EFSA Journal

SCIENTIFIC OPINION

ADOPTED: 28 January 2021

doi: 10.2903/j.efsa.2021.6427

Commodity risk assessment of *Citrus* L. fruits from Israel for *Thaumatotibia leucotreta* under a systems approach

EFSA Panel on Plant Health (PLH),
Claude Bragard, Katharina Dehnen-Schmutz, Francesco Di Serio, Paolo Gonthier, Marie-Agnès Jacques, Josep Anton Jaques Miret, Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Philippe Lucien Reignault, Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen, Lucia Zappalà, Andrea Lucchi, Alejandro Tena, Olaf Mosbach-Schulz, Eduardo de la Peña and Panagiotis Milonas

Abstract

The European Commission requested EFSA Panel on Plant Health to evaluate a dossier from Israel in which the application of the systems approach to mitigate the risk of entry of *Thaumatotibia leucotreta* to the EU when trading citrus fruits is described. After collecting additional evidence from the Plant Protection and Inspection Services (PPIS) of Israel, and reviewing the published literature, the Panel performed an assessment on the likelihood of pest freedom for *T. leucotreta* on citrus fruits at the point of entry in the EU considering the Israelian systems approach. An expert judgement is given on the likelihood of pest freedom following the evaluation of the risk mitigation measures on *T. leucotreta*, including any uncertainties. The Expert Knowledge Elicitation indicated, with 95% certainty that between 9,863 and 10,000 citrus fruits per 10,000 will be free from this pest. The Panel also evaluated each risk mitigation measure in the systems approach and identified any weaknesses associated with them. Specific actions are identified that could increase the efficacy of the systems approach.

Keywords: sweet orange, mandarins, clementines, false codling moth, European Union, pests

Requestor: European Commission

Question number: EFSA-Q-2020-00548

Correspondence: alpha@efsa.europa.eu

Panel members: Claude Bragard, Katharina Dehnen-Schmutz, Francesco Di Serio, Paolo Gonthier, Marie-Agnès Jacques, Josep Anton Jaques Miret, Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Panagiotis Milonas, Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Philippe L Reignault, Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen and Lucia Zappalà.

Declarations of interest: The declarations of interest of all scientific experts active in EFSA's work are available at https://ess.efsa.europa.eu/doi/doiweb/doisearch.

Acknowledgements: The Panel acknowledges Oresteia Sfyra for the preparation and drafting of this Scientific Opinion.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Dehnen-Schmutz K, Di Serio F, Gonthier P, Jacques M-A, Jaques Miret JA, Justesen AF, MacLeod A, Magnusson CS, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke H-H, Van der Werf W, Vicent Civera A, Yuen J, Zappalà L, Lucchi A, Tena A, Mosbach-Schulz O, de la Peña E and Milonas P, 2021. Scientific Opinion on the commodity risk assessment of *Citrus* L. fruits from Israel for *Thaumatotibia leucotreta* under a systems approach. EFSA Journal 2021;19(3):6427, 36 pp. https://doi.org/10.2903/j.efsa.2021.6427

ISSN: 1831-4732

Table of contents

1. Introduction

1.1. Background and Terms of Reference as provided by the European Commission

1.1.1. Background

In the Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council are established, as regards protective measures against pests of plants, and Commission Regulation (EC) No 690/2008 repealed and Commission Implementing Regulation (EU) 2018/2019 amended. Point 62 of Annex VII to Commission Implementing Regulation (EU) 2019/2072 defines the list of plants, plant products and other objects, originating from third countries and the corresponding special requirements for their introduction into the Union territory. In particular fruits of *Capsicum* (L.), *Citrus* L., other than *Citrus limon* (L.) Osbeck. and *Citrus aurantiifolia* (Christm.) Swingle, *Prunus persica* (L.) Batsch and *Punica granatum* L. an official statement is required that the fruits:

a) originate in a country recognised as being free from *T. leucotreta* (Meyrick), or;
b) originate in an area established by the national plant protection organisation in the country of origin as being free from *T. leucotreta* (Meyrick), or;
c) originate in a place of production established by the national plant protection organisation in the country of origin as being free from *T. leucotreta* (Meyrick) or;
d) have been subjected to an effective cold treatment to ensure freedom from *Thaumatotibia leucotreta* (Meyrick) or an effective systems approach or another effective post-harvest treatment to ensure freedom from *T. leucotreta* (Meyrick).

A systems approach is defined in the ISPM14 as a pest risk management option that integrates different measures, at least two of it act independently, with cumulative effect.

1.1.2. Terms of Reference

In accordance with point 62 of Annex VII to Commission Implementing Regulation (EU) 2019/2072 on specific import requirements for certain fruits of *Citrus* L. in relation to the pest *T. leucotreta.* Israel has chosen to apply a systems approach (option (d)) for the management of that risk. Despite the application of those systems approaches, the number of interceptions has remained high, which has triggered the need for reviewing the systems approach.

EFSA is expected to provide a scientific opinion assessing the level of certainty to which the systems approach followed by Israel ensures freedom of *Citrus* L. fruits from *T. leucotreta*. When key weaknesses of those systems approaches are identified, they should be analysed, and risk reduction options which could lead to the increase of the level of pest freedom of the commodity shall be described, where appropriate.

In view of the above and in accordance with Article 29 of Regulation (EC) No 178/2002, the Commission asks EFSA to provide a scientific opinion in the field of plant health.

1.1.3. Interpretation of the Terms of Reference

In its evaluation of the systems approach the Panel:

1) reviewed the information provided by Plant Protection and Inspection Service of Israel (hereafter PPIS) in the Dossier, in the hearing of November 10th 2020, and the additional information provided after the hearing;
2) evaluated the effectiveness of the proposed measures included in the systems approach described in the Dossier;
3) identified the critical aspects of the current system and made recommendations for improvements.

Risk management decisions are not within EFSA's remit. Therefore, the Panel provided a rating for the likelihood of pest freedom for *T. leucotreta* at the point of entry.

2. Data and methodologies

2.1. Data

2.1.1. Data provided by PPIS

The Panel considered all the data and information provided in the Dossier, including the additional material provided by the PPIS of Israel during the hearing of 10 November 2020. The Dossier and supplementary material are stored and are accessible by EFSA.

Table 1: Structure and overview of the information provided by PPIS of Israel

Dossier section	Overview of contents	Filename
1	Technical Dossier	
1.1	Systems approach management for the export of citrus fruit from Israel to the EU	IL_citrus FCM SA.pdf
1.2	Attachment 2 - *Thaumatotibia leucotreta* systems approach – effectiveness data	IL_effectiveness.pdf
1.3	Status of pests in Israel (confidential)	IL_effectiveness.pdf
1.4	Standard Operating Procedure for a packing house which exports citrus fruit to the EU according to a 'Systems Approach'	Guidelines for Citrus export to the EU 5.11.20.pdf
1.5	Guidelines for plots that export citrus fruit to the EU in areas that are under the Systems Approach for the False codling moth	Guidelines for plot approval 5.11.20.pdf
2	Answers to the Questions after the request of EFSA submitted by the PPIS of Israel	Answers to additional questions 8 NE 301120 DI SZ 021220 555.docx
2.1	Maps indicating the citrus production areas (confidential)	Appendix 1_Israel citrus production areas.pdf
2.2	Maps indicating the citrus production areas in the Northern region of Israel (confidential)	Appendix 2_Northern region citrus production areas.pdf
2.3	Maps indicating the citrus production areas in the Southern region of Israel (confidential)	Appendix 3_Southern region citrus production areas.pdf
2.4	Maps indicating the change in the Systems Approach area of citrus production the last years (confidential)	Appendix 4_Systems Approach area updatewith plots.pdf
3	Minutes of the Hearing with Israel held on the 10th of November 2020	Minutes_Hearing_EFSA_Israel_Final_for_web_publication 08_12_2020.pdf

The data and supporting information provided by the PPIS of Israel formed the basis of this commodity risk assessment.

2.1.2. Literature searches performed by EFSA

A literature search was undertaken by EFSA to assess the state of the art regarding the efficacy of pre- and post-harvest measures applied to control *T. leucotreta.* The searches were run on 23/12/2020 and 4/1/2021. No language, date or document type restrictions were applied in the search strategy. Additional searches, limited to retrieve documents, were run when developing the opinion. The available scientific information, including previous EFSA opinions on the relevant pest (see pest data sheets in Appendix A) and the relevant literature and legislation (e.g. Regulation (EU) 2016/2031; Commission Implementing Regulations (EU) 2018/2019; (EU) 2018/2018 and (EU) 2019/2072; and Delegated Regulation (EU) 2019/1702) were taken into account.

2.1.3. Commodity data

The characteristics of the commodity were summarised mainly based on the information provided in the Dossier and during the hearing with Israel.

2.1.4. Methodologies

When developing the opinion, the Panel followed the EFSA Guidance on commodity risk assessment for the evaluation of high-risk plant dossiers (EFSA PLH Panel, 2019). Therefore, the proposed risk mitigation measures for *T. leucotreta* were evaluated in terms of efficacy or compliance with EU requirements as explained in Section 1.1.2.

2.1.5. Listing and evaluation of risk mitigation measures

All risk mitigation measures included in the systems approach in Israel were listed and evaluated. The risk mitigation measures adopted in the production places and packinghouses as communicated by PPIS were evaluated.

To estimate the pest freedom of the commodity i.e. citrus fruits, the methodology for commodity risk assessments was adopted following the EFSA guidance (EFSA PLH Panel, 2018). Therefore, an elicitation was performed to estimate the likelihood of pest freedom in the exported commodities and the risk of entry of the pest. The final result of this elicitation indicates how many fruits out of 10,000 will be infested with *T. leucotreta* when arriving in the EU. Individual fruits were considered for the evaluation because the number of fruits per box differs between different citrus varieties (due to different fruit sizes).

The uncertainties associated with the EKE were taken into account and quantified in the probability distribution applying the semi-formal method described in Section 3.5.2 of the EFSA-PLH Guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018). Finally, the results were reported in terms of the likelihood of pest freedom. The lower 5% percentile of the uncertainty distribution reflects the opinion that pest freedom is with 95% certainty above this limit.

2.1.6. Identification of points for improvement under the systems approach

Following the EFSA guidelines for quantitative pest risk assessment (EFSA PLH Panel, 2018), the panel, based on the description of the systems approach implemented in Israel, identified all the steps in the production that could be considered as risk mitigation measures to decrease the likelihood of introduction of *T. leucotreta* and evaluated their efficacy. Limiting factors that reduce the effectiveness of each measure were identified based on the available scientific and technical data and/or expert knowledge (EFSA PLH Panel, 2018). Available evidence and uncertainties for each measure were listed to identify weak points in the systems approach. Those risk mitigation measures with apparent limiting factors affecting the efficacy of the measure were considered as those steps in the systems approach that could be further improved.

In preparation of the experts' assessment of the limiting factors, the evidence and related uncertainties should be systematically listed. The related uncertainties need to be clearly formulated in this process.

3. The pest

Thaumatotibia leucotreta is a Union quarantine pest listed in Part A of Annex II of Commission Implementing Regulation (EU) 2019/2072 and it is included in the list of priority pests in Commission Delegated Regulation (EU) 2019/1702.

Special import requirements are specified in Annex VII of Commission Implementing Regulation (EU) 2019/2072 regarding the fruit of *Capsicum*, *Citrus* spp. (other than *Citrus limon* and *C. aurantiifolia*), *Prunus persica* and *Punica granatum*. Other major hosts, such as cut flowers, need to have a phytosanitary certificate for their introduction into the EU, as they are listed in Annex XI of the same regulation.

T. leucotreta is native to sub-Saharan Africa and it was first found in Israel in 1984 on macadamia nuts (Wysoki, 1986).

3.1. Biology of *Thaumatotibia leucotreta*

T. leucotreta is a multivoltine insect species that can develop two to five overlapping generations annually, depending on temperature, food availability, photoperiod, humidity, latitude and the effect of predators and diseases (Venette et al., 2003). The life cycle proceeds from an egg, through five larval instars to the pupa and then adults emerge without diapause (Figure 3) (CABI, 2019). It takes, on average, 42–46 days to complete the life cycle at the optimum temperature of 25°C (Opoku-Debrah et al., 2014). However, the length of the life cycle varies between 30 and 117 days, depending on the temperature (de Jager, 2013). Survival decreases substantially at temperatures below 10°C (NAPPFAST, 2003).

