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Commodity risk assessment of *Momordica charantia* fruits from Sri Lanka

EFSA Panel on Plant Health (PLH),

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Abstract

The European Commission requested the EFSA Panel on Plant Health to prepare and deliver risk assessments for commodities listed in Commission Implementing Regulation (EU) 2018/2019 as 'High risk plants, plant products and other objects'. *Momordica* fruits originating from countries where *Thrips palmi* is known to occur qualify as high-risk plants. This Scientific Opinion covers the introduction risk for *T. palmi* posed by fruits of *Momordica charantia* L. imported from Sri Lanka, taking into account the available scientific information, including the technical information provided by the National Plant Quarantine Service of Sri Lanka. The risk mitigation measures proposed in the technical dossier from Sri Lanka were evaluated taking into account the possible limiting factors. An expert judgement is given on the likelihood of pest freedom taking into consideration the potential pest pressure in the field, the risk mitigation measures acting on the pest in the field and in the packing house, including uncertainties associated with the assessment. For *T. palmi* on *M. charantia* fruits from Sri Lanka, an expert judgement is given on the likelihood of pest freedom following the evaluation of the risk mitigation measures acting on *T. palmi*, including any uncertainties. The Expert Knowledge Elicitation indicated, with 95% certainty that between 9831 and 10,000 *M. charantia* fruits/10,000 will be free from *T. palmi*.

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1. Introduction

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

1.1.1. Background

The new Plant Health Regulation (EU) 2016/2031¹, on the protective measures against pests of plants, has been applied from December 2019. Provisions within the above Regulation are in place for the listing of 'high risk plants, plant products and other objects' (Article 42) on the basis of a preliminary assessment, and to be followed by a commodity risk assessment. A list of 'high risk plants, plant products and other objects' has been published in Regulation (EU) 2018/2019². Scientific opinions are therefore needed to support the European Commission and the Member States in the work connected to Article 42 of Regulation (EU) 2016/2031, as stipulated in the terms of reference.

1.1.2. Terms of reference

EFSA is expected to prepare and deliver risk assessments for commodities listed in the relevant Implementing Act as "High risk plants, plant products and other objects". Article 42, paragraphs 4 and 5, establishes that a risk assessment is needed as a follow-up to evaluate whether the commodities will remain prohibited, removed from the list and additional measures will be applied or removed from the list without any additional measures. This task is expected to be on-going, with a regular flow of dossiers being sent by the applicant required for the risk assessment.

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 for *Momordica charantia* fruits from Sri Lanka taking into account the available scientific information, including the technical dossier provided by Sri Lanka.

1.2. Interpretation of the Terms of Reference

The EFSA Panel on Plant Health (hereafter referred to as 'the Panel') was requested to conduct a commodity risk assessment of *Momordica charantia* fruits from Sri Lanka following the Guidance on commodity risk assessment for the evaluation of high-risk plant dossiers (EFSA PLH Panel, 2019).

As stated in the European Union (EU) implementing regulation 2018/2019, fruits of *Momordica* L. are known to host and provide a significant pathway for the introduction and establishment of the pest *Thrips palmi* Karny, which is known to have the potential to have a major impact on plant species which are of a major economic, social or environmental importance to the Union territory. However, this pest does not occur in all third countries nor in all areas within a third country where it is known to occur. Certain third countries also have effective mitigation measures in place for that pest. In view of this, fruits of *Momordica* L. that originate in third countries or parts thereof where that pest is known to occur and which lack effective mitigation measures for that pest qualify as high-risk plants, within the meaning of Article 42(1) of Regulation (EU) 2016/2031, and therefore, the introduction into the Union of those plants should be provisionally prohibited. Where demand for the importation of these plant products is identified, a risk assessment will be carried out in accordance with an implementing act to be adopted pursuant to Article 42(6) of Regulation (EU) 2016/2031.

Based on the information provided in the dossier, the panel will make an assessment to evaluate if the mitigation measures against *T. palmi* on *M. charantia* fruits from Sri Lanka are effective to guarantee pest freedom. When necessary, additional information was requested to the applicant.

Risk management decisions are not within EFSA's remit. Therefore, the Panel provided a rating based on expert judgement regarding the likelihood of pest freedom for *T. palmi* given the risk mitigation measures proposed by the applicant.

¹ Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) 228/2013, (EU) 652/2014 and (EU) 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317, 23.11.2016, pp. 4–104.

² Commission Implementing Regulation (EU) 2018/2019 of 18 December 2018 establishing a provisional list of high risk plants, plant products or other objects, within the meaning of Article 42 of Regulation (EU) 2016/2031 and a list of plants for which phytosanitary certificates are not required for introduction into the Union, within the meaning of Article 73 of that Regulation C/2018/8877. OJ L 323, 19.12.2018, pp. 10–15.

2. Data and methodologies

2.1. Data provided by the National Plant Quarantine Service of Sri Lanka

The Panel considered all the data and information (hereafter called 'the Dossier') provided by National Plant Quarantine Service of Sri Lanka on 23 of December of 2019, including the additional information provided on 8 of July of 2020 after EFSA's request. The Dossier is managed by EFSA.

The structure and overview of the Dossier is shown in Table 1. The number of the relevant section is indicated in the opinion when referring to a specific part of the Dossier.

Table 1: Structure and overview of the Dossier and the additional material submitted by the National Plant Quarantine Service of Sri Lanka

Dossier section	Overview of contents	Filename
1	Survey of thrips in Sri Lanka: A checklist of thrips species, their distribution and host plants (Tillekaratne et al., 2012)	Supporting Document 1, Checklist for Thrips in Sri Lanka.pdf
2	Pesticide recommendations	Supporting Document 2 Pesticide Recommendations.pdf
3	Technical dossier	Technical Dossier Section 3 Commodity Data.docx
4	Data on phytosanitary mitigation measures	Technical Dossier Section 5 Data on Phytosanitary Mitigation Measures.docx
5	Cover Letter	DOC covering letter.jpg
6	Explanatory note on literature search	Appendix B Explanatory note on literature search.docx
7	Point by point reply to requested additional information by EFSA	EU BG Dossier Additional Information final 08072020 (1).docx
7.1	GAP Report for Wanica B District for the period of January 2009–December 2009	ID 100_Annex 2 Annual GAP report of 2009_EN.pdf

2.2. Literature searches performed by EFSA

A literature search was undertaken by EFSA to assess the state of the art regarding 1) the pest pressure in the applicant country; 2) efficacy of pre- and post-harvest measures applied to control *T. palmi*; 3) efficacy of insecticides to control *T. palmi*. The searches were run on 29/6/2020 (Appendix B). 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) were taken into account.

2.3. Methodology

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. palmi* were evaluated in terms of efficacy or compliance with EU requirements as explained in Section 1.2. A conclusion on the likelihood of the commodity being free from *T. palmi* was determined and uncertainties identified using expert judgements. Pest freedom was assessed by estimating the number of infested fruits out of 10,000 exported fruits.

2.3.1. Listing and evaluation of risk mitigation measures

All currently used risk mitigation measures in the country of export were listed and evaluated.

The risk mitigation measures adopted in the production places and packing houses as communicated by National Plant Quarantine Service were evaluated with Expert Knowledge Elicitation (EKE) according to the Guidance on uncertainty analysis in scientific assessment (EFSA Scientific Committee, 2018).



Figure 1: Conceptual framework to assess the likelihood of pest freedom for *Thrips palmi* in *Momordica charantia* fruits

Estimates of pest pressure of *T. palmi* in the production places and the effect of the mitigation measures taken in the field during production and the postharvest mitigation measures taken in the packing house were summarised in a pest data sheet (see Appendix A).

To estimate the pest freedom of the commodity a three-step approach was adopted following EFSA guidance (Annex B.8 of EFSA Scientific Committee, 2018). Therefore, three independent elicitations were conducted, i.e. one to estimate pest pressure in the field; one to estimate the efficacy of mitigation measures applied in the field; and a final one to estimate the efficacy of postharvest mitigation measures applied in the packing house. Combining these three estimations, the level of pest freedom for *T. palmi* on *M. charantia* fruits from Sri Lanka was determined (see Section 2.3.2). The final result indicates how many fruits out of 10,000 will be infested with *T. palmi* when arriving in the EU.

The uncertainties associated to 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.

2.3.2. Conceptual model for risk of entry

The risk of entry of *T. palmi* via import of *M. charantia* fruits from Sri Lanka was estimated in three steps using a formal conceptual model. In this model, the estimated pest pressure is used as starting point and corrected by the independent effects of measures in the field and in the packing house. The result of this model is the level of infestation at import calculated as follows:

$$\text{Import risk} : r_{\text{import}} = p_{\text{pressure}} \times p_{\text{field}}/10,000 \times p_{\text{packing}}/10,000,$$

$$\text{Pestfreedom} : PF_{\text{import}} = 10,000 - r_{\text{import}}.$$

All values are expressed in numbers of fruits out of 10,000 (Table 2).

Table 2: Parameters for three-step conceptual model to estimate the likelihood of pest freedom in *Momordica charantia* fruits

Parameter	Unit	Description
r_{import}	[No out of 10,000 fruits]	The number (out of 10,000) <i>M. charantia</i> fruits imported to the European Union (EU) from Sri Lanka, which will be infested with <i>T. palmi</i> when arriving the EU
p_{pressure}	[No out of 10,000 fruits]	The number (out of 10,000) <i>M. charantia</i> fruits harvested on production sites in Sri Lanka, which will be infested with <i>T. palmi</i> without application of specific measures against the pest (pest pressure under general agricultural practice)
p_{field}	[No out of 10,000 fruits]	The number of <i>M. charantia</i> fruits (out of 10,000 infested fruits) that remain infested after applying measures on production sites
p_{packing}	[No out of 10,000 fruits]	The number of <i>M. charantia</i> fruits (out of 10,000 infested fruits) that remain infested after applying measures at the packing house
PF_{import}	[No out of 10,000 fruits]	The number (out of 10,000) <i>M. charantia</i> fruits imported to the EU from Sri Lanka, which will be pest free of <i>T. palmi</i> when arriving the EU

The input parameters p_{pressure} , p_{field} and p_{packing} are determined by separate EKE. The uncertainties associated to 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).

The model results r_{import} and PF_{import} were calculated using Monte Carlo simulation. A final distribution is fitted to the simulation results.

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.

3. *Thrips palmi*

3.1. Biology of the pest

Thrips palmi Karny (Thysanoptera: Thripidae), commonly known as melon thrips, oriental thrips and southern yellow thrips, was first described in 1925 from Sumatra and Java (Indonesia) (Karny, 1925). The species previously had the common name 'palm thrips'; however, no palm species are known to host this pest and the origin of this name is in honour of Dr B.T. Palm, a well-known specialist of this group.

