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Thrips palmi
Pest Report to support ranking of EU candidate priority pests

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1. Introduction to the report

This document is one of the 28 Pest Reports produced by the EFSA Working Group on EU Priority Pests under task 3 of the mandate M-2017-0136. It supports the corresponding Pest Datasheet published together on Zenodo[1] and applies the methodology described in the Methodology Report published on the EFSA Journal (EFSA, 2019).

This Pest Report has five sections. In addition to this introduction, a conclusion and references, there are two key sections, sections 2 and 3.

Section 2 first summarises the relevant information on the pest related to its biology and taxonomy. The second part of Section 2 provides a review of the host range and the hosts present in the EU in order to select the hosts that will be evaluated in the expert elicitations on yield and quality losses. The third part of Section 2 identifies the area of potential distribution in the EU based on the pest's current distribution and assessments of the area where hosts are present, the climate is suitable for establishment and transient populations may be present. The fourth part of Section 2 assesses the extent to which the presence of the pest in the EU is likely to result in increased treatments of plant protection products. The fifth part of section 2 reviews additional potential effects due to increases in mycotoxin contamination or the transmission of pathogens.

In Section 3, the expert elicitations that assess potential yield losses, quality losses, the spread rate and the time to detection are described in detail. For each elicitation, the general and specific assumptions are outlined, the parameters to be estimated are selected, the question is defined, the evidence is reviewed and uncertainties are identified. The elicited values for the five quantiles are then given and compared to a fitted distribution both in a table and with graphs to show more clearly, for example, the magnitude and distribution of uncertainty. A short conclusion is then provided.

The report has two appendices. Appendix A contains a host list created by amalgamating the host lists in the EPPO Global Database (EPPO, online) and the CABI Crop Protection Compendium (CABI, 2018). Appendix B provides a summary of the evidence used in the expert elicitations.

It should be noted that this report is based on information available up to the last day of the meeting[2] that the Priority Pests WG dedicated to the assessment of this specific pest. Therefore, more recent information has not been taken into account.

For *Thrips palmi,* the following documents were used as key references: EFSA Pest Categorisation (EFSA PLH Panel, 2019), CABI Crop Protection Compendium Datasheet (CABI, 2018).

[1] Open-access repository developed under the European OpenAIRE program and operated by CERN, https://about.zenodo.org/

[2] The minutes of the Working Group on EU Priority Pests are available at http://www.efsa.europa.eu/sites/default/files/wgs/plant-health/wg-plh-EU_Priority_pests.pdf

2. The biology, ecology and distribution of the pest

2.1. Summary of the biology and taxonomy

Thrips palmi (Karny) is a single taxonomic entity. This species is a gregarious sap feeder characterised by six stages: egg, four pre-imaginal stages (two active larval stages and two relatively inactive pupal stages) and adult. Eggs, larval stages and adults colonize the host plants, whereas propupae and pupae live in the soil or among the leaf litter.

Damage is caused by feeding on leaves around the growing tips before expansion. Leaves show a bronze/silver colour and terminal shoots are stunted. Fruit can be scarred and deformed. The pest is capable of reproducing through parthenogenesis. Aggregation behaviour is caused by the recently discovered male-produced aggregation pheromone (R)-lavandulyl 3-methyl-3-butenoate (Akella et al., 2014). *T. palmi* is a natural prey for other insects such as *Orius* spp. and *Franklinothrips vespiformis*.

The threat posed by *T. palmi* derives from its high reproductive rate, low sensitivity to insecticides and wide host range.

Thrips palmi is also a vector for several plant viruses (including Tomato spotted wilt virus and Watermelon silver mottle virus).

2.2. Host plants

2.2.1. List of hosts

Thrips palmi is a polyphagous pest, feeding on hosts of economic importance such as Cucurbitaceae and Solanaceae*:* eggplants (*Solanum melongena*), cotton (*Gossypium* spp.), cowpeas (*Vigna unguiculata*), cucumbers (*Cucumis sativus*), melons (*Cucumis melo*), peas (*Pisum sativum*), potatoes (*Solanum tuberosum*), sesame (*Sesamum indicum*), soyabeans (*Glycine max*), sunflowers (*Helianthus annuus*), tobacco (*Nicotiana tabacum*) and watermelons (*Citrullus lanatus*). Flowers (e.g. *chrysanthemums*) and weeds are also infested.