Female adults fly at night and attract the males with sex pheromones. Pheromone release peaks about 5 h after dark, and decreases until sunrise (Stibick, 2007). One female can lay up to 800 eggs during her lifetime, which spans about 3 weeks (ranging from 14 to 70 days; Daiber, 1980). Females deposit their eggs between 5 and 11 pm (Stibick, 2007; de Jager, 2013). Eggs can be deposited individually or in aggregations, up to 10–25 eggs per fruit depending on fruit size (Mkiga et al., 2019). Eggs are laid on smooth, non-pubescent surfaces, in the depressions of the rind of a fruit, on fallen fruit or on foliage (Stibick, 2007). Although visible to the naked eye or with a hand lens, they are difficult to detect since they are small, flat and often have a similar colour as the substrate.

After hatching, larvae feed inside the fruit, nuts, pods, seeds, berries, flower buds, cotton bolls, maize ears etc. (EPPO, 2013). Hard green fruit may also be infested. On citrus, larvae prefer the stylar end of 'Navel' cultivars but can burrow anywhere on the fruit. There may be one to three larvae per citrus fruit. Larvae bore into the albedo and usually feed just below the fruit surface. Young larvae can be found by checking fruits for entrance holes with or without frass and/or because the surface surrounding the hole of infestation turns yellowish-brown. Mature larvae can be found by cutting fruits showing symptoms. Larvae pupate away from their feeding substrate and can be found in the leaf litter underneath host plants, in fallen fruit, attached to bark or any manmade structure or surface in greenhouses, storing facilities and packing stations (EPPO, 2019) (Figure 1).

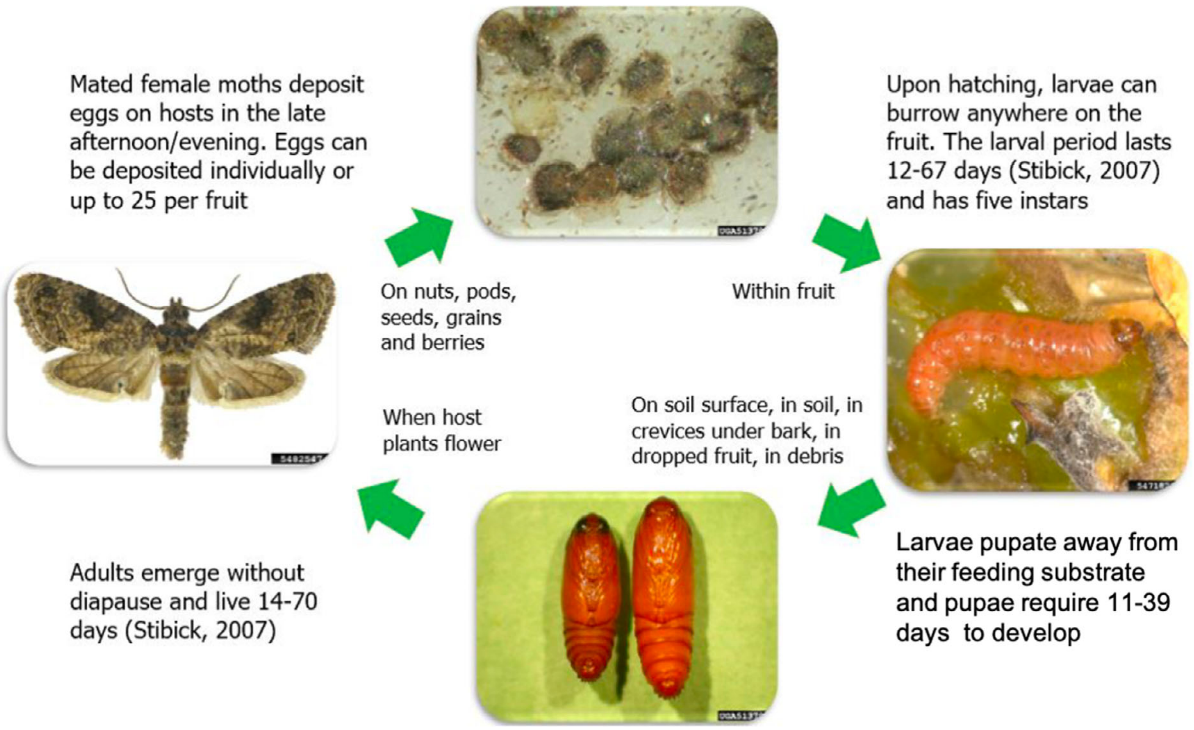

Figure 1: Life cycle of *Thaumatotibia leucotreta* (Sources: (top) JH Hofmeyr, Citrus Research International, Bugwood.org; (right) Marja van der Straten, NVWA Plant Protection Service, Bugwood.org; (bottom) JH Hofmeyr, Citrus Research International, Bugwood.org; (left) Todd M Gilligan and Marc E Epstein, Tort AI: Tortricids of Agricultural Importance, USDA APHIS PPQ, Bugwood.org)

3.2. Host plants

T. leucotreta is a polyphagous species with a wide range of host plants. The species is currently known from 105 genera of plants in 51 families encompassing more than 130 different plant species (EPPO 2013, EFSA, 2019). The host range includes both cultivated and wild species (de Jager, 2013; de Prins and de Prins, 2019; Gilligan et al., 2011).

In Africa, false codling moth is a serious pest of crops of major economic importance such as avocado, cacao, coffee, citrus, cotton, guava, maize, mango and peach (de Prins and de Prins, 2019).

3.3. Possibility of spread

In agricultural habitats, such as citrus orchards, adults are mostly confined to the habitat of origin or nearby when occurring outside these habitats. Females will fly a short distance only to reach another host plant for mating and egg laying, and as a result dispersal is limited (Newton et al., 1998). However, individuals occurring in urban environment may disperse over medium to long distances to locate host plants (Timm, 2005). EFSA estimated the spread rate of *T. leucotreta* with a median of 1.4 km per year, with a 99% percentile of 8.5 km per year (EFSA, 2019).

During mating flights at night, males can respond to females more than one kilometre away (Omer-Cooper, 1939 in Schwartz, 1981; Stotter and Terblanche, 2009).

4. General aspects of citrus production in the Mediterranean Basin

The genus Citrus, comprising some of the most widely cultivated fruit crops worldwide, includes a large number of species and numerous commercial varieties and rootstocks that allow to grow citrus under different conditions. Sweet orange, mandarin, satsuma and grapefruit varieties flower in spring and fruit grows during summer and matures (change colour) between fall and winter. The flowering period lasts 2–4 weeks, and it occurs between March and April.

Fruit growth can be divided in cell division (late spring to early summer) and cell expansion (mid-summer to early autumn). During cell division, citrus trees have a self-regulatory mechanism whereby they shed part of their fruit load (Gómez-Cadenas et al., 2000; Agustí, 2020). Fruit shedding ensures that fruits in excess under prevailing environmental conditions are not retained by the tree (Bangerth, 2000). For example, fruit drop can be exacerbated by low potassium levels when citrus trees are bearing high crop loads. Some pests can also induce fruit fall (Planes et al., 2014; Cass et al., 2020).

Fruit maturation is highly variable among citrus varieties. Citrus fruits can be harvested from the end of August to the beginning of September (i.e. Iwasaki atsuma or Clemenrubí mandarin) to June of the following year (i.e. Valencia Late or Lavalle sweet oranges) (Figure 2). Therefore, citrus fruit is vulnerable to *T. leucotreta* attack all year long. In general, mandarins are harvested from September to December (i.e. Clemenues, Oroval etc.) and hybrid mandarins from January to mid-May (i.e. Orri, Murcott, Fortune etc.). Sweet oranges (i.e. blood oranges) are divided in three large groups: navel (mature from October to May), Sanguinas (January–March) and white oranges (March–June). Grapefruits mature from mid-October to end of March and can remain in the tree for long periods. Finally, it is worth to mention that fruit maturation can be also affected by rootstock, which can advance or delay it up to several weeks (Bowman and Joubert, 2020).

Contrary to other varieties, lemons can have up to three flowering periods under Mediterranean conditions. The most important flowering period for lemons occurs in spring, the second in summer and sometimes a third in autumn. It can be harvested from October to July depending on the variety and flowering period (Figure 2).

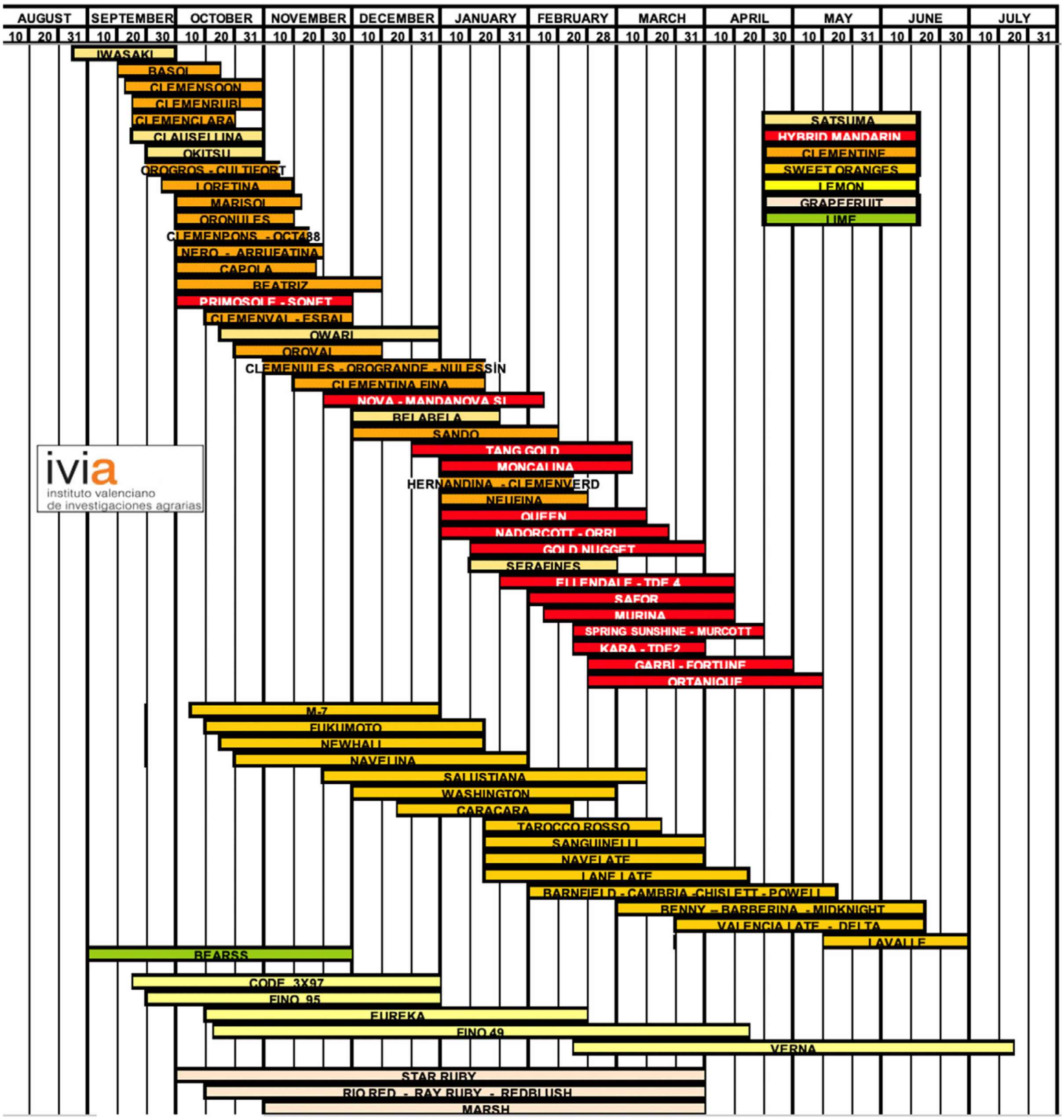

Figure 2: Comparison of harvesting periods of different citrus species and varieties in the Mediterranean basin, starting in August until July of the following year (source: Pardo and Buj, 2020)

5. Overview of available measures

A systems approach consists of a set of risk mitigating measures targeted to control a specific pest. In this section, a review of the available risk mitigating measures for *T. leucotreta*, including monitoring, inspection and control techniques is given largely based on the reviews by Moore (2019, CRI guidelines) and Hattingh et al. (2020) and references therein. For each risk mitigation measure, the factors affecting its efficacy were evaluated.

