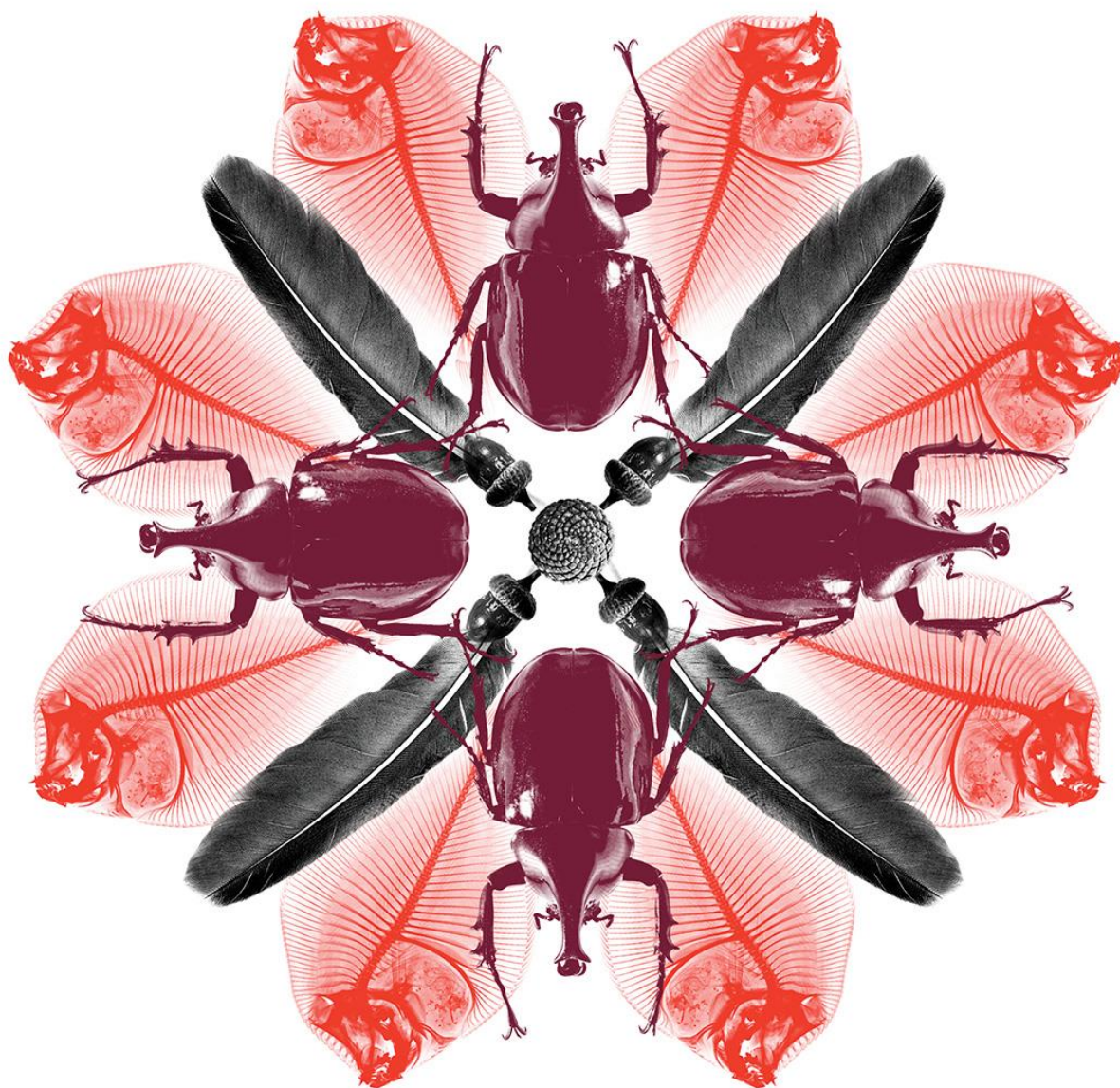




Australian Government
Department of Agriculture
and Water Resources

Final report for the review of biosecurity import requirements for fresh dragon fruit from Vietnam

January 2017



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Map 1 Map of Australia



Map 2 A guide to Australia's bio-climatic zones

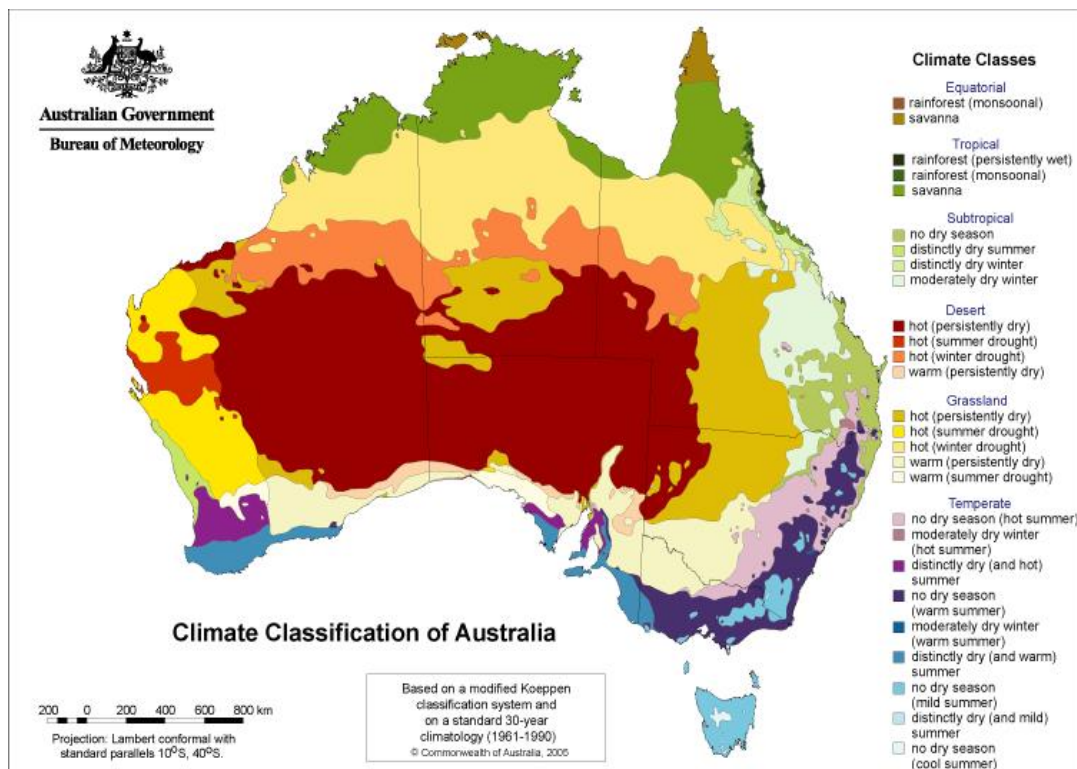
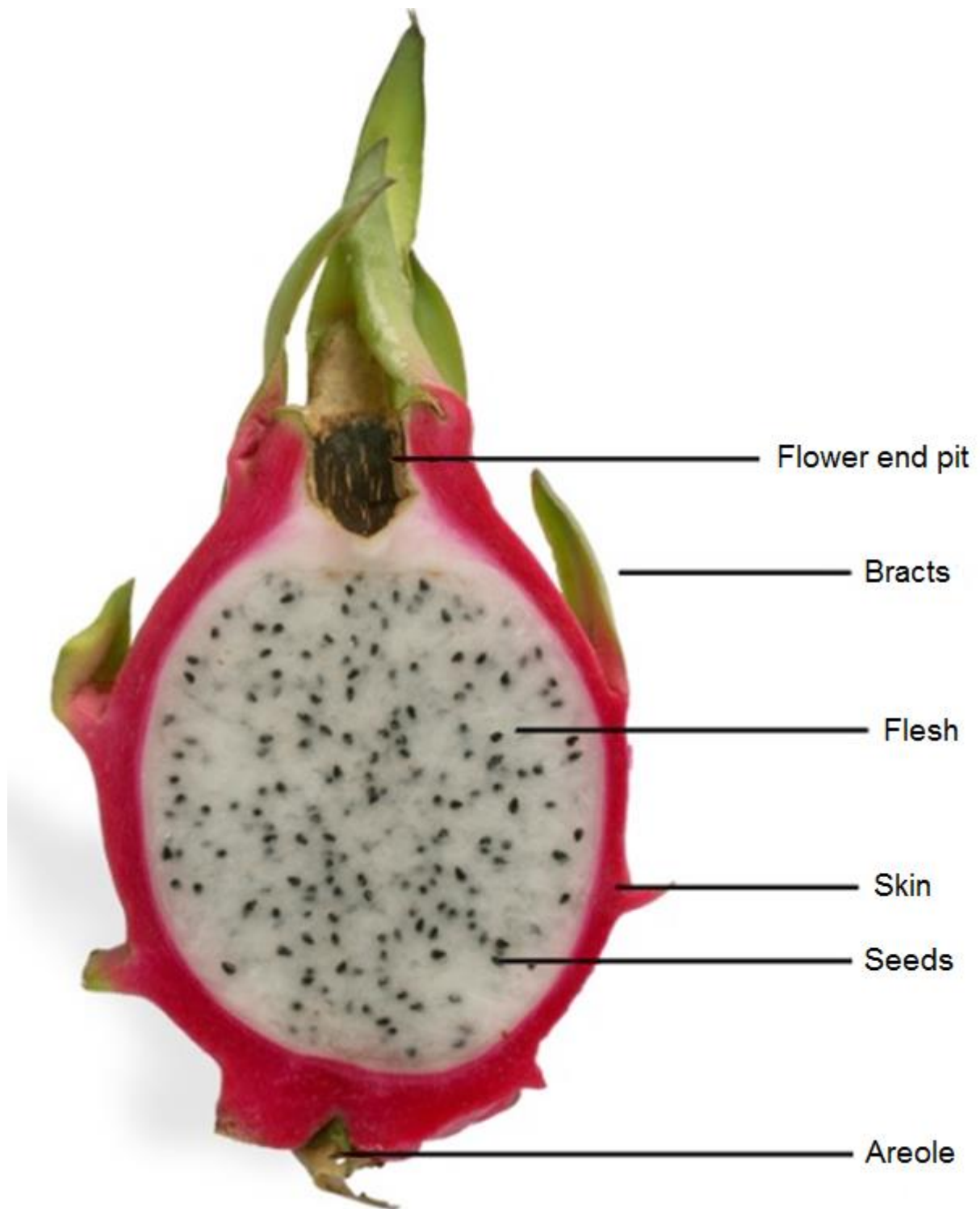


Figure 1 Diagram of dragon fruit



Acronyms and abbreviations

| Term or abbreviation | Definition |
|----------------------|---|
| ACT | Australian Capital Territory |
| ALOP | Appropriate Level of Protection |
| BA | Biosecurity Advice |
| BICON | Australia's Biosecurity Import Condition System |
| BIRA | Biosecurity Import Risk Analysis |
| CABI | CAB International, Wallingford, UK |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DAFF | The former Department of Agriculture , Fisheries and Forestry, which is now the Australian Government Department of Agriculture and Water Resources |
| The department | The Australian Government Department of Agriculture and Water Resources |
| DPIPWE Tasmania | Tasmania's Department of Primary Industries, Parks, Water and Environment |
| EP | Existing Policy |
| FAO | Food and Agriculture Organization of the United Nations |
| IPC | International Phytosanitary Certificate |
| IPPC | International Plant Protection Convention |
| ISPM | International Standard for Phytosanitary Measures |
| MARD | Vietnam's Ministry of Agriculture and Rural Development |
| MRL | Maximum Residue Limit |
| NSW | New South Wales |
| NPPO | National Plant Protection Organisation |
| NT | Northern Territory |
| PPD | Vietnam's Plant Protection Department |
| PRA | Pest Risk Analysis |
| Qld | Queensland |
| SA | South Australia |
| SPS Agreement | WTO agreement on the application of Sanitary and Phytosanitary measures |
| Tas. | Tasmania |
| VHT | Vapour Heat Treatment |
| Vic. | Victoria |
| WA | Western Australia |
| WTO | World Trade Organization |

Summary

The Australian Government Department of Agriculture and Water Resources has prepared this final report to assess the proposal by Vietnam for market access to Australia for fresh dragon fruit.

Australia has not previously permitted the importation of dragon fruit for human consumption from any country. However, Australia has considered the identified pests in previous risk analyses.

This final report recommends that the importation of fresh dragon fruit to Australia from all commercial production areas of Vietnam be permitted, subject to a range of biosecurity conditions.

This final report contains details of pests with the potential to be associated with the importation of dragon fruit that are of quarantine concern to Australia, the risk assessments for the identified quarantine pests and the recommended risk management measures in order to reduce the level of biosecurity risk to an acceptable level.