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

There are some discrepancies in the different sources regarding the hosts of *T. palmi*. Both EPPO and CABI list *Capsicum annuum* (pepper), *C. melo, C. sativus* and *S. melongena* as major (EPPO) or main (CABI) hosts. The list of main host plants in CABI is longer and includes several species mainly from the *Asteraceae, Cucurbitaceae, Fabaceae* and *Solanaceae* families.

In Japan, *T. palmi* became a major threat to vegetable growers in the 1980's (Murai, 2002) and, by 1990, it had become the most serious pest of cucumber, eggplant and pepper both in greenhouses and in open fields in the western part of Japan (Kawai, 1990).

Thrips palmi is continuously intercepted in the EU on imported cut flowers, *Momordica* spp. and *S. melongena* from various third countries (mainly from Thailand, Dominican Republic, Suriname and India) (EFSA PLH Panel, 2019).

Thrips palmi poses a threat to the following hosts in glasshouse conditions in the EU:

- cucurbits, pepper, eggplant

- lettuce (*Lactuca sativa*)
- chrysanthemum and orchids grown either in open air in Southern EU or in greenhouses.

Thrips palmi poses a threat to the following hosts outdoors in the EU:

- potato and bean

Thrips palmi is not considered to pose a threat to the following outdoor crops in the EU:

- tomato (no report on attacking tomatoes in Japan, by CABI, 2018),
- Mango and avocado are excluded as they are essentially grown outdoors and not in greenhouses.

Without detailed information concerning the potential impacts in the different environments, the experts decided to assess yield loss indoors (i.e. in heated greenhouses) and outdoors (i.e. in Southern Mediterranean coastal areas) together.

2.2.3. Conclusions on the hosts selected for the evaluation

The complete list of hosts is produced by merging

- the list of host plants defined by EPPO (online)
- the list of host species reported by CABI (2018)

The hosts on which the impact is assessed are:

- eggplants, peppers (sweet and chili), cucurbits, both in open air and under glass growing conditions
- leafy vegetables
- ornamentals (chrysanthemum and orchids)

2.3. Area of potential distribution

2.3.1. Area of current distribution

Figure 1 provides an overview of the current area of distribution of the pest. *Thrips palmi* is absent from the EU. Several interceptions have been recorded in Belgium, Czech Republic, Finland and France, whereas outbreaks have been successfully contained and eradicated in Netherlands (EPPO, 1997), UK (EPPO, 2005) and Germany (EPPO, 2016). In Portugal isolated findings in open air conditions were made in 2004 but in later surveys the pest was no longer found (EPPO, 2008).

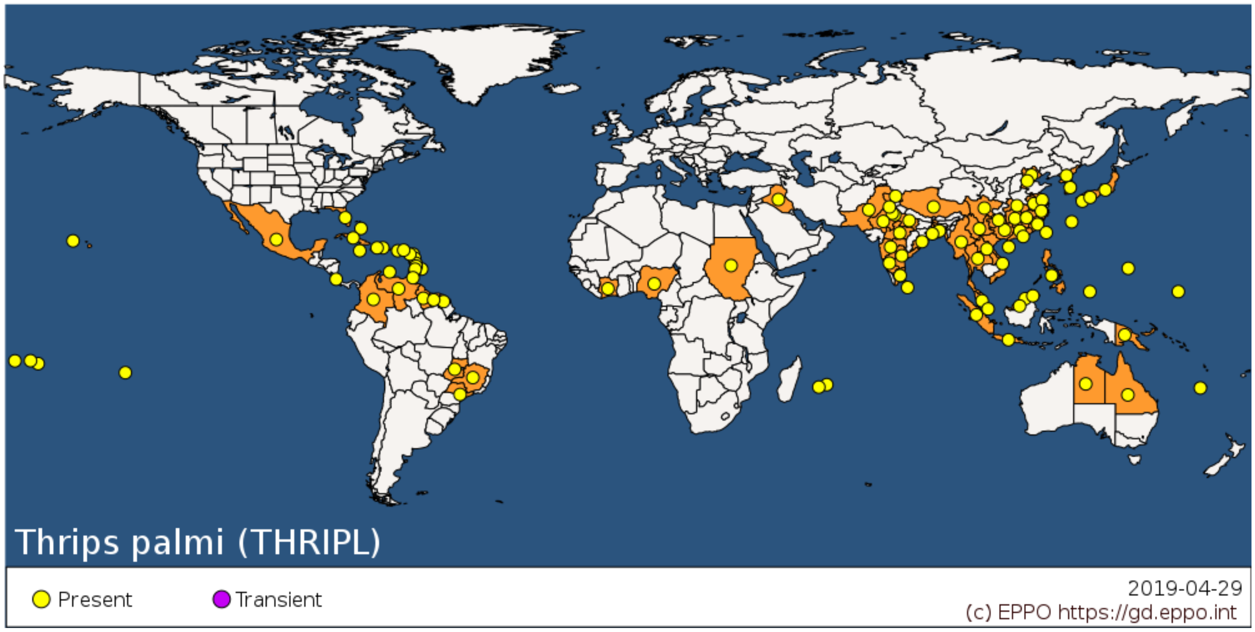


Figure 1 Distribution map of *Thrips palmi* from the EPPO Global Database accessed 29/04/2019.

