotted spider mite	Yes (APQA 2019; Choi, Park & Kim 2016).	Yes. NSW, NT, Qld, SA, Tas, Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
BACTERIA							
Acidovorax citrulli (Schaad et al. 1978) Schaad et al. 2009 Synonym: *Acidovorax avenae* subsp. *citrulli* (Schaad et al. 1978) [Burkholderiales: Comamonadaceae] Fruit blotch	Yes (APQA 2019; EPPO 2023; Kim & Koo 2009).	Yes. Qld, NSW, WA (APPD 2023; EPPO 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Agrobacterium rhizogenes (Riker et al. 1930) Conn 1942 (Approved Lists 1980) emend. Sawada et al. 1993, nom. approb. Synonym: *Rhizobium rhizogenes* (Riker et al. 1930) Young et al 2001 [Rhizobiales: Rhizobiaceae] Crown gall	Yes (Kim & Koo 2009).	Yes NSW, SA, Vic., WA (APPD 2023; EPPO 2023; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Agrobacterium tumefaciens (Smith and Townsend 1907) Conn 1942 (Approved Lists 1980), nom. approb. Synonym: *Rhizobium radiobacter* (Beijerinck & van Delden 1902) Young et al. 2001 [Rhizobiales: Rhizobiaceae] Crown gall	Yes (APQA 2019; EPPO 2023; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; EPPO 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Dickeya chrysanthemi (Burkholder et al. 1953) Samson et al. 2005 Synonyms: *Pectobacterium chrysanthemi* (Burkholder et al. 1953) Brenner et al.1973 emend. Hauben et al. 1999; *Erwinia chrysanthemi* (Burkholder et al. 1953) Young et al. 1978 [Enterobacteriales: Enterobacteriaceae] Bacterial wilt of chrysanthemum	Yes (EPPO 2023; Kim & Koo 2009).	Yes. NSW, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Erwinia tracheiphila (Smith 1895) Bergey et al. 1923 (Approved Lists 1980) emend. Hauben et al. 1999, nom. approb. [Enterobacteriales: Enterobacteriaceae] Bacterial wilt (cucurbits); Vascular wilt (cucurbits)	Yes (APQA 2019; Bradbury 1986; Kim & Koo 2009).	No records found.	Yes. *Erwinia tracheiphila* causes bacterial wilt of cucurbits. The pathogen invades the plant when the frass of vector beetles enters feeding wounds made in leaves, stems or flowers (Liu 2015; Liu et al. 2018; Sasu et al. 2010). Symptoms begin at the leaves and spread through the plant (Rojas et al. 2015). Once wilt symptoms appear, fruit are usually of such poor quality as to be unmarketable (CABI 2023). However, symptoms may take up to 21 days to manifest (Liu 2015; Rojas et al. 2015) therefore it may be possible for asymptomatic fruit to be harvested and packed for export.	No. *Erwinia tracheiphila* has only been reported as being transmitted by beetles in the family Chrysomelidae, (CABI 2023; Ferreira & Boley 1992; Rand & Enlows 1916), primarily *Acalymma vittatum* and some *Diabrotica* species (Liu et al. 2018; Sasu et al. 2010; Vrisman et al. 2016). All these beetles are leaf feeders and unlikely to feed on discarded melon fruit. As none of these species are present in Australia, it is unlikely that this pathogen could reach a new host in this country.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Janibacter melonis Yoon et al. 2004 [Micrococcales: Intrasporangiaceae]	Yes (APQA 2019; Elsayed & Zhang 2005; Kim & Koo 2009).	No records found.	No. There is a single record of *J. melonis* on *C. melo* reported in 2004 (Yoon et al. 2004). Since then there have been no records of this species affecting melon or any other plant.	Assessment not required	Assessment not required	Assessment not required	No
Pantoea ananatis (Serrano, 1928) Mergaert et al. 1993 [Enterobacteriales: Enterobacteriaceae] Fruitlet rot of pineapple	Yes (CABI 2023). While this species is present, there is no record of the Group II strains associated with melon being present in Korea.	Yes. NSW, NT, Qld, Vic. (APPD 2023; Cother et al. 2004). While this species is present, there is no record of the Group II strains associated with melon being present in Australia.	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Pectobacterium carotovorum subsp. *carotovorum* (Jones 1901) Hauben et al. 1999 emend. Gardan et al. 2003 *S*ynonyms: *Pectobacterium carotovorum* (Jones 1901) Waldee 1945 emend. Hauben et al. 1999; *Erwinia carotovora* (Jones 1901) Bergey et al. 1923 [Enterobacteriales: Enterobacteriaceae] Blackleg; Soft rot	Yes (APQA 2019; Kim & Koo 2009; Park et al. 2012b).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudomonas cichorii (Swingle 1925) Stapp 1928 [Pseudomonadales: Pseudomonadaceae] Bacterial blight of endive	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudomonas marginalis pv. *marginalis* (Brown 1918) Stevens 1925 [Pseudomonadales: Pseudomonadaceae] Bacterial leaf rot; Lettuce marginal leaf blight; Bacterial soft rot; Butt-rot	Yes (APQA 2019; EPPO 2023; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic. (APPD 2023; EPPO 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudomonas syringae pv. *aptata* (Brown & Jamieson 1913) Young, Dye & Wilkie 1978 [Pseudomonadales: Pseudomonadaceae] Bacterial leaf spot	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Vic. (APPD 2023; Moffett 1983; O'Brien & Sparshott 1999).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudomonas syringae pv. *lachrymans* (Smith & Bryan 1915) Young et al. 1978 [Pseudomonadales: Pseudomonadaceae] Cucurbit angular leaf spot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, Tas., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Pseudomonas syringae pv. *syringae* (van Hall 1902) Janse 1982 [Pseudomonadales: Pseudomonadaceae] Bacterial canker or blast	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudomonas syringae pv. *tabaci* (Wolf & Foster 1917) Young et al. 1978 [Pseudomonadales: Pseudomonadaceae] Angular leaf spot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudomonas viridiflava (Burkholder 1930) Dowson 1939 [Pseudomonadales: Pseudomonadaceae] Bacterial leaf blight of tomato	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
FUNGI							
Albifimbria verrucaria (Albertini & Schweinitz) L. Lombard & Crous Synonym: *Myrothecium verrucaria* (Alb. & Schwein.) Ditmar. [Hypocreales: Stachybotryaceae] Myrothecium blotch	Yes (CABI 2023; Kim & Koo 2009).	Yes. NSW, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Alternaria alternata (Fr.) Keissl. Synonym: *Alternaria tenuis* Nees [Pleosporales: Pleosporaceae] Alternaria leaf blight	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Alternaria brassicae (Berk.) Sacc. [Pleosporales: Pleosporaceae] Alternaria blight	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Alternaria brassicicola (Schwein.) Wiltshire [Pleosporales: Pleosporaceae] Dark leaf spot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Alternaria cucumerina (Ellis & Everh.) J.A. Elliott [Pleosporales: Pleosporaceae] Cucumber blight	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Alternaria tenuissima (Kunze) Wiltshire [Pleosporales: Pleosporaceae] Nailhead spot of tomato	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Arthrinium arundinis (Corda) Dyko & B. Sutton Synonym: *Apiospora montagnei* Sacc. [Xylariales: Apiosporaceae] Kernel blight	Yes (HerbIMI 2023).	Yes. NSW, Qld (APPD 2023; HerbIMI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Aspergillus flavus Link [Eurotiales; Aspergillaceae] Aspergillus ear rot	Yes (Kim 2003).	Yes. NSW, NT, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Aspergillus nidulans (Eidam) G. Winter [Eurotiales; Aspergillaceae]	Yes (Kim 2003).	Yes. NSW, SA, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Aspergillus niger Tiegh. [Euriotales: Aspergillaceae] Black mould	Yes (Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Aspergillus terreus Thom [Euriotales: Aspergillaceae]	Yes (Kim 2003).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Athelia rolfsii (Curzi) C.C. Tu & Kimbr. [Atheliales: Atheliaceae] Fruit rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Berkeleyomyces basicola (Berk. & Broome) W.J. Nel, Z.W. de Beer, T.A. Duong & M.J. Wingf. Synonym: *Thielaviopsis basicola* (Berk. & Broome) Ferraris [Microascales: Ceratocystidaceae] Black root rot	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Boeremia exigua (Desm.) Aveskamp, Gruyter & Verkley Synonyms: *Ascochyta phaseolorum* Sacc.; *Phoma exigua* Desm. [Pleosporales: Pleosporaceae] Leaf spot	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Vic., Tas. WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Botrytis cinerea Pers. [Helotiales: Sclerotiniaceae] Grey mould; Botrytis bunch rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Calonectria nivalis Schaffnit Synonyms: *Monographella nivalis* (Schaffnit) E. Müll.; *Microdochium nivale* (Fr.) Samuels & I.C. Hallett [Xylariomycetidae: Xylariales] Foot rot of cereals	Yes (HerbIMI 2023).	Yes. NSW, Tas., Vic., WA (APPD 2023; HerbIMI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Cercospora apii Fresen. [Capnodiales: Mycosphaerellaceae] Early blight of celery	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Choanephora infundibulifera f. *cucurbitarum* (Berk. & Ravenel) Schipper Synonym: *Choanephora cucurbitarum* (Berk. & Ravenel) Thaxt. [Mucorales: Choanephoraceae] Choanephora wet rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Cladosporium cladosporioides (Fresen.) G.A. de Vries [Capnodiales: Cladosporiaceae] Mould	Yes (Kim 2003; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Cladosporium cucumerinum Ellis & Arthur [Capnodiales: Cladosporiaceae] Scab (cucurbits)	Yes (APQA 2019; Kim & Koo 2009).	Yes. Tas. (APPD 2023; Persley, Cooke & House 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Cladosporium oxysporum Berk. & M.A. Curtis [Capnodiales: Cladosporiaceae] Leaf spot	Yes (Paul & Yu 2008).	