Seven arthropod pests have been identified as requiring risk management measures. These pests are *Bactrocera correcta* (guava fruit fly), *Bactrocera cucurbitae* (melon fly), *Bactrocera dorsalis* (Oriental fruit fly), *Planococcus lilacinus* (coffee mealybug), *Planococcus minor* (Pacific mealybug), *Pseudococcus jackbeardsleyi* (Jack Beardsley mealybug) and *Dysmicoccus neobrevipes* (grey pineapple mealybug).

The recommended risk management measures take account of regional differences within Australia. One pest requiring risk management, *Planococcus minor*, has been identified as a regional quarantine pest for Western Australia.

This final report recommends a range of risk management measures, combined with operational systems to reduce the risks posed by the seven quarantine pests to achieve the ALOP for Australia. These measures include:

- area freedom or vapour heat treatment for fruit flies
- consignment freedom verified by visual inspection and, if detected, remedial action for mealybugs.

Written submissions on the draft report were received from five stakeholders. The final report takes into account stakeholder comments on the draft report. The department has made a number of changes to the risk analysis following consideration of stakeholder comments on the draft report and subsequent review of the literature. These changes include:

- amendments to the text in Appendix A for several pests to improve clarity
- the addition of Appendix B 'Issues raised in stakeholder comments', which summarises key stakeholder comments and how they were considered in the final report
- minor corrections, rewording and editorial changes for consistency, 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 policies. 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 proposed 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.

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.

Risk analyses may take the form of a biosecurity import risk analysis (BIRA) or a non-regulated risk analysis (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* on the [Australian Government Department of Agriculture and Water Resources website](#).

1.2 This risk analysis

1.2.1 Background

Vietnam's Plant Protection Department (PPD) formally requested market access for dragon fruit to Australia in a submission received in October 2010 (PPD 2010). This submission included information on the pests associated with dragon fruit crops in Vietnam, including the plant part affected, and the standard commercial production practices for dragon fruit in Vietnam (PPD 2010). A further submission was received in June 2016 (letter from PPD of 06/06/2016) with an extended list of major production provinces and updated production statistics.

The preliminary pest categorisation for dragon fruit from Vietnam indicated that the pest species of quarantine concern are the same as or similar to those assessed previously by the department. For this reason, the department is using a review of biosecurity import requirements, previously referred to as a non-regulated analysis of existing policy, to consider this market access request.

On 20 April 2016, the department announced the formal commencement of this risk analysis, advising that it would be progressed as a review of biosecurity import requirements.

Officers from the department visited major dragon fruit production areas in Vietnam in June 2016 to observe production systems and packinghouse operations.

1.2.2 Scope

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the importation of commercially produced fresh dragon fruit (*Hylocereus* spp.) (henceforth dragon fruit), from Vietnam, for human consumption in Australia.

In this risk analysis, dragon fruit are defined as dragon fruit with skin, flesh and seeds, including full bracts protruding from the skin and a small portion of areole (0.5-1 centimetre) attached (Figure 1). This risk analysis covers all commercial dragon fruit cultivars of the genus *Hylocereus* produced in all dragon fruit production regions for export.

1.2.3 Existing policy

International policy

Dragon fruit for human consumption has not been previously assessed for import into Australia. However, there are established import conditions for seed (for sowing) and nursery stock of some varieties of dragon fruit. Import conditions also exist for a number of fresh fruits from several tropical Asian countries, including Vietnam. The potential pests of quarantine concern identified for dragon fruit from Vietnam are the same as or similar to those commodities for which import conditions exist. Examples include for: lychees from Taiwan and Vietnam (DAFF 2013), and mangoes from Taiwan (Biosecurity Australia 2006), Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015).

The import requirements for these commodity pathways can be found at the Biosecurity Import Conditions (BICON) system on the [department's website](#).

The department has considered all the pests previously identified in the existing policies and where relevant, the information in those assessments has been taken into account in this risk analysis. The department has also reviewed the latest literature to ensure that information in previous assessments is still valid.

Domestic arrangements

The Commonwealth Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within their individual jurisdiction. Legislation relating to resource management or plant health may be used by state and territory government agencies to control interstate movement of plants and their products. Once plant and plant products have been cleared by Australian Government biosecurity officers, they may be subject to interstate movement conditions. 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 dragon fruit from Vietnam that are assessed in this risk analysis, there are other organisms that may arrive with the imported commodity. These organisms could include pests of other crops or predators and parasitoids of other arthropods. The department considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are identified and addressed using existing operational procedures that require a 600 unit inspection of all consignments or equivalent. The department will investigate if any pest identified may be of quarantine concern to Australia and require remedial action.

1.2.5 Consultation

On 20 April 2016 the department notified stakeholders, in Biosecurity Advice 2016/13, of the formal commencement of a review of biosecurity import requirements for fresh dragon fruit from Vietnam.

Prior to and after announcement of this review the department communicated with key Australian dragon fruit growers regarding this risk analysis process. Departmental officers met with dragon fruit growers in the Northern Territory on 19 July 2016.

The department provided a draft pest categorisation to Australian state and territory agricultural departments for their advance consideration of regional pests, prior to the formal release of the draft report.

The draft report was released on 13 September 2016 (Biosecurity Advice 2016/31) for comment by stakeholders, for a period of 60 days that concluded on 14 November 2016. The department received five submissions on the draft report. All submissions were carefully considered and, where relevant, changes were made to the final report. A summary of major stakeholder comments and how they were considered is contained in Appendix B.

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

2 Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Australian Government Department of Agriculture and Water Resources has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2007) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2013) that have been developed under the SPS Agreement (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 2015a). A pest is ‘any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products’ (FAO 2015a). This definition is also applied in the *Biosecurity Act 2015*.

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

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

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is ‘any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests’ (FAO 2015a).

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

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

2.1 Stage 1 Initiation

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

Appendix A of this risk analysis report lists the pests with the potential to be associated with the exported commodity produced using commercial production and packing procedures.

Appendix A does not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia’s current approach to contaminating pests.

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

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

For pests that had been considered by the department in other risk assessments and for which import conditions already exist, this risk analysis considered the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration in this risk analysis.

2.2 Stage 2 Pest risk assessment

A pest risk assessment (for quarantine pests) is the 'evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences' (FAO 2015a).

The following three, consecutive steps were used in pest risk assessment:

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2015a).

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

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

The results of pest categorisation are set out in Appendix A. The quarantine pests identified during categorisation were carried forward for pest risk assessment and are listed in Tables 4.1 and 4.2.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2013). The SPS Agreement (WTO 1995) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

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

Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The likelihood of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in Chapter 3. These practices are taken into consideration by the department when estimating the likelihood of entry.

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

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

Factors considered in the likelihood of importation include:

- distribution and incidence 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 of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence 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.

Factors considered in the likelihood of distribution 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 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 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.

Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2015a). 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 considered in the likelihood of establishment in the PRA area include:

- availability of hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Likelihood of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2015a). 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 considered in the likelihood of spread 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.

Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2.1). Definitions for these descriptors and their indicative probability ranges are given in Table 2.1. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative probability ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table 2.1 Nomenclature of likelihoods

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

Combining likelihoods

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 2.2). 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 the likelihood of importation is assigned a descriptor of 'low' and the likelihood of distribution is assigned a descriptor of 'moderate', then they are combined to give a likelihood of 'low' for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of 'high' to give a likelihood for entry and establishment of 'low'. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of 'very low' to give the overall likelihood for entry, establishment and spread of 'very low'. This can be summarised as:

importation x distribution = entry [E]

low x moderate = low

entry x establishment = [EE]

low x high = low

[EE] x spread = [EES]

low x very low = very low

Table 2.2 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.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2015a) and ISPM 11 (FAO 2013).

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

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

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

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

For each of these six criteria, the consequences were estimated over four geographic levels, defined as:

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

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

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

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

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

Indiscernible—pest impact unlikely to be noticeable.

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

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

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

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A-G) using Table 2.3. For example, a consequence with a magnitude of ‘significant’ at the ‘district’ level will have a consequence impact score of D.

Table 2.3 Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic scales

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

Note: In earlier qualitative PRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A to F has been changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 2.4 were adjusted accordingly.

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 2.4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

Table 2.4 Decision rules for determining the overall consequence rating for each pest

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

2.2.4 Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread and for potential consequences are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 2.5) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the combination of likelihood and consequence.

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

Table 2.5 Risk estimation matrix

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

2.2.5 The appropriate level of protection (ALOP) for Australia

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

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which is defined in the *Biosecurity Act 2015*, is a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked ‘very low risk’ represents the ALOP for Australia.

2.3 Stage 3 Pest risk management

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

The conclusions from 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 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 2013) 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.

Risk management measures are identified for each quarantine pest where the risk does not achieve the ALOP for Australia. These are presented in Chapter 5: Pest risk management, of this report.

3 Vietnam's commercial production practices for dragon fruit

This chapter provides information on the pre-harvest, harvest and post-harvest practices considered to be standard practices in Vietnam for the production of dragon fruit for export. The export capability of Vietnam is also outlined.

3.1 Assumptions used in estimating unrestricted risk

Vietnam provided Australia with information on the standard commercial practices used in the production of dragon fruit of the genus *Hylocereus* in different regions in Vietnam. This information was complemented with data from other sources and was taken into consideration when estimating the unrestricted risks of pests that may be associated with the import of this commodity.

Officers from the department visited dragon fruit production areas in Vietnam's provinces of Tien Giang, Long An and Binh Thuan in June 2016, to verify the pest status and observe the harvest, processing and packing procedures for export of dragon fruit. The department's observations and additional information provided during the visit confirmed the production and processing procedures described in this chapter as standard commercial production practices for dragon fruit for export.

In estimating the likelihood of pest introduction it was assumed that the pre harvest, harvest and post-harvest production practices for dragon fruit as described in this chapter are implemented for all regions and for all commercial dragon fruit within the scope of this analysis. Where a specific practice described in this chapter is not taken into account to estimate the unrestricted risk, it is clearly identified and explained in Chapter 4.

3.2 Dragon fruit production areas

Originating in what is now Mexico, dragon fruit is widely distributed in tropical and subtropical regions. Production of dragon fruit in Vietnam mainly occurs in the southern Provinces of Binh Thuan, Long An, Tien Giang, Kien Giang, Binh Phuoc and Tay Ninh. The majority of production is concentrated in Long An, Tien Giang and Binh Thuan. From 2008 to 2013 the area under cultivation increased from 12 000 hectares to 25 000 hectares (Hung 2016) and in 2016 has further expanded to almost 40 000 hectares, yielding about 1 million tonnes of fruit per year (letter from PPD of 06/06/2016). Dragon fruit production has also extended into some of the northern provinces (Mai 2015). However, the majority of the dragon fruit for export is expected to come from the southern provinces. The main dragon fruit production areas in Vietnam are shown in Map 3.

3.3 Climate in production areas

The climate of Vietnam is typically warm and humid, has a considerable amount of sunshine, and is characterised by strong monsoonal influences (Weatheronline 2016).

The climate in the southern production areas of Vietnam is tropical (Goode's world atlas 2005) with two main seasons-the wet or rainy season, and the dry season. The wet season typically lasts from May to November and brings regular heavy afternoon rains and occasional typhoons (Hickery et al. 2015; Vietnam Travel Guide 2010). Average rainfall during the wet season in the southern region of Vietnam is 1 600 millimetres. The dry season in the south is between

December and April and is characterised by winds from the northeast monsoon, little rain, and warm temperatures (Hickery et al. 2015; Vietnam Travel Guide 2010). Minimum and maximum temperatures in the dry season tend to be around two degrees Celsius cooler than in the wet season. The monthly average temperature is around 25-29 °C in the southern production areas (Climate-data.org 2016).

Map 3 Major dragon fruit production provinces in Vietnam (shown in red)



Based on information provided by PPD (2010; 2016)

Figure 2 Mean monthly maximum and minimum temperatures and rainfall in main dragon fruit production provinces



Source: (World Weather Online 2016)

3.4 Pre-harvest

3.4.1 Cultivars

The main cultivars of dragon fruit grown in Vietnam belong to two species of the genus *Hylocereus*; *H. undatus* and *H. costaricensis*. It is expected that Vietnam intends to export cultivars of these two species to Australia. The characteristics of these two species are described here.

Hylocereus undatus

The plant of *H. undatus* has long green stems and produces very long flowers up to 29 centimetres long that are green on the outside and white on the inside. The oblong shaped fruit is 15-22 centimetres long weighing 300-800 grams. The fruit skin is rosy red and covered with large and long red bracts with green tips. The flesh is white with many small black seeds (Le Bellec, Vaillant & Imbert 2006).

Hylocereus costaricensis

The plant of *H. costaricensis* has stout waxy white stems and produces 25-30 centimetre long flowers with red margins on the petals (Le Bellec, Vaillant & Imbert 2006). The fruit is ovoid in shape, 10-15 centimetres in diameter, weighs 250-600 grams, and the skin is scarlet in colour. The surface is covered in bracts of varying size. The flesh is reddish purple with many small black seeds.

