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Pest categorisation of coconut cadang-cadang viroid

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Abstract

The EFSA Panel on Plant Health updated its 2017 pest categorisation of coconut cadang cadang viroid (CCCVd) for the EU territory due to new data on its host range. The identity of CCCVd, a member of the genus *Cocadviroid* (family Pospiviroidae), is established and detection and identification methods are available. It is included as a quarantine pest for the EU in the Commission Implementing Regulation (EU) 2019/2072. CCCVd has been reported from the Philippines and Malaysia. It is not known to be present in the EU. The host range of CCCVd is restricted to Arecaceae species (palms), in particular, coconut palm (*Cocos nucifera*) to which it causes a lethal disease. Oil palm (*Elaeis guineensis*) and buri palm (*Corypha utan*) are other natural hosts of CCCVd. Palm species of several genera, including *Phoenix* spp. and other species grown and/or cultivated in the EU, have been identified as potential hosts. The viroid is naturally transmitted at low rate by seeds and pollen and possibly by additional not yet identified natural transmission means. It can be transmitted through vegetative propagation applied to some palm species. Plants for planting including seeds of its hosts have been identified as the main entry pathway of CCCVd. Potential hosts of CCCVd are present in the EU, therefore establishment is possible. Should the pest establish in the EU, an impact is expected, with uncertainty on its magnitude. The Panel identified the susceptibility of palm species grown in the EU as a key uncertainty potentially affecting the conclusion of this pest categorisation. Nevertheless, the pest satisfies the criteria that are within the remit of EFSA to assess for this viroid to be regarded as potential Union quarantine pest.

Keywords: Arecaceae, CCCVd, *Cocadviroid*, pest risk, plant health, plant pest, quarantine

Requestor: European Commission

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, is applying from 14 December 2019. Conditions are laid down in this legislation in order for pests to qualify for listing as Union quarantine pests, protected zone quarantine pests or Union regulated non-quarantine pests. The lists of the EU regulated pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072. Additionally, as stipulated in the Commission Implementing Regulation 2018/2019, certain commodities are provisionally prohibited to enter in the EU (high risk plants, HRP). EFSA is performing the risk assessment of the dossiers submitted by exporting to the EU countries of the HRP commodities, as stipulated in Commission Implementing Regulation 2018/2018. Furthermore, EFSA has evaluated a number of requests from exporting to the EU countries for derogations from specific EU import requirements.

In line with the principles of the new plant health law, the European Commission with the Member States are discussing monthly the reports of the interceptions and the outbreaks of pests notified by the Member States. Notifications of an imminent danger from pests that may fulfil the conditions for inclusion in the list of the Union quarantine pest are included. Furthermore, EFSA has been performing horizon scanning of media and literature.

As a follow-up of the above-mentioned activities (reporting of interceptions and outbreaks, HRP, derogation requests and horizon scanning), a number of pests of concern have been identified. EFSA is requested to provide scientific opinions for these pests, in view of their potential inclusion by the risk manager in the lists of Commission Implementing Regulation (EU) 2019/2072 and the inclusion of specific import requirements for relevant host commodities, when deemed necessary by the risk manager.

1.1.2. Terms of Reference

EFSA is requested, pursuant to Article 29(1) of Regulation (EC) No 178/2002, to provide scientific opinions in the field of plant health.

EFSA is requested to deliver 53 pest categorisations for the pests listed in Annex 1A, 1B, 1D and 1E (for more details see mandate M-2021-00027 on the Open.EFSA portal). Additionally, EFSA is requested to perform pest categorisations for the pests so far not regulated in the EU, identified as pests potentially associated with a commodity in the commodity risk assessments of the HRP dossiers (Annex 1C; for more details see mandate M-2021-00027 on the Open.EFSA portal). Such pest categorisations are needed in the case where there are not available risk assessments for the EU.

When the pests of Annex 1A are qualifying as potential Union quarantine pests, EFSA should proceed to phase 2 risk assessment. The opinions should address entry pathways, spread, establishment, impact and include a risk reduction options analysis.

Additionally, EFSA is requested to develop further the quantitative methodology currently followed for risk assessment, in order to have the possibility to deliver an express risk assessment methodology. Such methodological development should take into account the EFSA Plant Health Panel Guidance on quantitative pest risk assessment and the experience obtained during its implementation for the Union candidate priority pests and for the likelihood of pest freedom at entry for the commodity risk assessment of High Risk Plants.

1.2. Interpretation of the Terms of Reference

A pest categorisation on coconut cadang-cadang viroid (CCCVd) has already been carried out (EFSA PLH Panel, 2017). However, recent information on its host range (EPPO, 2021) required an update of the previous pest categorisation of CCCVd to determine whether it still fulfils the criteria that are within the remit of EFSA to assess for this viroid to be regarded as a Union quarantine pest (QP) for the area of the EU excluding Ceuta, Melilla and the outermost regions of Member States referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores, and so inform EU decision making as to its appropriateness for potential inclusion in the lists of pests of Commission Implementing Regulation (EU) 2019/2072. If a pest fulfils the criteria to be potentially listed as a Union QP, risk reduction options will be identified.

2. Data and Methodologies

2.1. Data

2.1.1. Literature search

A literature search on CCCVd was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as search term. Papers relevant for the pest categorisation were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature.

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the EPPO Global Database, the CABI databases and scientific literature databases as referred above in Section 2.1.1.

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt and TRACES databases were consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTÉ) of the European Commission as a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. TRACES is the European Commission's multilingual online platform for sanitary and phytosanitary certification required for the importation of animals, animal products, food and feed of non-animal origin and plants into the EU, and the intra-EU trade and EU exports of animals and certain animal products. Up until May 2020, the Europhyt database managed notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the Member States and the phytosanitary measures taken to eradicate or avoid their spread. The recording of interceptions switched from Europhyt to TRACES in May 2020.