Yes. NSW, NT, Qld, Vic., WA (APPD 2023; Bensch et al. 2012; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Colletotrichum fructicola Prihastuti, L. Cai & K.D. Hyde [Glomerellales: Glomerellaceae] Bitter rot of apple; bitter rot of pear	Yes (Joa et al. 2016).	Yes. NSW, Qld, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Colletotrichum karsti Y.L. Yang, Zou Y. Liu, K.D. Hyde & L. Cai Synonyms: *Colletotrichum karstii* (orthographic variant) Y.L. Yang, Zou Y. Liu, K.D. Hyde & L. Cai *Colletotrichum boninense* Moriwaki, Toy. Sato & Tsukib. [Glomerellales: Glomerellaceae] Anthracnose	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, Vic. (APPD 2023; Shivas et al. 2016).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Colletotrichum orbiculare Damm, P.F. Cannon & Crous Synonym: *Colletotrichum orbiculare* (Berk.) Arx. [Glomerellales: Glomerellaceae] Anthracnose (cucurbits)	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Colletotrichum truncatum (Schwein.) C.L. Armstr. & Banniza Synonyms: *Colletotrichum capsici* (Syd.) E.J. Butler & Bisby; *Glomerella truncata* (Schwein.) C.L. Armstr. & Banniza [Glomerellales: Glomerellaceae] Anthracnose	Yes (Kim & Koo 2009).	Yes. NSW, Qld, NT, WA (APPD 2023; Government of Western Australia 2023; Shivas et al. 2016).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei Synonyms: *Cercospora melonis* Cooke; *Corynespora melonis* (Cooke) Sacc. [Pleosporales: Corynesporascaceae] Target leaf spot; Cucumber target spot	Yes (Kim & Koo 2009; Kwon et al. 2001).	Yes. NT, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023; Silva et al. 1995).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Curvularia lunata (Wakker) Boedijn Synonym: *Cochliobolus lunatus* R.R. Nelson & F.A. Haasis [Pleosporales: Pleosporaceae] Black kernel	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, Vic., WA (APPD 2023; Hyde & Alcorn 1993; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Curvularia spicifera (Bainier) Boedijn Synonym: *Bipolaris spicifera* (Bainier) Subram; *Cochliobolus spicifer* R.R. Nelson [Pleosporales: Pleosporaceae] Spring dead spot	Yes (Jeon, Nguyen & Lee 2015).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Curvularia verruculosa Tandon & Bilgrami ex M.B. Ellis Synonyms: *Cochliobolus verruculosus* (Tsuda & Ueyama) Sivan.; *Pseudocochliobolus verruculosus* Tsuda & Ueyama [Pleosporales: Pleosporaceae] Leaf blight	Yes (Farr & Rossman 2023).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Epicoccum nigrum Link Synonym: *Epicoccum purpurascens* Kunze ex Schltdl. [Incertae sedis: Pleosporaceae] Red blotch of grains	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Erysiphe cruciferarum Opiz ex L. Junell [Erysiphales; Erysiphaceae] Powdery mildew	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Tas., Vic., WA (APPD 2023; Cunnington 2003; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Fusarium acuminatum Ellis & Everh. Synonym: *Gibberella acuminata* Wollenw. [Hypocreales: Nectriaceae] Fusarium blight	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium avenaceum (Fr.) Sacc. Synonym *Gibberella avenacea* R.J. Cook [Hypocreales: Nectriaceae] Fusarium blight	Yes (CABI 2023).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium chlamydosporum Wollenw. & Reinking [Hypocreales: Nectriaceae] Kernel rot of maize	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA, (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium equiseti (Corda) Sacc. Synonym: *Gibberella intricans* Wollenw. [Hypocreales: Nectriaceae] Fruit rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Fusarium fujikuroi Nirenberg Synonym: *Gibberella fujikuroi* (Sawada) S. Ito [Hypocreales: Nectriaceae] Top rot	Yes (Kim & Koo 2009).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium graminearum Schwabe Synonym: *Gibberella zeae* (Schwein.) Petch [Hypocreales: Nectriaceae] Root rot; Headblight	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Summerell et al. 2011).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium incarnatum (Roberge ex Desm.) Sacc. Synonym: *Fusarium semitectum* Berk. & Ravenel [Hypocreales: Nectriaceae]	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; Summerell et al. 2011; Zahid et al. 2001).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Fusarium oxysporum f. sp. *cucumerinum* J.H. Owen [Hypocreales: Nectriaceae] Fusarium wilt of cucurbits	Yes (Kim & Koo 2009).	Yes. SA (Cook & Dubé 1989; Summerell et al. 2011; Wicks, Volle & Baker 1978).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium oxysporum f. sp. *melonis* W.C. Snyder & H. N. Hansen [Hypocreales: Nectriaceae] Melon fusarium wilt	Yes (APQA 2019; Kim & Koo 2009).	Yes. SA, Qld, WA (Government of Western Australia 2023; Summerell et al. 2011).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium oxysporum f. sp. *niveum* (E.F. Sm.) W.C. Snyder & H.N. Hansen [Hypocreales: Nectriaceae] Fusarium wilt (watermelon)	Yes (Kim & Koo 2009; Kwon, Om & Kim 1998).	Yes, NSW, Qld, SA, WA (APPD 2023; Government of Western Australia 2023; Summerell et al. 2011).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Fusarium proliferatum (Matsush.) Nirenberg ex Gerlach & Nirenberg [Hypocreales: Nectriaceae] Foot rot; Fruit rot; Leaf spot	Yes (APQA 2019; Kim & Koo 2009; Seo & Kim 2017).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023; Summerell et al. 2011).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium sambucinum Fuckel [Hypocreales: Nectriaceae] Dry rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Cunnington 2003; Wong, Barbetti & Sivasithamparam 1985).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Fusarium verticillioides (Sacc.) Nirenberg Synonym: *Fusarium moniliforme* J. Sheld [Hypocreales: Nectriaceae] Fruit rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Nelson et al. 1991; Petrovic et al. 2009; Summerell et al. 2011).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Geotrichum candidum Link [Saccharomycetales: Dipodascaceae] Sour rot	Yes (Kim & Koo 2009).	Yes. NSW, NT, Qld, Tas., Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Gibellulopsis nigrescens (Pethybr.) Zare, W. Gams & Summerb. Synonym: *Verticillium nigrescens* Pethybr. [Glomerellales: Plectosphaerellaceae]	Yes (Nguyen et al. 2018).	Yes. Qld, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Golovinomyces cichoracearum (DC.) V.P. Heluta Synonym: *Erysiphe cichoracearum* DC. [Erysiphales: Erysiphaceae] Powdery mildew	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Cook & Dubé 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Golovinomyces orontii (Castagne) V.P. Heluta Synonyms: *Erysiphe orontii* Castagne; *Erysiphe polyphaga* Hammarl. [Erysiphales: Erysiphaceae] Cucurbit powdery mildew (CPM)	Yes (APQA 2019; CABI 2023).	Yes. NSW, NT, Qld, SA, Tas., Vic. (APPD 2023; Cunnington 2003).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Hyaloperonospora parasitica (Pers.) Constant. Synonym: *Peronospora parasitica* (Pers.) de Bary [Peronosporales: Peronosporaceae] Downy mildew	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Cunnington 2003; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. Synonyms: *Botryodiplodia theobromae* Pat.; *Physalospora rhodina* Berk. & M.A. Curtis; *Diplodia natalensis* Pole-Evans; *Botryosphaeria rhodina* (Berk. & Curtis) Arx [Botryosphaeriales: Botryosphaeriaceae] Stem end rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, WA (APPD 2023; Burgess et al. 2006; Muller & Burt 1989; Taylor et al. 2005).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Leveillula taurica (Lév.) G. Arnaud Synonym: *Oidiopsis taurica* (Lév.) E.S. Salmon [Erysiphales: Erysiphaceae] Powdery mildew	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023; Cunnington 2003; Glawe et al. 2005).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Macrophomina phaseolina (Tassi) Goid Synonyms: *Sclerotium bataticola* Taubenh.; *Macrophomina phaseoli* (Maubl.) S.F. Ashby; *Rhizoctonia bataticola* (Taub.) E.J. Butler [Botryosphaeriales: Botryosphaeriaceae] Charcoal root rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023; Persley, Cooke & House 2010; Walker & Wicks 1994).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Monosporascus cannonballus Pollack & Uecker [Sordariales: Incertae sedis] Melon root rot	Yes (APQA 2019; EPPO 2023; Kim & Koo 2009).	No records found.	No. *Monosporascus cannonballus* causes root rot and vine decline in affected plants. It is a soil-borne fungus with no evidence of being present on fruit (EPPO 1999; Markakis et al. 2018).	Assessment not required.	Assessment not required.	Assessment not required.	No