2.3.2. Area of potential establishment

In Japan, *T. palmi* is unable to overwinter at latitudes north of 26 °N when outdoors and not in greenhouses (CABI, 2018). Assuming it is warm enough, the thrips is able to reproduce and increase population density during any season, warm weather being the most favourable. Tropical and subtropical areas show the highest establishment potential. In general, rainfall reduces thrips populations.

Because the pest is unable to survive low winter temperatures typical of central and northern European climates, it mostly overwinters in infested greenhouses in EU. However, in southern EU countries, overwintering may also take place outdoors (2.3.4).

2.3.3. Transient populations

Thrips palmi is not expected to form transient populations in the EU (for “transient” see the definition in EFSA, 2019).

2.3.4. Conclusions on the area of potential distribution

A careful evaluation of the published temperature thresholds for survival and development and thermal sums for completing a generation led to the conclusion that most of southern Europe is suitable for the establishment of *T. palmi*, particularly: the Iberian peninsula, the Mediterranean area of France, Italy, the coastal part of the Balkan peninsula and the whole Greece. In Figure 2 the area of potential distribution in NUTS2 regions is reported.

The pest is unable to survive the low temperatures typical of central and northern European climates, but the pest can overwinter in infested glasshouses here and throughout the EU.

Since outdoor transient populations have not been taken into account, the assessment is limited to the area of potential establishment.