3.4.2 Cultivation practices

Dragon fruit are semi epiphytic plants with aerial roots that enable them to attach to and climb over any natural or artificial support they come in contact with (Le Bellec, Vaillant & Imbert 2006). Most individual farms in Vietnam are small (0.5-1 hectare) with a few larger operations covering up to 100 hectares each.

Cuttings

Commercially, new plants are produced from cuttings selected from 6 to 24 month old stock that has begun lignification. Lignification averts rotting of the planted cuttings. The 40-50 centimetre cuttings are treated with pesticides about one month before being placed against support posts. Usually four cuttings are against each support post, usually one cutting per post face (Figure 3).

Planting

In Vietnam, dragon fruit plants are mostly grown against reinforced concrete support posts with a square profile (Figure 3). Although rare, support posts can be made from brick or wood. The posts are 10-20 centimetres wide and typically extend 1.5-1.6 metres above ground. Each post has four 30-40 centimetre spikes extending horizontally from the top to bear the weight of the plants. Raised mounds of loose soil and fertiliser are usually constructed around the base of the support posts into which the cuttings are planted and tied to the posts (Figure 3).

Planting density is 70-100 plants per 1 000 square metres. During the dry season, a mulch of rice straw, dried grass, coconut fibres, or water hyacinth roots may be spread around the base of the plant to a distance of 5-10 centimetres in order to retain soil moisture (Mai ; PPD 2010). Posts are usually planted in north-south aligned bed rows, and positioned alternately in a staggered pattern between adjacent rows on a three metre spacing. Drainage ditches may be dug between bed rows depending on topography and ground water level (PPD 2010).

Planting time

Planting time varies between regions. In the wetter lowlands, planting from October to November is preferable to reduce the risk of waterlogging, while in areas prone to water shortage, planting from May to June at the beginning of the wet season is appropriate (PPD 2010). Planting within farms is usually spread out over time to facilitate replanting. Plants are typically replaced with new cuttings when a plant becomes 15 years old.

Pruning and weeding

Short weeds may be left as ground cover to prevent moisture loss. Large weeds are removed when fertilisers are applied (four times annually: the first application after the main harvest in September or October; three subsequent applications occur in December, February and April) (PPD 2010).

Pruning is done once each year to remove damaged, diseased and old branches, and to promote airflow through the farm during the wet conditions. Pruned branches are removed from the farm to promote hygiene of the plants.

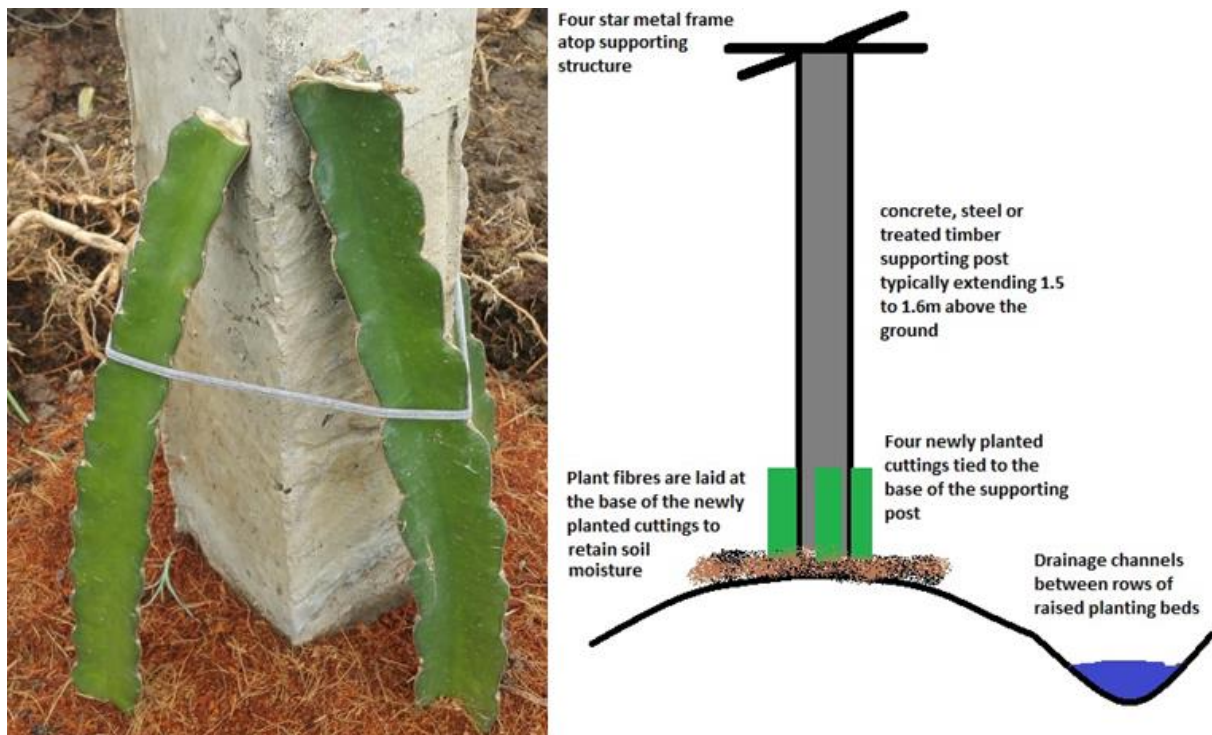
Bagging

Fruit may be bagged in perforated nylon bags to prevent injury by insect pests while still attached and developing on the plant (PPD 2010). However, this is not a common practice due to the intensive labour requirement of this method.

Irrigation

The drainage ditches between planting beds can act as an irrigation reservoir when needed. When there is insufficient precipitation, irrigation is conducted through pumping from local water supplies such as dams or rivers (PPD 2010). This is usually applied through understory drip irrigation and occasionally by overhead sprinklers.

Figure 3 Placement of cuttings against support post



Forced flower induction

The dragon fruit plant is photoperiodic, it blooms under long daylight conditions. Insufficient daylight results in weak, emaciated stems and delayed fruit set. Flowering is induced during the non-fruiting season by using artificial lights, usually activated from 7 pm to 1 am. Lights are hung between the rows of planting beds (Figure 4) to provide additional light during the short day length period from August to February (Hung 2016). Originally the industry used 65 watt incandescent bulbs but is undergoing a shift towards 20 watt compact power saving bulbs or 7 watt LED lights (Nguyen et al. 2015).

The lighting must be applied twice annually and over the course of 15-25 days. Flowering occurs several days after the lighting application has ceased (PPD 2010). Typically, lighting is also staggered to further extend the flowering during the cooler season and is applied every second pair of rows and subsequently reversed to cover the remaining rows.

Figure 4 Dragon fruit farm lit to induce flowering



3.4.3 Pest management

Commercially grown dragon fruit in Vietnam is less vulnerable to pests and diseases than other kinds of fruit crops (PPD 2010). The main pests reported to be of concern are snails and mealybugs. Management of pests begins at planting stage with pesticide application to cuttings occurring 30 days prior to planting. Vietnamese farmers apply some insecticide sprays according to a spray schedule that varies depending on the province (Table 3.1).

Pruning to promote aeration, removal of damaged or diseased branches from the farms, weeding schedules and well aerated and drained planting beds are part of a farm hygiene regimen which reduces incidence of disease. Irrigation practices are important in disease management, especially in elevated areas with well draining soils where water stress and sunburn can promote fungal infection.

Table 3.1 An example pest spray program recommended for dragon fruit production areas in Long An and Binh Thuan

| Pest/pathogen | Chemical spray | Number of applications |
|---------------|---|--|
| Aphids | <ul style="list-style-type: none"> • Abamectin • Imidacloprid • Withholding period of 10 days prior to harvest | 1-2 seasonal applications in Long An 1-3 seasonal applications in Binh Thuan |
| Stink bug | <ul style="list-style-type: none"> • Trebon 0.2% concentration on discovery • Bassa 0.2% concentration on discovery • Applaud 0.2% concentration on discovery • Mipc 0.2% concentration on discovery | 1-2 seasonal applications in Long An 1-3 seasonal applications in Binh Thuan |
| Fruit flies | <ul style="list-style-type: none"> • Protein bait spot spray with insecticides: malathion, pyrinex, regent • Sprayed on each support post at the base between 8 and 10am • Trapping network for male insects using imbibe pheromone mixed with insecticides. | Approximately one application between fruit set and harvest (Kumar et al. 2011). |

3.5 Harvesting and handling procedures

With proper irrigation and fertilising the plant can produce fruit almost all year round (Hung 2016). Under tropical conditions, peak production and harvesting occurs from April to September, with light induced flowering providing additional fruit for harvesting from October to March of the following year (Nguyen et al. 2015).

Fruit is usually harvested 30-32 days after flowering, when the fruit skin changes colour from green to red (Mai 2015). To ensure quality, increase shelf life, and prevent moisture loss, fruit is harvested during the cooler part of the day. The fruit is harvested manually using a garden knife, scissors or pruning shears, to cut the fruit from the stems. Harvested fruit is placed in plastic or woven baskets and left in the shade until being transported from the farm by open air small trucks or motorcycles to the collection centre or packing house (Mai 2015; PPD 2010).

Collection centres conduct preliminary washing and sorting of the fruit before it is transported to the packing house (PPD 2010).

3.6 Post-harvest

3.6.1 Packing house

Dragon fruit is generally picked in the morning and packed in the afternoon. Packinghouse layout is functional and provides unidirectional process flow from receipt to dispatch of product. Dragon fruit arrives from a collection centre or directly from the farm and is unloaded in the receiving area where documentation is checked and fruit quality assessed for colour, size, scarring and bruising. At this stage in the process, the fruit are designated as being either:

- For Export
- Not For Export
- Rejected

Rejected fruit is stored in a secure, segregated area until being disposed of off-site. Only fruit for export is processed further. Fruit temperature is recorded and the fruit transferred into plastic crates, which are labelled for traceability.

Fruit is then moved to the washing area where the stems are trimmed to 0.5-1.0 centimetres and each fruit thoroughly washed in water using soft brushes and cloths. This step may also be done at the collection centre as part of preliminary sorting and cleaning prior to transfer to the packing house (Figure 5). Facilities use either chlorinated wash water or hot water dipping to control post-harvest diseases. Following washing or dipping, the fruit are passed across a drying table or rack where staff use compressed air nozzles to dry each fruit (Figure 6) before being transferred into grading and packing rooms.

The grading and packing rooms are clean and secure, and staffed only by authorised and trained personnel. The rooms are equipped with positive pressure systems and electric insect killers, and accessed only via double door pass-through systems. Fruit may be temporarily stored in an adjoining cool room to remove excess heat from the fruit (Figure 7). Prior to packing, the fruit is dry-brushed over the surface, under the bracts and inside the flower end pit with a test tube brush or similar (Figure 8). Each fruit is then wiped with a soft cloth and graded for size and weight before being packed into a carton.

Fruit are packed in a number of ways including directly into a cardboard carton fitted with a plastic carton-liner, or placed individually into expandable polystyrene sleeves or clear plastic bags (Figure 8) and packed into non-lined cartons. The cartons generally hold 5-10 kilograms of fruit and have vent holes that are covered with insect proof screen. Packed fruit is stored in secured cool rooms and held at 5-10 °C until loading into sealed refrigerated trucks for shipment.

Figure 5 Trimming stems, cleaning out the flower end pit and washing the dragon fruit at a collection centre



Figure 6 Air guns and drying rack in the washing area of a packing house



Export quality standards

Quality standards assessment is based on colour and fruit shape. Fruit are graded based on the weight class for a particular export market. Fruit must be clean, evenly coloured, and free from

symptoms of disease or damage. Fruit for export are required to be evenly tinted red over 70 per cent of the fruit surface. The flower end pit should be no deeper than one centimetre and should not be swollen and bracts should not be damaged or discoloured (PPD 2010).

Export procedures

Phytosanitary inspection occurs at the packing house, where PPD inspection officers randomly sample fruit for visual phytosanitary inspection (PPD 2010).