5.1. General phytosanitary procedures

The NPPO of the exporting country is responsible for the design and implementation of systems approach according to ISPM 14. This includes the official registration of producers and packing stations involved in the export of citrus. At several points of the production chain, inspection should take place to check compliance with the systems approach.

Efficacy factors: A systems approach protocol should be available, including inspections and/or sampling points in the production, packaging and shipping chain.

5.2. Monitoring with pheromone traps

Pheromone-based trapping systems have been developed to provide means to monitor insect species presence in an area or to assess local population activity and density. Traps contain dispensers loaded with species-specific synthetic components of the female pheromone, which attracts male moths to the trap. The monitoring data of male moth trap captures can provide information on female moth activity.

To monitor *T. leucotreta* activity levels in citrus production in South Africa, the recommendation is to use at least one monitoring trap per 4 ha. A peak in *T. leucotreta* moth activity is in general followed by a peak in *T. leucotreta* -induced fruit drop 3–5 weeks later. Research (in South Africa) indicates that when 10 or more moths are caught per trap per week, subsequent *T. leucotreta* infestation is likely to exceed one *T. leucotreta* infested fruit dropping per tree per week. This trap capture threshold has been used in South Africa as a guideline to trigger control measures targeted against *T. leucotreta* (Hattingh et al., 2020), such as entomopathogenic virus-based products targeted at neonate larvae (Moore et al., 2015) or augmentative parasitoid releases targeted at eggs.

Although moth activity is fairly well synchronised in the beginning of the season, as the season progresses generations begin to overlap with one another.

Historical data with a standard trapping protocol (trap density, monitoring schedule) in the same orchard or region can give information on expected population pressure.

Efficacy factors: Trapping efficacy is dependent on lure durability and trap placement. There are different traps and lures available in the market. It is important to appreciate that zero or low catches of a monitoring trap do not imply that the pest is absent or present at low prevalence in the orchard as a whole. The monitoring trap (e.g. one trap per four hectares) samples only a restricted area (~ 50–100 m radius) within the crop and there could be other reasons (e.g. a cold period, rain) for low trap catches other than pest density. Therefore, it is good practice to use more than one monitoring trap per plot. The relationship between moth trap captures and fruit damage at harvest is not always reliable.

5.3. Field inspection of fruits on tree

Trap monitoring data can provide information on the possible presence of the pest in the production orchard. However, confirmation of presence and prevalence of the pest can be done with inspection of fruits on the tree. Citrus fruit are susceptible to *T. leucotreta* infestation from the early pea-sized fruit to the mature fruits at harvest (this period in some varieties can last more than 1 year). Female moths lay their eggs directly on fruit and often near the stylar end. The newly hatched larvae immediately try to find a suitable spot to penetrate the fruit. Eggs and fresh larval penetration holes in fruit can only be found with the aid of thorough inspection. The penetration hole becomes easier to detect after a few days due to decay of damaged tissue and changes in the colour of the peel. The mature larva enlarges the original hole sufficiently to leave the fruit and pupate. An infested fruit usually falls from the tree 3–5 weeks after penetration by a larva. The mature larva leaves the fruit about a month later and pupates just under the soil surface.

Efficacy factors: A protocol should be defined for the sampling design and intensity and inspection method. Some early-infested fruit may remain undetected.

5.4. Field inspection of dropped fruits

A citrus fruit colonised by a *T. leucotreta* larva usually drops from the tree 3–5 weeks after infestation. Monitoring the level of *T. leucotreta* infestation of dropped fruit is an important information source to estimate pest pressure in the orchard. Monitoring infestation levels of dropped fruit has been used in insecticide efficacy trials in South Africa (Moore et al., 2015). In this case dropped fruit from specific reference trees were collected and carefully dissected for any signs of *T. leucotreta* larval infestation. Infested fruit were identified either by the presence of a *T. leucotreta* larva or its tunnelling and frass.

Efficacy factors: A protocol should be defined for the sampling design and intensity and inspection method.

5.5. Examination of harvested fruit

Citrus fruits are generally harvested by hand therefore, every individual fruit can be examined for quality and fruits with clear symptoms of (cosmetic) damage are not harvested or discarded. However, this process is carried out by field workers that are not trained at detecting potentially infested fruit.

Efficacy factors: Some *T. leucotreta* infested citrus fruits will be sorted out during the harvest procedure. However, early stages of *T. leucotreta* infestation may remain undetected.

5.6. Official inspection at entry of packing station

Before a packing house accepts a citrus consignment for the sorting, grading and packaging procedures, an inspection is usually carried out for the presence of pests. The inspection protocol used by the packing house staff (or NPPO inspector) determines the sampling design and intensity as well as the inspection method. Early infested fruit may remain undetected with visual inspections and destructive sampling may be required.

Efficacy factors: The sampling protocol determines the inspection efficacy in detecting infesting fruits. Early infested fruit may remain undetected. Inspection protocols should follow ISPM 31.

5.7. Examination of fruit during packaging process

In the packaging process, non-marketable fruit will be sorted out by packing house staff, and in general, this procedure is not specifically targeted to pests. However, citrus fruit with clear visible signs of damage will be sorted out and packing house staff can be specifically trained to recognise *T. leucotreta* symptoms.

Efficacy factors: Packing house staff may need training to recognise *T. leucotreta* symptoms. Early stages of *T. leucotreta* may remain undetected without destructive sampling.

5.8. Official inspection of fruit prior to export

A pre-export inspection is carried out to ensure that the consignment meets specified phytosanitary requirements of the importing country at the time of inspection. Typical damage symptoms on fruits of citrus may be detected by visual inspection of the consignment. However, as *T. leucotreta* is an internal feeder, these symptoms are not always easy to detect, particularly if infestation takes place close to the time of harvest.

Efficacy factors: The inspection protocol should be based on ISPM 31 defining sampling design, intensity and inspection method. Early stages of *T. leucotreta* may remain undetected.

5.9. Orchard sanitation

T. leucotreta larvae remain in dropped fruit from citrus trees. Late instar larvae will leave the fruit and pupate in the soil. The population of pupae in the soil forms the basis of the next generation of *T. leucotreta* in the orchard. Interruption of this population cycle by picking, removing and destructing of all fallen fruit on at least a weekly basis can prevent population build up in the orchard. It is estimated that 60–75% of the larvae present in dropped fruit will be removed when fallen fruits are collected weekly (Moore and Kirkman, 2009).

Efficacy factors: A sanitation protocol (either by hand or mechanical) where frequency and phytosanitary-sound disposal of waste (e.g. burying place of removed fruit) should be in place. Mechanical sanitation is difficult to be done between trees within the same row.

5.10. Sterile Insect Technique

The Sterile Insect Technique (SIT) is based on the mass production and release of sterile males that compete with the wild target population. In general, SIT is used for area wide control of high impact insect pests with a low reproductive rate (Vreysen et al., 2007).

The SIT has been developed in South Africa to control *T. leucotreta* in specified areas. In general, a ratio of 10 sterile to 1 wild male moth is recommended for successful application of SIT (Hofmeyr et al., 2016). After mating with the sterile males, wild female moths lay infertile eggs. In South Africa, the recommendation is to release 1,000 sterile adults/ha biweekly. Because the technique is based on the probability that a calling female attracts and mates with a sterile male, the efficacy is dependent on the local pest density.

Efficacy factors: SIT should be applied on an area wide basis and is only reliable in areas with low pest prevalence.

5.11. Mating disruption

Mating disruption (MD) technology uses synthetically produced sex pheromones in large amounts to confuse males and limit their ability to locate calling females. The synthetic pheromone used in the orchard is distributed by dispensers.

The mechanism and factors affecting the efficacy of mating disruption have been reviewed by Miller and Gut (2015). The release of sufficiently large quantities of synthetic sex pheromone into the crop atmosphere interferes with mate location by affecting the males' ability to respond to calling females (desensitisation) and causing the male to follow 'false pheromone trails' at the expense of finding mates (competitive disruption). By introducing many sources of the sex pheromone into the crop, the probability of the male finding the female is reduced, as is the likelihood of successful mating. As a result, mating is either delayed, with a subsequent negative affect on overall fertility or prevented.

According to Miller and Gut (2015), the competitive disruption effect is the most important mechanism. The mating disruption dispensers are in competition with the calling (i.e. pheromone releasing) females and hence the technique is density dependent and the control effect may not be achieved at high population densities. The possibility will always exist that some females will mate, and, the more females and males present, the higher will be that probability even when many competitive dispensers are deployed.

In any case, it should be noted that there is not always a strong positive correlation between trap catches and the subsequent crop damage; therefore, catches in the monitoring traps cannot be a reliable indicator of population density and assessment parameter for efficacy (Ioriatti et al., 2004; Miller and Gut, 2015; EPPO, 2019).

Two main products are available for MD of *T. leucotreta:* a sprayable encapsulated formulation (Checkmate® FCM-F) and a passive hand-applied dispenser formulation (Isomate® FCM). Both products are effective against low-density populations, with reductions of up to 95% (Moore and Hattingh, 2012). A total of 800 dispensers per ha per production season are used irrespective of the tree density with a minimum orchard size of 6 ha. To compensate for the dilution effect along the edges, a double number of dispensers are placed along the outer side of the perimeter of the treated area.

Capture of zero (complete shutdown) or very few moths in pheromone-baited traps within the crop is the most common parameter used to indicate successful disruption of the pest.

Efficacy factors: moths are not killed, and some males may be able to locate and mate with females; therefore, it is an unreliable method of control at high population densities; in case orchards are small (< 6 ha), there can be an edge effect of immigrating gravid females. When temperatures are relatively low (autumn), pheromone release may be too low to induce the disruptive effect.

5.12. Attract and Kill

The lure and kill approach is based on the mass trapping principle. However, instead of using costly cumbersome physical traps, a formulation is used that contains the attractant (e.g. sex pheromone) and an insecticidal agent. Droplet killing potential is a combination of the relative attractiveness of the pheromone component and the knockdown potential of the insecticidal component (e.g. pyrethroid). The probability that a male is killed by an attracticide spot is dependent on the number of attracticide spots and their relative attractiveness compared to a calling female. Hence, in contrast to the mating disruption technique, males are removed from the population. The use of an attracticide paste allows the necessary density of killing point sources needed to compete with the local population of calling females.

For the closely related codling moth (*Cydia pomonella*), Lösel et al. (2000) reported efficacy values in the attract and kill plots of 80–90% comparable to the efficacy values of the insecticide treatment (73–88%).

Efficacy factors: The attracticide droplet potency decreases with exposure time to ambient weather conditions (Lösel et al., 2002). The factors limiting the reliability of an attract and kill technique include the durability of pheromone and insecticide in the formulation, and the density and spacing of the formulation in relation to the local pest density effect. In case orchards are small, there can be an edge effect of immigrating gravid females.

5.13. Virus-based products

There are three virus-based products on the market against *T. leucotreta*: Cryptogran®, Cryptex® and Gratham®. All of the products are based on the naturally occurring pathogen of *T. leucotreta*, called the *Cryptophlebia leucotreta* granulovirus (CrleGV), therefore a biological control agent. Timing of application of a virus-based product is very important. The only *T. leucotreta* life-stage which can be targeted with virus is the neonate larva. Therefore, there is a very small window of opportunity for a virus application to be effective. In order to achieve this, pheromone traps must be used to monitor moth activity. Virus should be sprayed within a few days after the start of moth catches. Neonate larvae sometimes do not spend more than a few minutes on the surface of the fruit and do not move more than a few centimetres before penetrating into the fruit. During this brief period, a larva will need to encounter and ingest sufficient virus to induce mortality. Hence, spray coverage must be absolutely thorough.

Moore et al. (2015) reported efficacy levels of CrleGV against *T. leucotreta* between 30% and 92%. In this field experiment, results were comparable with and sometimes better than those achieved with chemical insecticides.

Efficacy factors: The target of a virus application is the neonate larvae before entering the fruit. Therefore, timing of application of virus and spray coverage on the fruits are very important. An homogenous spray coverage is difficult to achieve on citrus trees. The risk of development of resistance by *T. leucotreta* to CrleGV has been reported (Moore et al., 2015).