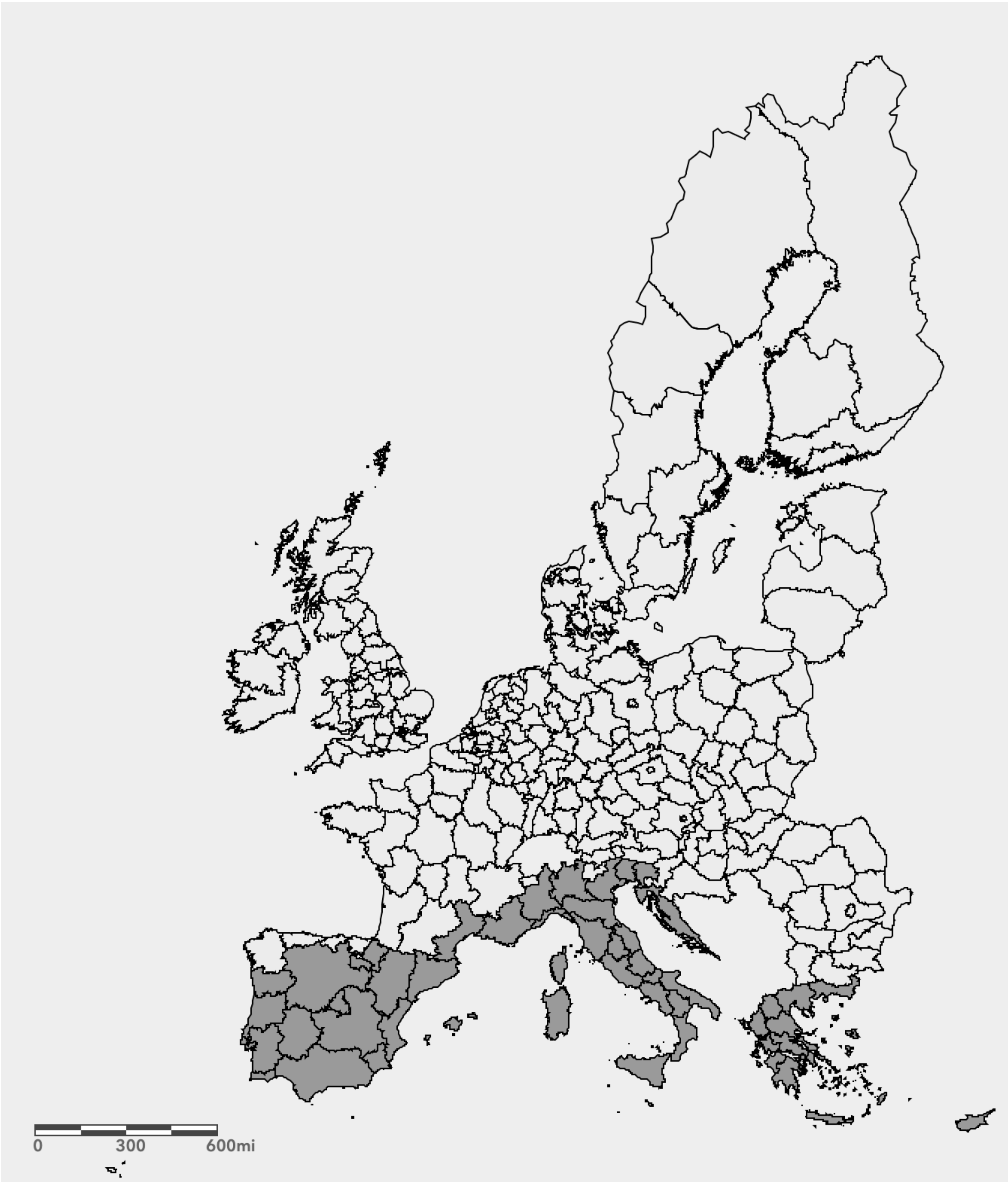


Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/P18z5

2.4. Expected change in the use of plant protection products

Eggs are deposited within the plant tissue, whereas larvae are usually found deep within developing buds and flowers and under leaves and are thus not easily targeted by insecticide sprays. Pupae, which reside in the soil, are also relatively protected from insecticide applications. In addition, *T. palmi* shows a tendency to develop resistance to insecticides because of its high reproductive capability and very short life cycle.

A broad overview of *T. palmi* control is given by Cannon et al. (2007a). Effective products include imidacloprid and pyrethroids, although they also deplete the pool of natural enemies which are more sensitive to these products than the thrips themselves (Capinera, 2015). Insecticidal soaps, which are effective as well, are not considered to affect the natural enemies of *T. palmi* (Zhang and Brown, 2008).

It is expected that when *T. palmi* reaches a new greenhouse in the EU it will be subjected to quite a high level of control considering the current horticultural practices. However, since *T. palmi* easily develops resistance to insecticides, existing control practices may not remain effective for long. The failure of ongoing control methods, that are successfully applied against other thrips, has been reported, e.g. MacLeod et al. (2004) noted that in the UK the pest was discovered because, in spite of the ongoing control against other thrips, *T. palmi* was not affected.

A detailed EPPO protocol for disinfestation of production sites was published in 2009 (EPPO, 2009).

Some biocontrol agents currently used against thrips in the EU (e.g. *Orius* spp.) are also effective against *T. palmi*.

However, it should be noted that most references regarding control of *T. palmi* are not very recent and may refer to pesticides (molecules and formulations) that have been substituted by effective strategies such as IPM.

In conclusion, the most suitable PPP indicator is Case "C" and the category is "1" based on Table 2, with high uncertainty, since this scenario will not be appropriate in all the different growing conditions and its capacity for developing resistance to insecticides.

Table 1: Expected changes in the use of Plant Protection Products (PPPs) following *Thrips palmi* establishment in the EU in relation to four cases (A-D) and three level score (0-2) for the expected change in the use of PPPs

Expected change in the use of PPPs	Case	PPPs indicator
PPPs effective against the pest are not available/feasible in the EU	**A**	**0**
PPPs applied against other pests in the risk assessment area are also effective against the pest, without increasing the amount/number of treatments	B	0
PPPs applied against other pests in the risk assessment area are also effective against the pest but only if the amount/number of treatments is increased	**C**	**1**
A significant increase in the use of PPPs is not sufficient to control the pest: only new integrated strategies combining different tactics are likely to be effective	D	2

2.5. Additional potential effects

2.5.1. Mycotoxins

The species is not known to be related to problems caused by mycotoxins.

2.5.2. Capacity to transmit pathogens

The species is a vector of the following viruses:

- Calla lily chlorotic spot virus (CCSV)
- Capsicum chlorosis virus (CaCV)
- Groundnut bud necrosis virus (GBNV)
- Melon yellow spot virus (MYSV)
- Tomato necrosis ringspot virus (TNRV)
- Tomato spotted wilt virus (TSWV; A2 EPPO List; Annex I Part B Directive 2000/29/EC)
- Watermelon bud necrosis virus (WBNV)
- Watermelon silver mottle virus (WSMoV; A1 EPPO List)

3. Expert Knowledge Elicitation report

3.1. Yield and quality losses

3.1.1. Structured expert judgement

3.1.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.1.1 of the Methodology Report (EFSA, 2019).