Neocosmospora solani (Mart.) L. Lombard & Crous Synonym: *Fusarium solani* (Mart.) Sacc. [Botryosphaeriales: Botryosphaeriaceae]	Yes (Farr & Rossman 2023).	Yes. NSW, Qld, SA, WA (Pitt et al. 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Neofusicoccum parvum (Pennycook & Samuels) Crous, Slippers & A.J.L. Phillips [Botryosphaeriales: Botryosphaeriaceae]	Yes (Farr & Rossman 2023).	Yes. NSW, Qld, SA, WA (APPD 2023; Pitt et al. 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Paecilomyces variotii Bainier [Eurotiales: Trichocomaceae]	Yes (HerbIMI 2023; Nguyen, Paul & Lee 2016).	Yes. NSW, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Paramyrothecium roridum (Tode) L. Lombard & Crous Synonym: *Myrothecium roridum* Tode. [Hypocreales: Stachybotriaceae] Leaf spot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium chrysogenum Thom [Eurotiales: Trichocomaceae] Mould	Yes (Kim 2003; Yu, Sang & Park 2015).	Yes. NSW, Qld, Tas, Vic., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium citrinum Thom [Eurotiales: Trichocomaceae] Post-harvest decay	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Vic. (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium digitatum (Pers.) Sacc. [Eurotiales: Trichocomaceae] Green mould	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Penicillium expansum Link [Eurotiales: Trichocomaceae] Blue mould	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Vic., WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium italicum Wehmer [Eurotiales: Trichocomaceae] Blue mould	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Cook & Dubé 1989; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium oxalicum Currie & Thom [Eurotiales: Trichocomaceae] Blue mould; Cucumber rot	Yes (APQA 2019; HerbIMI 2023; Kim & Koo 2009).	Yes, NSW, Qld (HerbIMI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Penicillium viridicatum Westling Synonym: *Penicillium aurantiogriseum* var. *viridicatum* (Westling) Frisvad & Filtenborg [Eurotiales: Trichocomaceae]	Yes (Yu, Sang & Park 2015).	Yes. NSW, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023; Yip & Weste 1985).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phoma sp. Sacc. [Pleosporales: Didymellaceae] Stem rot	Yes (APQA 2019; Kim & Koo 2009).	Uncertain, as species not specified. Many *Phoma* species have been recorded throughout Australia (APPD 2023). *Phoma* spp. known to be associated with *C. melo* in Korea are also present in Australia: *P. cucurbitacearum* (assessed here as *Stagonosporopsis cucurbitacearum*), *P. exigua* var. *exigua* (*Ascochyta phaseolorum*) and *P. terrestris.*	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Physarum cinereum (Batsch) Pers. [Physarales: Physaraceae]	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic. (APPD 2023; Cook & Dubé 1989; Sampson & Walker 1982).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Plectosphaerella cucumerina (Lindf.) W. Gams Synonyms: *Plectosporium tabacinum* (J.F.H. Beyma) M.E. Palm, W. Gams & Nirenberg; *Monographella cucumerina* (Lindf.) Arx [Glomerellales: Plectosphaerellaceae]	Yes (Farr & Rossman 2023; Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; CABI 2023; Pascoe, Nancarrow & Copes 1984).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Podosphaera fuliginea (Schltdl.) U. Braun & S. Takam Synonyms: *Alphitomorpha fuliginea* Schltdl.; *Sphaerotheca fuliginea* (Schltdl.) Pollacci [Erysiphales: Erysiphaceae] Powdery mildew	Yes (Farr & Rossman 2023).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023; Sampson & Walker 1982).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Podosphaera fusca (Fr.) Braun & Shishkoff Synonyms: *Podosphaera xanthii* (Castagne) Braun & Shishkoff; *Sphaerotheca fusca* (Fr.) S. Blumer [Erysiphales: Erysiphaceae] Powdery mildew	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic. WA (APPD 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pseudoperonospora cubensis (Berk. & M.A. Curtis) Rostovzev Synonym: *Peronospora cubensis* Berk. & M.A. Curtis [Peronosporales: Peronosporaceae] Downy mildew	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, WA (APPD 2023; Persley, Cooke & House 2010; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudothielavia terricola (J.C. Gilman & E.V. Abbott) X. Wei Wang & Houbraken Synonym: *Thielavia terricola* (J.C. Gilman & E.V. Abbott) C.W. Emmons [Sordariales: Chaetomiaceae]	Yes (Adhikari et al. 2016).	Yes. NSW, Tas, WA (APPD 2023; HerbIMI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Rhizoctonia solani J.G Kühn Synonyms: *Thanatephorus cucumeris* (A.B. Frank) Donk; *Corticium sasakii* (Shirai) H. Matsumoto; *Corticium solani* (Prill. & Delacr.) Bourdot & Galzin [Cantharellales: Ceratobasidiaceae] Root rot; Damping off; Thread blight	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Anderson et al. 2004; APPD 2023; Neate & Warcup 1985; Persley, Cooke & House 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Rhizopus arrhizus A. Fisch. Synonym: *Rhizopus oryzae* Went & Prins. Geerl. [Mucorales: Rhizopodaceae] Soft rot; barn rot of tobacco	Yes (Kwon et al. 2010).	Yes. NSW, Qld, Vic., WA (APPD 2023; HerbIMI 2023; Simmonds 1966).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Rhizopus stolonifer (Ehrenb.) Vuill. Synonyms: *Rhizopus nigricans* Ehrenb.; *Mucor stolonifer* Ehrenb. [Mucorales: Rhizopodaceae] Fruit rot; Bulb rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; Persley, Cooke & House 2010; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Sclerotinia sclerotiorum (Lib.) de Bary Synonym: *Sclerotinia libertiana* Fuckel [Helotiales: Sclerotiniaceae] Sclerontinia stem rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Horne, de Boer & Crawford 2002; Li et al. 2006).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	**Potential for distribution**			
Septoria apiicola Speg. [Capnodiales: Mycosphaerellaceae] Black blight	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Setophoma terrestris (H.N. Hansen) Gruyter, Aveskamp & Verkley Synonyms: *Phoma terrestris* H.N. Hansen; *Pyrenochaeta terrestris* (H.N. Hansen) Gorenz, J.C. Walker & Larson [Pleosporales: Didymellaceae] Pink root	Yes (Kim & Koo 2009).	Yes. NSW, Qld, Tas., WA (APPD 2023; Government of Western Australia 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Stagonosporopsis cucurbitacearum (Fr.) Aveskamp, Gruyter & Verkley Synonyms: *Didymella bryoniae* (Auersw.) Rehm; *Cercospora citrullina* Cooke; *Phoma cucurbitacearum* (Fr.) Sacc. [Pleosporales: Didymellaceae] Gummy stem blight (cucurbits)	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; Persley, Cooke & House 2010; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Trichoderma koningii Oudem. [Hypocreales: Hypocreaceae]	Yes (CABI 2023; NCBI 2023).	Yes. NSW, Vic., WA (APPD 2023; CABI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Trichoderma viride Pers. [Hypocreales: Hypocreaceae]	Yes (Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Trichothecium roseum (Pers.) Link [Hypocreales: Incertae sedis] Pink mould fruit rot; Pink fruit rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Persley, Cooke & House 2010; Upsher & Upsher 1995).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Verticillium dahliae Kleb. [Glomerellales: Plectosphaerellaceae] Verticillium wilt	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Ramsay, Multani & Lyon 1996; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
FUNGUS-LIKE ORGANISMS							
Fuligo gyrosa (Rostaf.) Jahn Synonym: *Physarum gyrosum* Rostaf. [Physarales: Physaraceae] Slime mould of melon	Yes (APQA 2019; Kim & Koo 2009).	No records found.	No. This species produces fruiting bodies on leaves, stems and petioles (Kim et al. 2009; Kim & Koo 2009). It is not known to be associated with melon fruit.	Assessment not required.	Assessment not required.	Assessment not required.	No
Phytophthora cactorum (Lebert & Cohn) J. Schröt [Peronosporales: Peronosporaceae] Apple collar rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Golzar, Phillips & Mack 2007; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Phytophthora capsici Leonian [Peronosporales: Peronosporaceae] Stem rot (capsicum); Fruit rot (capsicum)	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, WA (APPD 2023; Government of Western Australia 2023; Weinert et al. 1998).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Phytophthora citrophthora (R.E. Sm. & E.H. Sm.) Leonian [Peronosporales: Peronosporaceae] Crown and trunk canker	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA Tas., Vic., WA (APPD 2023; Cook & Dubé 1989; Hardy 2004; Irwin, Cahill & Drenth 1995; Sampson & Walker 1982).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Phytophthora cryptogea Pethybr. & Laff. [Peronosporales: Peronosporaceae] Crown and root rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; Stukely et al. 2007).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Phytophthora drechsleri Tucker [Peronosporales: Peronosporaceae] Watermelon fruit rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, Vic., WA (APPD 2023; Government of Western Australia 2023; Stukely et al. 2007).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phytophthora melonis Katsura Synonym: *Phytophthora sinensis* Yu & Zhuang [Peronosporales: Peronosporaceae] Late blight or foot rot of cucumber	Yes (APQA 2019; Farr & Rossman 2023; Kim & Koo 2009).	No records found.	Yes. *Phytophthora melonis* is a soil-borne disease causing root rot of *C. melo* (Mirtalebi & Banihashemi 2019). However, it is also known to infect all parts of cucurbit hosts (Chen et al. 2012; Ho, Lu & Gong 1984; Mirtalebi & Banihashemi 2019), including the fruit (APQA 2019). Fruit infection of cucurbits results in dark green, water-soaked lesions causing soft rot of the fruit (Ristaino 2023; Zitter, Hopkins & Thomas 1996).	Yes. Produces motile zoospores which can travel to new host plant tissues through soil or water (Erwin & Ribeiro 1996; Ho, Lu & Gong 1984). These zoospores could potentially enter the environment from discarded waste.	Yes. Host are mainly cucurbits (Farr & Rossman 2023; Ho, Gallegly & Hong 2007; Mills, Förster & Coffey 1991). Hosts and suitable climatic conditions are available in Australia to allow the pathogen to establish and spread.	Yes. *Phytophthora melonis* is one of the most severe diseases of the Cucurbitaceae, significantly reducing crop yield worldwide (Erwin & Ribeiro 1996; Hashemi et al. 2020). It has been reported to cause root rot on *C. melo* resulting in significant yield loss (Mirtalebi & Banihashemi 2019). In cucumber, it is the causal agent of damping-off or crown rot, which often causes rapid wilting and death of the whole plant, resulting in severe economic losses (Hashemi et al. 2020; Ho, Gallegly & Hong 2007).	Yes