5.14. Other biological control techniques

For biological control of *T. leucotreta* mass production and augmentative release of the egg parasitoid *Trichogrammatoidea cryptophlebiae* Nagaraja (Hymenoptera: Trichogrammatidae) has been developed in South Africa (Moore and Richards, 2001; Hofmeyr, 2003). In general, a total of 100,000 parasitoids per ha are recommended (in four monthly releases of 25,000) to achieve population control. Moore and Hattingh (2004) reported an efficacy of 60% reduction in *T. leucotreta* infestation with *T. cryptophlebiae*. Other natural enemies include parasitoid species that have been reported to parasitise larvae of *T. leucotreta* (Prinsloo, 1984) and generalist predators (e.g. *Orius* bugs and ants) that have been found to prey on *T. leucotreta* (Moore, 2017).

Entomopathogenic nematodes (*Heterorhabditis bacteriophora*) and fungi (*Beauveria bassiana, Metarhizium anisopliae*) have been tested targeting pupae in the soil, with variable efficacy (Moore et al., 2013; Coombes et al., 2016).

Bacillus thuringiensis (Bt) is used for control of Lepidoptera. The efficacy of their formulations is considered as poor because larvae enter into fruits very soon after hatching (Kirkman, 2007). However, if targeted properly against neonate larvae on the fruit a Bt application could be effective.

Efficacy factors: Entomopathogenic nematodes and fungi are affected by soil properties such as moisture, temperature, soil type and aeration (Love, 2015). The target of Bt is the neonate larvae before entering the fruit. Therefore, timing and spray coverage of the fruits are important. Insecticide treatments can disrupt the control efficacy of parasitoids and predators.

5.15. Insecticide treatments

The effectiveness of chemical control on the destructive larval stage of *T. leucotreta* is limited due to the protection that the larva gains by living within the fruit of the attacked host. Most of the insecticides used are targeted at adults, eggs and neonate larvae. There are several active substances available for control of *T. leucotreta*. In South Africa, various active substances are used to control *T. leucotreta* in citrus orchards; the chitin synthesis inhibitors triflumuron (Alsystin®) and teflubenzuron (Nomolt®), the anthranilic diamide chlorantraniliprole (Coragen®) and the carbohydrazide methoxyfenozide (Runner® and Walker®) are all effective against *T. leucotreta* eggs and larvae (Newton, 1989; Moore, 2017). Moreover, the pyrethroid cypermethrin has a larvicidal effect on *T. leucotreta*, whereas spinetoram (Delegate®) of spinosyn group is active across multiple insect growth stages.

The influence of cypermethrin, deltamethrin, fenpropathrin, fenvalerate, flucythrinate and permethrin on various developmental stages of *T. leucotreta* was investigated on citrus in the laboratory and field in South Africa (Hofmeyr, 1983). These synthetic pyrethroids were found to have detrimental effects on *T. leucotreta*, including an inhibitory effect on egg-laying and direct and residual action against eggs. Fruit damage by larvae was prevented for several months following a single application of a suitable pyrethroid. A single spray application of 0.00125% cypermethrin or 0.005% deltamethrin 2–3 months before harvest reduced fruit drop in Navel sweet oranges (caused by *T. leucotreta*) in South Africa by an average of 90%.

In Ghana, the binary insecticides acetamiprid 16 g L−1 + indoxacarb 30 g L−1 (Viper®) and lambda cyhalothrin 15 g L−1 + acetamiprid 20 g L−1 EC (Protocol®) gave a 100% protection to the chilli fruits against *T. leucotreta*, while dimethoate (400 g L−1) + cypermethrin (36 g L−1) (Cydim Super®) and maltodextrin (Eradicoat T GH®) offered 71.2 and 85.8% protection, respectively (Adom et al., 2020).

T. leucotreta has developed resistance to some insecticides in South Africa, principally chitin synthesis inhibitors (i.e. triflumuron) (Hofmeyr and Pringle, 1998). Though the rational use of insecticides by alternating different modes of action will minimise the possibility of pest resistance (Fening et al., 2016), the maximum residue limits established by some foreign markets and the steady demand for high-quality fruit has recently translated into a need for the adoption of new, efficient and effective integrated pest management (IPM) strategies (Malan et al., 2018).

Efficacy factors: The use of pyrethroids and/or neonicotinoids in some crops such as citrus or pepper can result in serious disruptions of the IPM programmes currently in place. Because of their negative impact on beneficial insects, pyrethroids and neonicotinoids are not recommended, in order to avoid high infestations caused by other pests. Treatments with pyrethroids caused an increase in populations of *Panonychus citri* (McGregor) (Acari: Prostigmata) in South Africa (Hofmeyr, 1983). *T. leucotreta* can develop resistance against some active substances hampering the efficacy of chemical control.

5.16. Stand alone: cold treatment

T. leucotreta is cold sensitive and mortality occurs at temperatures below zero. Post-harvest cold treatment of citrus fruit is suggested as a standalone measure based on the authorised cold treatment protocols for citrus fruit imported into the US (EPPO, 2013). A cold treatment is the process in which a commodity is cooled until it reaches a specified temperature for a minimum period of time according to an official technical specification in order to eliminate all life stages of the targeted pest in the commodity. Moore et al. (2016a,b) evaluated the probit 9 level efficacy of near-zero temperature exposure of fourth and fifth instar *T. leucotreta,* which are the most tolerant instars to cold treatment, for 16, 18 and 20 days. All treatments were shown to cause mortality at or in excess of the probit 9 level (99.9968% efficacy at the 95% confidence level).

A draft annex to ISPM 28 for two cold treatment schedules for *T. leucotreta* in *Citrus sinensis* is currently under review by the IPPC.

Efficacy factors: Not all citrus varieties are cold tolerant. A cold treatment should be applied in accordance with the requirements of ISPM 42 (Requirements for the use of temperature treatments as phytosanitary measures).

5.17. Stand alone: pest free area

A pest-free area (PFA) is defined according to ISPM 4 as an area in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained. To verify the pest-free status of an area pheromone trap monitoring data can be used with additional checks of the presence of the pest in harvested produce of host plants.

Efficacy factors: A surveillance protocol should be provided defining the sampling design and efforts in place.

6. The commodity

6.1. Description

In Israel, citrus are grown for commercial purpose since mid of the 19th Century. Nowadays the citrus industry consists of ca. 18,500 hectares. Citrus production in Israel in the last decade is estimated at 500,000 tons per year.

Several species varieties of citrus are grown in Israel. These include:

- Sweet orange varieties (*C. sinensis*): Washington Navel, Powell Navel, Newhall Navel, Lane Late, Navel Late, Shamouti, Valencia Late and Cara-Cara.

- Grapefruit varieties (*C. paradisi*): Marsh seedless, Star – Ruby, Rio – Red, Sweetie.
- Easy peelers varieties (*C. reticulata*): Satsuma, Michal, Meirav, Nova, Mineolla, Ortanique, Temple, Murcott, Mor, Hadas, Orah, Odem, Orri, Tami.
- Others: Lemons (*C. lemon*), Limes (*C. aurantiifolia*), Kumquat (*Fortunella japonica*), Limequat (hybrid), White and red Pomelo (*C. maxima*).

Table 2: Overview of the citrus industry (for local market, processing and export) in Israel (in tons per year) as specified in the Dossier

	Sweet oranges	Grapefruit	Easy peelers	Lemons	Others	Total
Local market	46,000	8,000	68,000	60,000	6,000	188,000
Processing	30,000	80,000	54,500	4,000	–	168,500
Export	4,600	60,600	119,650	2,500	1,650	189,000
Total	80,600	148,600	242,150	66,500	7,650	545,500

The two main products of citrus industry in Israel are:

1) Israeli mandarin variety Orri, 160,000 tons produced in 2016/17, including 105,000 tons that were exported (~ 65%).
2) Rio-Red grapefruit, 65,000 tons produced in 2016/17, including 42,500 tons that were exported (~ 65%).

Israel citrus exports – destinations & quantities (as reported in the dossier) are presented in Figure 3.

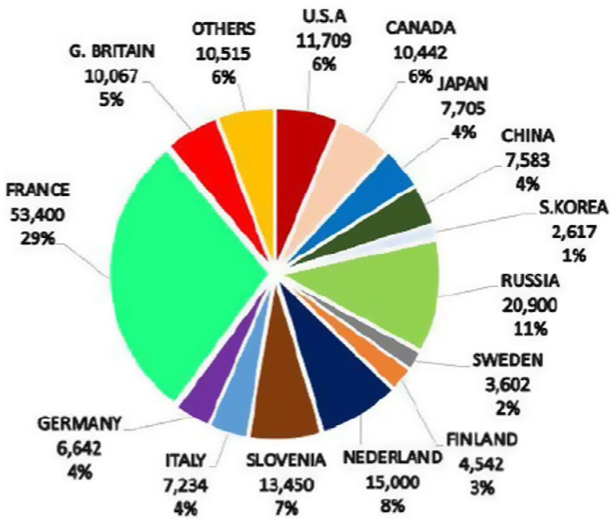

Figure 3: Percentage of citrus export volumes from Israel

The harvesting periods in different export citrus cultivars in Israel are presented in Table 3.

Table 3: Harvesting period in Israel for different export citrus varieties

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May
White and red grapefruit	■	■	■	■	■	■	■	■	■
Orri (easy peeler)				■	■	■	■	■	
Nova (easy peeler)				■	■				
Sweetie	■	■	■	■	■	■			
Red pomelo	■	■							
White pomelo				■	■				
Shamouti (orange)				■	■	■	■	■	

6.2. Data on exports to the EU

The EU is the main export market for Israeli citrus. In 2018, 7,086,309 boxes of citrus were exported to the EU with a significant rise to 9,713,309 exported boxes in 2019 (Dossier Section 1). According to Eurostat, the import volumes for citrus from Israel range from ca. 858,527 to (Table 4).

Table 4: EU Import volumes (in tons) of citrus from Israel (source: Eurostat)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Volume (tons)	11,3705.9	8,5852.7	10,6539.2	93,667	95,258.8	100,844.5	91,033.9	10,7639.7	91,939.7	88,710

6.3. Production areas

Citrus production in Israel is spread throughout the country, although the main production areas are placed in the Northern part and also near the coast. Citrus destined for the export to the EU falls within two types of production schemes i.e. plots under a systems approach, where the pest is present and plots in pest free areas. The average plot size in Israel is 1.2 ha (0.5–30 ha). There are ca. 15,000 production citrus plots in Israel, about half of them, i.e. 7,720, are for export; 1,200 plots are in *T. leucotreta* pest-free area, and 6,500 plots under the systems approach. The systems approach is considered in detail in this opinion in point 6.

The official pest-free area for *T. leucotreta* in Israel (which is not assessed in this opinion) is monitored for the presence of the pest and the boundaries of the PFA are adjusted by an official committee established by the NPPO and other stakeholders according to the results in the monitoring.

6.4. Overview of interceptions

Table 5 presents the list of interceptions found in EUROPHYT/TRACES-NT of citrus fruits infested with *T. leucotreta*. Since 2017, almost all the interceptions are in *Citrus reticulata* (synonym of *C. tangerina*).

Table 5: List of interceptions found in EUROPHYT/TRACES-NT (online) of citrus fruits from Israel with *T. leucotreta,* from 1995 until 2020 (Accessed on 6 October 2020)

Year	Month	Citrus species	Interception country
2016	January	*Citrus tangerina*	FRANCE
	January	*Citrus tangerina*	FRANCE
	March	*Citrus tangerina*	FRANCE
2017	January	*Citrus reticulata*	FRANCE
	January	*Citrus tangerina*	FINLAND
	April	*Citrus reticulata*	FRANCE
2018	February	*Citrus reticulata*	FRANCE
	April	*Citrus reticulata*	FRANCE
2019	February	*Citrus reticulata*	FRANCE
	February	*Citrus reticulata*	FRANCE
	February	*Citrus reticulata*	CYPRUS
	March	*Citrus reticulata*	FRANCE
	March	*Citrus reticulata*	FRANCE
	April	*Citrus reticulata*	FRANCE
	April	*Citrus reticulata*	FRANCE
2020	January	*Citrus reticulata*	FRANCE

7. The systems approach described by the PPIS of Israel

Since January 2018, the export of citrus from areas infested with *T. leucotreta* to the EU is under a systems approach. The systems approach consists of various inspection points within the production area, the packinghouse and before shipment. In addition, PPIS carry out specific audits on packinghouses to ensure that they follow the requirements of the systems approach.