3.1.1.2. Specific scenario assumptions

- Only the direct impact caused by *T. palmi* is assessed and not the damage by pathogens to potentially carried by *T. palmi* as vector
- Any type of damage produced by *T. palmi* on leafy vegetables and ornamentals is considered to be a complete loss and so quality losses are not estimated for these two categories.
- The control in place includes that applied against the other species of thrips.

3.1.1.3. Selection of the parameter(s) estimated

The first group of hosts includes pepper (sweet and chili), eggplant, cucurbits, either growing outdoors or in protected cultivation, where the yield loss is mainly the effect of fruit deformation.

The second group allows for the assessment of aesthetic damage on leaves of those crops where the leaves are the main product.

The quality loss is assessed separately for eggplants and for peppers/cucurbits, due to the differences in the parts of the plant that are primarily attacked (fruit on eggplants but young leaves on peppers/cucurbits)

Losses on ornamentals (chrysanthemum and orchid) are assessed in terms of the percentage of cut flowers or potted plants that are damaged and therefore no longer marketable, as a consequence of *T. palmi* attack.

3.1.1.4. Defined question(s)

What is the percentage yield loss in eggplant, pepper, cucurbit production under the scenario assumptions in the area of the EU under assessment for *Thrips palmi*, as defined in the Pest Report?

What is the percentage yield loss in leafy vegetables production under the scenario assumptions in the area of the EU under assessment for *Thrips palmi*, as defined in the Pest Report?

What is the percentage yield loss in ornamentals production under the scenario assumptions in the area of the EU under assessment for *Thrips palmi*, as defined in the Pest Report?

What is the percentage of the harvested pepper and cucurbit damaged by *Thrips palmi* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

What is the percentage of the harvested eggplant damaged by *Thrips palmi* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

3.1.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.1 in Appendix B) selecting the data and references used as the key evidence for the EKE on impact.

Some general points were made:

- Kawai (1990) states that, depending on the host plant, damages are located differently (on leaves, on fruits or on flowers).
- For eggplants, peppers and cucurbits the calculations are based on Welter et al. (1990) with data from Kawai (1986)
- A quarter of pepper production is under glass in the northern EU
- The production of cucumber in non-Mediterranean MSs (e.g. Poland) is not expected to be affected by established outdoor populations of *T. palmi*, given the cold winter conditions
- Eggplant fruits are more attractive than pepper and cucurbit to *T. palmi*
- The life cycle on leafy vegetables is shorter so pesticides are less likely to be effective (a.i. and application period)
- Continuous pest pressure is expected in lettuce production sites since the rapid turnover in the crop is likely to guarantee there is always a part of the area where the crop is present on which the pest can survive
- The absence of observations on damage by *T. palmi* on lettuce is considered to be due to the fact that lettuce is not a major host
- Palumbo (2016a—b) provides observations of damage to lettuce by thrips with information on the control and Benavente-García and Marín (2003, p. 51) provide a picture on the damage caused by thrips on lettuce
- The chrysanthemum crop takes 12-15 weeks before harvest (a much longer production time than for lettuce)

3.1.1.6. Uncertainties identified

- Differences in the cropping period for eggplant, peppers and cucurbits in the EU
- No evidence is available on impacts on leafy vegetables and ornamentals
- Thrips damage on lettuce is difficult to distinguish from the damage caused by the pathogens it vectors
- There are mainly circumstantial observations of damage to ornamentals with very limited clear evidence (translated paper by Miyashit and Soichi, 1993)

3.1.2. Elicited values for yield losses on eggplant, pepper and cucurbits

What is the percentage yield loss in eggplant, pepper, cucurbit production under the scenario assumptions in the area of the EU under assessment for *T. palmi*, as defined in the Pest Report?

The five elicited values on yield loss on eggplant, pepper and cucurbits on which the group agreed are reported in the table below.