GenBank was searched to determine whether it contained any nucleotide sequences for coconut cadang-cadang viroid which could be used as reference material for molecular diagnosis. GenBank® (www.ncbi.nlm.nih.gov/genbank/) is a comprehensive publicly available database that as of August 2019 (release version 227) contained over 6.25 trillion base pairs from over 1.6 billion nucleotide sequences for 450,000 formally described species (Sayers et al., 2020).

2.2. Methodologies

This is an update of the pest categorisation of coconut cadang-cadang viroid (CCCVd) previously published by EFSA (EFSA PLH Panel, 2017). The text of such scientific opinion was modified taking into consideration new information and the need to follow a different template (EFSA PLH Panel, 2018) with respect to the previous version.

The Panel updated the pest categorisation for CCCVd, following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018), the EFSA guidance on the use of the weight of evidence approach in scientific assessments (EFSA Scientific Committee, 2017) and the International Standards for Phytosanitary Measures No. 11 (FAO, 2013).

The criteria to be considered when categorising a pest as a potential Union QP is given in Regulation (EU) 2016/2031 Article 3 and Annex I, Section 1 of the Regulation. Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. In judging whether a criterion is met the Panel uses its best professional judgement (EFSA Scientific Committee, 2017) by integrating a range of evidence from a variety of sources (as presented above in Section 2.1) to reach an informed conclusion as to whether or not a criterion is satisfied.

The Panel's conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, deemed to be a risk management decision, the Panel will present a summary of the observed impacts in the areas where the pest occurs, and make a judgement about potential likely impacts in the EU. Whilst the Panel may quote impacts reported from areas where the pest occurs in monetary terms, the Panel will seek to express potential EU impacts in terms of yield and quality losses and not in monetary terms, in agreement with the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018). Article 3 (d) of Regulation (EU) 2016/2031 refers to unacceptable social impact as a criterion for QP status. Assessing social impact is outside the remit of the Panel.

Table 1: Pest categorisation criteria under evaluation, as derived from Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest (article 3)
Identity of the pest (Section 3.1)	Is the identity of the pest clearly defined, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways for entry and spread.
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?
Available measures (Section 3.6)	Are there measures available to prevent pest entry, establishment, spread or impacts?
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

Is the identity of the pest clearly defined, or has it been shown to produce consistent symptoms and/or to be transmissible?

Yes, the identity of coconut cadang-cadang viroid is clearly defined. The pathogen has been shown to produce consistent symptoms and to be transmissible.

Coconut cadang-cadang viroid (CCCVd) is a well characterised viroid, currently classified in the species *Coconut cadang-cadang viroid* belonging to the genus *Cocadviroid* (family Pospiviroidae) (https://ictv.global/taxonomy). As a viroid, CCCVd consists of a circular, non-coding RNA able to replicate and spread systemically in its hosts (Navarro et al., 2021). It is transmissible and causes lethal diseases (cadang-cadang or yellow-mottling) in coconut palm (*Cocos nucifera*) (Randles et al., 1977) and orange spotting (OS) in oil palm (*Elaeis guineensis*) (Vadamalai et al., 2017, Vadamalai, personal communication).

The EPPO code[1] (Griessinger and Roy, 2018; EPPO, 2019) for this species is: CCCVD0 (EPPO, online).

[1] An EPPO code, formerly known as a Bayer code, is a unique identifier linked to the name of a plant or plant pest important in agriculture and plant protection. Codes are based on genus and species names. However, if a scientific name is changed the EPPO code remains the same. This provides a harmonised system to facilitate the management of plant and pest names in computerised databases, as well as data exchange between IT systems (Griessinger and Roy, 2015; EPPO, 2019).

3.1.2. Biology of the pest

Coconut cadang-cadang disease was first observed in coconut plants grown in the Philippines early in the 20th century and its causal agent was identified to be a viroid, named coconut cadang-cadang viroid (Randles et al., 1977; Randles and Rodriguez, 2003).

CCCVd is seed-transmitted at a low rate of about 1 out of 300 in naturally infected palms (Pacumbaba et al., 1994; Randles and Rodriguez, 2003). It can also be transmitted at a low rate through pollen to progeny seeds and seedlings (Pacumbaba et al., 1994; Randles and Rodriguez, 2003 citing Manalo et al., 2000). The viroid was also detected in seedlings, embryos and plantlets grown *in vitro* originating from naturally infected palms (Pacumbaba et al., 1994).

Human-assisted transmission through contaminated scythes or machetes has not been demonstrated (Vadamalai et al., 2017). However, years after inoculation with multiple slashing of leaf fronds or peduncles with scythe dipped in CCCVd inoculum, up to 10% coconut inoculated seedlings turned out to be infected by the viroid (Randles and Rodriguez, 2003). Therefore, transmission at a low rate by mechanical means (e.g. via contaminated tools) cannot be excluded.

No vector has been identified for CCCVd (Vadamalai et al., 2017). Some coleopterans have been suspected, but never confirmed as vectors in coconut (Zelazny and Pacumbaba, 1982). In addition, as for other viruses and virus-like pathogens, CCCVd is transmitted by vegetative propagation.

In the Philippines, CCCVd epidemics have been reported in different times and places. However, outbreak boundaries expand at a low rate of about 0.5 km per year with no specific pattern of disease increase. At a local scale, infected palms have a scattered distribution, but the spread of the disease over large areas appeared somehow clustered (Randles and Rodriguez, 2003). Disease incidence is negligible in palms of pre-bearing age (up to 10-year-old), and later on it is positively correlated with the age of palm plantations up to 40 years (Pacumbaba et al., 1994), but negatively correlated with the altitude (Zelazny, 1980). Overall, knowledge of the CCCVd epidemiology is only partial since epidemiological observations suggest the presence of additional unknown means of natural spread, other than seeds and pollen (Pacumbaba et al., 1994; Vadamalai et al., 2017).