At 25°C, the life cycle from egg to egg lasts 17.5 days (OEPP/EPPO, 1989). The life cycle differs little from that of most phytophagous Thripidae (Figure 1). The adults emerge from the pupa in the soil, and consequently, move to the leaves, flowers and fruits of the plant, where they lay their eggs in an incision made with the ovipositor. They preferably lay their eggs in young growing tissue of leaves, and also the flowers and fruit of a wide range of host plants, especially Cucurbitaceae, Solanaceae and Leguminosae. The two larval stages (LI and LII) and male and female adults feed on the maturing leaves, stems, flowers and flower petals and surfaces of fruits. They suck the contents of tissue cells with their specialised mouthparts, leaving them empty, causing silvery scars or leaf bronzing. The second-stage larva drops from the plant to the soil (or packing cases or growing medium) and completes its cycle by pupating (pupa I and pupa II) in the substrate (EPPO, 2018a,b).

The life cycle and population dynamics of *T. palmi* in Japan have been reviewed by Kawai (1990) (Figure 2).

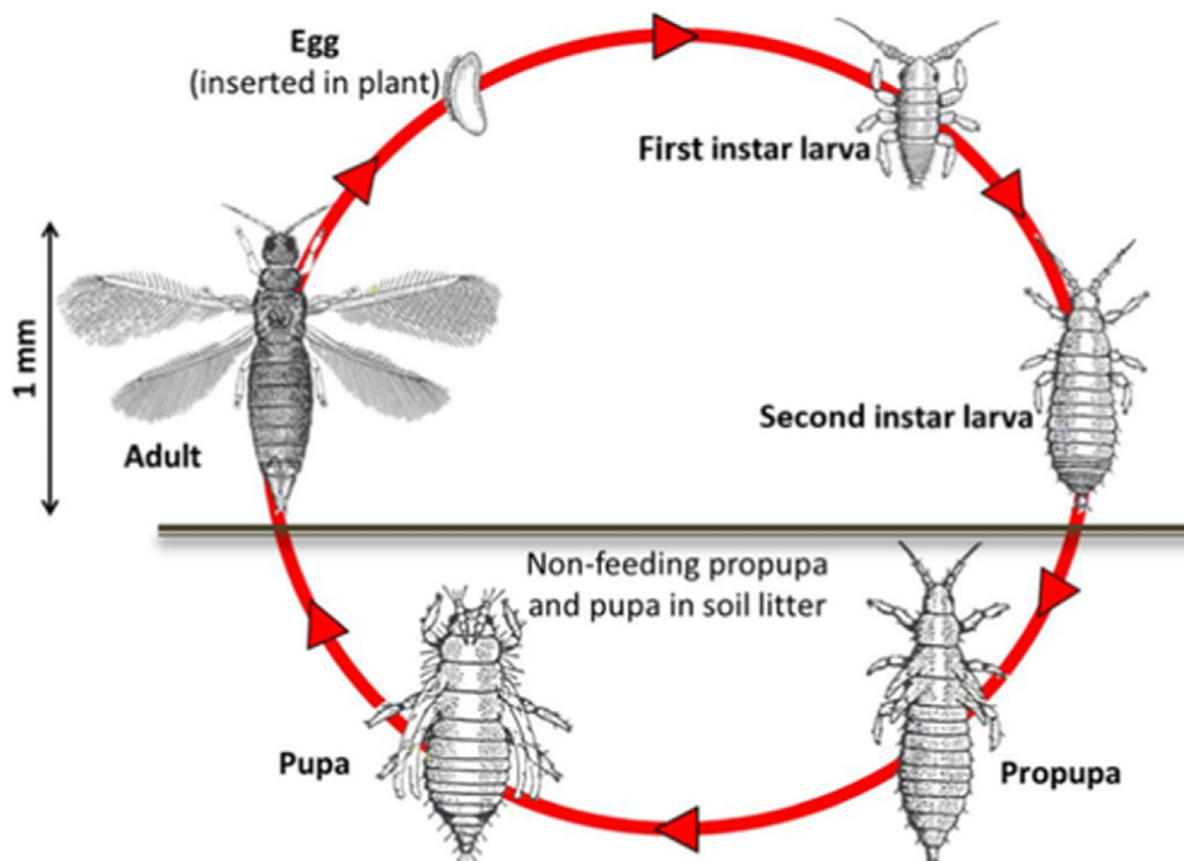


Figure 2: Life cycle of Thripidae (e.g. *Thrips palmi*)

Thrips palmi is primarily a subtropical and tropical species. Tsumuki et al. (1987) analysed the cold hardiness of *T. palmi* in Japan and concluded that it could not survive outdoor winter conditions in southern Honshu Island.

Sakimura et al. (1986a,b) set the outdoor northern limit to 34°N, which corresponds to the very south of Honshu. However, Nagai and Tsumuki (1990) reported no reduction of adult populations at temperatures as low as from –3°C to –7°C on weeds in an unheated glasshouse between mid-January and mid-February in Japan. Developmental time decreased with increasing temperature up to 32.5°C in all stages. The total developmental time was longest at 12.5°C (64.2 days) and shortest at 32.5°C (9.2 days), 12.7 days at 25°C (Park et al., 2010). The mean developmental time for the egg stage varied between 24 days at 12.5°C, 6–7 days at 25°C, 4–5 days at 30°C and 3.3 days at 32.5°C (Park et al., 2010). Developmental times varied, however, between different laboratory assays, host plants, photoperiod, etc., by a few days between different experiments in particular larval development at lower temperatures. The lower developmental threshold was 10.6, 10.6, 9.1 and 10.7°C for egg, larva, prepupa and pupa, respectively. The thermal constant required to complete the respective stage was 71.7, 59.2, 18.1 and 36.8 degree-days (DD). The lower threshold temperature and thermal requirements varied a bit between different studies ranging from 10.1°C and 194 DD (McDonald et al., 1999) and 10.6°C and 183.3 DD for egg to adult development (Park et al., 2010) to 11.3°C and 196 DD (Yadav and Chang, 2014) and 11.6°C and 189.1 DD (Kawai, 1985).

Parthenogenesis (arrhenotoky) in *T. palmi* has been reported by Yoshihara and Kawai (1982). The oviposition behaviour of the species was observed in Taiwan (Wang et al., 1989); a preoviposition period of 1–3 days for virgin females and 1–5 days for mated ones was recorded. Virgin females laid 3–164 eggs (1.0–7.9 eggs/day) during their lifespan, while mated females laid 3–204 eggs (0.8–7.3 eggs/day). At 25°C, the net reproductive rate (28.0), female fecundity (59.6 eggs/female) and daily oviposition rate (3.8 eggs/day) reached the maximum level (Kawai, 1985). At the optimum temperature for population growth (25–30°C), the number of generations was estimated in 25–26/year (Huang and Chen, 2004). Significant differences in population growth among crops were highlighted (Kawai, 1986). The survival rates of the larval and pupal stages fed on cucumber, kidney bean,

eggplant and balsam pear were high, whereas the survival rates of those fed on okra and chrysanthemum were low. The larvae fed on tomato and strawberry were unable to pupate. Duration of the larval and pupal stages fed on chrysanthemum and okra was longer than the duration of those fed on other crops. The longevity of the adults fed on cucumber, pumpkin, eggplant and kidney bean was increased, whereas the longevity of those fed on chrysanthemum, tomato and strawberry was decreased. The fecundity of adult females (no of eggs/female) fed on cucumber was maximum (60), while the fecundity of those fed on melon, eggplant and pumpkin amounted to 20. The differences in the generation time were not significant among crops, unlike the differences in the net reproductive rate. The intrinsic rate of natural increase of *T. palmi* fed on cucumber was maximum and the value was 0.134, while that of *T. palmi* fed on melon, eggplant and pumpkin ranged from 0.08 to 0.11 (Kawai, 1986).

3.2. Symptoms

3.2.1. General symptoms

On plant material, at inspection, silvery feeding scars on the leaf surface, especially alongside the midrib and veins, can be seen (Cannon et al., 2007). Heavily infested plants are characterised by a silvered or bronzed appearance of the leaves, stunted leaves and terminal shoots. At high densities, feeding by *T. palmi* may cause damage to fruits (Kawai, 1986) as well, such as scarring, discoloration and deformation in developed fruits or fruit abortion in an early stage. Cucumber, eggplant and pepper fruit are damaged when thrips feed in the blossoms. Symptoms may be found on all parts of a wide range of plant species (Sakimura et al., 1986a,b). Although *T. palmi* feeds on *Momordica* sp., no specific information of symptoms and damage caused to fruits of *M. charantia* is available.

3.2.2. Pest density of *Thrips palmi* in fruits

Despite its wide host range, including fruits and vegetables, the information about the actual pest density levels of *T. palmi* itself in various crops is limited. Most relevant papers measure the economic injury level (EIL) and the economic threshold (ET), which are calculated by the damage caused by the pest correlated with pest density. Yet, no information has been found of EILs and ETs calculated for *T. palmi* infestations in *M. charantia* under greenhouse or semi-field conditions in particular.

Rosenheim et al. (1990) recorded that in cucumber, densities of *T. palmi* (number per unit area of plant substrate) were greatest on foliage, and lowest on fruits, with an average ratio of 0.55 per female flower and 0.19 per fruit compared to foliage. During the early stage of development, fruits physically support the female flowers, but as the densities of *T. palmi* in flowers is low, the opportunities for them to incidentally feed upon and scar young fruit are low as well, this in contrast to *Frankliniella occidentalis*.

At high densities, *T. palmi* feeding may cause damage to fruits (Kawai, 1986; Welter et al., 1990). No records, however, are available specifically for *M. charantia*, and data available in literature for cucumber likely better reflect the incidence on *M. charantia* than those on Solanaceous crops like eggplant or sweet pepper. Kawai (1985) estimated EILs for cucumber the tolerable density of adults – at a constant high density – at 4.4 per leaf for uninjured fruit yield and at 5.3 adults per leaf for the total fruit yield (at a level of yield loss of 5%) and 8.8 adults per leaf (at a level of yield loss of 10%). In addition, Kawai (1990) reported EILs of 0.08 adults per leaf for eggplant and 0.11 adults per flower for sweet pepper. In other studies, in Japan, EILs were estimated at densities of 1–10 adults per cucumber leaf or 2–3 adults or larvae per pepper flower in south Florida, USA, (Capinera, 2020). In case of high infestations in eggplant, less fruits are produced and of smaller size (Yadav and Chang, 2014). They recommended as an action threshold 1.05–1.50 thrips per flower or 4.91–10.17 adults per sticky trap over a 4-day period. Welter et al. (1990) calculated an action threshold of 94 thrips/cucumber leaf early in the growing season, showing that an EIL for fruits is relatively high for *T. palmi*. EILs are quite variable and differ per crop, per country, and timing in the season and ETs depend on variable and dynamic economic factors such as costs for control, labour, yield, market price, etc. (Pedigo et al., 1986). Yadav and Chang (2014) indicated that the percentage of fruit damage correlates with the population dynamics of the thrips. Besides, thrips-related fruit damage in eggplants can best be evaluated in terms of the damaged fruit percentage, not in terms of yield loss.