Figure 7 Washed and dried fruit in a cool room waiting for brushing, grading and packing



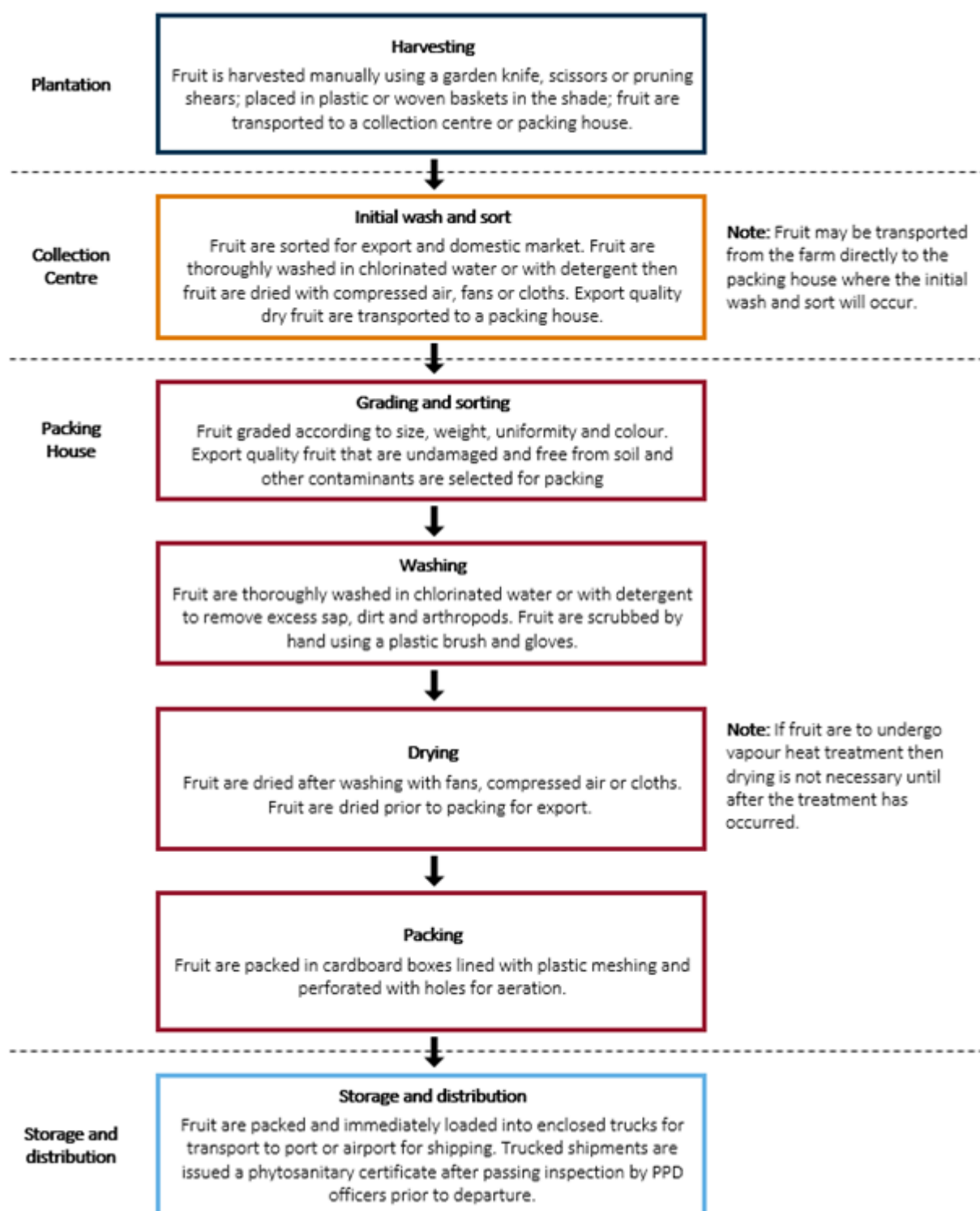
Figure 8 Brushing of the flower end pit and packing into clear plastic bags before weighing and packing into cartons



3.6.2 Transport

Shipments of dragon fruit are transported from the packing house or treatment facility to port in enclosed trucks (Mai 2015). Temperature during storage and transit is recommended at 5-10 °C, which supports a shelf life of up to 35 days (USDA 2004).

Figure 9 Summary of operational steps from harvesting to distribution for dragon fruit grown in Vietnam for export



3.7 Export capability

3.7.1 Production statistics

Dragon fruit production in Vietnam has expanded since 2005 (Nguyen et al. 2015; PPD 2010). The most recent data from Vietnam reports approximately 40 000 hectares of dragon fruit production area producing about 1 million tonnes per year (letter from PPD of 06/06/2016). A summary of production statistics in previous years is provided in Table 3.2.

Table 3.2 Area, yield and production of dragon fruit in Vietnam's main production provinces in 2005 and in 2010-2014

| Items | Year | | | | | |
|----------------------------|---------|---------|---------|---------|---------|---------|
| | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Total | | | | | | |
| Total area (hectares) | 8 607 | 16 207 | 22 021 | 23 586 | 26 528 | 33 811 |
| Harvesting area (hectares) | 7 498 | 13 444 | 18 228 | 19 326 | 22 233 | 25 095 |
| Yield (tonnes/hectare) | 17.9 | 26.6 | 25.4 | 24.7 | 23.4 | 23.3 |
| Production (tonnes) | 134 465 | 357 480 | 463 040 | 477 784 | 519 245 | 583 729 |
| 1. Binh Thuan | | | | | | |
| Total area (hectares) | 5 799 | 13 404 | 18 616 | 19 419 | 20 551 | 24 191 |
| Harvesting area (hectares) | 4 880 | 10 825 | 15 287 | 15 807 | 18 184 | 19 927 |
| Yield (tonnes/hectare) | 19.8 | 27.6 | 26.0 | 24.8 | 22.0 | 21.6 |
| Production (tonnes) | 96 806 | 299 302 | 397 584 | 392 373 | 400 800 | 430 120 |
| 2. Long An | | | | | | |
| Total area (hectares) | 1 155 | 918 | 1 247 | 1 718 | 2 838 | 5 568 |
| Harvesting area (hectares) | 1 152 | 809 | 972 | 1 387 | 1 685 | 2 154 |
| Yield (tonnes/hectare) | 13.0 | 31.4 | 31.0 | 30.5 | 36.6 | 36.4 |
| Production (tonnes) | 15 004 | 225 380 | 30 154 | 42 303 | 61 622 | 78 500 |
| 3. Tien Giang | | | | | | |
| Total area (hectares) | 1 653 | 1 885 | 2 158 | 2 449 | 3 139 | 4 052 |
| Harvesting area (hectares) | 1 466 | 1 810 | 1 969 | 2 132 | 2 364 | 3 014 |
| Yield (tonnes/hectare) | 15.5 | 18.1 | 17.9 | 20.2 | 24.0 | 24.9 |
| Production (tonnes) | 22 655 | 32 798 | 35 302 | 43 108 | 56 823 | 75 109 |

3.7.2 Export statistics

The majority of dragon fruit (80-86 per cent) in Vietnam is destined for export (Nguyen et al. 2015). Vietnam has been exporting dragon fruit to over 40 countries and territories throughout the world. The main markets are China, Thailand, Indonesia, Malaysia, Singapore, the Netherlands, Spain, Germany, United Kingdom, Canada and the United States. Dragon fruit has contributed to more than 40 per cent of total fruit export from Vietnam since 2011 (Nguyen et al. 2015).

3.7.3 Export season

The peak harvest season of dragon fruit in Vietnam is from May to September (letter from PPD of 06/06/2016). It is expected that exports to Australia would primarily occur in this period.

4 Pest risk assessments for quarantine pests

A total of seven quarantine pests associated with dragon fruit from Vietnam are identified in the pest categorisation process (Appendix A) and are listed in Table 4.1. This chapter assesses the likelihood of the entry (importation and distribution), establishment and spread of these pests and the economic, including environmental, consequences these pests may cause if they were to enter, establish and spread in Australia.

Assessments of risks associated with these pests are presented in this chapter unless otherwise indicated.

All seven quarantine pests considered here have been assessed previously by the department. Therefore, the outcomes of previous assessments have been adopted, unless new information is available that suggests the risk would be different in this case. The adoption of the outcomes of previous assessments is outlined here.

The likelihood of establishment and of spread of a pest in the PRA area will be comparable regardless of the fruit commodity/country pathway in which the pest is imported into Australia, as these likelihoods relate specifically to events that occur in the PRA area and are independent of the importation pathway. The consequences of a pest are also independent of the importation pathway. For pests that have been assessed previously, the department reviewed the latest literature. If there is no new information available that would significantly change the likelihood ratings for establishment and for spread, and the consequences the pests may cause, the ratings given in the previous assessments for these components will be adopted.

The reassessment of the likelihood of distribution for pests that have been assessed previously is considered on a case-by-case basis by comparing factors relevant to the distribution of dragon fruit from Vietnam with those assessed previously. These factors include commodity type, time of year at which import takes place, and availability and susceptibility of hosts during the time of import. After comparing these factors and reviewing the latest literature, the ratings of likelihood of distribution from the previous assessments will be adopted if the department considers that the likelihood of distribution for dragon fruit from Vietnam would be comparable to that given in the previous assessments.

The reassessment of the likelihood of importation for pests that have been assessed previously is also considered on a case-by-case basis by comparing factors relevant to the importation of dragon fruit from Vietnam with those assessed previously. These factors include the commodity type, prevalence of the pest and commercial production practices. After comparing these factors and reviewing the latest literature, the department considers it appropriate not to reassess the likelihood of importation of these pests for dragon fruit from Vietnam, as it would be comparable to that concluded in the previous assessments. In addition, where changes to the likelihood rating for importation will not alter the unrestricted risk estimate (URE); there is no need to reassess the likelihood of importation.

The URE of achieving or not achieving the ALOP for Australia, from the previous assessments will be adopted for pests for which the reassessment of both the likelihood of importation and the likelihood of distribution is considered unnecessary because the URE outcome would not change from the previous assessment.

One pest identified in this assessment has been recorded in some regions of Australia and, due to interstate quarantine regulations and their enforcement, is considered a pest of regional concern. The acronym for the state for which the regional pest status is considered, 'WA' (Western Australia), is used to identify this organism.

Table 4.1 Quarantine pests of dragon fruit from Vietnam for which the URE outcome is adopted from previous assessments

| Pest | Common name |
|--|-------------------------|
| Fruit flies [Diptera: Tephritidae] | |
| <i>Bactrocera correcta</i> (EP) | Guava fruit fly |
| <i>Bactrocera cucurbitae</i> (EP) | Melon fly |
| <i>Bactrocera dorsalis</i> (EP) | Oriental fruit fly |
| Mealybugs [Hemiptera: Pseudococcidae] | |
| <i>Dysmicoccus neobrevipes</i> (EP) | Grey pineapple mealybug |
| <i>Planococcus lilacinus</i> (EP) | Coffee mealybug |
| <i>Planococcus minor</i> (EP, WA) | Pacific mealybug |
| <i>Pseudococcus jackbeardsleyi</i> (EP) | Jack Beardsley mealybug |

EP: Species has been assessed previously and import policy already exists.

WA: Pest of quarantine concern for Western Australia.

4.1 Fruit flies

***Bactrocera correcta* (EP), *Bactrocera cucurbitae* (EP) and *Bactrocera dorsalis* (EP)**

Bactrocera correcta (guava fruit fly), *Bactrocera cucurbitae* (melon fly) and *Bactrocera dorsalis* (Oriental fruit fly) belong to the Tephritidae or fruit fly family. They have been grouped together because of their related biology and taxonomy, and are considered to pose a similar risk and to require similar mitigation measures.

Bactrocera invadens Drew, Tsuruta & White, 2005, *B. papayae* Drew & Hancock, 1994 and *B. philippinensis* Drew & Hancock, 1994 have recently been synonymised with *B. dorsalis* (Schutze et al. 2014). References to these previously accepted species are now considered to be references to *B. dorsalis*, and this is reflected in the assessment of fruit flies for dragon fruit from Vietnam.

Several fruit flies species, including the species assessed here, were assessed previously in a number of existing import policies, for example the import policy for mangoes from Taiwan (Biosecurity Australia 2006), India (Biosecurity Australia 2008a), Pakistan (Biosecurity Australia 2011), Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015); longan and lychee from China and Thailand (DAFF 2004a); mangosteen from Thailand (DAFF 2004b) and Indonesia (DAFF 2012b); apple from China (Biosecurity Australia 2010); lychees from Taiwan and Vietnam (DAFF 2013); and table grapes from India (Department of Agriculture 2015).

In these existing policies, the unrestricted risk estimate for fruit flies were assessed as not achieving the ALOP for Australia. Therefore, specific risk management measures are required for fruit flies.

The likelihood of establishment and spread of fruit flies in Australia for dragon fruit from Vietnam will be comparable to previous assessments. These likelihoods relate specifically to events that occur in Australia and are essentially independent of the importation pathway. The consequences of fruit flies are also independent of the importation pathway.

Fruit flies have a wide host range, and host material is likely to be available all year in Australia. The likelihood of distribution for fruit flies for dragon fruit from Vietnam would be comparable to that for commodities assessed previously.

The department considered factors affecting the likelihood of importation for fruit flies for dragon fruit from Vietnam and those previously assessed. The likelihood of importation for fruit flies for dragon fruit from Vietnam would be comparable to that in the previous assessments.

In addition, the department has also reviewed the latest literature (for example Boontop 2016; Hallman 2012; Hill et al. 2016; Huang & Chi 2014; Kunprom, Sopaladawan & Pramual 2015) and no new information is available that would significantly change the risk ratings for importation, distribution, establishment, spread and consequences as set out for fruit flies in the existing policies.

4.1.1 Unrestricted risk estimate

The unrestricted risk estimate for fruit flies for dragon fruit from Vietnam is comparable to the estimates in previous assessments, and does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for these pests.