The viroid was transmitted under experimental conditions using high pressure transmission and razor slashing with nucleic acid preparations from infected plants to palm trees (Randles et al., 1977; Imperial et al., 1985). In these conditions, the minimum period from inoculation of CCCVd in coconut palm seedlings to the appearance of first leaf symptoms was estimated to be between 19 and 22 months (Randles et al., 1977). In oil palm, OS symptoms were observed 6 to 9 months after CCCVd inoculation (Vadamalai, personal communication).

3.1.3. Host range/species affected

All known hosts of CCCVd belong to the Arecaceae family (owing to historical usage, the family is also referred-to as Palmae as in Commission Implementing Regulation 2019/2072)[2], a large family of about 180 genera and 2,600 perennial species of trees and shrubs (Christenhusz and Byng, 2016).

Coconut palm (*C. nucifera*) is the main host of CCCVd (Randles, 1975; Vadamalai et al., 2017), with all coconut populations tested for resistance reported as susceptible (Randles and Rodriguez, 2003 citing Orolfo et al., 2000). Other natural hosts include oil palm (*E. guineensis*) and buri palm (*Corypha utan* syn. *C. elata*) (Randles et al., 1980). In addition, only a single plant of *Livistona rotundifolia* (syn. *Saribus rotundifolius*) has been reported to be naturally infected by CCCVd so far (Pacumbaba et al., 1998).

While susceptibility to CCCVd of the natural hosts reported above was also confirmed by experimental inoculation by high pressure injection and slash inoculation of nucleic acid preparations from infected hosts (Imperial et al., 1985; Mohamed et al., 1985), no conclusive data are available for experimentally inoculated *L. rotundifolia* (see below). In addition, other hosts identified under laboratory conditions using the same inoculation technique include *Adonidia merrillii* (Manila palm, syn. *Veitchia merrillii*), *Areca catechu* (Betel palm), *Dypsis lutescens* (palmera, syn. *Chrysalidocarpus lutescens*) and *Roystonia regia* (royal palm, syn. *Oreodoxa regia*) (Imperial et al., 1985). With the exception of Betel palm, stunting and/or leaf yellowing were observed in all these hosts a few years after inoculation (Imperial et al., 1985).

Experimental inoculation of date palm (*Phoenix dactylifera*), Macarthur palm (*Ptychosperma macarthurii* syn. *Actinophtoeus macarthurii*) and anahaw palm (*Livistona rotundifolia*) was mentioned by Imperial et al. (1985)), but the final results of these experiments were not reported. However, date

[2] https://www.bgbm.org/IAPT/Nomenclature/Code/SaintLouis/0022Ch3Sec2a018.htm

palm, which also grows in the EU, and Macarthur palm have been considered to be susceptible to CCCVd inoculation (https://pca.gov.ph/pdf/techno/cadangcadang.pdf, Hanold and Randles, 1991a; Randles and Rodriguez, 2003; Vadamalai et al., 2017).

Since the ascertained natural and experimental hosts of coconut cadang-cadang viroid belong to several botanical genera, the possibility that palms native to the EU, such as Cretan palm (*P. theophrasti*) and European fan palm (*Chamaerops humilis*), may also be hosts of CCCVd cannot be excluded, although with high uncertainty due to the lack of evidence. For the same reason, it cannot be excluded that the host range of CCCVd may include other species in the family Arecaceae relevant for the EU.

There is only one report of a Poaceae species (*Chloris*) as a host of CCCVd (CABI, 2008), but the Panel was unable to identify the source of this information and to verify it.

RNA sequences sharing some similarity with CCCVd RNA have been detected by molecular hybridization in other Arecaceae species and in asymptomatic herbaceous monocots (Hanold and Randles, 1991a,b), but the nucleotide sequence of these RNAs was not determined and, based on comparative analysis of the molecular hybridization signals, they appeared to be different from CCCVd (Hodgson and Randles, 1999).

A detailed list of natural and experimental hosts of CCCVd is reported in Appendix A.

3.1.4. Intraspecific diversity

Viroids occur in nature as complex populations of closely related sequence variants. CCCVd sequence variants currently classified in the species *Coconut cadang-cadang viroid* share a genomic RNA with more than 97.6% identity (Chiumenti et al., 2021).

Several CCCVd molecular forms of the viroid, differing in size from 246 to 301 nt, have been reported in infected coconut palms, with larger forms mainly detected in the late stages of the disease (Haseloff et al., 1982). These different length forms of the viroid have been associated with the development of specific symptoms in the infected coconut plants (Hanold and Randles, 1991a).

In addition, specific sequence variants of CCCVd have been identified and are associated with different disease phenotypes in coconut and oil palm (Rodriguez and Randles, 1993; Wu et al., 2013). The lamina-depleting 'brooming' disease of coconut is associated with CCCVd sequence variants showing specific point mutations in the pathogenicity and the central conserved domains (Rodriguez and Randles, 1993) with respect to the reference variant (GenBank Accession Number J02049). A variant of CCCVd (GenBank Accession Number HQ608513) with mutations in the same domains was recovered from African oil palms (*E. guineensis*) affected by OS in Malaysia (Wu et al., 2013). However, different variants of CCCVd have also been described from oil palms in Malaysia (GenBank Accession numbers DQ097183–DQ097185) with no OS symptoms (Vadamalai et al., 2006).