3.3. Confusion with other pests

Thrips palmi identification is hampered by its small size and great similarity with other yellow species of thrips. Indeed, *T. palmi* can be mistaken for common thrips species with similar characteristics, e.g. *T. flavus* Schrank and *T. tabaci* Lindeman distributed worldwide, *T. alatus* Bhatti and *T. pallidulus* Bagnall in the Oriental region, *T. nigropilosus* Uzel and *T. alni* Uzel in the Palaearctic region and *T. urticae* Fabricius in Europe. For the distinction between look-alike species, microscopic examination by a seasoned expert of the morphological characteristics is required, or by molecular analysis (EPPO, 2018a,b).

3.4. Effectiveness of control options worldwide

A variety of chemical, cultural, biological and physical measures is used by growers across the world to manage *T. palmi* (Morse and Hoddle, 2006; Cannon et al., 2007), to prevent or maintain populations at a very low-density level. Management measures include the use of systemic and contact insecticides, insecticidal soaps, essential oils/plants extracts, soil treatments, the use of resident or introduced natural enemies, exclusion of the crops by physical barriers such as windbreaks, screenhouses, row covers, bagging of fruits, covering the soil with organic or plastic mulch or film, the removal of alternative weed hosts, trap crops (Salas, 2004), alternation of susceptible crops (Young and Zhang, 1998; Maltby and Walsh, 2005) and the use of less susceptible cultivars. Each of them separately has an effect, to restrict the entry and colonisation of the crop, to limit or suppress population growth (Kawai, 1990; Matsui et al., 1995).

Other techniques are used to monitor the number of thrips in order to establish the level and distribution of thrips infestation in a crop, such as the use of sticky traps, alone or with lures or pheromones, water pan traps, sampling of leaves and leaf beating. Monitoring results can be used to establish the distribution in a crop, to establish economic threshold levels and to facilitate the decision-making for which and when measures need to be taken to manage *T. palmi* infestations (Dong and Hsiu, 2019; Nakamura et al., 2014; Sánchez et al., 2011; Shibao and Tanaka, 2014; Thongjua et al., 2015).

3.5. Detection and monitoring

3.5.1. Sampling

Thrips palmi adults and larvae generally are found on the foliage: adults aggregate on the young vegetative parts, sometimes in the flowers, larvae on the underside of maturing leaves, concentrated in the upper third part of the crop (Kawai, 1990; Bacci et al., 2008; Zhang et al., 2014). Which parts of the plant best reflect the relationship between the density of thrips and the resulting damage depends on the crop type: flowers in orchids (Maketon et al., 2014) and eggplant (Yadav and Chang, 2013), leaves in cucumber (Bacci et al., 2008) and bean (Osorio and Cardona, 2003). The number of leaves or flowers sampled depends on the crop, stage of infestation, the experimental setup, etc. For cucumber, reflecting best a bitter melon crop, the best sampling size consisted of 35 leaflets per field or 40 leaflets per hectare (Osorio and Cardona, 2003), taken at random from the uppermost part of plants to establish the action threshold.

3.5.2. Monitoring with traps

Adults can be sampled with water pan traps, sticky traps and LED light traps. The use of sticky traps is common practice around the world for monitoring thrips, whereas water pan traps are uncommon and LED light traps not yet implemented at a commercial level. Blue and white have shown to be attractive colours for monitoring *T. palmi* in cucumber, eggplant and sweet pepper (Kawai, 1983; Kawai and Kitamura, 1987, 1990; Kawai, 1990; Yadav and Chang, 2013; Zhang et al., 2014) or wax gourd, respectively (Huang, 1989); for some crops, e.g. in orchids, yellow is more attractive (Culliney, 1990; Thongjua et al., 2015). Besides trap colour and relation to the background colour of the crop and the environment, its efficacy in a crop also depends on placement height in the crop (upper third). In recent years, a combination of LED lights covered by transparent plates show that *T. palmi* is attracted to light at wavelengths from 500 to 525 nm (Hajime et al., 2014; Shibao and Tanaka, 2014).

3.6. Management options

3.6.1. Chemical control

Contact and systemic insecticides combined with insecticidal soaps, essential oils/plant extracts, are frequently applied for suppression of *T. palmi*, in particular during the first years after invading a new area or when the pest needs to be eradicated (MacLeod et al., 2004; Cannon et al., 2007). Then, efficacy of control can be very high (90–95%) when timely and regularly applied. However, application of insecticides alone is not an adequate tool to control *T. palmi* because the eggs (in the foliar tissue) and the pupae (in the soil) are relatively insensitive to insecticide application. Given the polyphagous nature of *T. palmi* and the short life cycle, the population density in the surrounding environment of a crop may be very high and this may require repeated insecticide applications.

In addition, *T. palmi* is able to develop insecticide resistance already after a few years requiring alternation of different active ingredients which most often do not match with integration of biological or integrated control methods. Insecticide resistance in *T. palmi* was recorded as early as 1994 (Nozawa et al., 1994). In recent years, resistance has been recorded in Asia for insecticides such as cypermethrin (Kim et al., 2019; Ghosh et al., 2020), imidacloprid (Bao et al., 2015; Kim et al., 2019; Ghosh et al., 2020), and in particular, spinosad (Kim et al., 2019) and spinetoram (Gao et al., 2019; Shi et al., 2020). Field populations in Korea also showed reduced mortality to emamectin benzoate, chlorfenapyr, cyantraniliprole and dinotefuran (Kim et al., 2019). Resistance varies geographically and locally (Kim et al., 2019). To slow down insecticide resistance, it is important to apply insecticides that are effective in a rotation programme.

3.6.2. Mass trapping

Mass trapping with sticky traps/ribbons can reduce the numbers of *T. palmi* in some crops, such as sweet pepper and eggplant (Kawai, 1990, 2001; Murai, 2002). When these ribbons were set every 2–3 m² in a greenhouse, the density of *T. palmi* was reduced 10–20% compared to that in greenhouses without ribbons (Nonaka and Nagai, 1984). In strawberry, it could reduce adult thrips (*F. occidentalis*) numbers per flower by 61% and fruit bronzing by 55% (Sampson and Kirk, 2013). However, in these and other studies on thrips (see Sampson and Kirk, 2013), either no assessment of crop damage was made, or it failed to prevent damage (Trdan et al., 2005 for *T. tabaci* in onion crops), and therefore, no evidence is available of its economic viability. Nevertheless, mass trapping could be cost-effective at an early stage of invasion (Kawai and Kitamura, 1987, 1990) in high-value crops (Sampson and Kirk, 2013) and when part of an overall IPM programme. As a part of a combination of measures it could maintain thrips numbers below the damage threshold during specific periods of preharvest, when pesticides cannot be used because of residue levels.

3.6.3. Cultural control

Several cultural practices can effectively reduce the level of infestation by *T. palmi*. Physical barriers hampering the access to the host plants can protect a crop from infestation, such as windbreaks, growing the crop in glasshouses or fine meshed screenhouses, crop covers and or row covers, bagging of fruits, covering the soil with organic or plastic mulch or silver plastic, or spraying kaolin. Additionally, intercropping, the use of trap plants and the removal of alternative weed hosts (Salas, 2004; Cannon et al., 2007) (Kawai, 2001; Salas, 2004; Ingrid et al., 2012; Shiotsuka et al., 2016; Razzak and Seal, 2017; Razzak et al., 2018) also contributes to a better crop hygiene and thus a lower infestation level. Population build up is often hampered by periods of heavy rains in the open field (Huang, 1989; Etienne et al., 1990), but overhead irrigation of the crop does not.

Cultural control measures can be part of a systems approach for the control of *T. palmi*.

3.6.3.1. Fruit bagging

Preharvest fruit bagging is an extensively used practice in many countries around the world (Faci et al., 2014; Sharma et al., 2014; Shen et al., 2014). The use is twofold, it ensures homogeneity, aesthetics and quality of the product and it protects against diseases and pests, such as fruit flies (Tephritidae) and fruit borers (Lepidoptera). In the literature, there is not so much information for the effect on the prevention of damage by thrips, indicating it is primarily for other insect pests.

Few studies have been performed on the use of fruit bagging in reducing the incidence of thrips pests: Affandi et al. (2008) found a reduction in scarring of mango fruits (caused by an unspecified

species of thrips) of 32–42% in Indonesia using double-layered bags of plastic and paper. Karar et al. (2019) found that harvested fruits of mango in closed paper bags (brown paper inner black and butter – wet resistant/greaseproof – paper) were 100% free of (unspecified) thrips in Pakistan. Martins (2018) noticed a 30–50% reduction in lesions caused by *F. brevicaulis* in Brazil, and according to de López et al. (2020) bagging alone of bananas reduced losses by 90–100% by the red rust thrips (*Chaetanaphothrips signipennis*) compared to bunches with no bags. In banana plantings, covering bunches with polyethylene bags during fruit development provides a physical barrier to insect infestations, but bags cannot fully protect the fruit when a thrips infestation is heavy (Hara et al., 2002). No records have been found in literature on the effect of pre-harvest fruit bagging of *M. charantia* fruits.

3.6.4. Biological control

Macroorganisms

Augmentative biological control by seasonal or inundative releases of natural enemies such as predatory mites (e.g. *Neoseiulus* spp. or *Amblyseius* spp.) or predatory bugs (e.g. *Orius* spp.) can be very effective in greenhouses or in an outdoor Mediterranean climate when other crop pests are carefully managed and applications are timely made. Other generalist predators such as lacewings (*Chrysoperla* spp.), mirid bugs (*Macrolophus* spp.) or lady bugs (Coccinellidae) can prey on *T. palmi*, but will predominantly target preys which are prevalent, and thus only partly contribute to thrips control (Van Lenteren and Loomans, 1999). Conservation biological control, relying on the natural colonisation of a crop by natural enemies already present in the environment, is often too late and too less and therefore much less effective in an early and timely control of *T. palmi*. Control of thrips pests heavily relies on chemical applications however the use of insecticides may have detrimental effects on biological control agents (Cuthbertson, 2014).

Microorganisms

Application of entomopathogens, such as the fungi *Akanthomyces lecanii* (previously named as *Lecanicillium lecanii* and *Verticillium lecani*), *Metarhizium anisopliae*, *M. rileyi* (synonym *Nomuraea rileyi*), *Beauveria bassiana* and *Paecilomyces fumosoroseus* can have a certain control effect on thrips, whereas others like *Bacillus thuringiensis* have a limited effect (Saito, 1991, 1992; Vestergaard et al., 1995; Castineiras et al., 1996; Ekesi et al., 2000; Ekesi and Maniania, 2002; Trujillo et al., 2003; Visalakshy et al., 2004; Cuthbertson et al., 2005; North et al., 2006; Panyarisi et al., 2007; Silva et al., 2011; Shao et al., 2015; Hadiya et al., 2016). Others, such as *Purpureocillium lilacinum* (Hotaka et al., 2015) and *Isaria javanica* (Park et al., 2018), are still in a developmental phase.