4.2 Mealybugs

***Planococcus lilacinus* (EP), *Planococcus minor* (EP, WA), *Pseudococcus jackbeardsleyi* (EP) and *Dysmicoccus neobrevipes* (EP)**

Planococcus lilacinus (coffee mealybug), *Planococcus minor* (Pacific mealybug), *Pseudococcus jackbeardsleyi* (Jack Beardsley mealybug) and *Dysmicoccus neobrevipes* (grey pineapple mealybug) belong to the Pseudococcidae or mealybug family. The mealybug species assessed here have been grouped together because of their related biology and taxonomy, and they are considered to pose a similar risk and require similar mitigation measures.

Planococcus minor is not present in Western Australia and is a pest of regional quarantine concern for that state.

Several mealybug species, including the species assessed here, were assessed previously in a number of existing import policies, for example the import policy for table grapes from Japan (Australian Department of Agriculture 2014); lychee from Taiwan and Vietnam (DAFF 2013); mangosteens from Indonesia (DAFF 2012b); pineapple from Malaysia (DAFF 2012a); Unshu mandarin from Japan (Biosecurity Australia 2009); bananas from the Philippines (Biosecurity Australia 2008b); and mangoes from India and Taiwan (Biosecurity Australia 2006, 2008a).

In these existing policies, the unrestricted risk estimate for mealybugs were assessed as not achieving the ALOP for Australia. Therefore, specific risk management measures are required for these species.

The likelihood of establishment and spread of mealybugs in Australia for dragon fruit from Vietnam will be comparable to previous assessments. These likelihoods relate specifically to events that occur in Australia and are principally independent of the importation pathway. The consequences of mealybugs are also independent of the importation pathway.

Mealybugs have a wide host range, and host material is likely to be available all year in Australia. The likelihood of distribution for mealybugs for dragon fruit from Vietnam would be comparable to that for commodities assessed previously.

The department considered factors affecting the likelihood of importation for mealybugs for dragon fruit from Vietnam and those previously assessed. The likelihood of importation for mealybugs for dragon fruit from Vietnam would be comparable to that in the previous assessments.

In addition, the department has also reviewed the latest literature (for example N'Guessan et al. 2014; Qin et al. 2013; Roda et al. 2013; Sirisena et al. 2013; Suh & Bombay 2015) and no new information is available that would significantly change the risk ratings for importation, distribution, establishment, spread and consequences as set out for mealybugs in the existing policies.

4.2.1 Unrestricted risk estimate

The unrestricted risk estimate for mealybugs for dragon fruit from Vietnam is comparable to the estimates in previous assessments, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for these pests.

4.3 Pest risk assessment conclusions

Key to Table 4.2 (starting next page)

Genus species (EP): pests for which policy already exists. The outcomes of previous assessments and/or reassessments in this risk analysis are presented in Table 4.2

Genus species (Acronym for state/territory): state/territory in which regional quarantine pests have been identified

Likelihoods for entry, establishment and spread

| | |
|-----|---|
| N | negligible |
| EL | extremely low |
| VL | very low |
| L | low |
| M | moderate |
| H | high |
| EES | overall likelihood of entry, establishment and spread |

Assessment of consequences from pest entry, establishment and spread

| | |
|-----|---|
| PLH | plant life or health |
| OE | other aspects of the environment |
| EC | eradication, control |
| DT | domestic trade |
| IT | international trade |
| ENC | environmental and non-commercial |
| A-G | consequence impact scores are detailed in section 2.2.3 |
| A | Indiscernible at the local level |
| B | Minor significance at the local level |
| C | Significant at the local level |
| D | Significant at the district level |
| E | Significant at the regional level |
| F | Significant at the national level |
| G | Major significance at the national level |
| URE | unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme. |

Table 4.2 Summary of unrestricted risk estimates for quarantine pests associated with dragon fruit from Vietnam for which the URE outcome is adopted from previous assessments

| Pest name | URE Outcome |
|--|---|
| Fruit flies[Diptera: Tephritidae] | |
| <i>Bactrocera correcta</i> (EP) | The URE outcome, which does not achieve the ALOP for Australia, has been adopted from existing policy |
| <i>Bactrocera cucurbitae</i> (EP) | |
| <i>Bactrocera dorsalis</i> (EP) | |
| Mealybugs [Hemiptera: Pseudococcidae] | |
| <i>Dysmicoccus neobrevipes</i> (EP) | The URE outcome, which does not achieve the ALOP for Australia, has been adopted from existing policy |
| <i>Planococcus lilacinus</i> (EP) | |
| <i>Planococcus minor</i> (EP, WA) | |
| <i>Pseudococcus jackbeardsleyi</i> (EP) | |

5 Pest risk management

This chapter provides information on the management of quarantine pests identified with an unrestricted risk level that does not achieve the appropriate level of protection (ALOP) for Australia. The recommended risk management measures are described in this chapter.

5.1 Pest risk management measures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Australia where they have been assessed to have an unrestricted risk level that does not achieve the ALOP for Australia. In calculating the unrestricted risk, existing commercial production practices in Vietnam have been considered, as have post-harvest procedures and the packing of fruit.

In addition to Vietnam's existing commercial production systems and packinghouse operations for dragon fruit and minimum border procedures in Australia, specific pest risk management measures, including operational systems, are recommended to achieve the ALOP for Australia.

In this chapter, the Australian Government Department of Agriculture and Water Resources has identified risk management measures that may be applied to consignments of dragon fruit sourced from Vietnam. Finalisation of the import conditions may be undertaken with input from the Australian states and territories as appropriate.

5.1.1 Pest risk management for quarantine pests

The pest risk analysis identified the quarantine pests listed in Table 5.1 as having an unrestricted risk level that does not achieve the ALOP for Australia. Therefore, risk management measures are required to manage the risks posed by these pests and the recommended measures are also listed in Table 5.1.

Table 5.1 Risk management measures recommended for quarantine pests of dragon fruit from Vietnam

| Pest | Common name | Measures |
|---|-------------------------|--|
| Fruit flies | | |
| <i>Bactrocera correcta</i> (EP) | Guava fruit fly | Area freedom a OR Fruit treatment considered to be effective against all life stages of fruit flies (e.g.: vapour heat treatment or irradiation b) |
| <i>Bactrocera cucurbitae</i> (EP) | Melon fly | |
| <i>Bactrocera dorsalis</i> (EP) | Oriental fruit fly | |
| Mealybugs | | |
| <i>Dysmicoccus neobrevipes</i> (EP) | Grey pineapple mealybug | Consignment freedom verified by pre-export visual inspection and remedial action c |
| <i>Planococcus lilacinus</i> (EP) | Coffee mealybug | |
| <i>Planococcus minor</i> (EP, WA) | Pacific mealybug | |
| <i>Pseudococcus jackbeardsleyi</i> (EP) | Jack Beardsley mealybug | |

EP: Species has been assessed previously and import policy already exists **WA:** Pest of quarantine concern for Western Australia **a:** Area freedom may include pest free areas, pest free places of production, and pest free production sites. **b:** The use of irradiation is subject to an approval by Food Standards Australia New Zealand that irradiated dragon fruit is safe for human consumption **c:** Remedial action (by PPD) may include applying approved treatment of the consignment to ensure that the pest is no longer viable or withdrawing the consignment from export to Australia.

Risk management measures recommended here are based on the import conditions for mangoes from India (Biosecurity Australia 2008a), Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015); and lychees from Taiwan and Vietnam (DAFF 2013), which include most of the pests identified in Table 5.1 of this report. Among these existing policies, there has been trade in mangoes from India and Vietnam, and lychees from Vietnam, with over 26 tonnes of mango imported into Australia between 2011 and 2016 and over 55 tonnes of lychee between 2015 and 2016. The risk management measures implemented for these commodities have successfully managed pests associated with the pathway. The risk management measures recommended for dragon fruit from Vietnam are the same as or similar to those applied for mango and lychee from India, Indonesia, Taiwan, Thailand and Vietnam, for example irradiation or vapour heat treatment for fruit flies, and consignment freedom verified by visual inspection and remedial action for mealybugs.

This report recommends that when the following risk management measures are followed, the restricted risk for all identified quarantine pests assessed achieves the ALOP for Australia. They include:

- area freedom or fruit treatment (such as vapour heat treatment) for fruit flies
- consignment freedom verified by visual inspection and, if detected, remedial action for mealybugs.

Management for *Bactrocera correcta*, *Bactrocera cucurbitae* and *Bactrocera dorsalis*

The Australian Government Department of Agriculture and Water Resources recommends the options of vapour heat treatment or area freedom as measures to reduce the risks associated with *B. correcta*, *B. cucurbitae* and *B. dorsalis*. The objective of each of these measures is to reduce the likelihood of importation of these pests to at least 'extremely low'. The restricted risk would then be reduced to at least 'very low', which would achieve the ALOP for Australia.

Irradiation treatment is considered a suitable measure option for fruit flies of the family Tephritidae (FAO 2009). However, the use of irradiation on dragon fruit has not yet been approved by Food Standards Australia New Zealand (FSANZ). Therefore, irradiation cannot be used as a measure for dragon fruit until it is approved by FSANZ. Information on the irradiation of food and examples of previous FSANZ assessments can be found on the FSANZ website at <http://www.foodstandards.gov.au/consumer/foodtech/irradiation/Pages/default.aspx>.

Recommended measure 1: Vapour heat treatment

The Australian Government Department of Agriculture and Water Resources has reviewed efficacy data in support of vapour heat treatment, and considered it suitable to manage *B. correcta*, *B. cucurbitae* and *B. dorsalis* in dragon fruit. The treatment is:

- forty minutes at a pulp temperature of 46.5 °C or greater with relative humidity 90 per cent or above.

Recommended measure 2: Area freedom

The requirements for establishing pest free areas, pest free places of production, or pest free production sites are set out in ISPM 4: *Requirements for the establishment of pest free areas* (FAO 1995), ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999) and, more specifically, ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)* (FAO 2015b).

Bactrocera correcta, *B. cucurbitae* and *B. dorsalis* are widespread in Vietnam (Drew & Romig 2013). Therefore, area freedom may not be a viable option for these species in Vietnam. Should Vietnam wish to use area freedom as a measure to manage the risk posed by *B. correcta*, *B. cucurbitae* and *B. dorsalis*, PPD would need to provide a submission demonstrating area freedom to the Australian Government Department of Agriculture and Water Resources. The submission demonstrating area freedom must fulfil requirements as set out in ISPM 4 (FAO 1995), ISPM 10 (FAO 1999) or ISPM 26 (FAO 2015b) and is subject to approval by the Australian Government Department of Agriculture and Water Resources.

Recommended measure 3: Irradiation

The Australian Government Department of Agriculture and Water Resources recommends a treatment schedule of 150 gray minimum absorbed dose, consistent with ISPM 28 Annex 7: *Irradiation treatment for fruit flies of the family Tephritidae (generic)* (FAO 2009) for *B. correcta*, *B. cucurbitae* and *B. dorsalis*. Use of this measure will not be allowed until it is approved by FSANZ.

Management for *Dysmicoccus neobrevipes*, *Planococcus lilacinus*, *Planococcus minor* and *Pseudococcus jackbeardsleyi*

The Australian Government Department of Agriculture and Water Resources recommends consignment freedom verified by visual inspection to verify the absence of these pests and, if detected, remedial action as a measure for *Dysmicoccus neobrevipes* (grey pineapple mealybug), *Planococcus lilacinus* (coffee mealybug), *Planococcus minor* (Pacific mealybug) and *Pseudococcus jackbeardsleyi* (Jack Beardsley mealybug). The objective of the recommended visual inspection is to ensure that any consignments of dragon fruit from Vietnam infested with these pests are identified and subjected to appropriate remedial action. The appropriate remedial action will reduce the risk associated with these pests to at least 'very low', which would achieve the ALOP for Australia.

Recommended measure: Pre-export visual inspection and remedial action by PPD

All consignments of dragon fruit for export to Australia must be inspected by PPD and found free of these mealybugs. Export consignments found to contain any of these pests must be subject to remedial action. Remedial action may include withdrawing the consignment from export to Australia or, if available, applying approved treatment of the export consignment to ensure that the pest is no longer viable.

5.1.2 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2013), the Australian Government Department of Agriculture and Water Resources will consider any alternative measure proposed by PPD, providing that it manages the target pest to achieve the ALOP for Australia. Evaluation of such measures will require a technical submission from PPD that details the proposed measures and includes suitable information to support the efficacy.

5.2 Operational system for the maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of dragon fruit from Vietnam. This is to ensure that the recommended risk management measures have been met and are maintained.

5.2.1 A system of traceability to source farms

The objectives of the recommended procedure are to ensure that:

- dragon fruit are sourced only from farms producing commercial quality fruit
- farms from which dragon fruit are sourced can be identified so investigation and corrective action can be targeted rather than applying it to all contributing export farms in the event that live pests are intercepted.