In palms or other tropical monocotyledon plants, RNAs that hybridise with probes representing part or all of the basic 246 nt CCCVd sequence occur (CCCVd-related or CCCVd-like RNAs) (Randles et al., 1980; Hanold and Randles, 1991b). However, no sequence information or pathogenicity data is available for those CCCVd-like RNAs, so that their relationship with CCCVd remains uncertain. Moreover, based on hybridization signals with molecular probes, it was excluded that most of these sequences may correspond to CCCVd (Hodgson and Randles, 1999). Therefore, reports of the presence of CCCVd-related RNAs are not considered in the present opinion as an indication of the presence of CCCVd.

3.1.5. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, detection and identification methods are available for CCCVd.

Symptoms are not reliable for the early detection of CCCVd, as they may appear years after the initial infection [up to 6 years in the field or 8 years under experimental conditions (Imperial et al., 1985)] and they may resemble those caused by coconut tinangaja viroid (CTiVd, 'tinangaja disease'), physiological changes due to other biotic (insect, microbes) or abiotic stresses. In addition, CCCVd mutants or variants may be associated with distinct disease phenotypes (see Section 3.1.4).

Several molecular protocols are available for the detection of CCCVd. These include reverse transcription (RT)-PCR to detect CCCVd and its variants (Rodriguez and Randles, 1993; Vadamalai et al., 2006; Roslan et al., 2016), as well as specific protocols for the discrimination of CCCVd and CTiVd, which may induce similar symptoms. Regardless of the PCR protocol used, sequencing of PCR amplicons is strongly recommended for unequivocal viroid identification (Vadamalai et al., 2006; Wu et al., 2013; EPPO, 2021). A RT-loop-mediated isothermal amplification (LAMP) protocol is also available for the efficient detection of low concentration of CCCVd (Thanarajoo et al., 2014).

Molecular hybridization assays are also widely used for the detection of this viroid, which include dot-blot or Northern blot of nucleic acid preparations separated by one- or two- dimensional polyacrylamide gel electrophoresis (PAGE) (Mohamed and Imperial, 1984; Imperial et al., 1985; Hanold and Randles, 1991a,b; Hodgson et al., 1998). Detection results obtained using molecular hybridization assays should be considered with caution because of the presence in some palms or other tropical monocotyledons of RNAs that hybridise with probes representing part or all of the CCCVd genome but that has never been proven to be *bona fide* CCCVd (Randles et al., 1980; Hanold and Randles, 1991b). These so-called 'CCCVd-related RNAs' have been suspected, but never demonstrated, to be associated with CCCVd infection (Hanold and Randles, 1991b, 2003). In any case, conclusive identification of CCCVd is achieved mainly by sequencing the viroid genome. In addition, a ribonuclease protection assay (RPA) was developed by Vadamalai et al. (2009).

Lately, a new remote sensing approach based on the estimation of chlorophyll content using reflectance spectra (400–1,050 nm) has been developed and tested for CCCVd detection in seedlings of African oil palm under greenhouse conditions (Golhani et al., 2019), but the reliability of this method on other palm species or on plants in field conditions is currently not known.

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

CCCVd is widely distributed in the central and Eastern Philippines (Haseloff et al., 1982). The viroid has also been reported in Malaysia (Vadamalai et al., 2006; Wu et al., 2013; Thanarajoo et al., 2014) (Figure 1). Reports of CCCVd-related sequences from South-West Pacific region (Indonesia, Sri Lanka and Vanuatu), South Africa and Africa (Hanold and Randles, 1991a; Hanold and Randles, 1998) are not considered trustworthy since the identification of the viroid has not been conclusively established (it is based on hybridization assays with probes that can cross-hybridise with other sequences not corresponding to CCCVd).

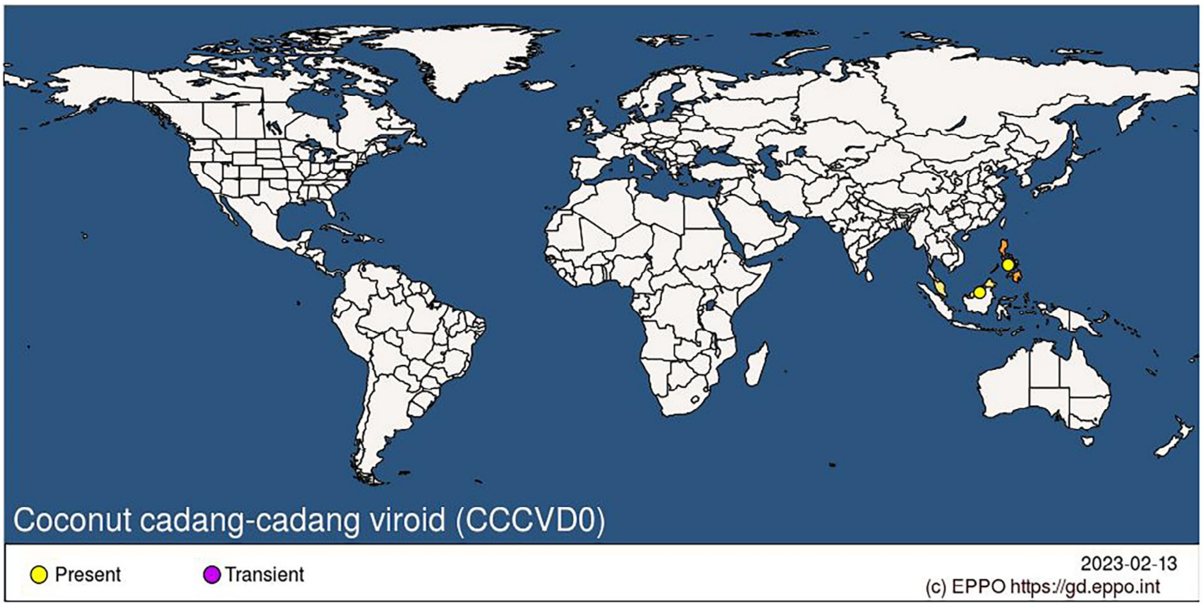

Figure 1: Global distribution of coconut cadang-cadang viroid (Source: EPPO Global Database accessed on 13 February 2023, last updated: 2022-10-11)

Oil palms showing OS symptoms have been reported in Nigeria and in other countries (Vadamalai et al., 2017), but infection by CCCVd was never confirmed.