Biotechnical control and semiochemicals

The effect of semiochemicals (Qing et al., 2004; Kirk, 2017) – either as a repellent or attractant – on the behaviour and trapping efficiency is still in an experimental phase. An aggregation pheromone for *T. palmi* has been identified (Akella et al., 2014), it can be used for monitoring, but implementation is still in an experimental phase (Kirk, 2017). In experimental setups, methyl salicylate (MeSA) has shown to attract natural enemies and to reduce populations in cucumber plants (Dong and Hsiu, 2019), but has not been developed to a commercial scale.

3.6.5. Host plant resistance

A few research reports mention differences in susceptibility to foliar injury among cultivars of pepper (Nuessly and Nagata, 1995), sweet pepper (Yasuda and Momonoki, 1988; Matsui et al., 1995; Visschers et al., 2019) and bean (Cardona et al., 2002; Frei et al., 2004), but host plant resistance has shown a low or no effectiveness in the management of *T. palmi*. No records have been found which specifically refer to breeding resistance genes into *M. charantia* or other *Momordica* species.

3.6.6. Post-harvest treatments

Potassium salts of fatty acids also known as insecticidal soaps are used as insecticides, herbicides, fungicides and algacides. Mixtures of potassium salts of fatty acids and essential oils may be used as selective acaricides (Tsolakakis and Ragusa, 2008) and insecticides (Wafula et al., 2017) as an alternative to synthetic chemical pesticides enabling farmers to produce with acceptable residue levels that meet market requirements. In snap bean in Kenya (Wafula et al., 2017), potassium salts of fatty acids reduced thrips (*Frankliniella* spp. and *Megalurothrips sjostedti*) populations up to 54%, comparable with synthetic pesticides.

Washing produce – fruits and vegetables – with chlorinated or ozonated water is used to sanitise water systems and to disinfect the surface of produce to prevent decay caused by microorganisms such as bacteria, fungi and yeasts and other pathogens at concentrations between 100 and 200 ppm active ingredient, at pH around 7 (Bornhorst et al., 2018; Ilic et al., 2018). It is not designed to kill insects, and little or no scientific evidence is available that it works as such.

4. Commodity data

4.1. Description of the commodity

The commodity to be imported are fruits of *M. charantia* also known as bitter gourd or bitter melons.

According to the export records, the monthly average exports of bitter gourds to EU from Sri Lanka is around 15–20 metric tons (Mt). However, during August and September, the amount exports decline due to product competitiveness from other countries.

There are 30–35 consignments exports by 18 major exporters to EU countries regularly in every week. The amount of bitter gourd exports to the EU has increased in last years (Dossier, Section 3).

4.2. Description of the production areas

The major bitter gourd growing areas in Sri Lanka are Kurunegala, Puttlam, Anuradhapura, Hambantota, Ratnapura, Kandy and Matale, and Ampara (www.doa.gov.lk). Export oriented cultivation is mainly concentrated in Kurunegala, Puttlum and Gampaha districts (Figure 3).

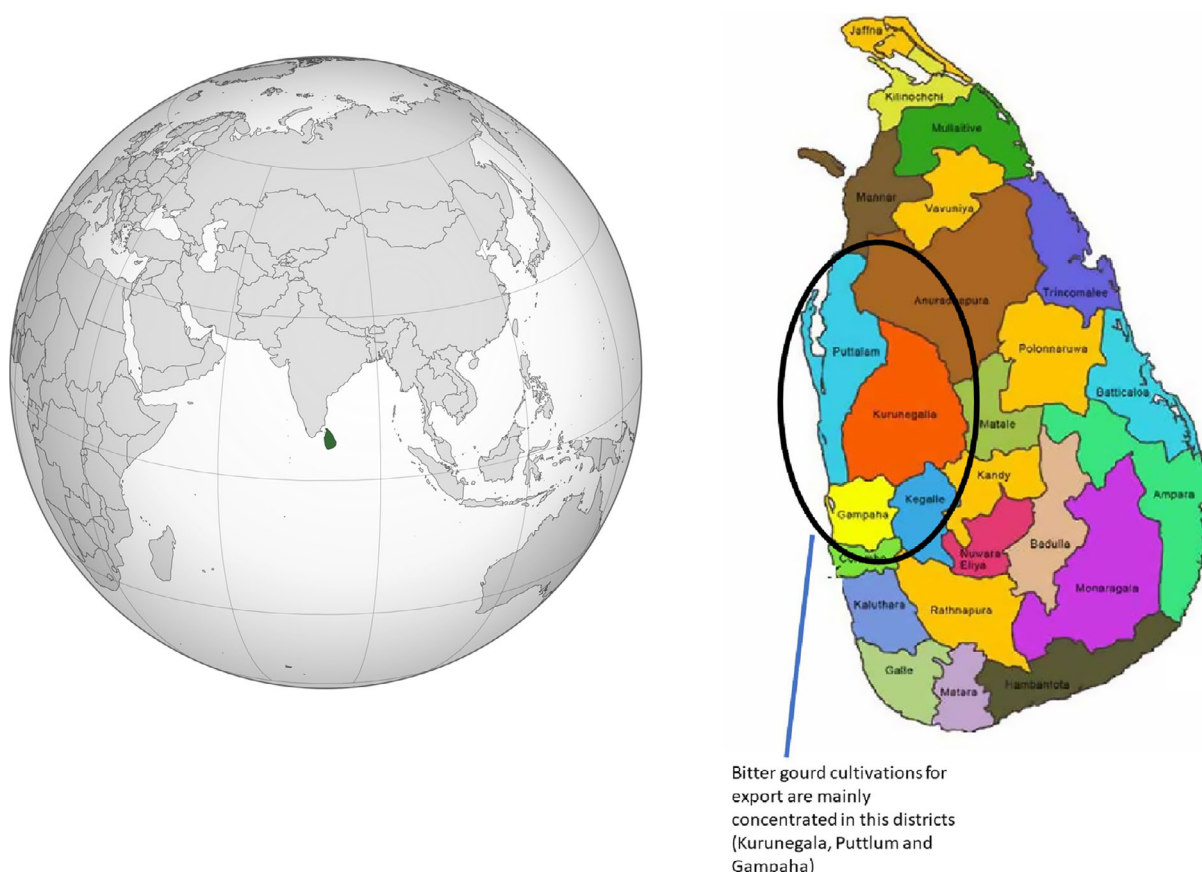


Figure 3: Location of Sri Lanka in Asia and areas (encircled) where *Momordica charantia* production is concentrated (map on the left taken from Wikipedia CC BY-SA 3.0)

4.2.1. Source of planting material

Different varieties are cultivated in Sri Lanka, e.g. Thinnaveli, MC43, Matale Green, Kalu Karawila, Maya and Shakthi.

Although there are commonly cultivated local bitter gourd varieties available in Sri Lanka, the seeds of the varieties Maya and Shakthi are imported from Thailand. The variety Maya produces a higher yield than the other varieties. The last two are the varieties most commonly exported to the EU.

Sri Lankan farmers usually use imported bitter gourd seeds from Thailand along with ISTA certification for export-oriented cultivation. Import permit issues based on the recommendation made by Horticulture Research and Development Institute, Department of Agriculture. After conducting subsequent two trials in research field, researchers evaluate quality, pest and disease resistance and yield characteristics of crops recommendations is given.

Farmer fields are also certified by Additional Director/NPQS based on the recommendation given by NPQS audit, after fulfilling the field conditions (phytosanitary measures) provided by Department of Agriculture/NPQS. Accordingly, bitter gourd exported to the EU comes from certified fields.

Locally produced seeds which are used for export cultivation are taken from local selections (i.e. Thinnaweli white) using certified seeds of the Department of Agriculture (Dossier, Section 3).

4.2.2. Production cycle

The production cycle of bitter gourd in Sri Lanka covers a period of 4–4.5 months. Practically only in few districts where favourable climatic conditions exist, cultivation can be done throughout the year. These favourable factors usually exist mainly in the wet and intermediate zones of Sri Lanka. Majority of exporting bitter gourd fields concentrate in the aforementioned zone.

A maximum of two production cycles per year are performed in the same field plot to prevent pest and disease incidences.

The duration per production cycle (115–130 days) depends on the crop variety used. Fruits harvested during the last two weeks of the harvest period are not exported to the EU to minimise the risk of *Bactrocer cucurbitae*. Therefore, exporting fields are only certified for one-month period by NPQS after first field audit. If the field is properly maintained without pests (*B. cucurbitae* and *T. palmi*), extension will be given for another 2 weeks even though total harvesting period is around 2 months.

Flowering starts 40–45 days after sowing and vines will bloom for about 2–3 months. Matured female flowers are fertilised and developed into fruits which can be harvested 12–14 days after fruit setting.

First harvest is used to confirm the pest density of the field for export. The first harvest is sent to the local market and from second harvest on fruit is for the export market (the time window for export lasts ~ 1 month). After confirmation of the pest status in the field, an extension for harvest is given for an additional 2 weeks (i.e., total period of export of around 45 days/crop).

5. Overview of interceptions

According to Europhyt/Traces-NT (accessed on 14 July 2020 and covering all interceptions since 1995), there were 12 interceptions of *M. charantia* fruits from Sri Lanka designated to the EU Member States due to the presence of *T. palmi* (Table 3).

Table 3: Number of interceptions of *M. charantia* with *T. palmi* exported from Sri Lanka into the EU (1995–2020)

Year	2009	2010	2011	2012	2016	2017	2019	Total
Number of interceptions	2	3	1	1	1	3	1	12

6. Pest pressure and risk mitigation measures

The evaluation of the efficacy of the risk mitigation measures against *T. palmi* was done in a three-step approach. First, an estimate was made for the pest pressure of *T. palmi* in the production environment. Second, the control effect of the pest management measures in the field was estimated. Third, the control effect of the post-harvest measures (packing house) was estimated.

The information used in the evaluation of the effectiveness of the risk mitigation measures is summarised in a pest data sheet (see Appendix A).

6.1. Pest pressure in production places

Based on the information available in the dossier (see Sections 1, 3 and 7) and literature data, the Panel estimated pest pressure in the production places under a no-intervention scenario (i.e. no mitigation measures). Moreover, the climatic conditions in Sri Lanka (based on monthly average temperatures) are very favourable for the development of this pest.

6.2. Risk mitigation measures applied in production fields

With the information provided by National Plant Quarantine Services of Sri Lanka (Dossier Sections 2, 3, 4 and 7), the Panel summarised the risk mitigation measures that are currently applied in the production places (Table 4).