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Phytophthora nicotianae Breda de Haan [Peronosporales: Peronosporaceae] Black shank	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2023; Cunnington 2003; Persley, Cooke & House 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium aphanidermatum (Edson) Fitzp. [Peronosporales: Pythiaceae] Root rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Cook & Dubé 1989; Male & Vawdrey 2010; Persley, Cooke & House 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium debaryanum Hesse Synonym: *Globisporangium debaryanum* (Hesse) Uzuhashi, Tojo & Kakish. [Peronosporales: Pythiaceae] Damping off	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Shivas 1989; Wong, Barbetti & Sivasithamparam 1985).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Pythium deliense Meurs [Peronosporales: Pythiaceae] Damping off: seedlings	Yes (Chee & Kim 2000; Kim & Koo 2009).	Yes. Qld, Tas. (APPD 2023; Le, Smith & Aitken 2016). However, identification of the Tasmanian record is in question (Sampson & Walker 1982).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium irregulare Buisman Synonym: *Globisporangium irregulare* (Buisman) Uzuhashi, Tojo & Kakish [Peronosporales: Pythiaceae] Root rot	Yes (EPPO 2023).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2023; EPPO 2023; Sampson & Walker 1982; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium myriotylum Drechsler [Peronosporales: Pythiaceae] Soft rot	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, Vic., WA (APPD 2023; Persley, Cooke & House 2010; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium oligandrum Drechsler [Peronosporales: Pythiaceae]	Yes (Kim & Park 1999).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Cook & Dubé 1989; Le, Smith & Aitken 2016; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Pythium periplocum Drechsler [Peronosporales: Pythiaceae] Root rot	Yes (Kim & Park 1999; Kim & Koo 2009).	Yes. NSW (APPD 2023; HerbIMI 2023).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium spinosum Sawada Synonym: *Globisporangium spinosum* (Sawada) Uzuhashi, Tojo & Kakish. [Peronosporales: Pythiaceae] Damping off	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, Qld, WA (APPD 2023; HerbIMI 2023; Shivas 1989; Zahid et al. 2001).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Pythium ultimum Trow Synonym: *Globisporangium ultimum* (Trow) Uzuhashi, Tojo & Kakish. [Peronosporales: Pythiaceae] Damping off	Yes (APQA 2019; Kim & Koo 2009).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; HerbIMI 2023; Shivas 1989).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
VIRUSES							
Bean yellow mosaic virus (BYMV) [Potyviridae: Potyvirus]	Yes (APQA 2018; CABI 2023).	Yes. NSW, Qld, SA, Tas., Vic., WA (EPPO 2023; Persley & Gambley 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Clover yellow vein virus (CYVV) [Potyviridae: Potyvirus]	Yes (APQA 2018; CABI 2023).	Yes. NSW, Qld, SA, Tas., Vic., WA (Alberts, Hannay & Randles 1985; Büchen-Osmond et al. 1988; CABI 2023; Norton & Johnstone 1998).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Cucumber fruit mottle mosaic virus (CFMMV) [Virgaviridae: Tobamovirus]	Yes (Rhee, Hong & Lee 2014).	No records found.	Yes. *Cucumis melo* is a natural host of CFMMV (Rhee, Hong & Lee 2014). Infection is systemic and symptoms on fruit may include bright mottling or mosaic (Antignus et al. 2001; Rhee, Hong & Lee 2014). As part of Korea's export process, any oriental melon or rockmelon fruit showing visible symptoms of viral infections at the packhouse are discarded as unsuitable for export. However, it is possible latent or early infection could result in infected asymptomatic fruits that may be missed.	Yes. CFMMV is not known to be seed-transmitted in *C. melo* but may be mechanically transmitted through contact with infected material (Dombrovsky & Smith 2017). Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Some asymptomatic infected fruit may be sold. Some melon fruit waste infected with CFMMV may be discarded into the environment near suitable host plants.	Yes. CFMMV naturally infects several species within the Cucurbitaceae family (Antignus et al. 2001; Dombrovsky, Tran-Nguyen & Jones 2017; Rhee, Hong & Lee 2014), which are widely planted throughout Australia. CFMMV has established in areas with similar climatic conditions to those in parts of Australia (Antignus et al. 2001; Rhee, Hong & Lee 2014). Tobamoviruses, including CFMMV are highly stable and persistent (Antignus et al. 2005; Lecoq & Katis 2014) and may remain infectious in the	Yes. CFMMV causes fruits to exhibit severe mottling or mosaic, rendering them unmarketable, and can cause severe wilting and collapse of the plant (Antignus et al. 2005; Antignus et al. 2001). Under favourable conditions, the disease incidence may reach up to 100%, leading to significant economic losses in cucumber crops (Antignus et al. 2005).	Yes (EP)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
					environment for long periods.		
Cucumber green mottle mosaic virus (CGMMV) [Virgaviridae: Tobamovirus]	Yes (APQA 2019; CABI 2023; Yoon et al. 2008).	Yes. Under official control (National) (DAWR 2017b). Present with restricted distribution in NSW, NT, Qld, SA, WA (Business Queensland 2019; DPIRD 2017; Hort Innovation 2019; Northern Territory Government 2020; NSW DPI 2020b; PIRSA 2019).	Yes. Melon is a natural host of CGMMV (Reingold et al. 2015; Sugiyama, Ohara & Sakata 2006; Tian et al. 2014). CGMMV can cause leaf mottling, mosaic symptoms on the leaves and fruit mottling or distortion (Reingold et al. 2015). Infected melon fruit may display mottled symptoms (AMA 2015). As part of Korea's export process, any oriental melon or rockmelon fruit showing visible symptoms of viral infections at the packhouse are discarded and are not considered suitable for export. However, asymptomatic fruits may be missed.	Yes. CGMMV can be mechanically transmitted or seed transmitted (Dombrovsky, Tran-Nguyen & Jones 2017). Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Some asymptomatic infected fruit may be sold. Some melon fruit waste infected with CGMMV may be discarded into the environment near suitable host plants.	Yes. CGMMV has established in various regions in Australia (Hort Innovation 2019). Climatic conditions in Australia are expected to favour the establishment of the pathogen. CGMMV is very stable and can be transmitted in infected plants mechanically, via infected tools and machinery which come in contact with the virus. Long distance dispersal of this virus could also occur through the movement of infected propagative material.	Yes. CGMMV is an economically important pathogen of cucumber, melon, squash and watermelon (Moradi & Jafarpour 2011). It is reported to cause yield losses of around 15% in cucurbitaceous crops (Nontajak et al. 2014). The damage it causes to the host plant and fruit can be extensive. Therefore, CGMMV is considered a threat to Australia's fresh vegetable market and the Cucurbitaceous seed industry.	Yes (EP)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cucumber mosaic virus (CMV) [Bromoviridae: Cucumovirus]	Yes (APQA 2019; Choi et al. 2005).	Yes. NSW, Qld, SA, Tas., Vic., WA (Alberts, Hannay & Randles 1985; APPD 2023).	Assessment not required	Assessment not required	Assessment not required	Assessment not required	No
Cucurbit aphid-borne yellows virus (CABYV) [Luteoviridae: Polerovirus]	Yes (Choi & Choi 2016).	No records found.	Yes. Transmission is limited to phloem cells for viruses in the genus *Polerovirus* (Hoffmann et al. 2001). The virus is systemic in the phloem of melons, causing symptoms on fruit (Choi & Choi 2016).	No. CABYV is not mechanically transmitted, and there is no evidence demonstrating that this virus is seed-borne in melon (Kassem et al. 2007). It is transmitted by at least 2 aphid species, *Aphis gossypii* and *Myzus persicae* (Lecoq et al. 1992). Although these aphid species are present in Australia (APPD 2023; Reinbold, Herrbach & Brault 2003), they are highly unlikely to feed on discarded rotting or desiccating melon fruit, as they	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
				prefer to feed on actively growing parts (e.g., growing shoots, young leaves) (Capinera 2008, 2018; Natwick, Stapleton & Stoddard 2016).			