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.

No, CCCVd is not known to occur in the EU.

To date, CCCVd has not been reported in the EU.

3.3. Regulatory status

3.3.1. Commission Implementing Regulation 2019/2072

Coconut cadang-cadang viroid is listed as a QP in Annex II part A, F. Viruses, viroids and phytoplasmas, point 3 of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031.

3.3.2. Hosts or species affected that are prohibited from entering the union from third countries

None of the natural host plants of coconut cadang-cadang viroid are prohibited from entering the EU from third countries under Commission Implementing Regulation (EU) 2019/2072.

3.4. Entry, establishment and spread in the EU

3.4.1. Entry

Is the pest able to enter into the EU territory? If yes, identify and list the pathways.

Comment on plants for planting as a pathway.

Yes, CCCVd could potentially enter the EU via plants for planting including seeds of its hosts.

The main pathway of entry identified by the Panel is the trade of plants for planting including seeds of susceptible host species. Within the EU, many nurseries commercialise young palms, including coconuts and other CCCVd potential hosts for ornamental use. According to the ISEFOR database[3], between the years 2000 and 2011 among several Arecaceae species, coconut plants were imported into the EU from the Philippines (30 plants) and Malaysia (1,393 plants), which are countries in which CCCVd is known to occur. Therefore, CCCVd is able to enter the EU with at least coconut plants and the same applies to other susceptible Arecaceae species possibly imported from countries where the pathogen is present. According to the current EU legislation, CCCVd is a QP (Section 3.3.1) and specific requirements to import Arecaceae plants for planting are currently in place (Table 2). However, no specific requirement is indicated for seeds of Arecaceae, including CCCVd hosts, which therefore represent an open pathway. A phytosanitary certificate is needed to import seeds of hosts from third countries (2019/2072, Annex XI, Part B). The main potential entry pathways are listed in Table 2 together with the relevant mitigation measures in place in the EU. In addition, there are also uncertainties about whether imported coconut would be viable and would be used as seeds for sowing.

[3] Database developed within the FP7 Project 'Increasing Sustainability of European Forests: Modelling for Security Against Invasive Pests and Pathogens under Climate Change.

Table 2: Potential pathways for CCCVd into the EU 27

Pathways	Life stage	Relevant mitigations [e.g. prohibitions (Annex VI), special requirements (Annex VII) or phytosanitary certificates (Annex XI) within Implementing Regulation 2019/2072]
Description (e.g. host/intended use/source)		
Plants for planting		Requirements are listed in Annex VII (point 55) for plants for planting other than seeds of Palmae (Arecaceae) from third countries other than Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo- Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug))., San Marino, Serbia, Switzerland, Turkey and Ukraine and the United Kingdom The requirements consist of Official statement that: (a) either the plants originate in an area known to be free from Palm lethal yellowing phytoplasmas and Coconut cadang-cadang viroid, and no symptoms have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation, or *[...]* (c) in the case of plants in tissue culture, the plants were derived from plants which have met the requirements laid down in point (a) or (b). A ban concerning import of plants of *Phoenix* spp. other than fruit and seeds is in force for Algeria and Morocco (Annex VI, 13). However, CCCVd has not been reported in these countries.
Seeds for sowing of Arecaceae hosts		Seeds of hosts imported from third countries require a phytosanitary certificate to be imported into the EU (2019/2072, Annex XI, Part B). However, no requirements are specified for CCCVd.

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As of 16 February 2023, there were no records of interception of CCCVd in the Europhyt and TRACES databases.

3.4.2. Establishment

Is the pest able to become established in the EU territory?

Yes, CCCVd is able to become established in the EU, with a key uncertainty resulting from the lack of conclusive data on the susceptibility of the other Arecaceae species growing or produced, traded and used as ornamentals in the EU.

Transfer of CCCVd from the pathway of entry to hosts grown in the EU is associated with uncertainty. CCCVd epidemiology is only partially known and, besides the documented seeds and pollen transmission, it is very likely that other natural means of spread, still unknown, exist, which could potentially be involved in such a transfer.

The only palm species growing naturally in the EU are the European fan palm (*Chamaerops humilis*, with a distribution mainly in coastal areas of the western half of the Mediterranean basin) and the Cretan date palm (*Phoenix theophrasti,* endemic to Crete (Greece) and a few east Aegean islands) (Vamvoukakis, 1988), for which data on their host status are missing.

The only known commercial cultivation of palms for non-ornamental purposes in the EU is that of date palm (*P. dactylifera*) in Spain (Ferry et al., 2002). Besides Elche, the biggest area in Europe where *P. dactylifera* is cultivated, other production areas in Spain are Abanilla and Huerta de Murcia in Murcia and Albatera, Alicante, Callosa, Crevillent and Orihuela, Comunidad Valenciana, which contribute to the overall date palm production of Spain (Rivera et al., 2015).

Many other palm species and mainly *Chamaerops* species*,* Canary Island palm (*Phoenix canariensis*) and date palm (*Phoenix dactylifera*) are widely used as ornamentals for landscaping in southern EU countries (Cohen, 2017). Several of these palm species are widely grown in the EU under protected cultivation conditions (Armengol et al., 2005), while *P. dactylifera, P. thoephrasti, P. canariensis and R. regia* are known to be grown in nurseries of Sicily, in screenhouses and open-field cultivations (Piante Faro, personal communication).