Each grower registered to export under a systems approach is obliged to work complying with Standard Operating Procedures (SOPs) approved by the PPIS. The SOP is a list of step-by-step instructions which details all the requirements and processes that should be implemented in the orchard during the entire season and comprise the integrated measures for pest risk management.

The systems approach as described in the dossier and the provided SOPs (sections 1 and 2 of the dossier) in Israel involves three defined areas: (1) Registration of places of production and packinghouses. This means that all places of production (orchards per grower) and packinghouses should be approved and registered by the PPIS before the beginning of every season, for participation in the exportation season of citrus fruit to the EU; (2) PPIS official export inspections; (3) Defined responsibilities in the production scheme, supervised and coordinated by the PPIS. Details can be found in Annex 2.

8. Evaluation of risk mitigation measures included in the systems approach

All the different risk mitigation measures applied during the production and handling of citrus fruits in Israel were identified and evaluated. The information used in the evaluation of the effectiveness of the risk mitigation measures under a systems approach is summarised in a pest data sheet (Tables 6–7).

Table 6: Mitigation measures in the field, uncertainties, limitations and suggestions for improvement for *T. leucotreta* under a systems approach in Israel

No.	Measure	Described measures by Israel	Uncertainties	Evaluation	Limitations and suggestions for improvement
1	Registration of export orchards	Official registration and survey results of export orchards in online GIS referenced database.		Registration procedures seem to be adequate.	No
2	Pheromone trapping for monitoring of *T. leucotreta*	A trapping density of 1 trap per 2.5 ha is established for monitoring; starting from August once every 2 weeks until November, from November once per week. Trapping data are used for timing the application of mating disruption (MD) according to a threshold of moth captures i.e. 3 consecutive weeks or > 10 moths/trap in 1 week.		Trap density is adequate to monitor flight activity (1 trap per 2.5 ha) but depending on the size the orchards at least two traps should be used. Monitoring data of plots is a weak indicator for fruit infestation.	In small orchards (< 2.5 ha.) only trapping data from one trap are used. At least two traps should be used for monitoring in small orchards.
3	Field inspection of infested fruits on trees (egg/larvae) and dropped fruit	A field scout should visit a plot for 20 min independently of orchard size (starting from August once every 2 weeks until November, from November once per week) and inspects suspicious fruits on the tree and fallen fruits. For 50% of the plots, the data are downloaded in an Excel file and examined by PPIS. Threshold: if more than three fruits are infested, orchard is suspended for 5 weeks	No detailed data. The number of fruits inspected during the 20-min inspections by the field scouts is uncertain.	Sampling effort cannot be deduced from the information provided. Infestation level of fallen fruit is a good indicator of pest pressure in the orchard. Sampling strategy in the inspection protocol could be improved by considering orchard size, potential spatial distribution of the pest, historical data and/or the use of reference trees for monitoring.	20 min may be a rather limited period for the inspection of trees and ground in large orchards. There is no specific sampling protocol for fallen fruits. Monitoring intensity is irrespective of orchard size. For estimating pest prevalence, standard reference trees can be used within a plot for monitoring fruit infestation on dropped fruits. The number of reference trees should be calculated according to plot size.

No.	Measure	Described measures by Israel	Uncertainties	Evaluation	Limitations and suggestions for improvement
4	Orchard sanitation	Fallen fruits are assembled in the middle of the alleyway and mechanically destroyed (crushed) No fruits left on the trees after harvest. Wild host plants (e.g. castor bean) are removed. 50% of the orchards are checked for the sanitation procedure.	Frequency (e.g. weekly, monthly etc.) of sanitation (destruction of fallen fruit) unclear. No data on the efficacy of the crushing procedure in the field.	Removal/destruction of dropped fruit is very important to disrupt the population build-up in the orchard if applied frequently. Post-harvest destruction of remaining fruits on the tree is an important factor and is considered in the dossier. Fruit waste after mechanical destruction is not removed from the orchard and surviving larvae may develop.	There is uncertainty about the frequency of sanitation; if fruit destruction is not performed completely and with an adequate frequency it may not disrupt the population build-up in the orchard. An efficient sanitation protocol with a defined frequency of application should be put in place. Experimental evidence demonstrating the efficacy of mechanical destruction of fruits against *T. leucotreta* should be provided.
5	Mating Disruption (MD)	Products registered for MD of *T. leucotreta* are available. 50% of farmers declare applying mating disruption as a prophylactic measure, other farmers to operate under the action threshold of 3 moths captured in 3 consecutive weeks or > 10 moths/trap in 1 week. Traps are used to check if MD is working (i.e. no male moth catches), then confirmed by fruit inspections (see measure no. 3 in this table). A curative biological control treatment (Virus, Bt) may be applied when moths are caught in MD field. MD may be continued afterwards.	Variation in population density across different production areas and orchards in Israel is uncertain. No data on the reliability of the action threshold. It is uncertain how orchard size is considered in the application of MD.	Efficacy of MD depends on the initial population density of *T. leucotreta*, the size of the orchard and the history of application on the same plot. Trapping data can be unreliable to evaluate the efficacy of MD.	With the defined action threshold currently used (i.e. three captured moths or more), mating disruption is not applied in low population densities. Low *T. leucotreta* prevalence (less than three captures) can lead to pest uncontrolled infestations. Prophylactic application of MD in all production plots is more reliable than the application of the current threshold. Size of non-isolated orchard may be too small (< 6 ha) for reliable MD due to pheromone dispersal and edge effect of immigrating gravid females

No.	Measure	Described measures by Israel	Uncertainties	Evaluation	Limitations and suggestions for improvement
6	Biological control (BC)- Virus	As a curative measure triggered by finding of eggs/larva on or in a fruit	No information on the protocol used was provided	Virus application can be highly effective; however, the timing of application is crucial (targeted at hatched neonate larvae).	Details on a well-defined protocol on the application of virus were not provided. It is advised to establish a well-defined protocol targeting hatched neonate larvae (e.g. inspection for egg presence and egg development).
7	Biological control-Bt	As a curative measure (no details provided), triggered by finding of eggs/larva on or in a fruit	The efficacy of a Bt treatment against *T. leucotreta* is uncertain (no data in literature)	The efficacy of a Bt treatment against *T. leucotreta* is not known, but it would probably need very frequent applications for achieving substantial efficacy against *T. leucotreta*.	The efficacy of a Bt treatment against young larvae of *T. leucotreta* is uncertain (no data in literature).
8	Insecticides	Not frequently applied, application ad hoc with advice from extension services	No information	No information	No information

Table 7: Mitigation measures in the packing house, uncertainties, limitations and suggestions for improvement for *T. leucotreta* under a systems approach in Israel

No.	Measure	Described measures by Israel	Uncertainties	Evaluation	Limitations and suggestions for improvement
1	Examination of harvested fruit	Fruits with visible damage are discarded for export during harvest	No detailed data about number of fruits that are discarded and infestation level of *T. leucotreta* in discarded fruit. Training level of people involved in harvest to detect infestations of *T. leucotreta* is uncertain.	Harvest as a process happens in a fast way and not meticulously done for observing infested fruits. Fruits with early infestation will not be detected.	
2	Protected transport to packing house	Harvested fruits are transported in tarpaulin covered trucks			
3	Inspection at entry of packing station (Step A)	100–300 fruits (25 fruits × 4 containers × stage) should be inspected in a 3-stage approach (depending on findings) by qualified packing house staff. Stage 1.: For the 1st 100 fruits, if 0 infested fruits are found, the set is approved. If one infested fruit is found, then it goes to Stage 2. If 2 or more infested fruits are found, then the set is disqualified for export. Stage 2.: Sampling additionally 100 fruits. If 0 infested fruits are found, the set is approved. If 1 infested fruit is found, it goes to Stage 3. If 2 infested fruits or more are found, then the set is disqualified for export. Stage 3.: Sampling additionally 100 fruits. If 0 infested fruits are found, the set is approved. If 1 infested fruit or more are found then the set is disqualified for export.	Sampling intensity is not clear in this step (number of containers per plot can vary).	The logic of the three-stage approach is not clear. Fruits are visually inspected without destructive sampling; therefore, recent infestations can be easily overlooked. Given that there are orchards with different sizes and production volumes, it is unclear how this is considered in the sampling intensity (under this three-step approach).	Sampling intensity does not seem to be related to the volume of harvest. 300 fruits should be sampled in the first step instead of sequentially (i.e. 3 × 100) as it is currently done to provide a confidence level of 95% to detect 1% infestation level (see ISPM 31 and EPPO 2020). Fruits with early infestation (e.g. young larvae) will only be detected with destructive sampling. In EPPO (2020), it is suggested that a minimum of 30 fruits (out of 300 visually inspected) are destructively examined to provide a 95% confidence level of detecting the pest at a 10% infestation level (assuming a perfect detection level during the inspection).

No.	Measure	Described measures by Israel	Uncertainties	Evaluation	Limitations and suggestions for improvement
4	Examination of fruit during packaging process (Step B)	During packaging process, 10 fruits per plastic container (1,000–2,000 fruits) for all the containers in the set are inspected (i.e. 0.5–1% of fruits are visually examined during packing process).	No detailed data about number of fruits that are discarded and infestation level of *T. leucotreta* in discarded fruit. Training level of people involved in packaging procedure to detect infestations of *T. leucotreta* is uncertain	Sampling intensity at this stage is very low and will only detect high infestation levels. Fruits with early stages of infestation will not be detected.	Fruits with early infestation (e.g. young larvae) will only be detected with destructive sampling. Further sampling at this stage may not be required if the suggested sampling procedure is followed at entry of packing station (see recommendation in row 3 of this table).
5	Examination of fruit after packaging (Step C)	After packaging, one box per pallet is inspected and marked (by packinghouse staff)	Training level of people involved in packaging procedure to detect infestations of *T. leucotreta* is uncertain	Fruits with early stages of infestation will not be detected.	Fruits with early infestation (e.g. young larvae) will only be detected with destructive sampling. Further sampling at this stage may not be required if the suggested sampling procedure is followed at entry of packing station (see recommendation in row 3 of this table).
6	Official inspection of fruit boxes prior to export	2% of the boxes in an export consignment are officially inspected visually by NPPO.	Fruits are visually inspected by PPIS staff	Fruits are visually inspected without destructive sampling; therefore, recent infestations can be overlooked.	300 fruits should be sampled to provide a confidence level of 95% to detect 1% infestation level. Furthermore, 30 fruits (out of 300 visually inspected) should be destructively examined to provide a 95% confidence level of detecting the pest at a 10% infestation level (see ISPM 31 and EPPO, 2020).

9. Outcome of Expert Knowledge Elicitation

Table 8 and Figure 4 show the outcome of the EKE regarding pest freedom after the evaluation of the currently systems approach for *T. leucotreta* on citrus in Israel.