Table 4: Overview of currently applied risk mitigation measures in the field for *Momordica charantia* fruits designated for export to the EU from Sri Lanka

Risk mitigation measure	Description of applied measure
Monitoring and inspection	Sticky traps (blue and yellow) are used for monitoring, i.e., 25 per acre. (Annex 5) (3–4 traps/1,000 sqm feed which is equivalent to ca. 1 trap every 5 × 5 m) Daily inspection is carried out by farmers and under the supervision of agricultural extension officers (Dossier Sections 3 and 4). They do thorough inspections of crops and weeds to prevent the establishment/occurrence of pests (aphids, flies, thrips, etc.). Very detailed labour-intensive inspection.
Physical protection of production fields	Fields for export are separated by insect-proof nets. However, details on the separation and exact location of local vs. export sites are not provided. The separation net is 3 m high and has a 40–50 mesh size
Chemical control	Thiocyclam (systemic insecticide) is only used in vegetative stages of production, twice during the growing season. There is sporadic use of other insecticides to control insect vector of plant viruses. In particular three products are mentioned: 1) imidacloprid; 2) thiamethoxam; and 3) Abamectin. In all cases, chemical control occurs before fruit setting. A biopesticide is used as well, i.e. a mix of garlic, ginger and green chili, which can be applied later in the season on fruits
Weed control	Removal of alternative host plants (Dossier Sections 3 and 4).
Biological control	Conservation biocontrol is applied, by conserving some vegetation around production sites to host and protect natural occurring enemies.
Cultural control (fruit bagging)	Polyethylene bags are used to prevent the fruits from infestation by insects. Bags are placed right after fruit setting.

6.3. Risk mitigation measures applied in the packing house

With the information provided by the National Plant Quarantine Service (Dossier Sections 3 and 7), the Panel summarised the risk mitigation measures that are currently applied in the packing house.

Table 5: Overview of currently applied risk mitigation measures in the packing house for *Momordica charantia* fruits designated for export to the EU from Sri Lanka

Risk mitigation measure	Description of applied measures
Sorting/Grading	Previous to washing and drying the fruits are manually sorted out (and graded when washed using the mechanical method), see main Dossier page 30.
Brushing	Individual fruits are brushed manually. The brush is regularly cleaned, and the water refreshed (Dossier Section 7)
Manual Washing	Fruits are washed with running water or put in series of baths with chlorine water to remove debris and pests (page 48 of Main Dossier).
High-pressure washing and drying	Washing can occur mechanically, and in this case, fruits are washed with ozonated water (page 48 of main dossier), subsequently fruits are air-dried

Risk mitigation measure	Description of applied measures
Inspection in packing house	Fruits are visually inspected by official inspectors at the packing house.
Inspection at border control (before export)	There is an inspection at border control prior to export, in this case a magnification lens or stereomicroscope is used.

6.4. Overview of the evaluation of *Thrips palmi*

Rating of the likelihood of pest freedom	Pest free with some exceptional cases (based on the median)				
	5%	25%	Median	75%	95%
Percentile of the distribution					
Proportion of pest free plants	9,831 out of 10,000 plants	9,934 out of 10,000 plants	9,972 out of 10,000 plants	9,994 out of 10,000 plants	9,999 out of 10,000 plants
Proportion of infested plants	1 out of 10,000 plants	16 out of 10,000 plants	28 out of 10,000 plants	66 out of 10,000 plants	169 out of 10,000 plants
Summary of the information used for the evaluation	<p>Possibility that the pest could become associate with the commodity Environmental conditions in Sri Lanka are optimal for <i>T. palmi</i> development. <i>T. palmi</i> is probably widespread in the area of production but neither the Sri Lanka Department of Agriculture nor farmers are considering it as a phytosanitary problem. Research has shown that <i>T. palmi</i> is occurring on many other plants and crops in Sri Lanka.</p> <p>Measures taken against the pest and their efficacy The main control measures applied in the field until harvest are inspections and monitoring, separation and registration of production fields and fruit bagging. The application of insecticides takes place before fruit setting and is targeting other pests than <i>T. palmi</i>. After fruit setting, only a homemade biopesticide is applied. Measures in the packing house include inspection before processing, brushing, high-pressure washing and consignment inspections before packing. Measures in the packing house target mainly adults and larvae and have minimal effect on eggs.</p> <p>Interception records There are 12 interceptions of <i>T. palmi</i> on <i>M. charantia</i> fruits from Sri Lanka into the EU since 2009. For the period comprised between 1995 and 2009, there are no interceptions reported.</p> <p>Shortcomings of current measures/procedures</p> <ul style="list-style-type: none"> • Application of insecticides is sporadic. • Most measures applied in the packing house are not likely to have an effect on eggs that may be present on fruits. <p>Main uncertainties</p> <ul style="list-style-type: none"> • There are limited data on population dynamics of <i>T. palmi</i> on <i>M. charantia</i>. • Specific efficacy data for field applied measures are either limited or not available. • Data on efficacy of the methods applied in the packing house in removing <i>T. palmi</i> from fruits are not available. 				

6.5. Outcome of expert knowledge elicitation

Table 5 and Figure 4 show the outcome of the EKE regarding pest freedom after the evaluation of the currently proposed risk mitigation measures for *T. palmi*.

Figure 4 provides an explanation of the descending distribution function describing the likelihood of pest freedom after the evaluation of the currently proposed risk mitigation measures for *M. charantia* fruits designated for export to the EU for *T. palmi* (Table 6).

Table 6: Assessment of the likelihood of pest freedom following evaluation of current risk mitigation measures against *Thrips palmi* on *Momordica charantia* fruits from Sri Lanka 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

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 always pest free
<i>Thrips palmi</i>				L		M		U

PANEL A

	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 median
	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		

PANEL B

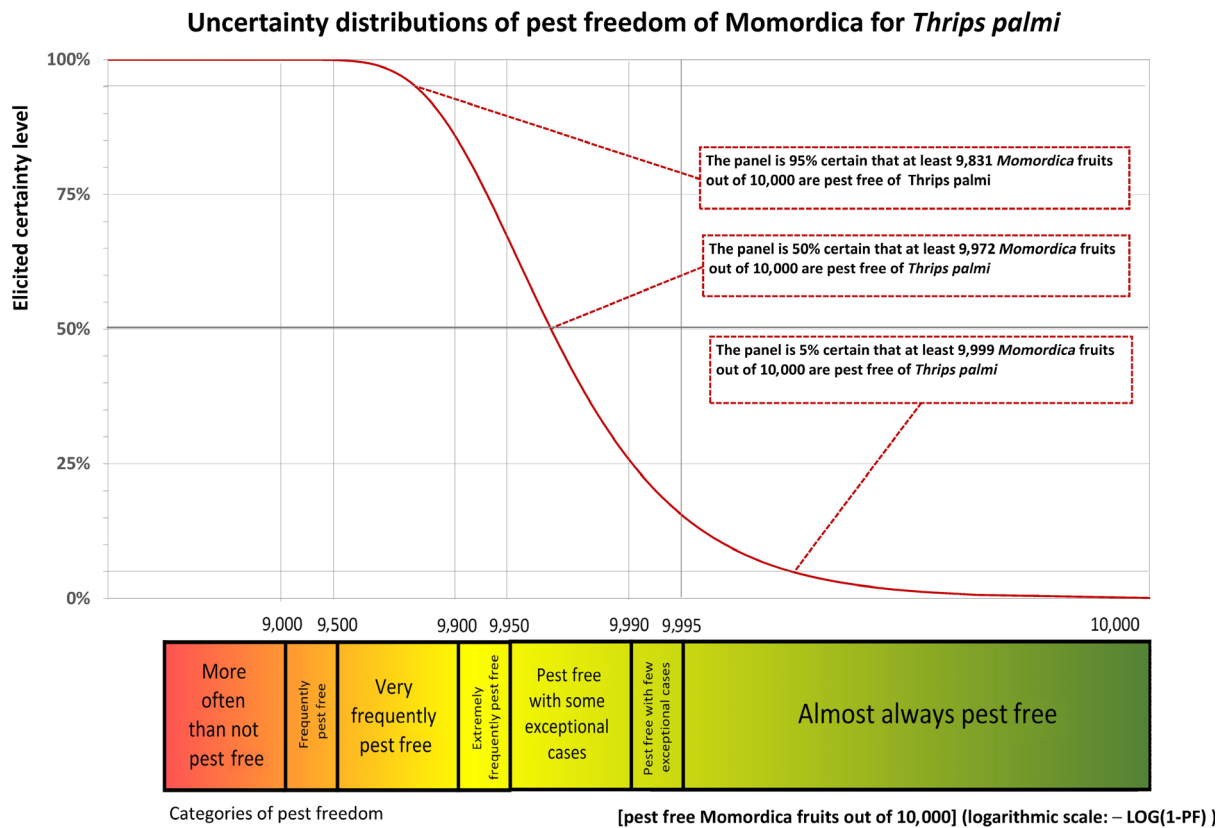


Figure 4: Explanation of the descending distribution function describing the likelihood of pest freedom from *Thrips palmi* after the evaluation of the currently proposed risk mitigation measures for fruits of *Momordica charantia* from Sri Lanka designated for export to the EU

7. Conclusions

For *T. palmi* on *M. charantia* fruits from Sri Lanka, the likelihood of pest freedom following evaluation of current risk mitigation measures was estimated as ‘*pest free with some exceptional cases*’ with the 90% uncertainty range reaching from ‘*very frequently pest free*’ to ‘*almost always pest free*’. The EKE indicated, with 95% certainty, that between 9,831 and 10,000 fruits per 10,000 will be free from *T. palmi*.

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Glossary

Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2017)
Measures	Control (of a pest) is defined in ISPM 5 (FAO 2017) as "Suppression, containment or eradication of a pest population" (FAO, 1995). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk mitigation measures that do not directly affect pest abundance.
Pathway	Any means that allows the entry or spread of a pest (FAO, 2017)
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)
Pest pressure	Local population density of a pest (often used in economic threshold levels in IPM)
Protected zone	A Protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union.

Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)
Risk mitigation measure	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A risk mitigation measure may become a phytosanitary measure, action or procedure according to the decision of the risk manager
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2017)

Abbreviations

CABI	Centre for Agriculture and Bioscience International
DD	degree-days
EIL	economic injury level
EKE	Expert Knowledge Elicitation
ET	economic threshold
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
ISPM	International Standards for Phytosanitary Measures
MeSA	methyl salicylate
PLH	Plant Health
PRA	Pest Risk Assessment

Appendix A – Data sheets of pests selected for further evaluation via Expert Knowledge Elicitation

A.1. Thrips palmi

A.1.1. Organism information

Taxonomic information	<p>Current valid scientific name: <i>Thrips palmi</i> Karny</p> <p>Synonyms: <i>Thrips leucadophilus</i> Priesner, <i>Thrips gossypicola</i> (Priesner)</p> <p>Ramakrishna & Margabandhu, <i>Chloethrips aureus</i> Ananthakrishnan & Jagadish, <i>Thrips gracilis</i> Ananthakrishnan & Jagadish</p> <p>Name used in the EU legislation: <i>Thrips palmi</i> Karny [THRIPL]</p> <p>Order: Thysanoptera</p> <p>Family: Thripidae</p> <p>Common name: oriental thrips, palm thrips, southern yellow thrips</p> <p>Name used in the Dossier: <i>Thrips palmi</i></p>
Group	Insects
EPPO code	THRIPL
Regulated status	<p><i>Thrips palmi</i> is regulated in the European Union, and it is listed in the Union Quarantine pests: Annex II Part A – Pests not known to occur in the European Union. Commission Implementing Regulation (EU) 2019/2072.</p> <p>A1 list: East Africa (2001), Egypt (2018), Southern Africa (2001), Argentina (2019), Chile (2019), Paraguay (1993), Uruguay (1993), Bahrain (2003), Jordan (2013), Kazakhstan (2017), Azerbaijan (2007), Georgia (2018), Moldova (2006), Russia (2014), Turkey (2016), Ukraine (2019), EAEU (2016), EPPO (1988)</p> <p>A2 list: CAHFSA (1990), COSAVE (2018)</p> <p>Quarantine: Morocco (2018), Tunisia (2012), Mexico (2018), Israel (2009), Norway (2012), New Zealand (2000)</p>
Pest status in Sri Lanka	<p>Present (EPPO, Online; CABI CPC, Online).</p> <p><i>T. palmi</i> is present and common in most of the areas where bitter melon is cultivated for export (Tillekaratne et al., 2012)</p>
Pest status in the EU	Absent (EPPO, Online; CABI CPC, Online)
Host status on <i>Momordica charantia</i> L.	According to the Pest categorisation of <i>Thrips palmi</i> (EFSA, 2019), <i>Momordica charantia</i> is one of the main host plants of <i>Thrips palmi</i> .
PRA information	<p>Pest Risk Assessments currently available:</p> <ul style="list-style-type: none"> – Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports (Australian Government Department of Agriculture and Water Resources, 2017) – Pest categorisation of <i>Thrips palmi</i> (EFSA Scientific Opinion, 2019)
Interceptions (Europhyt/Traces-NT)	There are 12 interceptions of <i>T. palmi</i> on <i>M. charantia</i> fruits from Sri Lanka into the EU since 2009. For the period comprised between 1995 and 2009 there are no interceptions reported.

Other relevant information for the assessment

Surveillance information

Councilors for Agri-Business (CAB), Department of Agriculture, carefully monitor and inspect farmer activities. Field inspections are continuously carried out by CAB officers (1–2 times per week) that are trained for the task. CAB officers train farmers for: crop observation: performed daily by farmers; fruit covering; use of sticky traps, use of insect proof nets. (dossier section 7)

Growers use sticky traps to monitor *T. palmi* in the field (3–4 traps per 100 square feet). Captures are checked weekly or every 10 days under CAB officer's guidance. (dossier section 7)

Country specific information

A.1.2. Pest pressure in the production area

The most economically important pest associated with bitter melon in Sri Lanka is the melon fly *Bactrocera cucurbitae* (Diptera Tephritidae), whereas 'there is no evidence that *Thrips palmi* is a major pest of bitter melon in the Country' (Tillekaratne et al., 2012). However, *T. palmi* was intercepted on other crops such as eggplant.

Thrips spp. have been observed in some areas of Sri Lanka, during the first phenological phases of the crop, but rarely in the fruiting stage. The paper of Tillekaratne et al. (2012) presents a list of 72 thrips species in 45 genera recorded during the survey from 324 host plant species in 83 plant families. *Megalurothrips usitatus*, *Thrips palmi* and *Haplothrips gowdeyi* were the most widely distributed species and *T. palmi* was the second most common species and was recorded from 43 plant species.

In the dossier submitted by Sri Lanka for import *Momordica* in the EU there is no information about important host plants occurring in the production area. However, the collection sites of Tillekaratne et al. (2012) seem to cover most of the districts where *Momordica* is grown for export.

Uncertainties:

- There are no detailed data on population dynamics of *T. palmi* on *M. charantia*.
- Since identification of thrips at species level is difficult in the field, it is possible that field observations of thrips refer to other species than *T. palmi*.

A.1.3. Evaluation of measures applied in the field

To start a cultivation for export, farmers need to be registered in the Sri Lanka Dept. of Agriculture (DOA) and must follow the instructions of CAB (Councilors for Agri-business) officers. DOA provides farmers with IPM guidelines to follow. If the pest pressure in the *M. charantia* fields is under control, the export certification is released by DOA. IPM package combines the use of various practices, such as use of insect proof nets (height 3 m to cover the crop, 40–50 mesh size, 0.26 mm hole size), pod covering by polythene tubes, use of pheromone traps, sticky traps or baits, use of mild chemicals and biopesticides when necessary. The pod covering by polythene tubes, if well done, can be an efficient way to prevent *T. palmi* contact with bitter melon.

Production fields for export are kept separated from those for local market with the aim to maintain export fields free from pests.

Continuous monitoring and record keeping by farmers and inspection by Agriculture extension officers is carried out during the entire production cycle. According to the dossier, daily assessments are carried out by farmers to identify pests and diseases in the field. Each fruit is covered after pollination and this can prevent direct contact of pests with fruits, for melon fly and thrips as well. Pheromone and sticky traps are used under the supervision of CAB officers, which regularly inspect the traps and train farmers to continuously check for pests. This helps farmers to prevent pest damage applying suitable control measures, though application of chemicals is not usually performed during the production cycle. Few chemicals have been recommended in the past to control virus vectors (imidacloprid, thiametoxam, thiacyclam, abamectine) but always at a very early stage (vegetative phase), before flowering and at the appearance of viral symptoms; chemical insecticides are not applied at fruiting stage.

Uncertainties:

- No specific information is provided on timing of trap checking, presence and number of *T. palmi* specimens collected in the traps along the season and, overall, about the methods they use for taxonomic discrimination of *T. palmi* from other thrips caught in the traps.
- Specific efficacy data are not available.

Table A.1: Overview, evaluation and uncertainties of measures applied in the field against *Thrips palmi* on *Momordica charantia* fruits from Sri Lanka designated for export to the EU

Overview of measures applied in the field		
Risk mitigation measure	Description of applied measure	Evaluation and uncertainties
Monitoring and inspection	<p>Sticky traps (blue and yellow) are used for monitoring, i.e., 25 per acre. (Annex 5) (3–4 traps/1,000 sqm feed which is equivalent to ca. 1 trap every 5 × 5 m)</p> <p>Daily inspection is carried out by farmers and by agricultural extension officers (dossier sections 3 and 4).</p> <p>They do thorough inspections of crops and weeds to prevent the establishment/occurrence of pests (aphids, flies, thrips, etc.). Very detailed labour-intensive inspection.</p>	<p>Inspection is thorough as this is conducted by the farmers, and by NPPO before delivering fruits to packing house and then after the post-harvest treatment. Nonetheless, examination of bagged fruits at farm level and detection of <i>T. palmi</i> is very difficult, especially for young larvae and eggs.</p> <p>Uncertainties:</p> <p>Trap density can be considered as a high intensity trapping but not mass-trapping. Details on size of sticky traps are unclear.</p> <p>Data on detection thresholds are not provided neither with the dossier or in the reply for clarification</p>
Physical protection of production fields	<p>Fields for export are separated by insect-proof nets. However, details on the separation and exact location of local vs. export sites are not provided.</p> <p>The separation net is 3 m high and has a 40–50 mesh size</p>	<p>Because the top is open, there can be still some dispersal among fields.</p> <p>This means that the net is not protective enough for <i>T. palmi</i>. It prevents infestation by aphids and fruit flies but is not efficient against <i>T. palmi</i> (both adults and larvae). For <i>T. palmi</i>, usually a 100-microns net must be used.</p>
Chemical control	<p>Thiocyclam (systemic insecticide) is only used in vegetative stages of production, twice during the growing season.</p> <p>There is sporadic use of other insecticides to control insect vector of plant viruses. In particular three products are mentioned: 1) imidacloprid; 2) thiamethoxam; 3) Abamectin. In all cases, chemical control occurs before fruit setting.</p> <p>A biopesticide is used as well, i.e., a mix of garlic, ginger and green chili, which can be applied later in the season on fruits</p>	<p>During the fruiting period no product is applied other than the mentioned biopesticide (mix of garlic, ginger and chili).</p> <p>Uncertainties:</p> <ul style="list-style-type: none"> – The application regime of the four mentioned insecticides is unclear – The efficacy against <i>T. palmi</i> of the biopesticide is uncertain, according to Sri Lanka it has a 100% efficacy in chili, but no data are provided for <i>M. charantia</i> and <i>T. palmi</i>.
Weed control	Removal of alternative host plants	<p>This measure has low control efficacy against <i>T. palmi</i></p> <p>Uncertainties:</p> <ul style="list-style-type: none"> – Species that are removed are not specified – Methodology and frequency not detailed
Biological control	Conservation biocontrol is applied, by conserving some vegetation around production sites to host and protect natural enemies.	As (some) weeds are also removed, this can also affect the population levels of the natural enemies. This method has a low efficacy against <i>T. palmi</i> .
Cultural control (fruit bagging)	Poly-ethylene bags are used to prevent the fruits from infestation by insects. Bags are placed right after fruit setting.	Fruit bagging can be effective against <i>T. palmi</i> as farmers apply the bags right after flowering and use a systemic insecticide; nonetheless, bagging cannot prevent the development of eggs already present in flower buds or in early-stage fruits. Also, the bags are open at the bottom so still some <i>T. palmi</i> could get inside.

Overview of measures applied in the field		
Risk mitigation measure	Description of applied measure	Evaluation and uncertainties
		Uncertainties: – Considering the small size of <i>T. palmi</i> juveniles, there is still the possibility of infestation. The bag should be very tight to prevent this. – Efficacy data are not available

Table A.2: Overview of insecticides and other phytosanitary products used for the control of *Thrips palmi* in *Momordica charantia* fields in Sri Lanka based on the information provided in sections of the dossier 1, 3 and 7

Insecticides and other phytosanitary products used to control <i>Thrips palmi</i>			
Product	Type of product	Efficacy as reported in dossier	Efficacy Evaluation by the Panel
Abamectin	Translaminar insecticide	Not reported	High effect
Thiametoxam	Systemic insecticide	Not reported	High effect
Thiocyclam	Systemic insecticide; neurotoxin analogue, contact insecticide	100%	High effect
Imidacloprid	Systemic insecticide	66–90%	High effect
Biopesticide composed: garlic, ginger and chili	Repellent	100% on chili plants, on <i>Momordica</i> and <i>T. palmi</i> efficacy not reported	Low effect

A.1.3.1. Evaluation of measures applied in the packing house

Two methods are adopted in the packing house to remove thrips and other pests from BG: a manual method and a machine method. The first method is used by 18 exporting companies. In this case fruits are cleaned by brushing with a fine brush and by washing in running water. To be effective, brush must be continuously cleaned, and water often changed. Machine cleaning is used only by one exporting company, though it is willing to be a service provider for other bitter gourd exporters. The machine process includes deep washing, rotating, pressure washing and blow drying of fruits.