It is recommended that PPD establishes a system to enable traceability to where dragon fruit for export to Australia are sourced. PPD would be responsible for ensuring that export dragon fruit growers are aware of pests of quarantine concern to Australia and control measures.

5.2.2 Registration of treatment providers and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- dragon fruit are sourced only from treatment providers approved by PPD
- treatment providers are capable of applying a treatment that suitably manages the target pests.

Where dragon fruit undergo treatment prior to export, this process must be undertaken by treatment providers that have been registered with and audited by PPD for that purpose. Records of PPD registration requirements and audits are to be made available to the Australian Government Department of Agriculture and Water Resources upon request.

Approval for treatment providers is subject to suitable systems to ensure compliance with the treatment requirements. This may include:

- documented procedures to ensure dragon fruit is appropriately treated and safeguarded post treatment

- staff training to ensure compliance with procedures
- record keeping procedures
- assurance that facilities and equipment are suitable
- PPD system of oversight of treatment application or system of authorisation of treatment oversight.

5.2.3 Packaging and labelling

The objectives of this recommended procedure are to ensure that:

- dragon fruit proposed for export to Australia and all associated packaging is not contaminated by quarantine pests or regulated articles (defined in ISPM 5: Glossary of phytosanitary terms (FAO 2015a))
- unprocessed packaging material such as unprocessed plant material—which may vector pests identified as not being on the pathway and pests not known to be associated with dragon fruit—is not imported with the dragon fruit
- all wood material used in packaging of dragon fruit complies with the Australian Government Department of Agriculture and Water Resources conditions
- secure packaging is used during storage and transport to Australia to prevent re-infestation and escape of pests on arrival to Australia. Packaging must meet Australia’s general import conditions for fresh fruits and vegetables, available on the Australian Government Department of Agriculture and Water Resources website
- the packaged dragon fruit are labelled with sufficient identification information for the purposes of trace-back. This may include:
 - for treated product: the treatment facility name/number and treatment identification number
 - for dragon fruit where the measures include orchard freedom/area freedom: the farm number
 - for dragon fruit where phytosanitary measures are applied at the packinghouse: packinghouse number.

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

5.2.4 Specific conditions for storage and movement

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

Dragon fruit for export to Australia that have been treated and/or inspected must be kept secure and segregated at all times from any fruit for domestic or other markets, untreated/non pre-inspected product, to prevent mixing or cross-contamination.

5.2.5 Freedom from trash

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

Freedom from trash must be confirmed by the inspection procedures. Export lots or consignments found to contain trash or foreign matter should be withdrawn from export unless

approved remedial action such as reconditioning is made available and applied to the export consignment and then re-inspected.

5.2.6 Pre-export phytosanitary inspection and certification by PPD

The objectives of this recommended procedure are to ensure that Australia's import conditions have been met.

All consignments must be inspected in accordance with official procedures for all visually detectable quarantine pests and other regulated articles (including soil, animal and plant debris) at a standard 600 unit sampling rate, or equivalent, per phytosanitary certificate.

An international phytosanitary certificate (IPC) must be issued for each consignment upon completion of pre-export inspection and treatment to verify that the relevant measures have been undertaken offshore.

Each IPC includes:

- a description of the consignment (including traceability information)
- details of disinfestation treatments (for example vapour heat treatment) which includes information such as date, temperature, and duration and/or attach treatment certificate
- other statements that may be required

5.2.7 Verification by the Australian Government Department of Agriculture and Water Resources

The objectives of this recommended procedure are to ensure that:

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

On arrival in Australia, the Australian Government Department of Agriculture and Water Resources will:

- assess documentation to verify that the consignment is as described on the phytosanitary certificate, that required phytosanitary procedures have been undertaken, and that product security has been maintained
- complete an inspection of dragon fruit consignments on arrival to verify that biosecurity status of consignments of dragon fruit from Vietnam meet Australia's import conditions using random samples of 600 units per phytosanitary certificate

5.2.8 Remedial action(s) for non-compliance

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

- any quarantine risk or regulated article 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 conditions is subject to a suitable remedial treatment (if one is available), destroyed or exported to manage the biosecurity risk.

Other actions may be taken depending on the specific pest intercepted and the risk management strategy put in place against that pest.

If dragon fruit consignments are repeatedly non-compliant, the Australian Government Department of Agriculture and Water Resources reserves the right to suspend imports (either

all imports or imports from specific pathways) and conduct an audit of the risk management systems. Imports will recommence only when the Australian Government Department of Agriculture and Water Resources is satisfied that appropriate corrective action has been undertaken.

5.3 Uncategorized pests

If an organism that has not been categorised, including contaminant pests, is detected on dragon fruit either in Vietnam or on-arrival in Australia, it will require assessment by the Australian Government Department of Agriculture and Water Resources to determine its quarantine status and whether phytosanitary risk management action is required.

Assessment is also required if the detected species was categorised as not likely to be on the import pathway. The detection of any pests of quarantine 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 appropriate level of protection for Australia.

5.4 Review of processes

5.4.1 Verification of protocol

Prior to or during the first season of trade, the Australian Government Department of Agriculture and Water Resources will verify the implementation of agreed import conditions and phytosanitary measures including registration, operational procedures and treatment providers, where applicable. This may involve representatives from the Australian Government Department of Agriculture and Water Resources visiting areas in Vietnam that produce dragon fruit for export to Australia.

5.4.2 Review of policy

The Australian Government Department of Agriculture and Water Resources will review the import policy after the first year of trade. In addition, the department reserves the right to review the import policy as deemed necessary, such as when there is reason to believe that the pest or phytosanitary status in Vietnam has changed.

PPD must inform the Australian Government Department of Agriculture and Water Resources immediately on detection in Vietnam of any new pests of dragon fruit that are of potential quarantine concern to Australia.

5.5 Meeting Australia's food 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).

The Australian Government Department of Agriculture and Water Resources administers the *Imported Food Control Act 1992*. This legislation provides for the inspection and control of imported food using a risk-based border inspection program, the Imported Food Inspection Scheme. More information on this inspection scheme, including the testing of imported food, is available from the [department's website](#).

Food Standards Australia New Zealand (FSANZ) is responsible for developing and maintaining the Code, including Standard 1.4.2 - Agvet chemicals. This standard is available on the [Federal Register of Legislation](#) or through the [FSANZ website](#).

Standard 1.4.2 and Schedules 20 and 21 of the Code set out the maximum residue limits (MRLs) and extraneous residue limits (ERLs) for agricultural or veterinary chemicals that are permitted in food, 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.

6 Conclusion

The findings of this final report for the review of biosecurity import requirements for dragon fruit from Vietnam are based on a comprehensive scientific analysis of relevant literature.

The Australian Government Department of Agriculture and Water Resources considers that the risk management measures recommended in this report will provide an appropriate level of protection against the pests identified as associated with the trade of dragon fruit from Vietnam.

Appendix A: Initiation and categorisation for pests of dragon fruit from Vietnam

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 the first 'No' for columns 4, 5 or 6.

Details of the method used in this risk analysis are given in Section 2: Method for pest risk analysis.

This pest categorisation table does not represent a comprehensive list of all the pests associated with the entire plant of an imported commodity. Reference to soilborne nematodes, soilborne pathogens, wood borer pests, root pests or pathogens, and secondary pests have not been listed, as they are not directly related to the export pathway of fresh commodity fruit and would be addressed by Australia's current approach to contaminating pests.

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. As official lists of accepted and rejected fungal names become available, these accepted names will be adopted.