Based on current evidence (Section 3.1.3), the palm species reported above are considered as experimental hosts (*R. regia*) or potential hosts of CCCVd. Moreover, it cannot be excluded that the host range of CCCVd may include other species in the family Arecaceae present in the EU (Section 3.1.3). Knowledge of the CCCVd epidemiology is only partial and, besides the documented seeds and pollen transmission, it is very likely that other natural means of spread, still unknown, exist (Pacumbaba et al., 1994; Vadamalai et al., 2017). Therefore, CCCVd is considered to be able to establish in the EU, with uncertainties resulting from the lack of conclusive data on the susceptibility of the Arecaceae species growing or produced, traded and used as ornamentals in the EU and the mechanisms of transfer from the entry pathway to the hosts in the EU.

3.4.2.1. EU distribution of main host plants

Date palms are cultivated in some EU countries. Details on date production reported in the FAOSTAT (2023) database are provided in Table 3.

Table 3: Date production [harvested area in ha (production in tonnes)]. FAOSTAT database, date of extraction 16th February 2023

MS/TIME	2017	2018	2019	2020	2021
Spain (dates)	492 (1,848)	NA	NA	NA	NA

3.4.2.2. Climatic conditions affecting establishment

Climatic conditions in the EU are not a limiting factor for CCCVd establishment, because establishment is dependent on the availability of host plants in the EU.

3.4.3. Spread

Describe how the pest would be able to spread within the EU territory following establishment.

Following its establishment, CCCVd could spread within the EU territory by natural (seeds and pollen) and human-assisted means. There is uncertainty on the existence of additional natural spreading mechanism(s) (see Section 3.1.2).

Comment on plants for planting as a mechanism of spread.

Trade of host plants for planting, including seeds, is the main means of spread of the pathogen.

CCCVd systemically invades its hosts (see Section 3.1.2) and therefore can be transmitted through vegetative propagation practiced either by offshoot or tissue culture applied to some palm species e.g. date palm (Abdelouahhab and Arias-Jimenez, 1999). Therefore, trade of host plants for planting, including seeds, is the main means of CCCVd spread. On the other hand, low rates of pollen and seed transmission of CCCVd can also be responsible for pathogen spread (Hanold and Randles, 1991a; Pacumbaba et al., 1994), but this mechanism is expected to be significant only for species able to reproduce naturally under conditions prevailing in the EU. This applies in particular to the date palm species. Transmission via contaminated tools during cultural practices does not seem to be adequately tested and remains uncertain (Hanold and Randles, 1991a).

In the infested areas in the Philippines, the extent and the patterns of CCCVd natural spread cannot be fully explained by vegetative and pollen or seed transmission suggesting that the main mean of natural spread is still unknown (Pacumbaba et al., 1994). Therefore, additional mechanisms of spread cannot be excluded, although with high uncertainty.

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?

Yes, the introduction of CCCVd in the EU would potentially cause economic and environmental impact. However, uncertainty exists on the magnitude of the potential impacts, as the susceptibility of the species grown in the EU is not known.

Coconut palms are severely affected by CCCVd. The disease is characterised by a slow progression of symptoms, closely associated with the progress of the infection and the presence of the different molecular forms of the viroid (Mohamed et al., 1982). It results eventually in the death of the diseased coconut trees (Randles and Rodriguez, 2003). Symptoms of cadang-cadang disease generally appear after palm flowering and progress through early, medium and late stages. Nuts become rounded and scarified with an increasing incidence, while only at a later stage chlorotic (or water-soaked) spots appear on the leaves, inflorescences are stunted with tip necrosis and show loss of some male florets. As disease progresses, symptoms become more severe, there is a decline in fruit production as fewer nuts, spathe and inflorescences are produced, leaf spot numbers increase and coalesce while plants appear chlorotic, stunted, with a progressive decline and eventually die. On the other hand, it was observed that susceptibility to viroid infection decreases with the age of the plant (Velasco, 1997).

CCCVd is considered a serious economic threat for coconut palms, causing their premature decline and death (Hanold and Randles, 1991a). It was estimated that in the Philippines about 40 million coconut palms have died from cadang-cadang with a loss of about US$ 100 per infected palm (Randles and Rodriguez, 2003). The impact of the coconut lamina-depleting 'brooming' disease associated with the presence of single mutations (Rodriguez and Randles, 1993), and the OS disease, possibly associated with the occurrence of CCCVd variants in African oil palm in Malaysia (Vadamalai et al., 2006), is not yet estimated.

A. merrillii, D. lutescens and *R. regia,* which have been successfully inoculated with CCCVd, develop stunting and leaf yellowing, while *A. catechu* remained apparently symptomless (Imperial et al., 1985). One palm species (*P. dactylifera*) grown in the EU has been reported to be an experimental host of CCCVd, with uncertainty (Section 3.1.3), but whether the viroid causes symptoms in this host is unknown (Imperial et al., 1985). For the other palm species native in the EU (*C. humilis* and *P. theophrasti*) no information on susceptibility is available.

None of the known hosts of CCCVd represents an important EU agricultural crop, however a few of them are of high ornamental or landscape importance in the Mediterranean countries of the EU. A large number of those ornamental palms is produced in EU countries such as Spain and Italy (see Section 3.4.2) and are traded in the European markets, therefore, they are of considerable economic importance. Several palm species are widely grown in the EU under protected cultivation conditions. Spain produces about 2 million palm trees annually with *P. canariensis* being the predominant species (1.2 million plants), followed by other species such as *P. dactylifera*, *P. reclinata,* and other ornamental palms (*Washingtonia filifera, W. robusta, C. humilis* and *Trachycarpus fortunei*) (Armengol et al., 2005).