Figure 5 provides an explanation of the descending distribution function describing the likelihood of pest freedom after the evaluation of the systems approach for citrus fruits designated for export to the EU from Israel for *T. leucotreta.*

Table 8: Assessment of the likelihood of pest freedom following evaluation of current risk mitigation measures against *T. leucotreta* on citrus from Israel designated for export to the EU. In panel A, the median value for the assessed level of pest freedom for each pest is indicated by 'M', the 5% percentile is indicated by L and the 95% percentile is indicated by U. The percentiles together span the 90% uncertainty range regarding pest freedom. The pest freedom categories are defined in panel B of the table

Panel A

Number	Group	Pest species	Sometimes pest free	More often than not pest free	Frequently pest free	Very frequently pest free	Extremely frequently pest free	Pest free with some exceptional cases	Pest free with few exceptional cases	Almost pest free
1		T. leucotreta				L	M	U		

Panel B

	Pest freedom category	Pest-free fruits out of 10,000	Legend of pest freedom categories	
	Sometimes pest free	≤ 5,000	L	Pest freedom category includes the elicited lower bound of the 90% uncertainty range
	More often than not pest free	5,000–≤ 9,000	M	Pest freedom category includes the elicited mean
	Frequently pest free	9,000–≤ 9,500	U	Pest freedom category includes the elicited upper bound of the 90% uncertainty range
	Very frequently pest free	9,500–≤ 9,900		
	Extremely frequently pest free	9,900–≤ 9,950		
	Pest free with some exceptional cases	9,950–≤ 9,990		
	Pest free with few exceptional cases	9,990–≤ 9,995		
	Almost always pest free	9,995–≤ 10,000		

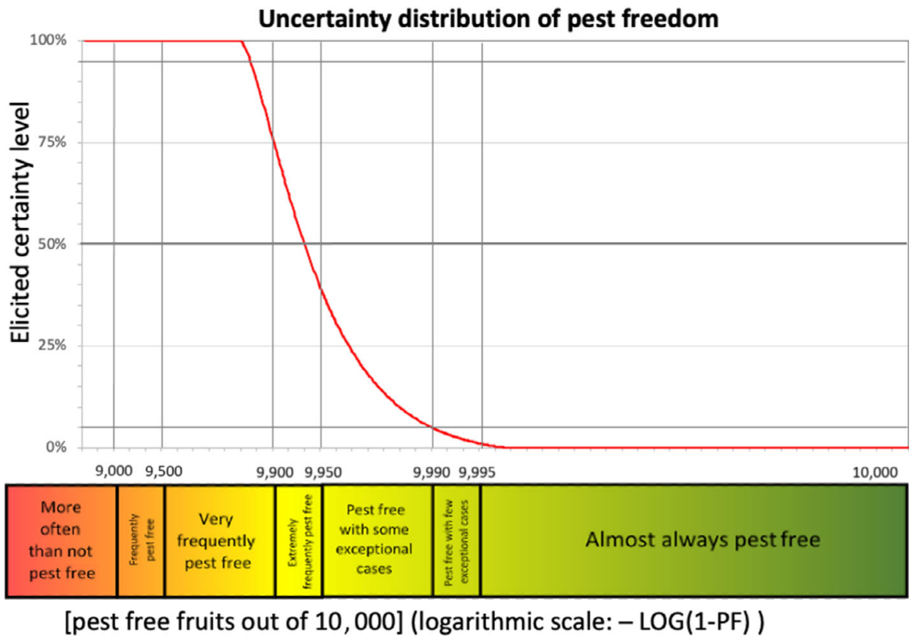

Figure 4: Explanation of the descending distribution function describing the likelihood of pest freedom for *Thaumatotibia leucotreta* in citrus fruits in Israel after the implementation of the described systems approach

10. Conclusions

For *T. leucotreta* on citrus fruits from Israel, an expert judgement is given on the likelihood of pest freedom following the evaluation of the risk mitigation measures, after the defined systems approach, acting on *T. leucotreta*, including any uncertainties. The Expert Knowledge Elicitation indicated, with 95% certainty that between 9,863 and 10,000 citrus fruits per 10,000 will be free from this pest.

11. Recommendations

Based on the review of the systems approach and the associated mitigation measures implemented in Israel to reduce the likelihood of infestation in citrus fruits exported to the EU, the following points may be considered to improve the systems approach:

1) In the field:
   - At least two traps should be used for monitoring in small orchards.
   - For estimating pest prevalence, standard reference trees can be used within a plot for monitoring fruit infestation on dropped fruits. The number of reference trees should be according to plot size.
   - Prophylactic application of mating disruption in all production plots is more reliable than the application of the current threshold.
   - For entomopathogenic virus application, a well-defined protocol could be established for proper timing of application (e.g. inspection for egg presence and egg development).
   - An efficient sanitation protocol with a defined frequency of application should be put in place. Sanitation and fruit destruction should be applied frequently within the production cycle. Fruit debris after mechanical destruction should be removed, unless it is empirically demonstrated that pest survival is not possible.
2) In the packing house:
   - 300 fruits should be sampled at entry to provide a confidence level of 95% to detect 1% infestation level. Furthermore, 30 fruits (out of 300 visually inspected) should be destructively examined to provide a 95% confidence level of detecting the pest at a 10% infestation level (see ISPM 31 and EPPO 2020).

3) Official inspection prior to export

   – 300 fruits should be sampled to provide a confidence level of 95% to detect 1% infestation level. Furthermore, 30 fruits (out of 300 visually inspected) should be destructively examined to provide a 95% confidence level of detecting the pest at a 10% infestation level (see ISPM 31 and EPPO, 2020).

References

Adom M, Fening KO, Billah MK, Wilson DD, Hevi W, Clottey VA and Bruce AY, 2020. Pest status, bio-ecology and management of the false codling moth, Thaumatotibia leucotreta (Meyrick)(Lepidoptera: Tortricidae) and its implication for international trade. Bulletin of Entomological Research, 1–14.

Agustí M, Mesejo C and Reig C, 2020. Citricultura 3ª ed. Editorial Paraninfo. Spain.

Bangerth F, 2000. Abscission and thinning of young fruit and their regulation by plant hormones and bioregulators. Plant Growth Regulation, 31, 43–59.

Bowman KD and Joubert J, 2020. Citrus rootstocks. The Genus Citrus. Woodhead Publishing. pp. 105–127.

CABI (Centre for Agriculture and Bioscience International), 2019. Invasive Species Compendium. Datasheet Thaumatotibia leucotreta. 17/6/20. Wallingford, UK: CAB International. Available online: https://www.cabi.org/isc/datasheet/6904 [Accessed: 21 December 2020]

Cass BN, Kahl HM, Mueller TG, Xi X, Grafton-Cardwell EE and Rosenheim JA, 2020. Profile of Fork-Tailed Bush Katydid (Orthoptera: Tettigoniidae) Feeding on Fruit of Clementine Mandarins. Journal of Economic Entomology.

Coombes CA, Hill MP, Moore SD and Dames JF, 2016. Entomopathogenic fungi as control agents of Thaumatotibia leucotreta in citrus orchards: field efficacy and persistence. BioControl, 61, 729–739.

Daiber CC, 1980. A study of the biology of the false codling moth Cryptophlebia leucotreta (Meyr.): the adult and generations during the year. Phytophylactica, 12, 187–193.

De Jager ZM, 2013. Biology and Ecology of the False Codling Moth, Thaumatotibia leucotreta (Meyrick) (MSc thesis in Agriculture (Entomology)). Stellenbosch University, Stellenbosch, South Africa.

EFSA (European Food Safety Authority), Baker R, Gilioli G, Behring C, Candiani D,Gogin A, Kaluski T, Kinkar M, Mosbach-Schulz O, Neri FM, Siligato R, Stancanelli G and Tramontini S, 2019. Scientific report on the methodology applied by EFSA to provide a quantitative assessment of pest-related criteria required to rank candidate priority pests as defined by Regulation (EU) 2016/2031. EFSA Journal 2019;17(6):5731, 61 pp. https://doi.org/10.2903/j.efsa.2019.5731

EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Grégoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van Der Werf W, West J, Winter S, Hart A, Schans J, Schrader G, Suffert M, Kertész V, Kozelska S, Mannino MR, Mosbach-Schulz O, Pautasso M, Stancanelli G, Tramontini S, Vos S and Gilioli G, 2018. Guidance on quantitative pest risk assessment. EFSA Journal 2018;16(8):5350, 86 pp. https://doi.org/10.2903/j.efsa.2018.5350

EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Dehnen-Schmutz K, Di Serio F, Gonthier P, Jacques M-A, Jaques Miret JA, Fejer Justesen A, MacLeod A, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Reignault PL, Thulke H-H, Van der Werf W, Vicent Civera A, Yuen J, Zappala L, Jeger MJ, Gardi C, Mosbach-Schulz O, Preti S, Rosace MC, Stancanelli G and Potting R, 2019. Guidance on commodity risk assessment for the evaluation of high risk plants dossiers. EFSA Journal 2019;17(4):5668, 16 pp. https://doi.org/10.2903/j.efsa.2019.5668

EPPO (European and Mediterranean Plant Protection Organization), 2013. Pest risk analysis for Thaumatotibia leucotreta. EPPO, Paris. Available online: http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm

EPPO (European and Mediterranean Plant Protection Organization), 2019. PM 7/137 (1) Thaumatotibia leucotreta. EPPO Bulletin, 49, 248–258. https://doi.org/10.1111/epp.12580

EPPO (European and Mediterranean Plant Protection Organization), 2020. PM 3/90 Inspection of citrus fruits consignments. Bulletin OEPP/EPPO Bulletin, 50, 383–400. ISSN 0250-8052. https://doi.org/10.1111/epp.12684

Fening KO, Billah MK and Kukiriza CN, 2016. Protocol for evaluating the efficacy of six products against the False Codling moth, Fruit flies, Thrips and Whiteflies on Chillies, Garden egg and Ridged Gourd in Ghana. GhanaVeg, Accra. 35 pp.

Gilligan TM, Epstein ME and Hoffman KM, 2011. Discovery of false codling moth, Thaumatotibia leucotreta (Meyrick), in California (Lepidoptera: Tortricidae). Proceedings of the Entomological Society of Washington, 113, 426–435.

Gómez-Cadenas A, Mehouachi J, Tadeo FR, Primo-Millo E and Talon M, 2000. Hormonal regulation of fruitlet abscission induced by carbohydrate shortage in citrus. Planta, 210, 636–643.

Hattingh V, Moore S, Kirkman W, Goddard M, Thackeray S, Peyper M and Pringle K, 2020. An Improved Systems Approach as a Phytosanitary Measure for Thaumatotibia leucotreta (Lepidoptera: Tortricidae) in Export Citrus Fruit From South Africa. Journal of Economic Entomology, 113, 700–711.

Hofmeyr JH, 1983. Valskodlingmot: vermindering van oesverliese met behulp van kunsmatige piretroides. Citrus and Sub-Tropical Fruit Journal, 600, 4–6 (In Dutch).

Hofmeyr JH, 2003. Integrated pest and disease management. Integrated Production Guidelines for Export Citrus. Vol III. Citrus Research International, Nelspruit. pp. 95–101.

Hofmeyr JH and Pringle KL, 1998. Resistance of false codling moth, Cryptophlebia leucotreta (Meyrick) (Lepidoptera: Tortricidae), to the chitin synthesis inhibitor, triflumuron. African Entomology, 6, 373–375.

Hofmeyr H, Hofmeyr M and Slabbert K, 2016. Postharvest phytosanitary disinfestation of Thaumatotibia leucotreta (Lepidoptera: Tortricidae) in citrus fruit: tolerance of eggs and larvae to ionizing radiation. Florida Entomologist, 48–53.

Ioriatti C, Bagnoli B, Lucchi A and Veronelli V, 2004. Vine moths control by mating disruption in Italy: results and future prospects. Redia, 87, 117–128.

Kirkman W and Moore S, 2007. A study of alternative hosts for the false codling moth, *Thaumatotibia leucotreta* in the Eastern Cape. SA Fruit Journal, (apr/may), 33–38.

Lösel PM, Penners G, Potting RPJ, Ebbinghaus D, Elbert A and Scherkenbeck J, 2000. Laboratory and field experiments towards the development of an attract and kill strategy for the control of the codling moth, Cydia pomonella. Entomologia Experimentalis Et Applicata, 95, 39–46.

Lösel PM, Potting RPJ, Ebbinghaus D and Scherkenbeck J, 2002. Factors affecting the field performance of an attracticide against the codling moth Cydia pomonella. Pest Management Science, 58, 1029–1037.

Love CN, 2015. The biology, behaviour and survival of pupating false codling moth, Thaumatotibia leucotreta (Meyrick)(Lepidoptera: Tortricidae), a citrus pest in South Africa.

Malan AP, Von Diest JI, Moore SD and Addison P, 2018. Control options for false codling moth, Thaumatotibia leucotreta (Lepidoptera: Tortricidae), in South Africa, with emphasis on the potential use of entomopathogenic nematodes and fungi. African Entomology, 26, 14–29.

Miller JR and Gut LJ, 2015. Mating disruption for the 21st century: matching technology with mechanism. Environmental Entomology, 44, 427–453.

Mkiga AM, Mohamed SA, du Plessis H, Khamis FM and Ekesi S, 2019. Field and laboratory performance of false codling moth, Thaumatotibia leucotreta (Lepidoptera: Troticidae) on orange and selected vegetables. Insects, 10, 63.

Moore SD, 2017. Moths and butterflies: false codling moth. Citrus Research International, 3, 1–9.