			Potential to enter on pathway				
Pest	**Present in Korea**	**Present within Australia**	**Potential for importation**	**Potential for distribution**	**Potential for establishment and spread**	**Potential for economic consequences**	**Pest risk assessment required**
Cucurbit chlorotic yellows virus (CCYV) [Closteroviridae: Crinivirus]	Yes (Cho et al. 2021).	No records found.	Yes. CCYV has been reported to naturally affect *Cucumis melo*, causing yellowing and vein clearing symptoms (Cho et al. 2021). This virus is known to infect host plants systemically (Okuda et al. 2010), and it has been detected on symptomatic watermelon fruit (Luria et al. 2019).	No. As a crinivirus, CCYV is not mechanically transmissible or seed transmitted (Okuda et al. 2010; Orfanidou et al. 2017). CCYV is only known to be vectored by some members of the *Bemisia tabaci* complex (Orfanidou et al. 2017). While some of these vectors may be present in Australia, they are highly unlikely to feed on discarded, rotting or desiccating melon fruit, as they are leaf-sap feeders that infest leaves, stems and buds of host plants (Alegbejo & Banwo 2005; CABI 2023; McAuslane 2009).	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Kyuri green mottle mosaic virus (KGMMV) [Virgaviridae: Tobamovirus]	Yes (Daryono et al. 2016; Daryono, Somowiyarjo & Natsuaki 2005a).	No records found.	Yes. *Cucumis melo* is a natural host of KGMMV (Kim, Lee & Natsuaki 2009). Infection is systemic and infected fruit may be seriously deformed, with mottle mosaic symptoms (Daryono, Somowiyarjo & Natsuaki 2005a; Kim, Lee & Natsuaki 2009), rendering the fruits unmarketable. As part of Korea's export process, any oriental melon or rockmelon fruit showing visible symptoms of viral infections at the packhouse are discarded as unsuitable for export. However, it is possible latent or early infection could result in infected asymptomatic fruits that may be missed.	Yes. KGMMV is not known to be seed-transmitted in *C. melo* but may be mechanically transmitted through contact with infected material (Dombrovsky & Smith 2017). Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Some asymptomatic infected fruit may be sold. Some melon fruit waste infected with KGMMV may be discarded into the environment near suitable host plants.	Yes. KGMMV naturally infects several species within the Cucurbitaceae family (Kim, Lee & Natsuaki 2009) which are widely planted throughout Australia. KGMMV has established in areas with a wide range of climatic conditions (Daryono, Somowiyarjo & Natsuaki 2005a). There are similar climatic regions in parts of Australia that would be suitable for the establishment of this virus. Tobamoviruses, including KGMMV, are highly stable and persistent (Daryono, Somowiyarjo & Natsuaki 2005b; Lecoq & Katis 2014) and may	Yes. KGMMV causes serious diseases of cucurbit crops and is responsible for significant economic losses in several countries (Kim, Lee & Natsuaki 2009). In Japan, KGMMV is considered a major virus, causing severe yield reduction in cucumber (Fukuta et al. 2012).	Yes (EP)