Manual method is used for 60% of bitter gourd consignments, machine method for 40% as well. No internal rejections were recorded in the case of manual and machine cleaning in 2019, whereas two internal rejections have been recorded after manual cleaning in previous years.

Both methods (manual and by machine) appear effective in cleaning fruits from adults and juveniles of *T. palmi* but not from the eggs, that are internally laid in the fruits. In fact, rejections already occurred in the case of manual cleaning leave a door open to possible failures in the process. Differently from the machine cleaning, which appears a standardized tested method, the manual cleaning strongly depends on the skill and the accuracy of the worker.

Uncertainties:

- Data on efficacy of the above methods in removing *T. palmi* from fruits were not made available.

Table A.3: Overview of post-harvest measures used in *Momordica charantia* packing houses in Sri Lanka based on the information provided in sections of the dossier 3 and 7

Overview of post-harvest measures applied		
Risk mitigation measure	Description of applied measures	Evaluation and uncertainties
Sorting/Grading	Previous to washing and drying the fruits are manually sorted out (and graded when washed using the mechanical method) (Dossier Section 3)	This method is intended mainly as first filter to discard fruits infested by pests or when they do not fulfil quality (visual) requirements. As such, this process is not aimed to detect <i>T. palmi</i> in particular. It will only detect heavily infested fruits showing clear symptoms of infestation.
Brushing	Individual fruits are brushed manually. The brush is regularly cleaned, and the water refreshed (Dossier Sections 3 and 7)	The brushing has no effect on eggs, especially when using soft brushing, as eggs are laid inside the fruit tissue. Brushing has only low to intermediate effect on larvae and adults. Brushed adults may not be killed and therefore they can re-infest other fruits in the packing station. Efficacy data on brushing are not provided
Manual Washing	Fruits are washed with running water or put in series of baths with chlorine water to remove <i>debris</i> and pests (page 48 of main dossier). – Chlorine: is mainly used to disinfect material and to prevent microbial infection.	As such, chlorine treatment is mainly addressed to disinfect fruits and to prevent microbial infections. The effect of chlorine water on insects is uncertain as this compound is mainly used as a bacterial disinfectant. Manual washing has no effect on <i>T. palmi</i> eggs and it shows an intermediate effect on larvae and adults. If water is not refreshed frequently, there is a risk of re-infesting clean material. Data on the efficacy of this method are not provided
High-pressure washing and drying	Washing can occur mechanically, and in this case, fruits are washed with ozonated water (page 48 of Main Dossier), subsequently fruits are air-dried	Ozonated water is mainly used to disinfect material and to prevent microbial infections. The effect of ozonated water on insects is uncertain. Based on the information provided in the dossier 40% of the fruits for export are washed mechanically. Data on the efficacy of this method are not provided
Inspection in packing house	Fruits are visually inspected by official inspectors at the packing house.	Eggs are present inside fruit tissues so are extremely difficult to detect during visual inspections. Without a magnifying lens or a stereomicroscope, official inspection may not only detect eggs <i>in primis</i> but also larvae and, sometimes, even adults.
Inspection at border control (before export)	There is an inspection at border control prior to export, in this case a magnification lens or stereomicroscope is used.	In this case, the chances of detecting infested material are higher. Following ISPM 23 guidelines, a subset of the consignment is inspected. At this stage, even using a stereomicroscope you may easily overlook <i>T. palmi</i> eggs.

A.1.4. Information from interceptions

There are five interceptions of *T. palmi* from Sri Lanka into the EU in the last five years.

A.1.5. Overall likelihood of pest freedom

Rating of the likelihood of pest freedom	Pest free with some exceptional cases (based on the median)				
	5%	25%	Median	75%	95%
Percentile of the distribution					
Proportion of pest free plants	9,831 out of 10,000 fruits	9,934 out of 10,000 fruits	9,972 out of 10,000 fruits	9,994 out of 10,000 fruits	9,999 out of 10,000 fruits
Proportion of infested plants	1 out of 10,000 fruits	10 out of 10,000 fruits	28 out of 10,000 fruits	66 out of 10,000 fruits	169 out of 10,000 fruits
Summary of the information used for the evaluation	<p>Possibility that the pest could become associate with the commodity Environmental conditions in Sri Lanka are optimal for <i>T. palmi</i> development. <i>T. palmi</i> is probably widespread in the area of production but neither the Sri Lanka Department of Agriculture nor farmers are considering it as a phytosanitary problem. Research has shown that <i>T. palmi</i> is occurring on many other plants and crops in Sri Lanka.</p> <p>Measures taken against the pest and their efficacy The main control measures applied in the field until harvest are inspections and monitoring, separation and registration of production fields and fruit bagging. The application of insecticides takes place before fruit setting and is targeting other pests than <i>T. palmi</i>. After fruit setting, only a homemade biopesticide is applied. Measures in the packing house include inspection before processing, brushing, high-pressure washing and consignment inspections before packing. Measures in the packing house target mainly adults and larvae and have minimal effect on eggs.</p> <p>Interception records There are 12 interceptions of <i>T. palmi</i> on <i>M. charantia</i> fruits from Sri Lanka into the EU since 2009. For the period comprised between 1995 and 2009 there are no interceptions reported.</p> <p>Shortcomings of current measures/procedures</p> <ul style="list-style-type: none"> • Application of insecticides is sporadic. • Most measures applied in the packing house are not likely to have an effect on eggs that may be present on fruits. <p>Main uncertainties</p> <ul style="list-style-type: none"> • There are limited data on population dynamics of <i>T. palmi</i> on <i>M. charantia</i>. • Specific efficacy data for field applied measures are either limited or not available. • Data on efficacy of the methods applied in the packing house in removing <i>T. palmi</i> from fruits are not available. 				

A.1.5.1. Reasoning for a scenario which would lead to a reasonably low number of infested consignments

Pest pressure

- *Thrips palmi* is not a major pest of *Momordica* in Sri Lanka.
- *Momordica* is not a good host in Sri Lanka compared to other crops present in the country so it will not be preferred.
- The frequency of insecticides treatments for *T. palmi* is very low, so probably it reflects a low incidence of the pest.
- The number of interceptions in relation to the number of export consignments is low.
- The surrounding environment provides very few hosts for *T. palmi* (i.e. population sources).
- Natural biological control agents are very active and preserved and keep *T. palmi* at bay.
- There is general pest management in place for thrips in agricultural areas where *M. charantia* is cultivated.

Field measures

- Fields for export are monitored and supervised for consecutive growing cycles resulting in high awareness of farmers for detection and measures implementation against *T. palmi*.
- Application of insecticides is highly effective at a very early time when thrips populations are low.
- Fruit bagging prevents thrips infestation. Survival of hatched larvae from earlier oviposited eggs is limited due to systemic action of applied insecticide.

Measures in the packing house

- Applied cleaning methods (washing, brushing, etc.) will remove larvae and adults from the fruits.
- Inspection prior to delivering will sort out heavily infested fruits.
- Inspections prior to placing to packages by experienced personnel will detect infested fruits including eggs.

A.1.5.2. Reasoning for a scenario which would lead to a reasonably high number of infested consignments

Pest pressure

- The fact that the first production period is for local market indicates that the pest pressure is high and sufficient control cannot be achieved.
- *Momordica* is a preferred host in Sri Lanka compared to other crops.
- *T. palmi* was the second most common species and was recorded from 43 plant species.
- *T. palmi* has been intercepted in the past twelve years on *M. charantia* fruits from Sri Lanka.
- The surrounding environment provides many hosts for *T. palmi*.
- Environment contains uncontrolled sites of the pest (e.g., and eggplant plantation without efficient control).
- Natural biological control agents are not active and preserved to control *T. palmi* due to poor management in other crops.

Field measures

- Traps are not dense enough for mass trapping of *Thrips palmi*.
- Examination of bagged fruits at farm level and detection of *T. palmi* is very difficult, especially for young larvae and eggs.
- Efficacy of insecticide is moderate. No insecticides are applied during the harvesting period.
- Bagging cannot prevent the development of eggs already present in flower buds or early-stage fruits. Also, the bags are open at the bottom so still some *T. palmi* could get inside.

Measures in packing house

- Inspections at packing house and initial sorting of fruits are not conducted properly and are not effective in detecting and discarding infested fruits.
- Cleaning measures (with water and other products, manually or using machines) are not effective against *T. palmi* and do not render pest-free fruits.
- Interceptions do occur despite all cleaning precautions.
- Additives and other products used do not have an effect on the mortality of *T. palmi*.
- Large proportion of infestation are eggs.

A.1.5.3. Reasoning for a central scenario equally likely to over- or underestimate the number of infested consignments (Median)

- The surrounding environment provides sufficient hosts for *T. palmi*.
- Most monitored thrips are likely to be *T. palmi*.
- Procedures in the packinghouse are effective in removing larvae and adult stages of *T. palmi* and detecting infested fruits.

A.1.5.4. Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

- Specific efficacy data for field applied measures are either limited or not available.
- Data on efficacy of the methods applied in the packing house in removing *T. palmi* from fruits are not available.
- It is uncertain to what extent infestation reported in the field on vegetative plant parts (e.g. leaves) is related to infestation numbers on the fruits.
- The schemes of insecticide application and their efficacy in Sri Lanka are uncertain.
- The clarification is given by the level of uncertainty which is higher for the values below the median.