Moore SD, 2019. Integrated pest and disease management, Integrated Production Guidelines Vol. 3, Chapter 3: Part 9.4: False codling moth. Available online: https://www.citrusres.com/downloads/production-guidelines/integrated-production-guidelines-vol-3/integrated-pest-and-disease

Moore SD and Richards GI, 2001. Assessment and development of the augmentation technique for FCM control with the parasitoid Trichogrammatoidea cryptophlebiae. CRI Group Annual Report. pp. 68–74.

Moore SD and Hattingh V, 2004. Augmentation of natural enemies for control of citrus pests in South Africa: a guide for growers. SA Fruit Journal (South Africa).

Moore SD and Kirkman W, 2009. Citrus orchard sanitation with emphasis on false codling moth control. South African Fruit Journal, 8, 57–60.

Moore S and Hattingh V, 2012. A review of current pre-harvest control options for false codling moth in citrus in southern Africa. South African Fruit Journal, 11, 82–85.

Moore SD, Coombes C, Manrakhan A, Kirkman W, Hill M, Ehlers RU, Daneel JH, de Waal J, Dames J and Malan A, 2013. Subterranean control of an arboreal pest: EPNs and EPFs for FCM. Insect Pathogens and Entomoparasitic Nematodes. IOBC-WPRS Bulletin, 90, 247–250.

Moore SD, Kirkman W, Richards GI and Stephen PR, 2015. The Cryptophlebia leucotreta granulovirus—10 years of commercial field use. Viruses, 7, 1284–1312.

Moore SD, Kirkman W, Albertyn S and Hattingh V, 2016a. Comparing the use of laboratory-reared and field-collected Thaumatotibia leucotreta (Lepidoptera: Tortricidae) larvae for demonstrating efficacy of postharvest cold treatments in citrus fruit. Journal of Economic Entomology, 109, 1571–1577.

Moore SD, Kirkman W, Albertyn S, Love CN, Coetzee JA and Hattingh V, 2016b. Partial cold treatment of citrus fruit for export risk mitigation for Thaumatotibia leucotreta (Lepidoptera: Tortricidae) as part of a systems approach. Journal of Economic Entomology, 109, 1578–1585.

Moore SD, Kirkman W, Stephen PR, Albertyn S, Love CN, Grout TG and Hattingh V, 2017. Development of an improved postharvest cold treatment for Thaumatotibia leucotreta (Meyrick) (Lepidoptera: Tortricidae). Postharvest Biology and Technology, 125, 188–195.

NAPPFAST (North-Carolina-State-University/Animal-and-Plant-Health-Inspection-Service Plant Pest Forecasting System), Borchert DM, Magarey RD and Fowler GA, 2003. Pest assessment: false codling moth, *Cryptophlebia leucotreta* (Meyrick), (Lepidoptera: Tortricidae).

Newton PJ, 1989. The influence of citrus fruit condition on egg laying of the false codling moth, Cryptophlebia leucotreta. Entomologia Experimentalis et Applicata, 52, 113–117.

Newton PJ, Bedford ECG, Van den Berg MA and De Villiers EA (eds.), 1998. False codling moth Cryptophlebia leucotreta (Meyrick). Citrus Pests in the Republic of South Africa, Dynamic Ad, Nelspruit. pp. 192–200.

Opoku-Debrah JK, Hill MP, Knox C and Moore SD, 2014. Comparison of the biology of geographically distinct populations of the citrus pest, Thaumatotibia leucotreta (Meyrick) (Lepidoptera: Tortricidae) South Africa. African Entomology, 22, 530–537.
Pardo J, Soler G and Buj A, 2020. CALENDARIO DE RECOLECCIÓN DE LOS CITRICOS CULTIVADOS EN ESPAÑA. IVIA, Instituto Valenciano de Investigación Agraria. Available online: http://ivia.gva.es/documents/161862582/161863536/calendarios_recoleccion-citricos.pdf/acdddf5c-4798-4ff9-b4e0-b66d88b6353a
Planes L, Catalan J, Urbaneja A and Tena A, 2014. Within-tree and temporal distribution of Pezothrips kellyanus (Thysanoptera: Thripidae) nymphs in citrus canopies and their influence on premature fruit abscission. Environmental Entomology, 43, 689–695.
de Prins J and de Prins W, 2019. Afromoths, online database of Afrotropical moth species (Lepidoptera): Thaumatotibia leucotreta (Meyrick, 1913). Available online: http://www.afromoths.net/species/show/7446 [Accessed: 21 December 2020].
Prinsloo GL, 1984. An illustrated guide to the parasitic wasps associated with citrus pests in the Republic of South Africa. Republic of South Africa, Department of Agriculture.
Schwartz A, 1981. 'n Bydrae tot die biologie en beheer van die valskodlingmot Cryptophlebia leucotreta (Meyr.) (Lepidoptera: Eucosmidae) op nawels. (Doctoral dissertation, Stellenbosch: Stellenbosch University).
Stibick J, 2007. New pest response guidelines: false codling moth Thaumatotibia leucotreta. USDA–APHIS–PPQ–Emergency and domestic programs, Riverdale, Maryland. Available online: https://www.cdfa.ca.gov/plant/fcm/pdfs/publications/Stibick_2006-FCM_NPRG.pdf [Accessed: 21 December 2020].
Stotter RL and Terblanche JS, 2009. Low-temperature tolerance of false codling moth Thaumatotibia leucotreta (Meyrick)(Lepidoptera: Tortricidae) in South Africa. Journal of Thermal Biology, 34, 320–325.
Timm AE, 2005. Morphological and molecular studies of Tortricid moths of economic importance to the South African fruit industry. PhD Thesis, University of Stellenbosch, 127 pp. Available online: https://scholar.sun.ac.za/handle/10019.1/1404 [Accessed: 15 December 2020].
TRACES-NT, online. TRAde Control and Expert System. Available online: https://webgate.ec.europa.eu/tracesnt [Accessed: 6 October 2020].
Venette RC, Davis EE, DaCosta M, Heisler H and Larson M, 2003. Mini risk assessment: false codling moth, Thaumatotibia (= Cryptophlebia) leucotreta (Meyrick)[Lepidoptera: Tortricidae]. University of Minnesota, Department of Entomology, CAPS PRA, St. Paul, MN. pp. 1–30.
Vreysen MJB, Robinson AS and Hendrichs J, 2007. Area-Wide Control of Insect Pests From Research to Field Implementation. Springer. 744 pp.
Wysoki M, 1986. New records of lepidopterous pests of macadamia in Israel. Phytoparasitica, 14.

Abbreviations

Bt	*Bacillus thuringiensis*
CrleGV	*Cryptophlebia leucotreta* granulovirus
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NPPO	National Plant Protection Organization
PFA	Pest-free area

Appendix A – Thaumatotibia leucotreta

A.1. *Thaumatotibia leucotreta*

A.1.1. Organism information

Taxonomic information	*Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) Synonyms: *Argyroploce batrachopa* *Argyroploce leucotreta* *Cryptophlebia leucotreta* *Enarmonia batrachopa* Common name: False Codling Moth (FCM)
Group	Insects
EPPO code	ARGPLE
Regulated status	*T. leucotreta* is regulated in the EU (A1 Quarantine pest (Annex II A) of Commission Implementing Regulation (EU) 2019/2072. *T. leucotreta* is regulated as priority pest in the EU by Commission Delegated Regulation (EU) 2019/1702. *T. leucotreta* is listed in EPPO A2 list and it is currently regulated in America, Turkey in A1 list. *T. leucotreta* is a quarantine pest in Israel since 2009.
Pest status in Israel	*T. leucotreta* is present in Israel.
Pest status in the EU	*T. leucotreta* is not present in the EU.
Host status on *Citrus* spp.	*T. leucotreta* is a polyphagous insect and citrus are common host plants.
PRA information	Report of a Pest Risk Analysis for *T. leucotreta* (EPPO, 2013) EFSA Pest report on priority pests (EFSA, 2019)
Host plant range	Other common hosts in Israel are pomegranate, macademia, castor bean (*Ricinus communis*), cotton, peach. Occasionally the pest is found on pepper, avocado and guava.
Interceptions (Europhyt/ Traces NT)	Since 2016 there are 15 interceptions with 7 interceptions in 2019 and one in 2020.
Surveillance information	PPIS is in charge of the coordination and follow-up of all surveillance activities in citrus production in Israel. There is an official pest-free area in Israel that is monitored with 300 pheromone traps and with field inspections on fruits. In production areas that are under a systems approach pheromones traps are used for *T. leucotreta* monitoring (1 trap/2.5 ha). Field inspections take place in citrus orchards where fruits are examined for *T. leucotreta* infestation.

A.1.2. Pest pressure in the production area

T. leucotreta is an introduced species in Israel and it has been established for at least 20 years. *T. leucotreta* has spread during the last years and therefore, the area under a systems approach has been extended accordingly. *T. leucotreta* is widespread in the area of production which is under a *systems approach*.

There is an official pest-free area that is identified and monitored with pheromone traps and field inspections. Three hundred traps are used in the pest-free area. Traps are spread across production areas and are placed in the margins or near agricultural areas and mainly in orchards in production sites.

In production areas that are under a systems approach, pheromones traps are used for *T. leucotreta* monitoring (1 trap/2.5 ha). Starting from August, traps are checked once every 2 weeks until November, from November once per week. In orchards under a systems approach, trapping results that were provided by PPIS ranges from 0 to 1 adult per trap per month. Other examples of pest pressure in the area of production are: trap captures reached 37 adults per trap per month in orchards that are not exporting; moreover, in a specific trial where mating disruption was applied, trap captures dropped from 5 to 1 after mating disruption (MD) application. In a field study from South

Africa, 0.4 moths trapped per week would result in 0.33% infested fruits during harvest (Hattingh et al., 2020).

It is likely that registered export plots are next to unregistered or private gardens where citrus trees and other potential host plants are present. The immigration of the moth from these population sources into export plots is possible.

The main varieties that are exported are easy peelers (e.g. 'Orri') which are sensitive to *T. leucotreta*.

Uncertainties:

- It is uncertain to what extent export plots are isolated from non-exporting orchards or gardens where citrus or other host plants are present

A.1.3. Evaluation of measures applied in the field and in the packing house

The main risk mitigation measures applied in the field until harvest are official inspections, monitoring, application of mating disruption, application of biological control, sanitation, removal of alternative wild host plants and inspection during harvesting.

The main risk mitigation measures applied in the packing house are inspection before processing, inspection during processing and official inspections before export.

The evaluation of the measures is summarised in Tables 6–8 (Section 8 of the Opinion) where the risk mitigation measures, uncertainties, evaluation, limiting factors and suggestions for improvement are detailed.

A.1.4. Information from interceptions

There are 15 interceptions reported in Europhyt/TRACES-NT (1995–2020) of *T. leucotreta* on citrus fruits originating from Israel.

A.1.5. Overall likelihood of pest freedom

Rating of the likelihood of pest freedom	**Extremely frequently pest free** (based on the median)				
Percentile of the distribution	5%	25%	Median	75%	95%
Proportion of pest free fruits	9,863	9,902	9,937	9,967	9,990
Proportion of infested fruits	10	33	63	98	137
Summary of the information used for the evaluation	**Possibility that the pest could become associate with the commodity** *T. leucotreta* is established in Israel for the last 20 years. Citrus plots under a systems approach are approximately 80% of the exporting plots to the EU, the rest of the export is coming from the pest free area. Monitoring data with pheromone traps suggest that in the systems approach trap captures are usually 0 up to 5 moths per trap within a month. In non-exporting plots as many as 37 males per trap within a month have been observed during surveys. Out of 4000 plots inspected by the PPIS, 107 were infested with *T. leucotreta* (season 2019–2020), additionally 14 plots were detected during packinghouse inspection. Easy peelers (cv. Orri) is one of the main citrus commodities exported to the EU which is known to be a susceptible variety. **Measures taken against the pest and their efficacy** Monitoring and inspections in the field Application of mating disruption and orchard sanitation Inspection during packaging by packing house staff and final official inspections by NPPO prior to export **Interception records** There are 15 interceptions reported in Europhyt/TRACES-NT (1995–2020) of *T. leucotreta* on *citrus* fruits originating from Israel.				