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
					remain viable in the environment for long periods (Dombrovsky & Smith 2017).		

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Melon aphid-borne yellows virus (MABYV) [Luteoviridae: Polerovirus]	Yes (Byun et al. 2022)	No records found.	Yes. MABYV has been reported to naturally affect *Cucumis melo*, causing yellowing symptoms (Xiang et al. 2008). Some viruses of this genus are known to infect hosts systemically (Delfosse, Barrios Barón & Distéfano 2021), and MABYV has been detected in fruit (Knierim et al. 2010).	No. MABYV is not mechanically transmitted (Sastry et al. 2019), and there is no evidence demonstrating that it is seed-borne in melon. MABYV is vectored by the aphid *Aphis gossypii* (Sastry et al. 2019). Although this aphid is present in Australia (APPD 2023), it is highly unlikely to feed on discarded rotting or desiccating melon fruit, as it prefers to feed on actively growing parts (e.g., growing shoots, young leaves) (Capinera 2018; Natwick, Stapleton & Stoddard 2016).	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	Potential for distribution			
Melon necrotic spot virus (MNSV) Synonym: *Muskmelon necrotic spot virus* [Procedovirinae: Gammacarmovirus]	Yes (APQA 2019; Kwak et al. 2015).	Yes. Under official control (National) (DAWE 2020). Present with restricted distribution in NSW, Vic. (Mackie et al. 2020) and Qld (Business Queensland 2021b).	Yes. Melon is the natural host of MNSV (Choi, Kim & Kim 2003). MNSV affects melon systemically and is present in the fruit and seeds (Hibi & Furuki 1985). On the outside of infected melon fruit, indentations and brown spots can appear, whilst the flesh may become dark, hollow and rotten (Agriculture Victoria 2015). As part of Korea's export process any oriental melon or rockmelon fruit showing visible symptoms of viral infections at the packhouse are discarded and are not considered suitable for export. However, asymptomatic fruits may be missed.	Yes. MNSV is seed-transmitted, soil- and water borne, and can be mechanically transmitted by contact between plants or by tools used for pruning (Lecoq & Desbiez 2012). Melon fruit imported from Korea will likely be distributed throughout Australia for retail sale. Some asymptomatic infected fruit may be sold. Some melon fruit waste infected with MNSV may be discarded into the environment near suitable host plants.	Yes. MNSV has been detected sporadically in Australia (Business Queensland 2021b). MNSV naturally infects members of the Cucurbitaceae family, including *C. melo* (Ayo-John et al. 2014; Kishi 1966; Koç, Fidan & Baloğlu 2014; Lecoq & Desbiez 2012; Tomlinson & Thomas 1986). Host species are widely planted in Australia. Virus particles can remain viable in the soil for several years and can also persist for a long period in association with its soil-borne fungal vector *Olpidium bornovanus,* which is present in Australia (Plant	Yes. MNSV is a serious pathogen of greenhouse melons and cucumbers worldwide, but it also causes problems in fields (Herrera-Vásquez et al. 2009; Lecoq & Desbiez 2012). MNSV has been reported to cause up to 100% loss in other melon growing regions of the world (Kwak et al. 2015). In greenhouse grown watermelon plants, it has been reported to cause rates of plant death of 80% (Ruiz et al. 2016).	Yes