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---------------------------------|--------------------------|--|---|--|-------------------------------|
| ARTHROPODS | | | | | | |
| Diptera | | | | | | |
| <i>Bactrocera correcta</i> Bezzi, 1916 [Tephritidae] Guava fruit fly | Yes (Hoa et al. 2006; PPD 2010) | No records found | Yes. This species is recorded on the fruit of dragon fruit in Vietnam (Hoa et al. 2006; PPD 2010). | Yes. <i>Bactrocera correcta</i> has a wide host range including mango, peach and mandarin (CABI 2016). It has a wide distribution in Asia ranging from China, Japan, India, Sri Lanka and Pakistan to Thailand (Drew & Romig 2013). The wide host range and geographic distribution of this pest suggest that there are suitable environments for this pest to establish and spread in Australia. | Yes. <i>Bactrocera correcta</i> is a pest of numerous tropical and subtropical fruit crops and is capable of causing serious economic damage to fruit production (Liu, Yan & Ye 2013). | Yes (EP) |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|--|---|--|--|--|--------------------------------------|
| <i>Bactrocera cucurbitae</i> Coquillett, 1899 [Tephritidae] Melon fly | Yes (CABI 2016; Hoa et al. 2006; PPD 2012) | No. Records of <i>Bactrocera cucurbitae</i> in Australia refer to Christmas Island and occasional outbreaks in the Torres Strait Islands (CSIRO 2005). The Torres Strait Islands is a group of more than 270 islands in a narrow channel (150 km wide) between Australia and Papua New Guinea. There are quarantine measures in place to prevent the spread of <i>B. cucurbitae</i> to mainland Australia from the Torres Strait islands (Australian Government Department of Agriculture 2014). Christmas Island is an external territory of Australia situated in the Indian Ocean lying more than 1500 km northwest of the mainland. | Yes. This species has been intercepted in infested dragon fruit consignments from Vietnam to Japan (McQuate 2010). | Yes. <i>Bactrocera cucurbitae</i> infests commercially grown cucurbit species including squash, cucumber and watermelon (White & Elson-Harris 1992). It is widely distributed throughout India, South East Asia and Central Africa (CABI 2016; Dhillon et al. 2005). The host range and current geographic distribution of this pests suggests that there are environments for this pest to establish and spread in Australia. | Yes. Depending on the host and season, losses due to <i>Bactrocera cucurbitae</i> can be up to 100% of a crop (Dhillon et al. 2005). | Yes (EP) |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|--|---|---|---|--|-------------------------------|
| <i>Bactrocera dorsalis</i> Hendel, 1912 Synonyms: <i>Bactrocera invadens</i> Drew, Tsuruta & White, 2005, <i>B. papayae</i> Drew & Hancock, 1994 and <i>B. philippinensis</i> Drew & Hancock, 1994 have recently been synonymised with <i>B. dorsalis</i> (Schutze et al. 2014) [Tephritidae] Oriental fruit fly | Yes (Drew & Hancock 1994; Hoa et al. 2006; PPD 2010) | No. Eradicated from Australia (Hancock et al. 2000). | Yes. This species is known to infest the fruit of dragon fruit in Vietnam and has been intercepted in infested dragon fruit consignments from Vietnam to Japan (Hoa et al. 2006; McQuate 2010; PPD 2010). | Yes. <i>Bactrocera dorsalis</i> attacks over 300 cultivated and wild fruits, and has a broad global distribution due to its ability to establish when introduced into new environments (Mau & Martin Kessing 2007). | Yes. Feeding by <i>Bactrocera dorsalis</i> larvae directly damages fruit and causes rotting due to bacteria and fungi (Mau & Martin Kessing 2007). | Yes (EP) |
| Hemiptera | | | | | | |
| <i>Aphis gossypii</i> Glover, 1877 [Aphididae] Cotton aphid | Yes (PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Coccus hesperidum</i> Linnaeus, 1758 [Coccidae] Brown soft scale | Yes (García et al. 2016; PPD 2010) | Yes. ACT, NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Diaspis echinocacti</i> Bouche, 1833 [Diaspididae] Cactus scale | Yes (PPD 2010) | Yes. NSW, Qld (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Dysmicoccus brevipes</i> Cockerell, 1893 Synonym: <i>Pseudococcus brevipes</i> Fernald, 1903 [Pseudococcidae] Pineapple mealybug | Yes (García et al. 2016; PPD 2010) | Yes. NSW, NT, Qld, SA, WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|------------------------------------|---|---|---|---|--------------------------------------|
| <i>Dysmicoccus neobrevipes</i> Beardsley, 1959 [Pseudococcidae] Grey pineapple mealybug | Yes (PPD 2010; Williams 2004) | No records found | Yes. Attacks the flowers, fruit and stems of dragon fruit (PPD 2010). | Yes. <i>Dysmicoccus neobrevipes</i> feeds on a wide range of host plants including citrus and mango, and has been reported as an important economic pest of pineapple and banana throughout its pantropical distribution (CABI 2016). The host range and current geographic distribution of this pests suggests that there are environments for this pest to establish and spread in Australia. | Yes. Mealybugs directly damage their plant hosts, reducing productivity. <i>Dysmicoccus neobrevipes</i> is an important pest of pineapple and is a vector of pineapple wilt disease (Khoo, Ooi & Ho 1991; Williams 2004). | Yes (EP) |
| <i>Ferrisia virgata</i> Cockerell, 1893 [Pseudococcidae] Striped mealybug | Yes (García et al. 2016; PPD 2010) | Yes. NSW, NT, Qld, WA (Plant Health Australia 2001; Poole 2010). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Mictis longicornis</i> Westwood, 1842 [Coreidae] Rose coreid | Yes (PPD 2010) | No records found | No. Attacks the stem and shoots of dragon fruit (PPD 2010). | Assessment not required | Assessment not required | No |
| <i>Nezara viridula</i> Linnaeus, 1758 [Pentatomidae] Green vegetable bug | Yes (PPD 2010) | Yes. ACT, NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|------------------------------------|---|---|---|--|--------------------------------------|
| <i>Pentalonia nigronervosa</i> Coquerel, 1859 [Aphididae] Banana aphid | Yes (PPD 2010) | Yes. NSW, NT, Qld, limited distribution in WA (Plant Health Australia 2001). Regulated as a Declared Organism (Prohibited (s22(2))) of WA Biosecurity and Agriculture Management Act (2007) (Government of Western Australia 2016). | No. Attacks the stems of dragon fruit (PPD 2010). | Assessment not required | Assessment not required | No |
| <i>Phenacoccus madeirensis</i> Green, 1923 [Pseudococcidae] Madeira mealybug | Yes (García et al. 2016; PPD 2010) | No records found | No. Attacks the stems of dragon fruit (PPD 2010). | Assessment not required | Assessment not required | No |
| <i>Planococcus citri</i> Risso, 1813 [Pseudococcidae] Citrus mealybug | Yes (García et al. 2016) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---|--|--|--|--|--------------------------------------|
| <i>Planococcus lilacinus</i> Cockerell, 1905 [Pseudococcidae] Coffee mealybug | Yes (García et al. 2016; Plant Health Australia 2001) | No (García et al. 2016; Plant Health Australia 2001) Although detected in the Torres Strait Islands (Plant Health Australia 2001), a group of more than 270 islands in a narrow channel (150 km wide) between Australia and Papua New Guinea, there are quarantine measures in place to prevent spread to mainland Australia (Australian Government Department of Agriculture 2014). | Yes. <i>Planococcus lilacinus</i> attacks the fruit of dragon fruit (USDA-APHIS 2008). | Yes. <i>Planococcus lilacinus</i> has a wide host range and is distributed throughout many tropical areas (Entwistle 1972). Reproduction is usually parthenogenetic (Khoo, Ooi & Ho 1991). | Yes. <i>Planococcus lilacinus</i> is common in Southern Asia and has been reported attacking many economically important crops (Williams 2004). It is considered a major threat to agriculture (Miller, Miller & Watson 2002). | Yes (EP) |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|------------------------------------|--|---|---|---|--------------------------------------|
| <i>Planococcus minor</i> Maskell, 1897 [Pseudococcidae] Pacific mealybug | Yes (García et al. 2016; PPD 2010) | Yes. ACT, NSW, NT, Qld, SA, Vic. (Plant Health Australia 2001) Regulated as a Declared Organism (Prohibited (s12)) of WA Biosecurity and Agriculture Management Act (2007) (Government of Western Australia 2016). | Yes. Attacks the fruit of dragon fruit in Vietnam (PPD 2010). | Yes. <i>Planococcus minor</i> has a wide host range including mango, banana, mandarin, potato and grapevine (CABI 2016). It is distributed in the Australian states and territories of ACT, NSW, NT, Qld, SA and Vic. Internationally it is distributed in most of Asia, Eastern Europe and parts of Africa in environments ranging from temperate to tropical (García et al. 2016) | Yes. <i>Planococcus minor</i> is a significant pest of over 250 plant species, including several commercial crops (Venette & Davis 2004). The potential economic consequences would only apply to WA should this species enter, establish and spread. | Yes (EP, WA) |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|------------------------------------|--|--|---|---|-------------------------------|
| <i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller, 1996 [Pseudococcidae] Jack Beardsley mealybug | Yes (García et al. 2016; PPD 2010) | No (García et al. 2016). Although detected in 2010 in the Torres Strait Islands, a group of more than 270 islands in a narrow channel (150 km wide) between Australia and Papua New Guinea, and at Weipa in 2013, there are quarantine measures in place to prevent its further spread on mainland Australia (Australian Government Department of Agriculture 2014). | Yes. Attacks the flowers, fruit and stems of dragon fruit in Vietnam (PPD 2010). | Yes. <i>Pseudococcus jackbeardsleyi</i> feeds on a wide variety of commercial fruit, including banana, tomato and hibiscus (CABI 2016). It is widely distributed over both tropical and temperate environments (García et al. 2016). The fact that host plants and suitable climatic conditions are available in Australia suggests that this pest can establish and spread in Australia. | Yes. <i>Pseudococcus jackbeardsleyi</i> is reported on many vegetable and ornamental crop species including banana, tomato, potato, pepper and Hibiscus (García et al. 2016). | Yes (EP) |
| Thysanoptera | | | | | | |
| <i>Scirtothrips dorsalis</i> Hood, 1919 [Thripidae] Chilli thrips | Yes (CABI 2016) | Yes. NSW, QLD, NT (Plant Health Australia 2001). Listed as Permitted under s11 of WA Biosecurity and Agriculture management Act (2007) (Government of Western Australia 2016). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|--|---|---|--|-------------------------------------|-------------------------------|
| BACTERIA | | | | | | |
| <i>Enterobacter cloacae</i> (Jordan 1890) [Enterobacteriales: Enterobacteriaceae] | Yes (Nagano et al. 2000) | Yes. NSW, Qld, WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Erwinia chrysanthemi</i> Burkholder et al. 1953 [Enterobacteriales: Enterobacteriaceae] Fruit soft rot | Yes (Hoa et al. 2014) | Uncertain as this species has been reclassified into multiple species within a new genus (Marrero et al. 2013; Samson et al. 2005). Due to the uncertainty around the taxonomy of this complex, the identity of the species recorded from either Australia or Vietnam cannot be assessed with confidence without in-depth molecular work. | No. This species infects flowers and young fruit, forming water soak blisters and obvious secondary infections which spread to the whole fruit within 24 hours (Hoa et al. 2014). Infected fruits will be culled during standard commercial production practices. | Assessment not required | Assessment not required | No |
| <i>Pectobacterium carotovorum</i> (Jones 1901) Synonym: <i>Erwinia carotovora</i> (Jones 1901). [Enterobacteriales: Enterobacteriaceae] | Yes (Do et al. 2011) | Yes. NSW, Qld, SA, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| CHROMALVEOLATA | | | | | | |
| <i>Phytophthora cactorum</i> (Lebert & Cohn) Schröt. [Peronosporales: Peronosporaceae] Apple collar rot | Yes (CABI 2016; Drenth & Guest 2004; PPD 2010) | Yes. NSW, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|--------------------------------|---|----------------------------|--|-------------------------------------|-------------------------------|
| <i>Phytophthora nicotianae</i> Breda de Haan Synonym: <i>Phytophthora parasitica</i> Dastur [Peronosporales: Peronosporaceae] Black shank | Yes (CABI 2016) | Yes. NSW, NT, Qld, SA, Vic. (Plant Health Australia 2001) Listed as Permitted under s11 of WA Biosecurity and Agriculture management Act (2007) (Government of Western Australia 2016). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Pythium aphanidermatum</i> (Edson) Fitzp [Peronosporales: Pythiaceae] Damping-off | Yes (CABI 2016) | Yes. NSW, Qld, WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Pythium irregulare</i> Buisman [Peronosporales: Pythiaceae] | Yes (CABI 2016) | Yes. NSW, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| FUNGI | | | | | | |
| <i>Alternaria alternata</i> (Fr.) Keissl. [Pleosporales: Pleosporaceae] Alternaria leaf spot | Yes (Le et al. 2000; PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|----------------------|--|--|--|-------------------------------------|-------------------------------|
| <i>Alternaria cheiranthi</i> (Lib.) P.C. Bolle Synonym: <i>Helminthosporium cheiranthi</i> Libert [Pleosporales: Pleosporaceae] | Yes (Le et al. 2000) | Yes. NSW (Plant Health Australia 2001). However, this is a single record 1985 on wallflower leaf (<i>Cheiranthus cheiri</i>) as a leaf spot. | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting the presence of <i>Alternaria cheiranthi</i> in Vietnam or being a pest of dragon fruit. | Assessment not required | Assessment not required | No |
| <i>Aspergillus avenaceus</i> G. Sm. [Eurotiales: Trichocomaceae] | Yes (Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting the presence of <i>Aspergillus avenaceus</i> in Vietnam or being a pest of dragon fruit. | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|---|--|--|---|--|--------------------------------------|
| <i>Aspergillus awamori</i> Nakaz. Synonym: <i>Aspergillus niger</i> var. <i>awamori</i> [Eurotiales: Trichocomaceae] | Yes (Hong Mien et al. 2012; Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting <i>Aspergillus awamori</i> being a pest of dragon fruit. | Assessment not required | Assessment not required | No |
| <i>Aspergillus clavatus</i> Desm. [Eurotiales: Trichocomaceae] | Yes (Le et al. 2000) | Yes. Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Aspergillus flavus</i> var. <i>columnaris</i> Raper & Fennell [Eurotiales: Trichocomaceae] | Yes (Hong Mien et al. 2012; Le et al. 2000) | No records found for this variant, but <i>A. flavus</i> is recorded in NSW, NT, Qld, Vic., WA (Plant Health Australia 2001). | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting <i>Aspergillus flavus</i> var. <i>columnaris</i> being a pest of dragon fruit. | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---|--|---|---|--|--------------------------------------|
| <i>Aspergillus fumigatus</i> Fresen. [Eurotiales: Trichocomaceae] | Yes (Farr & Rossman 2016; Le et al. 2000) | Yes. NSW, Qld, WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Aspergillus niger</i> Tiegh. [Eurotiales: Trichocomaceae] Collar rot | Yes (CABI 2016; PPD 2010) | Yes. NSW, NT, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Aspergillus oryzae</i> (Ahlburg) Cohn [Eurotiales: Trichocomaceae] | Yes (Hong Mien et al. 2012; Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting <i>Aspergillus oryzae</i> being a pest of dragon fruit. | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---|--|--|---|--|--------------------------------------|
| <i>Aspergillus tubingensis</i> Mosseray [Eurotiales: Trichocomaceae] | Yes (Hong Mien et al. 2012; Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting <i>Aspergillus tubingensis</i> being a pest of dragon fruit. | Assessment not required | Assessment not required | No |
| <i>Bipolaris cactivora</i> (Petr.) Alcorn Synonym: <i>Drechslera cactivora</i> (Petr.) M.B. Ellis, [Pleosporales: Pleosporaceae] Stem rot | Yes (He et al. 2012) | Yes NSW, Vic. (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Botrytis cinerea</i> Pers. [Helotiales: Sclerotiniaceae] Grey mould | Yes (Nene, Sheila & Sharma 1996) | Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---------------------------|--|---|--|-------------------------------------|-------------------------------|
| <i>Capnodium</i> sp. [Capnoiales: Capnodiaceae] Sooty mould | Yes (PPD 2010) | Uncertain as species not specified. Many <i>Capnodium</i> species have been recorded throughout Australia (Plant Health Australia 2001). | No. <i>Capnodium</i> species form a black, velvety coating (sooty mould) on leaves, twigs and fruit (Lim & Khoo 1985). Easily removed through postharvest washing and brushing (Cooke, Persley & House 2009). | Assessment not required | Assessment not required | No |
| <i>Cladosporium herbarum</i> (Pers.) Link [Capnodiales: Mycosphaerellaceae] | Yes (PPD 2010) | Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Cladosporium oxysporum</i> Berk. & M.A. Curtis [Capnodiales: Mycosphaerellaceae] | Yes (Le et al. 2000) | Yes. NSW, NT, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Colletotrichum coccodes</i> (Wallr.) S. Hughes [Sordariomycetidae: Glomerellaceae] Anthracnose | Yes (CABI 2016; PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc. Synonym: <i>Glomerella cingulata</i> (Stonem.) Spaud. & H. Schrenk. [Sordariomycetidae: Glomerellaceae] Anthracnose | Yes (CABI 2016; PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---|--|-----------------------------------|---|--|--------------------------------------|
| <i>Colletotrichum musae</i> (Burk. & Curtis) Arx. [Sordariomycetidae: Glomerellaceae] Tip rot of banana | Yes (PPD 2010) | Yes. NSW, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Colletotrichum truncatum</i> (Schwein) Andrus & W.D. Moore Synonym: <i>Colletotrichum capsici</i> (Syd. & P. Syd.) E.J. Butler & Bisby [Sordariomycetidae: Glomerellaceae] | Yes (PPD 2010) | Yes. NSW, NT, Qld, Vic. (Plant Health Australia 2001) Qld, WA (Ash et al. 2014). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Curvularia crustacea</i> (Henn.) Y.P. Tan & R.G. Shivas Synonym: <i>Bipolaris crustacea</i> (Henn.) Alcorn [Pleosporales: Pleosporaceae] Yellow cladode brown spot | Yes (Hoa et al. 2014) | Yes. Qld, (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Curvularia lunata</i> (Wakker) Boedijn [Pleosporales: Pleosporaceae] | Yes (Le et al. 2000) | Yes. NSW, Qld, Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Curvularia oryzae</i> Bugnic. [Pleosporales: Pleosporaceae] | Yes (Farr & Rossman 2016; Le et al. 2000) | Yes. Qld (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No. |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|-------------------------------------|---|---|---|--|--------------------------------------|
| <i>Diplodia</i> sp. [Botryosphaerales: Botryosphaeriaceae] | Yes (PPD 2010) | Uncertain as species not specified. Some <i>Diplodia</i> species have been recorded throughout Australia (Plant Health Australia 2001). | No. Mainly reported for affecting leaves and twigs in other plant species (Horst 2008). | Assessment not required | Assessment not required | No |
| <i>Fusarium equiseti</i> (Corda) Sacc. Synonym: <i>Gibberella intricans</i> Wollenw. [Hypocreales: Nectriaceae] Brown rot | Yes (Hoa et al. 2014) | Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Fusarium lateritium</i> Nees Synonym: <i>Gibberella baccata</i> (Wallr.) Sacc. [Hypocreales: Nectriaceae] | Yes (Le et al. 2000; PPD 2010) | Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001) Listed as Permitted under s11 of WA Biosecurity and Agriculture management Act (2007) (Government of Western Australia 2016). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Fusarium oxysporum</i> Schltdl.: Fr. [Hypocreales: Nectriaceae] | Yes (Burgess et al. 2008; PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Fusarium semitectum</i> Berk. & Ravenel Synonym: <i>Fusarium incarnatum</i> (Desm.) Sacc. [Hypocreales: Nectriaceae] | Yes (Le et al. 2000) | Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|---|--|--|---|--|--------------------------------------|
| <i>Fusarium solani</i> (Mart.) Sacc. [Hypocreales: Nectriaceae] Root rot | Yes (Burgess et al. 2008) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Elmer et al. 1997; Pung & Cox 1999; Sangalang et al. 1995). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Fusarium verticillioides</i> (Sacc.) Nirenberg Synonym: <i>Gibberella moniliformis</i> Wineland [Hypocreales: Nectriaceae] Bakanae disease of rice | Yes (PPD 2010) | Yes. NSW, Qld, (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Haplariopsis fagicola</i> Oudem. [incertae sedis] | Yes (Hong Mien et al. 2012; Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting <i>Haplariopsis fagicola</i> being a pest of dragon fruit. | Assessment not required | Assessment not required | No |
| <i>Lasiodiplodia theobromae</i> (Pat) Griffon & Maubl. [Botryosphaerales: Botryosphaeriaceae] Diploid pod rot of cocoa | Yes (CABI 2016; PPD 2010) | Yes. NSW, NT, Qld, SA, WA (CABI 2016; Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Mucor hiemalis</i> Wehmer [Mucorales: Mucoraceae] | Yes (Le et al. 2000) | Yes. NSW, Qld, SA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|--|------------------------------|--|--|---|--|--------------------------------------|
| <i>Neoscytalidium dimidiatum</i> (Penz.) Crous & Slippers [Botryosphaeriales: Botryosphaeriaceae] Stem canker disease | Yes (Hoa et al. 2014) | Yes. NT, WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |
| <i>Penicillium charlesii</i> G. Sm. Synonym: <i>Penicillium fellutanum</i> Biourge [Eurotiales: Trichocomaceae] | Yes (Le et al. 2000) | No records found | No. There has been only one report of this pest on dragon fruit in Vietnam (Le et al. 2000). This quality assurance system report incidentally lists a number of fungi found on the stored fruit used in the study. There is no other evidence supporting the presence of <i>Penicillium charlesii</i> in Vietnam or being a pest of dragon fruit. | Assessment not required | Assessment not required | No |
| <i>Phoma</i> sp. [Pleosporales: Pleosporaceae] | Yes (PPD 2010) | Uncertain as species not specified. Many <i>Phoma</i> species have been recorded throughout Australia (Plant Health Australia 2001). | No. Infects leaves and shoots of its hosts. In serious infection plant and fruit growth are affected. (Aveskamp, de Gruyter & Crous 2008; Horst 2008; Kishi 1998). | Assessment not required | Assessment not required | No |
| <i>Rhizoctonia solani</i> J.G. Kühn [Cantharellales: Ceratobasidiaceae] | Yes (Matsumoto & Cuong 2014) | Yes. NSW, NT, Qld, Vic., SA, Tas., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