Table 2: The 5 elicited values on yield loss (%) on eggplant, pepper and cucurbits

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	4%	6%	8%	20%

3.1.2.1. Justification for the elicited values for yield loss on eggplant, pepper and cucurbits

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

- Production systems with poor hygiene lead to higher pest population densities from the beginning of the cropping season.
- The endangered area is suitable for this pest species.
- Pest populations are resistant to the main pesticide products applied.
- Damages on fruits, including attack on young eggplants/cucumbers/peppers.
- Absence of effective natural enemies.
- Impacts in open fields are expected to be higher.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

- Low pest population density, and the pest reaches the crop later in the growing season.
- EU climate conditions that are not ideal to this species, e.g. some greenhouses in Northern EU countries.
- Current control practices are effective in reducing *T. palmi* populations; the value is not lower due to the uncertainty concerning the effectiveness (e.g. the correct timing of the applications) of current thrips control against *T. palmi* because the biology of this thrips could be different from other thrips species. *Thrips palmi* mainly feeds on leaves and not on flowers so there could be different timing of the treatments.
- Effect of a series of consecutive years with not favourable summer conditions.
- The damage to fruit happens only after serious damage to leaves.
- Natural enemies may reduce populations, particular in open field conditions
- This best case scenario is most representative of the situation in glasshouses.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

It is expected that the median value is closer to the lower value. The effectiveness of control is considered to be the key driver of the median value, and pesticides resistant populations are not expected to play an important role.

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

The precision indicates that there is a higher uncertainty around the lower values, the median is shifted to the lower values. Clear right skewed curve.

3.1.2.2. Estimation of the uncertainty distribution for yield loss on eggplant, pepper and cucurbits

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 3: Fitted values of the uncertainty distribution on the yield loss (%) on eggplant, pepper and cucurbits

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					4%		6%		8%					20%
Fitted distribution	1.7%	2.1%	2.5%	3.0%	3.5%	4.1%	4.6%	5.8%	7.3%	8.2%	9.6%	11.3%	13.6%	16.1%	19.4%

Fitted distribution: Lognorm(0.066418,0.036938), @RISK7.5

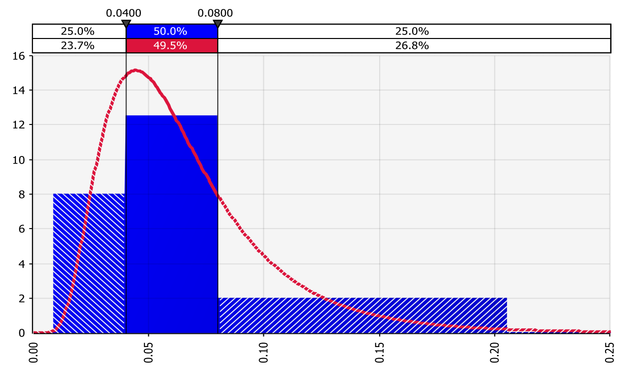


Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on eggplant, pepper and cucurbits.

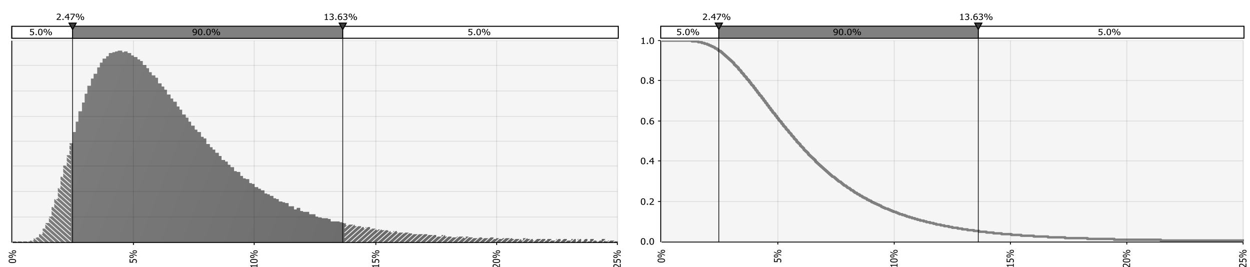


Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on eggplant, pepper and cucurbits.

3.1.3. Elicited values for quality losses on pepper and cucurbits

What is the percentage of the harvested pepper and cucurbit damaged by *T. palmi* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

The five elicited values on quality loss on pepper and cucurbits on which the group agreed are reported in the table below.

Table 4: The 5 elicited values on quality loss (%) on pepper and cucurbits

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0.1%	2.5%	5%	10%	20%

3.1.3.1. Justification for the elicited values for quality loss on pepper and cucurbits

Reasoning for a scenario which would lead to high quality loss (99th percentile / upper limit)

Here the evaluation is only done for Class I, which is only part of the total pepper/cucurbit production.

Peppers have a lower threshold for damage and could be damaged more than cucurbits. Thrips in general are considered as pests that cause greater quality losses than yield losses.