On the other hand, three major heritage palm groves exist in the Mediterranean EU countries, in Elche in Spain, Bordighera in Italy and Crete in Greece. The major one is that of Elche (Spain) which is made up of about 180,000 adult date palms, in an area of almost 400 ha. The total date fruit production in Elche is estimated to be 5,000 tons per year, of which only about 100 tons are sold for human consumption (Ferry et al., 2002). However, the grove of date palm in Elche (Valencia) trees known as 'Palmeral de Elche' was designated in 2000 as a World Heritage Site (http://whc.unesco.org/en/list/930). There are also a couple of additional historical groves in the same area of Spain, in Orihuela and Alicante, but they are not as large as the one in Elche (Suárez, 2010; Jacas et al., 2011). In Bordighera, Italy, date palms have been cultivated since at least the 16th century for religious purposes, and even though their number has significantly dropped since the last century, they remain of high landscape significance. Other threatened native species may include the Cretan date palm (*P. theophrasti*) that is present only in Crete (Greece) and a few east Aegean islands (Vamvoukakis, 1988) and is a species with a near threatened status (*2006 IUCN Red List of Threatened Species*).

Due to the above-mentioned uncertainties on the host range and on the natural spread mechanisms of CCCVd, the magnitude of impact of this viroid, if introduced in the EU, is difficult to assess and is associated with high uncertainty.

3.6. Available measures and their limitations

Are there measures available to prevent pest entry, establishment, spread or impacts such that the risk becomes mitigated?

Yes, there are measures available to prevent the entry into, establishment and spread of CCCVd within the EU. CCCVd is a QP (Section 3.3.1). Moreover, special requirements for importing plants for planting other than seeds of CCCVd hosts from third countries are listed in the legislation, while the existing measures concerning seeds do not specifically target CCCVd (Section 3.3.2).

As the epidemiology of CCCVd is largely unknown, the relevance of some measures is uncertain.

3.6.1. Identification of potential additional measures

Phytosanitary measures (special requirements) are currently applied to CCCVd host plants for planting (see Section 3.3.2).

Additional potential risk reduction options and supporting measures are shown in Sections 3.6.1.1 and 3.6.1.2.

3.6.1.1. Additional potential risk reduction options

Potential additional control measures are listed in Table 4.

Table 4: Selected control measures (a full list is available in EFSA PLH Panel, 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Control measure/ Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/ spread/impact)
Require pest freedom	Use of plants originating from a country officially free from CCCVd or from a pest free area or from a pest free production site is highly effective	Entry/Spread
Growing plants in isolation	Description of possible exclusion conditions that could be implemented to isolate the crop from pests and if applicable relevant vectors. E.g. a dedicated structure such as glass or plastic greenhouses. Growing plants in insect-proof greenhouses may be effective in reducing spread by pollen or potential unknown vector(s)	Entry (reduce contamination/infestation)/ Spread
Roguing and pruning	Although eradication was shown to be ineffective (Randles and Rodriguez, 2003), replacement of infected palms could contribute to reduce the impact of CCCVd, especially if the plants are removed at early stages of infection (Vadamalai et al., 2017)	Entry/Spread/Impact
Cleaning and disinfection of facilities, tools and machinery	The physical and chemical cleaning and disinfection of facilities, tools, machinery, transport means, facilities and other accessories (e.g. boxes, pots, pallets, palox, supports, hand tools). The measures addressed in this information sheet are: washing, sweeping and fumigation. Prior to their export machinery and vehicles which have been operated for agricultural or forestry purposes are cleaned and free from soil and plant debris. Since transmission via contaminated tools cannot be excluded (Section 3.1.2), their cleaning and disinfection may contribute to reduce the probability of mechanical transmission to other plants (Ling, 2017).	Entry/Spread

Control measure/ Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/ spread/impact)
Waste management	Treatment of the waste (deep burial, composting, incineration, chipping, production of bio-energy...) in authorised facilities and official restriction on the movement of waste. Due to the lack of knowledge about CCCVd epidemiology (Section 3.1.2), the presence of the viroid on plant debris cannot be excluded, therefore, proper waste management may contribute to reduce possible source of infections	Establishment/Spread
Post-entry quarantine and other restrictions of movement in the importing country	This information sheet covers post-entry quarantine (PEQ) of relevant commodities; temporal, spatial and end-use restrictions in the importing country for import of relevant commodities; Prohibition of import of relevant commodities into the domestic country. 'Relevant commodities' are plants, plant parts and other materials that may carry pests, either as infection, infestation, or contamination.	Establishment/Spread

3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 5.

Table 5: Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance.

Supporting measure	Summary	Risk element targeted (entry/establishment/ spread/impact)
Inspection and trapping	Inspection is defined as the official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (ISPM 5). The effectiveness of sampling and subsequent inspection to detect pests may be enhanced by including trapping and luring techniques. Inspection can be useful, but not conclusive to identify diseased plants, as symptoms may appear several years after infection (Pacumbaba et al., 1994).	Entry/Establishment/ Spread
Laboratory testing	Examination, other than visual, to determine if pests are present using official diagnostic protocols. Diagnostic protocols describe the minimum requirements for reliable diagnosis of regulated pests. Laboratory tests are available to detect the possible presence of the pest in the host plants.	Entry
Sampling	According to ISPM 31, it is usually not feasible to inspect entire consignments, so phytosanitary inspection is performed mainly on samples obtained from a consignment. It is noted that the sampling concepts presented in this standard may also apply to other phytosanitary procedures, notably selection of units for testing.	Entry