| Pest | Present in Vietnam | Present within Australia | Potential to be on pathway | Potential for establishment and spread | Potential for economic consequences | Pest risk assessment required |
|---|---------------------------|--|-----------------------------------|---|--|--------------------------------------|
| <i>Thanatephorus cucumeris</i> (Frank) Donk. Synonym: <i>Rhizoctonia solani</i> J.G. Kühn [Ceratobasidiales: Ceratobasidiaceae] Rhizoctonia bud rot | Yes (PPD 2010) | Yes. NSW, NT, Qld, SA, Tas., Vic., WA (Plant Health Australia 2001). | Assessment not required | Assessment not required | Assessment not required | No |

Appendix B: Issues raised in stakeholder comments

This section summarises key stakeholder comments and the department's response. Most stakeholders commented favourably on the comprehensive nature of the report and expressed appreciation of the opportunity to provide comment.

Comment 1: One stakeholder raised concerns over the methodology used in the pest categorisation process that led to several organisms not requiring a pest risk assessment.

Response: The Australian Government Department of Agriculture and Water Resources has conducted the pest categorisation process in accordance with ISPM 11 (FAO 2013). Section 2.1 of ISPM 11 states 'The categorisation process examines for each pest whether the criteria in the definition for a quarantine pest are satisfied' and 'The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorisation process'.

Comment 2: One stakeholder noted that *Bactrocera papayae*, *B. invadens* and *B. philippinensis* are now all synonyms of *Bactrocera dorsalis* and suggested that this information be presented in the report.

Response: The Australian Government Department of Agriculture and Water Resources considered literature for all of these synonyms during the assessment for *Bactrocera dorsalis*. However, the department agrees that it is useful to present this information in the report. The report has been amended accordingly.

Comment 3: One stakeholder commented that a recommendation will be made to regulate *Diaspis echinocacti*, which is absent from its jurisdiction, as a prohibited organism under its respective legislation.

Response: The Australian Government Department of Agriculture and Water Resources noted this stakeholder advice and will review its assessment for *Diaspis echinocacti* once the status of this pest has changed. As stated in section 5.4.2 Review of Policy, the department reserves the right to review the import policy as deemed necessary. The department has conducted a preliminary assessment of *Diaspis echinocacti* in preparation of this change. The unrestricted risk estimate of this pest achieves the ALOP for Australia and therefore specific risk management measures will not be required.

Comment 4: One stakeholder commented that *Lopholeucaspis cockerelli* was considered by the United States and New Zealand as associated with dragon fruit from Vietnam and requested that this pest is included in the risk assessment.

Response: The Australian Government Department of Agriculture and Water Resources has conducted thorough research and could not find any records of *Lopholeucaspis cockerelli* being present in Vietnam. The department noted that the United States assessment stated the presence of this pest in Vietnam was uncertain. However, the pest was considered further by the United States based on the information that this pest was recorded from other Asian regions i.e. Hong Kong, India, Indonesia and the Philippines. The New Zealand assessment cited the United States assessment for the association of this pest with dragon fruit from Vietnam.

Comment 5: One stakeholder requested that the text relating to irradiation be modified to make it more explicit that irradiation of dragon fruit will not be allowed until it is approved by FSANZ.

Response: The Australian Government Department of Agriculture and Water Resources has amended the text in Section 5.1.1 (page 37) to explicitly state that irradiation cannot be used as a measure for dragon fruit until it is approved by FSANZ.

Glossary

| Term or abbreviation | Definition |
|--|---|
| 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. |
| Area | An officially defined country, part of a country or all or parts of several countries (FAO 2015a). |
| Areole | A modified axillary bud on a cactus from which spines grow (Altesor & Ezcurra 2003). The flowers (and subsequent fruit) of <i>Hylocereus</i> species (dragon fruit included within the scope of this risk analysis) grow from the areoles (Jiang et al. 2012). |
| Arthropod | The largest phylum of animals, including the insects, arachnids and crustaceans. |
| Asexual reproduction | The development of new individual from a single cell or group of cells in the absence of meiosis. |
| Australian territory | Australian territory as referenced in the <i>Biosecurity Act 2015</i> refers to Australia, Christmas Island and Cocos (Keeling) Islands. |
| Biosecurity | The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment. |
| Biosecurity measures | The <i>Biosecurity Act 2015</i> defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies |
| Biosecurity risk | The <i>Biosecurity Act 2015</i> refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities. |
| Biosecurity risk analysis (BIRA) | The <i>Biosecurity Act 2015</i> defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation. |
| Bract | A specialised leaf or leaf-like part. In dragon fruit the bracts are part of the fruit skin and not connected to the stem. |
| 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 2015a). |
| Control (of a pest) | Suppression, containment or eradication of a pest population (FAO 2015a). |
| The department | The Australian Government Department of Agriculture and Water Resources. |
| 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 2015a). |
| 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 2015a). |
| Establishment (of a pest) | Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2015a). |

| Term or abbreviation | Definition |
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| Fresh | Living; not dried, deep-frozen or otherwise conserved (FAO 2015a). |
| Fumigation | A method of pest control that completely fills an area with gaseous pesticides to suffocate or poison the pests within. |
| Genus | A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species. |
| Goods | The <i>Biosecurity Act 2015</i> defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property). |
| Host | An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter. |
| Host range | Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2015a). |
| Import permit | Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2015a). |
| 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 2015a). |
| 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 2015a). |
| Intended use | Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2015a). |
| Interception (of a pest) | The detection of a pest during inspection or testing of an imported consignment (FAO 2015a). |
| 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 2015a). |
| Introduction (of a pest) | The entry of a pest resulting in its establishment (FAO 2015a). |
| 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 2015a). 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 consumer-acceptable. 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 2015a). |

| Term or abbreviation | Definition |
|---|--|
| 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 2015a). |
| Parthenogenetic | Capable of a form of asexual reproduction whereby males are not required for eggs to develop into offspring. |
| Pathogen | A biological agent that can cause disease to its host. |
| Pathway | Any means that allows the entry or spread of a pest (FAO 2015a). |
| Pest | Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2015a). |
| 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 2015a). |
| Pest free area (PFA) | An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2015a). |
| Pest free place of production | Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2015a). |
| Pest free production site | A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2015a). |
| 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 2015a). |
| 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 2015a). |
| 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 2015a). |
| Pest risk management (for quarantine pests) | Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2015a). |
| 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 2015a). |
| 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 2015a). |
| Phytosanitary certificate | An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2015a). |
| Phytosanitary certification | Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2015a). |
| Phytosanitary measure | Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2015a). The term 'risk management measure' has been used in the risk analysis as this term is used in the <i>Biosecurity Act 2015</i> . |

| Term or abbreviation | Definition |
|-------------------------------|--|
| Phytosanitary procedure | Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2015a). |
| Phytosanitary regulation | Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2015a). |
| Pleomorphic | The property of a life cycle of fungi in which different stages have different morphology. |
| 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 2015a). |
| Practically free | Of a consignment, field or place of production, without pests (or a specific pests) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (FAO 2015a). |
| Production site | In this report, a production site is a continuous planting of dragon fruit plants treated as a single unit for pest management purposes. If a farm is subdivided into one or more units for pest management purposes, then each unit is a production site. If the farm is not subdivided, then the farm is also the production site. |
| Quarantine | Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2015a). |
| 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 2015a). |
| Regulated article | Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2015a). |
| 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 2015a). |
| Regulated pest | A quarantine pest or a regulated non-quarantine pest (FAO 2015a). |
| Restricted risk | Risk estimate with phytosanitary measure(s) applied. |
| Risk analysis | Refers to the technical or scientific process for assessing biosecurity risk and the development of risk mitigation measures (Biosecurity import risk analysis guidelines 2016). |
| Saprophyte | An organism deriving its nourishment from dead organic matter. |
| Spread (of a pest) | Expansion of the geographical distribution of a pest within an area (FAO 2015a). |
| SPS Agreement | WTO Agreement on the Application of Sanitary and Phytosanitary Measures. |
| Stakeholders | Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues. |
| Surveillance | An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures (FAO 2015a). |
| Trash | Soil, splinters, twigs, leaves, and other plant material, other than fruit stalks. |
| Treatment | Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2015a). |
| Unrestricted risk | Unrestricted risk estimates apply in the absence of risk mitigation measures. |

| Term or abbreviation | Definition |
|-----------------------------|---|
| Vector | An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another. |
| Vapour Heat Treatment | Measure for sterilisation of a fresh commodity through even heating with steam. |
| Viable | Alive, able to germinate or capable of growth. |

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