More damage expected in the open fields in the costal Mediterranean area.

Reasoning for a scenario which would lead to low quality loss (1st percentile / lower limit)

Thrips palmi is not expected to increase significantly the level of damage already caused by other Thripidae.

A bit more than yield losses, as quality is expected to be more impacted. *Thrips palmi* feeds on the leaves of pepper and cucurbits therefore the damage on these crops will be more to yield (reduction of production for the whole plant) than quality for these crops.

Reasoning for a central scenario equally likely to over- or underestimate the quality loss (50th percentile / median)

Even if the total of quality loss is lower than the total of yield loss, considering that the first affects only part of the production (Class I) while the second affects the total production, the two values can be similar.

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

The precision indicates that there is a higher uncertainty around the lower values, the median is shifted to the lower values. Clear right skewed curve.

3.1.3.2. Estimation of the uncertainty distribution for quality loss on pepper and cucurbits

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 5: Fitted values of the uncertainty distribution on the quality loss (%) on pepper and cucurbits

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0.1%					2.5%		5%		10%					20%
Fitted distribution	0.1%	0.3%	0.6%	1.0%	1.7%	2.4%	3.3%	5.2%	7.7%	9.5%	11.8%	14.6%	18.3%	21.9%	26.6%

Fitted distribution: Weibull(1.1625,0.071382), @RISK7.5

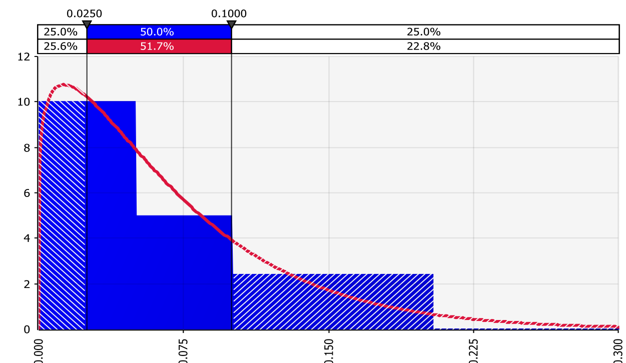


Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for quality loss on pepper and cucurbits.

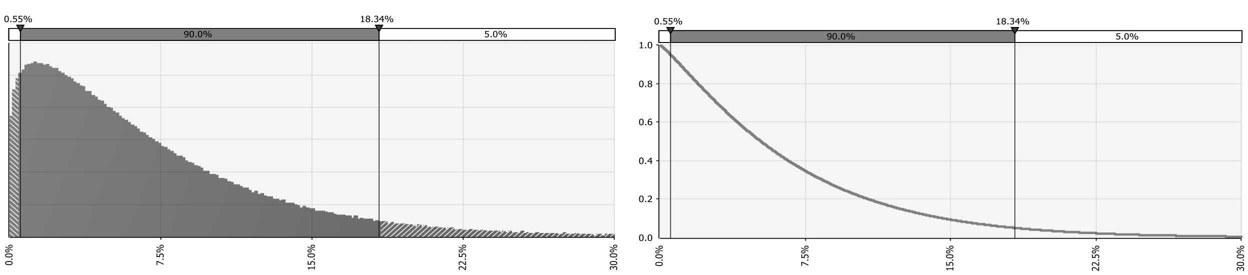


Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for quality loss on pepper and cucurbits.

3.1.4. Elicited values for quality losses on eggplant

What is the percentage of the harvested eggplant damaged by *T. palmi* that would lead to downgrading the final product because of quality issues under the scenario assumptions in the area of the EU under assessment as defined in the Pest Report?

The five elicited values on quality loss on eggplant on which the group agreed are reported in the table below.

Table 6: The 5 elicited values on quality loss (%) on eggplant

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	7%	10%	20%	30%

3.1.4.1. Justification for the elicited values for quality loss on eggplant

Reasoning for a scenario which would lead to high quality loss (99th percentile / upper limit)

The quality damage on eggplants, since *T. palmi* attacks the fruit of eggplants, is expected to be higher than yield losses and higher than the quality losses on pepper/cucurbit.

In addition, the growing conditions for eggplant, which are mainly grown in Italy, are expected to be more favourable than those in greenhouse for pepper/cucurbit**.**

Reasoning for a scenario which would lead to low quality loss (1st percentile / lower limit)

There is some loss in production, but total loss is similar to the amount that is downgraded.

Reasoning for a central scenario equally likely to over- or underestimate the quality loss (50th percentile / median)

Same reasoning provided above.