	Shortcomings of current measures/procedures In small orchards (< 2.5 ha.) only trapping data from 1 trap 20 min might be a limited period for inspection; Inspection of fallen fruit is only partly done in a systematic way; Inspection intensity seems to be irrespective of orchard size; With the action threshold currently used (i.e. three months or more) mating disruption is therefore not applied in low population densities; Starting mating disruption after moths have been captured may be too late to be fully effective; Size of non-isolated orchard may be too small (< 6 ha) for reliable mating disruption due to pheromone dispersal and edge effect of immigrating gravid females Sampling intensity in the packing house does not seem to be related to the volume of harvest Fruits with early infestation (e.g. young larvae) will only be detected with destructive sampling which is not applied **Main uncertainties** Frequency of sanitation is unclear, and the efficacy of the crushing procedure is not known. Sampling intensity is not clear upon delivery of fruits in the packing house (number of containers per plot can vary) Training level of people involved in harvest and packaging procedure to detect infestations of *T. leucotreta* is uncertain

A.1.6. Reasoning for a scenario which would lead to a reasonably low number of infested consignments

- Pest abundance is low.
- Export plots are isolated from other orchards where mating disruption is not applied.
- Regular visual inspection of fruits (20 min) is effective to identify infestation, e.g. large larvae, exit holes.
- Large proportion of farmers apply mating disruption preventively.
- Sanitation and fruit destruction occur frequently and accordingly disrupts population build-up in orchards.
- Biological control (virus) is applied timely and therefore is effective in controlling *T. leucotreta.*
- Visual inspection at the packing house is effective.
- Exported citrus varieties are not susceptible to *T. leucotreta* infestations (e.g. grapefruit).

A.1.7. Reasoning for a scenario which would lead to a reasonably high number of infested consignments

- Pest abundance is high.
- Export plots are not isolated from other orchards that do not apply mating disruption.
- The inspection time of 20 min per orchard is too short to assess infestation levels.
- Large proportion of farmers do not apply mating disruption preventively.
- Sanitation and fruit destruction do not occur frequently and accordingly do not disrupt population build-up in orchards.
- Biological control (virus) is not applied timely and therefore is not effective in controlling *T. leucotreta*.
- Visual inspection at the packing house is not effective.
- Exported citrus varieties are susceptible to *T. leucotreta* infestations.

A.1.8. Reasoning for a central scenario equally likely to over- or underestimate the number of infested consignments (median)

- Decrease of pest-free area in the last years.
- 20% of export comes from pest-free area/monitored following ISPM standards.
- Minimum 100 fruits will be visually inspected; additional inspections are conducted if pest is detected during initial inspection. With low infestation (about 1%) is possible to pass detection.
- 2% of boxes will be officially inspected before export by NPPO.

- 7–15 interceptions per 8,000 consignments at EU border (about 30 disqualification per 8,000 consignments in Israel).

A.1.9. Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

- Sampling intensity is not clear upon delivery of fruits in the packing house (number of containers per plot can vary).

A.1.10. References

EPPO (European and Mediterranean Plant Protection Organization), 2013. Pest risk analysis for *Thaumatotibia leucotreta*. EPPO, Paris. Available online: http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm

EPPO (European and Mediterranean Plant Protection Organization), 2019. PM 7/137 (1) Thaumatotibia leucotreta. EPPO Bulletin, 49, 248–258. https://doi.org/10.1111/epp.12580

EPPO (European and Mediterranean Plant Protection Organization), 2020. PM 3/90 Inspection of citrus fruits consignments. Bulletin OEPP/EPPO Bulletin, 50, 383–400. ISSN 0250-8052. https://doi.org/10.1111/epp.12684

Hattingh V, Moore S, Kirkman W, Goddard M, Thackeray S, Peyper M and Pringle K, 2020. An Improved Systems Approach as a Phytosanitary Measure for *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) in Export Citrus Fruit From South Africa. Journal of Economic Entomology, 113, 700–711.

Appendix B – Elicited values for pest freedom

The following tables show the elicited and fitted values for pest infestation/infection (Table B.1) and pest freedom (Table B.2).

Table B.1: Elicited and fitted values of the uncertainty distribution of pest infestation by *T. leucotreta* per 10,000 fruits

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	5					35		60		100					150
EKE	5.00	6.96	10.0	15.9	23.6	33.1	42.7	63.0	85.4	97.8	112	125	137	145	152

The EKE results is the BetaGeneral (1.0985, 1.6067, 3.5, 160) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested fruits, the pest freedom was calculated (i.e. = 10,000 – number of infested fruits per 10,000). The fitted values of the uncertainty distribution of the pest freedom are shown in Table B.2.

Table B.2: The uncertainty distribution of fruits free of *T. leucotreta* per 10,000 fruits calculated by Table B.1

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9,850					9,900		9,940		9,965					9,995
EKE results	9,848	9,855	9,863	9,875	9,888	9,902	9,915	9,937	9,957	9,967	9,976	9,984	9,989.96	9,993	9,995

The EKE results are the fitted values.

Appendix C – Details of the systems approach applied in Israel

All places of production (orchards per grower) and packinghouses should be approved and registered by the PPIS before the beginning of every season, for participation in the exportation season of citrus fruit to the EU.

C.1. Integrated phytosanitary measures

C.1.1. Measures related to the certified places of production

1) Each grower registered to export according to the systems approach is obliged to operate according to Standard Operating Procedure (SOP) approved by the PPIS.
2) Sanitation in the orchard is mandatory, i.e. removal and destruction of fallen, damaged and infested fruits from the trees and the ground regularly by the grower and destruction of wild host plants (i.e. *Ricinus communis*) in the surrounding area of the orchard. The grower is responsible of these sanitation measures.
3) Registered growers use the services of authorised plant protection field scouts for the monitoring throughout the growing season of production orchards. Pest findings ('FCM orchard report') is made for each single plot in the orchard and kept until the end of the season.
4) Monitoring for *T. leucotreta* using pheromone-baited traps is implemented regularly. Corrective measures or disqualification of the plot from the systems approach are implemented according to SOP. Reports are documented and kept for at least 24 months.
5) Packinghouses approve 2 weeks prior to harvest the grower's orchards that are registered and engaged to export through it to the EU, and to make sure they comply with the SOP.
6) Prior to harvest, the PPIS will grant the grower with permission to start harvesting based on inspection and monitoring reports during the production season and packinghouse approval for harvest.
7) Citrus fruit are harvested from September to May, according to variety. Fruits with visible damage marks are identified and removed during the picking and sorting in the plot.
8) Picking in Israel is done by hand; therefore, sorting and grading stage takes place initially in the field.

C.1.2. Measures related to transportation from the field

1) After harvest, fruits are transported in trucks covered with tarpaulin from the orchard to the packinghouse.
2) All containers and boxes are free of soil, foliage and pests and identified with the plot number to maintain traceability.

C.1.3. Measures related to the packinghouses

1) Packinghouses are registered and certified by the PPIS and operate in accordance to international food safety standards.
2) Each packinghouse registered to export according to this systems approach is obliged to work according to SOP approved by the PPIS.
3) The packinghouse keeps a list of all the approved growers that use its packing service for the EU. Any change in the list is immediately reported to the PPIS. A qualified field scout on behalf of the packinghouse should inspect the plots 2 weeks prior to harvest to verify compliance with the programme.
4) It is the responsibility of the packinghouse to make sure that the registered plot is approved by the PPIS for harvest.
5) To maintain integrity and the pest-free status of the fruit designated to the EU, when a packinghouse pack fruit for export to the EU, it must accept fruit from registered and approved plots only.
6) Each lot in a consignment should be traced back to the place of production and packinghouse.
7) Fruits are sorted manually by professional trained line workers, which remove any disqualified fruit.

8) All boxes must be marked with a label stating that the produce originated in Israel.
9) Packinghouses have Quality Control (QC) stations and qualified trained QC personnel who carry out the inspection, on representative samples of the fruit that arrive from the plot per arrival. The inspection is performed in several steps during sorting and handling of the fruit with a threshold for suitability to continue within the programme:
   - Arrival of the bins from the orchard.
   - Grading and sorting of fruit on the packing line.
   - Final packing.

C.1.4. PPIS official export inspection

PPIS Phytosanitary inspections carried out by authorised PPIS inspectors which ensure that phytosanitary certificates are issued to all plants and plant products after thorough inspection.

1) Overall inspection includes phytosanitary and quality parameters based on Israeli and international quality standards. Inspection is coordinated in advance with the PPIS for every shipment.
2) Official inspection of a representative fruit sample size, ranging 1–2% is performed per consignment according to PPIS procedures.
3) Additional declarations: consignments must be accompanied by a phytosanitary certificate issued by the PPIS with an Additional Declaration (AD) stating the following: The fruits meet all the requirements of the Directive 2000/29/EC, as amended by the Commission Implementing Directive 2017/1279, including special requirements for fruits of citrus – Annex IV. A. I, points 16.1, 16.2(a), 16.3(a), 16.4(a),16.5(a),16.6(d): 'The consignment was produced under a systems approach and was inspected and found free from *Thaumatotibia leucotreta*'.

Responsibilities under a systems approach in Israel

1) PPIS: To coordinate, perform and supervise all activities stipulated in this programme. To ensure that PPIS officers involved in this programme are properly trained. To approve, register and document all the places of production and packinghouses that comply with this programme and that are eligible to export citrus fruit to the EU. To inspect the places of production and packinghouses throughout the production season and verify that they comply with the requirements of this program. To suspend or cancel the approval of any place of production or packinghouse which does not comply with the requirements. Should *T. leucotreta* be intercepted during orchard or packinghouse inspection, all shipments from that facility will be suspended. Immediate corrective actions will be taken under the supervision of the PPIS and exports will resume after it is determined by the PPIS that risk mitigation has been achieved. To conduct export inspections. To issue phytosanitary certificates with the appropriate additional declarations.
2) Places of production and packinghouses approved and registered by the PPIS and exporters engaged in the export to the EU are obliged:
   - To comply with the requirements stipulated in this programme and guidance of the PPIS as detailed in the SOP, and properly perform the activities related to the export of citrus fruit from Israel to the EU.
   - To notify the PPIS immediately if *T. leucotreta* is observed in the plot or the packinghouse.
   - To ensure that the dedicated personnel involved in this programme are properly trained.

Appendix D – Web of Science All Databases Search String

In the table below, the search strings used in Web of Science are reported. Totally, 265 papers were retrieved. Titles and abstracts were screened.

Web of Science All databases	1st search-16 Results **TOPIC:** ("Thaumatotibia leucotreta" or "FCM" or "false codling moth" or "citrus codling moth" or "orange codling moth" or "Cryptophlebia leucotreta" or "Cryptophlebia roerigii" or "Olethreutes leucotreta" or "Thaumatotibia roerigii" or "T. leucotreta") **AND** **TOPIC:** ("Citrus") **AND** **TOPIC:** ("chemical control") **AND** **TOPIC:** ("biological control" or "biocontrol") 2nd search - 2 Results **Topic:** ("Thaumatotibia leucotreta" or "FCM" or "false codling moth" or "citrus codling moth" or "orange codling moth" or "Cryptophlebia leucotreta" or "Cryptophlebia roerigii" or "Olethreutes leucotreta" or "Thaumatotibia roerigii" or "T. leucotreta") **AND** **TOPIC:** ("Citrus") **AND** **TOPIC:** ("Israel") 3rd search-235 Results **TOPIC:** ("Thaumatotibia leucotreta" or "FCM" or "false codling moth" or "citrus codling moth" or "orange codling moth" or "Cryptophlebia leucotreta" or "Cryptophlebia roerigii" or "Olethreutes leucotreta" or "Thaumatotibia roerigii" or "T. leucotreta") **AND** **TOPIC:** ("Citrus") **AND** **TOPIC:** ("control*") 4th search – 7 Results **TOPIC:** ("Thaumatotibia leucotreta" or "FCM" or "false codling moth" or "citrus codling moth" or "orange codling moth" or "Cryptophlebia leucotreta" or "Cryptophlebia roerigii" or "Olethreutes leucotreta" or "Thaumatotibia roerigii" or "T. leucotreta") **AND** **TOPIC:** ("Israel") 5th search – 5 Results **TOPIC:** ("Thaumatotibia leucotreta" or "FCM" or "false codling moth" or "citrus codling moth" or "orange codling moth" or "Cryptophlebia leucotreta" or "Cryptophlebia roerigii" or "Olethreutes leucotreta" or "Thaumatotibia roerigii" or "T. leucotreta") **AND** **TOPIC:** ("insecticide$ resistance" or "chemical$ resistance")