A.1.5.5. Elicitation outcomes of the assessment of the pest freedom for *Thrips palmi*

The following Tables show the elicited values for pest freedom in *Momordica charantia* fruits according to a three-step approach (i.e. estimating pest pressure, effectiveness of the measures applied in the field and in the packing house) (Table A.4) to come to a final estimation of likelihood of pest freedom (Table A.5) (Figures A.1, A.2)

Table A.4: Elicited values to estimate the likelihood of pest freedom (i.e., no. of pest free fruits out of 10,000, elicited as 10,000 minus no. of infested fruits) and the fitted distributions in a three-step model (i.e. Import risk: $r_{import} = p_{pressure} \times p_{field}/10,000 \times p_{packing}/10,000$; Pestfreedom: $PF_{import} = 10,000 r_{import}$)

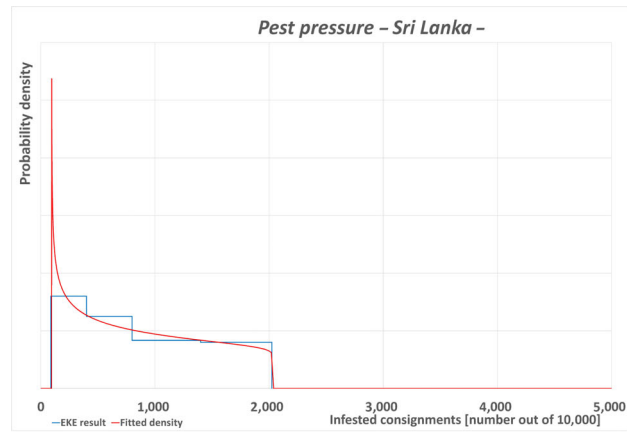
Percentile	Parameter	1%	25%	50%	75%	99%	Fitted distribution
Elicited values for pest pressure	$p_{pressure}$	100	400	800	1,400	2,000	BetaGeneral (0.74965, 1.0571, 95, 2040)
Elicited values for measures in the field	p_{field}	500	1,500	2,500	4,500	6,700	BetaGeneral (0.95631, 1.2207, 75, 4100)
Elicited values for measures in the packinghouse	$p_{packing}$	100	900	1,700	2,800	4,000	BetaGeneral (0.80872, 1.2947, 480, 6950)
Resulting model values for the import risk after Monte Carlo simulation	r_{import}	0.6	8.8	25	64	295	Calculated with @Risk version 7.6
As pest free fruits		9,705	9,936	9,975	9,991.2	9,999.4	

Table A.5: The uncertainty distribution of fruits free of *Thrips palmi* per 10,000 fruits calculated by taking into account a 3-step procedure and according to elicited values in Table A.4

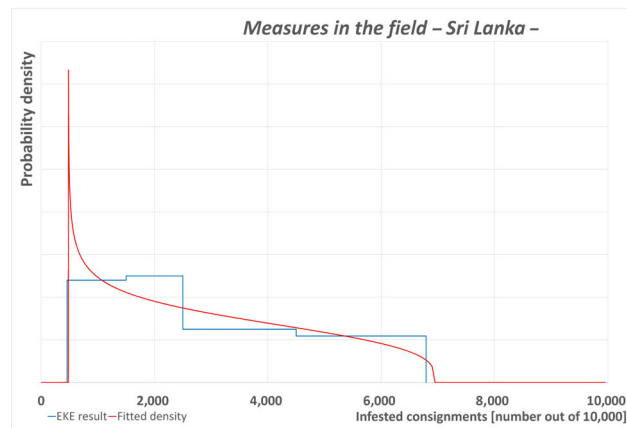
Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
3-step approach for pest freedom	9,705	9,766	9,817	9,869	9,908	9,936	9,953	9,975	9,987	9,991.2	9,994.5	9,996.7	9,998.2	9,999.0	9,999.4
EKE results	9,714	9,782	9,831	9,878	9,910	9,934	9,951	9,972	9,985	9,990.4	9,994.5	9,997.2	9,998.8	9,999.5	9,999.8

The EKE results are the fitted values for a Weibull distribution (0.81611,43.983) fitted with @Risk version 7.6.

(a)



(b)



(c)

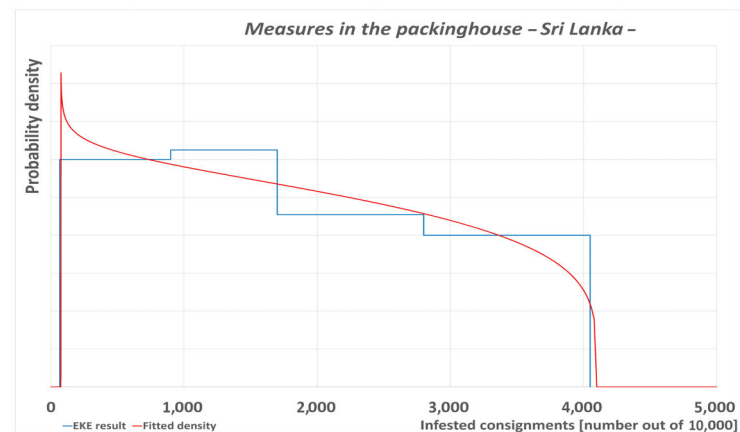


Figure A.1: Probability densities for the number of pest-free *Momordica charantia* fruits (x-axis) out of 10,000 designated for export to the EU introduced according to (a) estimated pest pressure in the field; (b) measures applied in the field; and (c) measures applied in the packing house for *Thrips palmi*

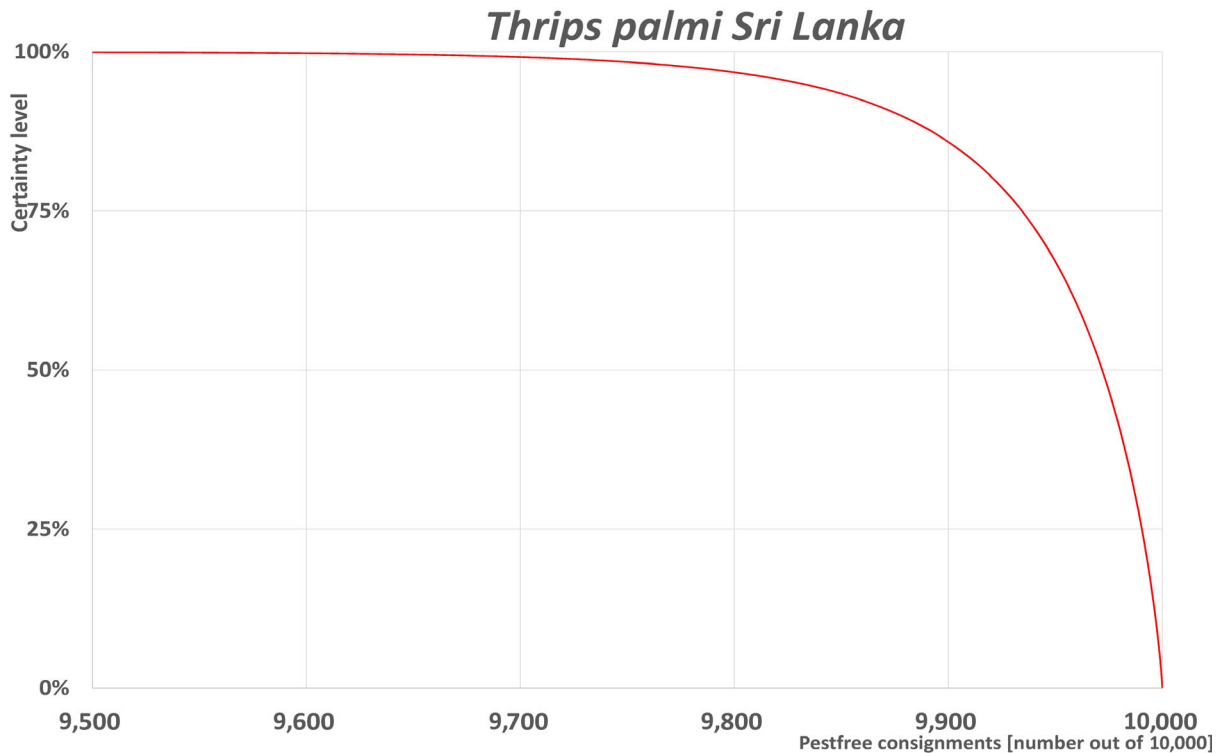


Figure A.2: Elicited certainty (y-axis) of the number of pest-free *Momordica charantia* fruits (x-axis; log-scaled) out of 10,000 plants designated for export to the EU introduced from Sri Lanka for *Thrips palmi* visualised as descending distribution function. Horizontal lines indicate the percentiles (starting from the bottom 5%, 25%, 50%, 75%, 95%). The Panel is 95% sure that 9406 or more fruits per 10,000 will be free from *Thrips palmi*

A.1.6. Reference list

- Australian Government Department of Agriculture and Water Resources, 2017. Final group pest risk analysis for thrips and orthospoviruses on fresh fruit, vegetable, cut-flower and foliage imports.
- EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Dehnen-Schmutz K, Gonthier P, Jacques MA, Di Serio F, Justesen AF, Macleod A, Magnusson CS, Milonas P, Nava-Cortes JA, Parnell S, Potting R, Reignault PL, Thukle HH, Van der Werf W, Civera AV, Yuen J, Zappala L, Bosco D, Chiumenti M, Di Serio F, Galetto L, Marzachi C, Pautassco M and Jacques MA, 2019. Pest categorisation of *Thrips palmi*. EFSA Journal, 17(2).
- EUROPHYT, online. European Union Notification System for Plant Health Interceptions – EUROPHYT Available online: http://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/index_en.htm [Accessed: 22 April 2020].
- EPPO (European and Mediterranean Plant Protection Organization), online. *Thrips palmi* Available online: <https://gd.eppo.int/taxon/THRIPL> [Accessed: 20 July 2020].
- CABI CPC (Centre for Agriculture and Bioscience International), online. Datasheet *Thrips palmi* Available online: <https://www.cabi.org/cpc/datasheet/5374> [Accessed: 22 July 2020]

Appendix B – Web of Science All Databases Search String

In the table below the search string used in Web of Science is reported.

Web of Science	<p>TOPIC: ("Momordica" OR "<i>Momordica charantia</i>" OR "<i>M. charantia</i>" OR "Momordica anthelmintica Guin." OR "Momordica elegans Salisb." OR "Momordica muricata Willd." OR "Momordica operculata Vell." OR "Momordica senegalensis Lam." OR "bitter gourd" OR "bitter melon" OR "Cucurbitaceae" OR "balsam apple" OR "balsam pear" OR "bitter balsam apple" OR "bitter cucumber" OR "bitter melon" OR "carilla gourd" OR "paria" OR "wild balsam- apple" OR "cucumber" OR "melon") AND TOPIC: ("<i>Thrips palmi</i>" OR "melon thrips" OR "<i>Thrips palmi</i> Karny, 1925" OR "Chloethrips aureus Ananthkrishnan & Jagadish, 1967" OR "Thrips clarus Moulton, 1928" OR "Thrips gossypicola (Priesner, 1939)" OR "Thrips gracilis Ananthkrishnan & Jagadish, 1968" OR "Thrips leucadophilus Priesner, 1936" OR "Thrips nilgiriensis Ramakrishna 1928" OR "Oriental thrips" OR "southern yellow thrips") AND TOPIC: ("pest pressure" OR "population build-up" OR "pesticide application\$" OR "pesticide\$" OR "risk reduction option\$" OR "mitigation measure\$" OR "efficac*" OR "resistance" OR "population dynamic\$" OR "phytosanitary product\$" OR "registered pesticide\$" OR "high pressure water*" OR "air pressur*" OR "population dynamic\$" OR "field densit*" OR "occurrence" OR "monitor*" OR "sticky trap\$" OR "sticky trap\$ efficac*") AND TOPIC: ("Sri Lanka")</p>
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