Pest	Present in Korea	Present within Australia	Potential to enter on pathway: Potential for importation	Potential to enter on pathway: Potential for distribution	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
					Health Australia 2016).		
Papaya ringspot virus-Type W (PRSV-W) cucurbit-infecting strain [Potyviridae: Potyvirus]	Yes (APQA 2019; Ko et al. 2007).	Yes. NSW, NT, Qld, Vic., WA (Persley & Gambley 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Squash mosaic virus (SqMV) [Comovirinae: Comovirus]	Yes (Kim et al. 2012).	Yes. NT, WA, Qld, NSW, Vic., Tas., SA (Büchen-Osmond et al. 1988; Coutts & Jones 2005; Persley & Gambley 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Tomato spotted wilt orthotospovirus (ToSWV) [Tospoviridae: Orthotospovirus]	Yes (APQA 2018; Cho et al. 2005).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2023; Persley, Thomas & Sharman 2006).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
Watermelon mosaic virus (WMV) Synonym: *Watermelon mosaic virus – 2* [Potyviridae: Potyvirus]	Yes (APQA 2019; Ko et al. 2007).	Yes. NSW, Qld, SA, Vic., WA (APPD 2023; Persley & Gambley 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No

Pest	Present in Korea	Present within Australia	Potential to enter on pathway		Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
			Potential for importation	**Potential for distribution**			
Zucchini yellow mosaic virus (ZYMV) [Potyviridae: Potyvirus]	Yes (APQA 2019; Ko et al. 2007).	Yes. NSW, NT, Qld, Tas., WA (APPD 2023; EPPO 2023; Persley & Gambley 2010).	Assessment not required.	Assessment not required.	Assessment not required.	Assessment not required.	No
No mealybug species associated with commercially produced oriental melon and rockmelon fruit were identified by Korea in their Technical Market Access Submission. Application of the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2019) did not identify any mealybugs that are associated with the oriental melon and rockmelon fruit from Korea pathway. A further literature search found no mealybug species that are likely to be present on the oriental melon and rockmelon fruit from Korea pathway.							
No hard scale species associated with commercially produced oriental melon and rockmelon fruit were identified by Korea in their Technical Market Access Submission. Application of the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (DAWE 2021) did not identify any hard scales that are associated with the oriental melon and rockmelon fruit from Korea pathway. A further literature search found no hard scale species that are likely to be present on the oriental melon and rockmelon fruit from Korea pathway.							
No soft scale species associated with commercially produced oriental melon and rockmelon fruit were identified by Korea in their Technical Market Access Submission. Application of the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (DAWE 2021) did not identify any soft scales that are associated with the oriental melon and rockmelon fruit from Korea pathway. A further literature search found no soft scale species that are likely to be present on the oriental melon and rockmelon fruit from Korea pathway.							

Appendix C: Stakeholder comments

This section outlines key technical issues raised by stakeholders during consultation on the draft report, and the department responses. Additional information on other issues commonly raised by stakeholders, which are outside the scope of this technical report, is available on the department website.

Issue 1: Clarification sought on the verification process to ensure CGMMV infected fruit is not entering Australia

A pest risk assessment was undertaken to evaluate the likelihood of the introduction (entry and establishment) and spread of CGMMV on the oriental melon and rockmelon fruit from Korea pathway, and the magnitude of the associated potential consequence. The combination of the likelihoods and consequences gives an overall estimate of the biosecurity risk of CGMMV, known as the unrestricted risk estimate (URE). The URE takes into account the existing commercial production practices as described in Chapter 2. The URE of CGMMV was assessed as Very Low, which achieves the ALOP for Australia. Therefore, there are no specific risk management measures recommended for CGMMV.

As the existing commercial practices were taken into account when determining that the URE for CGMMV achieves the ALOP for Australia, the department will verify that these systems and processes are being applied through a system of operational procedures. The system of operational procedures ensures the phytosanitary status of oriental melon and rockmelon fruit from Korea is maintained, and that this can be verified.

The operational procedures are explained in section 4.2 of the report, and include a system of traceability, registration of greenhouses and packing houses, auditing of procedures, pre-export phytosanitary inspection, and on-arrival phytosanitary verification by the department. The department will verify that the consignments of oriental melon and rockmelon fruit from Korea are as described on the phytosanitary certificate and meet Australia's import requirements. This system of operational procedures is considered to provide adequate assurance that the biosecurity risk, including that of CGMMV has been reduced to an acceptable level.

Issue 2: Clarification and review of the likelihood of distribution risk estimate ratings for CFMMV, KGMMV and MNSV in comparison with CGMMV

The department has reviewed the risk assessments for CFMMV, KGMMV, MNSV and CGMMV, and considers the risk ratings for likelihood of distribution for each of these viruses to be appropriate. The risk assessments took into account the key elements of each of the viruses associated with transmission and dispersal. While each of the viruses share similar characteristics, there are key differences which support a lower risk estimate for likelihood of distribution of CFMMV, KGMMV and MNSV compared to CGMMV.

CFMMV and KGMMV

The department acknowledges that CGMMV, CFMMV and KGMMV are all tobamoviruses, and they share common biological characteristics (e.g., extremely stable, mechanically transmissible).

However, key elements affecting the virus dispersal vary between CGMMV and the other two viruses, which support a different risk rating for the likelihood of distribution for CFMMV and KGMMV compared to CGMMV. The key elements considered are outlined below:

- CGMMV has been reported to be seed-borne and seed transmitted in melon. However, there are no records of CFMMV or KGMMV being seed-borne or seed transmitted in melon.
- Transmission of CGMMV by some beetle species has been demonstrated. However, no insect vector has been reported to be associated with the transmission of CFMMV or KGMMV.
- The host range of CGMMV includes many species within the Cucurbitaceae family and various weed species from several families. However, the known host range of CFMMV and KGMMV is limited to several species within the Cucurbitaceae family.

Due to these differences, the department considers that a likelihood of distribution risk estimate ratings of Very Low for CFMMV and KGMMV, compared to a likelihood of distribution risk estimate rating of Low for CGMMV, is technically justified.

MNSV

CGMMV and MNSV are from different virus families, and they are not taxonomically or phylogenetically related. CGMMV belongs to the genus *Tobamovirus* of the family Virgaviridae, while MNSV is in the genus *Gammacarmovirus* of the family Tombusviridae.

The department acknowledges that CGMMV and MNSV share some common biological characteristics relating to virus transmission. For example, both CGMMV and MNSV have been demonstrated to be seed-borne and seed transmitted in melon, and they are also mechanically transmissible. However, they also have distinct differences in their transmission mechanisms and these differences were considered when assessing the likelihood risk estimate of distribution for MNSV. Some key differences are summarised below:

- MNSV is seed-borne through an unusual mode: the vector-assisted seed transmission, which is different from CGMMV. Seed transmission of MNSV is therefore largely dependent on the availability of the fungal vector, which greatly reduces the likelihood of virus transmission through this pathway. When contaminated seeds produced on infected plants are sown in sterile soil, no or very limited seed transmission is observed.
- Conditions that allow for mechanical transmission differ between the two viruses. CGMMV is highly contact-transmissible and can be easily transmitted via contact in the field. Transmission of MNSV via contact in the natural environment may also be possible, but it has only been demonstrated to be mechanically transmissible through inoculation in laboratories.
- The host range of MNSV is much narrower than that of CGMMV, which further reduces the likelihood of distribution. The host range of CGMMV includes many species within the Cucurbitaceae family and various weed species from several families. However, the known host range of MNSV is limited to some species within the Cucurbitaceae family.

Due to these differences, the department considers that a likelihood of distribution risk estimate rating of Very Low for MNSV, compared to a likelihood of distribution risk estimate rating of Low for CGMMV, is technically justified.

Issue 3: Review of the Z*eugodacus depressus* consequence impact score for domestic and international trade

Australia's method for pest risk analysis, outlined in Appendix A, was followed in all pest risk assessments. This method for pest risk analysis is consistent with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2019a), ISPM 11: *Pest Risk Analysis for Quarantine Pests* (FAO 2019b) and the SPS Agreement (WTO 1995).

It is important to note that in estimating the consequences of a pest if it were to enter, establish and spread in Australia, the department uses a 2-step process: assigning an impact descriptor to each of the criteria in terms of the level and magnitude, and combining the impacts for each criterion to obtain an 'overall consequence' estimation.

In response to a comment that the *Z. depressus* consequence impact estimate is too low for the indirect criteria of domestic and international trade, the department has reviewed the consequence assessment to clarify the evidence and rationale supporting the impact descriptor and overall consequence rating.