Supporting measure	Summary	Risk element targeted (entry/establishment/spread/impact)
	For inspection, testing and/or surveillance purposes the sample may be taken according to a statistically based or a non-statistical sampling methodology.	
Phytosanitary certificate and plant passport	An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (ISPM 5) (a) export certificate (import) (b) plant passport (EU internal trade) A phytosanitary certification and plant passport confirming that plants for planting and seeds of CCCVd hosts are pest-free could be an effective measure to reduce the risk of entry and spread	Entry/Spread
Certified and approved premises	Mandatory/voluntary certification/approval of premises is a process including a set of procedures and of actions implemented by producers, conditioners and traders contributing to ensure the phytosanitary compliance of consignments. It can be a part of a larger system maintained by the NPPO in order to guarantee the fulfilment of plant health requirements of plants and plant products intended for trade. Key property of certified or approved premises is the traceability of activities and tasks (and their components) inherent the pursued phytosanitary objective. Traceability aims to provide access to all trustful pieces of information that may help to prove the compliance of consignments with phytosanitary requirements of importing countries. Certified and approved premises may guarantee the absence of the pest.	Entry/Spread
Certification of reproductive material (voluntary/official)	Plants come from within an approved propagation scheme and are certified pest free (level of infestation) following testing; Used to mitigate against pests that are included in a certification scheme The risk may be reduced if plants for planting including seeds are produced under an approved certification scheme	Entry/Spread
Delimitation of Buffer zones	ISPM 5 defines a buffer zone as 'an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimise the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate' (ISPM 5). The objectives for delimiting a buffer zone can be to prevent spread from the outbreak area and to maintain a pest free production place (PFPP), site (PFPS) or area (PFA). Delimitation of a buffer zone could potentially contribute to prevent CCCVd spread	Establishment/Spread
Surveillance	CCCVd is not present in the EU. Surveillance would be an efficient supporting measure.	Establishment/Spread

3.6.1.3. Biological or technical factors limiting the effectiveness of measures

- Existence of a long asymptomatic phase of the CCCVd disease of up to 6 years in the field;
- Symptoms, especially the early ones, of the CCCVd disease resemble those caused by abiotic stress or other pests;
- Knowledge gaps on the biology and epidemiology of the viroid.

3.7. Uncertainty

The Panel identified the susceptibility of palm species grown in the EU as a key uncertainty potentially affecting the conclusion of this pest categorisation.

4. Conclusions

Despite the key uncertainty on the susceptibility of palm species grown in the EU, coconut cadang-cadang viroid satisfies the criteria that are within the remit of EFSA to assess for this viroid to be regarded as potential Union QP (Table 6).

Table 6: The Panel's conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Key uncertainties
Identity of the pest (Section 3.1)	Yes, the identity of the pest is clearly defined. CCCVd has been shown to produce consistent symptoms and to be transmissible	None
Absence/presence of the pest in the EU (Section 3.2)	CCCVd is not known to be present in the EU	None
Pest potential for entry, establishment and spread in the EU (Section 3.4)	CCCVd is able to enter into, become established in and spread within the EU territory through the movement of plants for planting, including seeds.	Uncertainty on the susceptibility of Arecaceae species growing in the EU
Potential for consequences in the EU (Section 3.5)	CCCVd introduction may have an economic and environmental impact in areas in the EU, where palms are grown.	None
Available measures (Section 3.6)	There are measures available to prevent the entry into, establishment within and spread in the EU of CCCVd.	None
Conclusion (Section 4)	Despite the key uncertainty on the susceptibility of palm species grown in the EU, coconut cadang-cadang viroid still satisfies the criteria that are within the remit of EFSA to assess for this viroid to be regarded as potential Union quarantine pest	
Aspects of assessment to focus on/scenarios to address in future if appropriate:	Studies on the susceptibility of palm species growing in the EU	

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Abbreviations

CCCVd	coconut cadang cadang viroid
CTiVd	Tinangaja disease
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
MS	Member State
OS	orange spotting
QP	Potential Union Quarantine Pest
PLH	EFSA Panel on Plant Health
PZ	protected zone
RT	reverse transcription
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2022).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2022).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2022).
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2022).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2022).
Greenhouse	A walk-in, static, closed place of crop production with a usually translucent outer shell, which allows controlled exchange of material and energy with the surroundings and prevents release of plant protection products (PPPs) into the environment.
Hitchhiker	An organism sheltering or transported accidentally via inanimate pathways including with machinery, shipping containers and vehicles; such organisms are also known as contaminating pests or stowaways (Toy and Newfield, 2010).
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units.
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2022).
Pathway	Any means that allows the entry or spread of a pest (FAO, 2022).
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2022).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2022).
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2022).

Appendix A – CCCVd host plants/species affected

Host status	Host name	Plant family	Common name	Reference
Cultivated hosts	*Cocos nucifera*	Arecaceae	Coconut	EPPO (2021)
	Elaeis guineensis	Arecaceae	Oil palm	EPPO (2021)
	Corypha utan syn. *C. elata*	Arecaceae	Buri palm	EPPO (2021)
	Livistona rotundifolia	Arecaceae	Anahaw palm	Pacumbaba et al. (1998)
Artificial/ experimental host	*Adonidia merrillii*	Arecaceae	Manila palm	EPPO (2021)
	Areca catechu	Arecaceae	Betel nut	EPPO (2021)
	Dypsis lutescens	Arecaceae	Palmera	EPPO (2021)
	Roystonia regia	Arecaceae	Royal palm	EPPO (2021)
	Phoenix dactylifera	Arecaceae	Date palm	EPPO (2021)*
	Ptychosperma macarthurii syn. *Actinophtoeus macarthurii*	Arecaceae	Macarthur palm	EPPO (2021)*
	Livistona rotundifolia	Arecaceae	Anahaw palm	EPPO (2021)*

*: This plant species is reported as a doubtful host by EPPO (2021).
Source: EPPO Global Database (EPPO, online).