The biology, host range and preferred environment of *Z. depressus* are different to most fruit flies of economic concern, either exotic or endemic to Australia. For example, this species produces only one generation per year, has a narrow host range compared to other tephritids and its distribution is limited to higher altitudes. These factors are considered in the assessment and in considering the level and magnitude of impact of *Z. depressus* if it were to establish in production areas. The global distribution of *Z. depressus* and its presence in export markets are also considered, as well as whether there are phytosanitary measures available for markets where this pest is not present. Upon review of the assessment, the department considers the indirect impact of 'Major significance at the District level' for domestic and international trade, and overall consequences estimate of Moderate to be appropriate for *Z. depressus.* Additional information has been included in the assessment to further clarify the rationale and support the consequence assessment.

The overall consequence rating of Moderate, when combined with the likelihood of entry, establishment and spread assessment of Low, results in a URE of Low for *Z. depressus*, which does not achieve the ALOP for Australia, and therefore the department continues to recommend specific risk management measures for *Z. depressus* on the greenhouse-grown oriental melon and rockmelon fruit from Korea pathway.

Issue 4: Clarification and review of the rationale for the risk assessment of the likelihoods of establishment and spread for *Zeugodacus depressus*

The likelihoods of establishment and of spread of *Zeugodacus depressus* in Australia from the oriental melon and rockmelon from Korea pathway were both assessed as Moderate. While the likelihood risk estimate ratings were supported in principle, it was requested that a number of factors be re-examined as part of the pest risk assessment, these being:

- how cooler microclimates present in areas of high temperatures can provide refuges for the survival and therefore establishment of *Z. depressus*
- the effectiveness of lures to control and therefore prevent the spread of *Z. depressus*

- the risk of spread in parts of Australia where there are no natural barriers.

After consideration of stakeholder comments, these factors have been reviewed and minor amendments made to clarify the rationales presented in the assessment. However, the review has not resulted in a change to the likelihood risk estimate ratings for establishment and spread.

Issue 5: Review and clarification of the trapping requirements to support the risk management measure of pest free places of production or pest free production sites (during a limited seasonal period) for *Zeugodacus depressus*

The department has reviewed the risk management measure of pest free places of production or pest free production sites (during a limited seasonal period) for *Zeugodacus depressus* and further information has been added to this section to clarify the trapping requirements.

While the measure of pest free places of production or pest free production sites (during a limited seasonal period) was supported, stakeholders requested clarity around the trapping regime to verify the absence of *Z. depressus*. Further information has been added to clarify the trapping regime prior to, during and after the export period of 1 December to 31 May. The biology of *Z. depressus* means reproductively active adult flies are not present during winter production periods (i.e., December to May). Trapping for *Z. depressus* during this period provides confirmation that the flies are absent.

In addition, a stakeholder raised concerns around the effectiveness of trapping to verify pest freedom given *Z. depressus* does not respond to any known parapheromone lure.

The department acknowledges that parapheromone traps are not effective for detecting this species and therefore recommends a suitable trap that attracts *Z. depressus* adults be used, such as protein-based traps. While protein baits may not be as effective at attracting flies over as long a distance as parapheromone lures, protein-based traps are to be placed in and immediately outside each production site (greenhouse). Therefore, these traps will be in close enough proximity to every commercially produced fruit to attract any flies that are present. The enclosed nature of greenhouses also removes any effects of wind. Korea currently uses protein bait traps in export registered greenhouses as a requirement for export of melons to other markets. The department has analysed the trapping data for the past 3 years and no *Z. depressus* flies have been detected in traps during the seasonal absence period.

Glossary, acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
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 or regulated articles (FAO 2022).
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 *Biosecurity Act 2015* 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.
APQA	Korea's Animal and Plant Quarantine Agency
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2022).
Area of low pest prevalence	An area, whether all of a country, part of a country, or all parts of several countries, as identified by the competent authorities, in which a specific pest is present at low levels and which is subject to effective surveillance or control (FAO 2022).
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Asexual reproduction	The development of a new individual from a single cell or group of cells in the absence of meiosis.
Australian territory	Australian territory as referenced in the *Biosecurity Act 2015* refers to Australia, Christmas Island and Cocos (Keeling) Islands and any external Territory to which that provision extends.
BICON	Australia's Biosecurity Import Conditions system bicon.agriculture.gov.au/BiconWeb4.0
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 import risk analysis (BIRA)	The *Biosecurity Act 2015* 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 *Biosecurity Act 2015* 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.
Brix	The concentration of sugar in a solution or fruit according to the Brix Scale.
Calyx	A collective term referring to all of the sepals in a flower.
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 2022).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2022).
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 2022).

Term or abbreviation	Definition
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
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 2022).
EP	Existing policy. This denotes that a pest species has previously been assessed in another policy published by the department.
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2022).
FAO	Food and Agriculture Organization of the United Nations
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2022).
FSANZ	Food Standards Australia New Zealand (foodstandards.gov.au/Pages/default.aspx) and the Australia New Zealand Food Standards Code (foodstandards.gov.au/code/Pages/default.aspx)
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 *Biosecurity Act 2015* 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).
GP	Group policy. This refers to the *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (thrips Group PRA) (DAWR 2017a), the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (mealybugs Group PRA) (DAWR 2019) and the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (scales Group PRA) (DAWE 2021).
Hermaphroditic	An animal or a flower having normally both the male and the female organs of generation.
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2022).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2022).
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 2022).
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 2022).
Instar	An insect life stage in between moults.
Intended use	Declared purpose for which plants, plant products, or other articles are imported, produced or used (FAO 2022).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2022).

Term or abbreviation	Definition
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 2022).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2022).
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin et cetera, forming part of a consignment (FAO 2022). Within this report a 'lot' refers to a quantity of fruit of a single variety, harvested from a single production site during a single pick and packed at one time.
Mature fruit	Commercial maturity is the start of the ripening process. The ripening process will then continue and provide a product that is acceptable to consumers. Maturity assessments include colour, starch, index, soluble solids content, flesh firmness, acidity, and ethylene production rate.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2022).
NSW	The state of New South Wales in Australia.
NT	The Northern Territory of Australia.
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
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 2022).
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2022).
Peduncle	A flower stalk bearing either a cluster or a solitary flower, which develops into fruit.
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2022).
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 2022).
Pest free area (PFA)	An area in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2022).
Pest free place of production (PFPP)	Place of production in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2022).
Pest free production site (PFPS)	A production site in which a specific pest is absent, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2022).

Term or abbreviation	Definition
Pest risk analysis (PRA)	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 2022).
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 2022).
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 2022).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2022).
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 2022).
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 2022).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2022).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2022).
Phytosanitary measure	Phytosanitary relates to the health of plants. Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2022). 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 2022).
Phytosanitary regulation	Official rule to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2022).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2022).
Production site	In this report, a production site is a continuous planting of *Cucumis melo*. plants treated as a single unit for pest management purposes. If a property is subdivided into one or more units for pest management purposes, then each unit is a production site.
Qld	The state of Queensland in Australia.
Quarantine	Official confinement of regulated articles, pests or beneficial organisms for inspection, testing, treatment, observation or research (FAO 2022).
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 2022).
Regulated article (RA)	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 2022).

Term or abbreviation	Definition
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 2022).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2022).
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.
SA	The state of South Australia.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2022).
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 presence or absence by survey, monitoring or other procedures (FAO 2022).
Tas.	The state of Tasmania in Australia.
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 (as a phytosanitary measure)	Official procedure for killing, inactivating, removing, rendering infertile or devitalizing regulated pests (FAO 2022).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.
Vector	In this report, a vector is an organism that is capable of harbouring and spreading a pest from one host to another.
Viable	Alive, able to germinate or capable of growth and/or development.
Vic.	The state of Victoria in Australia.
WA	The state of Western Australia.
WTO	World Trade Organization

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