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

The curve is right skewed being the uncertainty higher on higher values.

3.1.4.2. Estimation of the uncertainty distribution for quality loss on eggplant

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 7: Fitted values of the uncertainty distribution on the quality loss (%) on *eggplant*

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					7%		10%		20%					30%
Fitted distribution	0.8%	1.4%	2.1%	3.3%	4.7%	6.3%	7.9%	11.2%	15.4%	18.0%	21.5%	25.5%	30.5%	35.0%	40.4%

Fitted distribution: BetaGeneral(1.7290,11.474,0,1), @RISK7.5

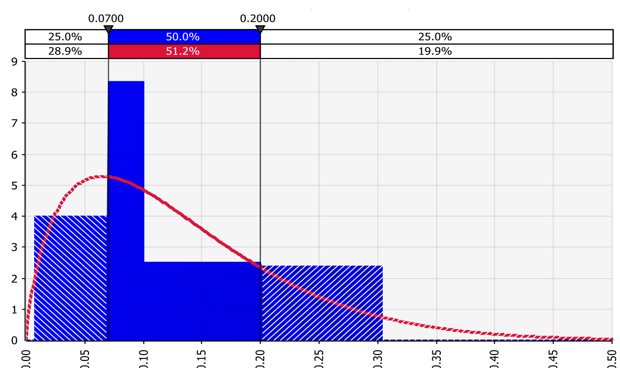


Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for quality loss on eggplant.

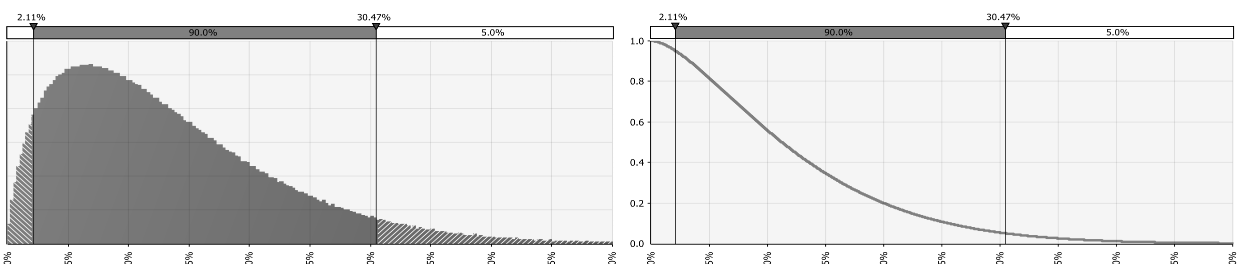


Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for quality loss on eggplant.

3.1.5. Elicited values for yield losses on lettuce

What is the percentage yield loss in leafy vegetables production under the scenario assumptions in the area of the EU under assessment for *T. palmi*, as defined in the Pest Report?

The five elicited values on yield loss on leafy vegetables on which the group agreed are reported in the table below.

Table 8: The 5 elicited values on yield loss (%) on leafy vegetables

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0%	0.5%	1%	1.5%	5%

3.1.5.1. Justification for the elicited values for yield loss on leafy vegetables

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

Poor hygiene and situations where control mechanisms do not work properly. There is also the possibility of development of resistance by populations of *T. palmi*.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

There is no evidence supporting high yield losses on lettuce.

Thrips species are the key pests affecting lettuce so it is expected that control measures would already be in place that would also be effective against *T. palmi*.

There could be some secondary losses, on lettuce, due to virus transmission that are not considered in the assessment.

Lettuce is sprayed/irrigated more than many other crops and the very high humidity could limit the thrip population therefore limiting the damage.

IPM crop rotations (instead of continuous cropping system) where there is a period without lettuce, cleaning between crops and overall better hygiene.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

The low yield loss scenario would be more probable. Compared with the yield loss to eggplants, peppers and cucurbits, the yield loss is expected to be lower.

Most of the literature describes lettuce as a host without describing the damage.

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

High uncertainty for the lower values. More confidence in the median for the higher values

3.1.5.2. Estimation of the uncertainty distribution for yield loss on lettuce

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 9: Fitted values of the uncertainty distribution on the yield loss (%) on leafy vegetables

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0%					0.5%		1%		1.5%					5%
Fitted distribution	0.07%	0.12%	0.18%	0.28%	0.39%	0.52%	0.66%	0.95%	1.32%	1.56%	1.90%	2.30%	2.83%	3.35%	4.01%

Fitted distribution: Gamma(1.7973,0.0064139), @RISK7.5

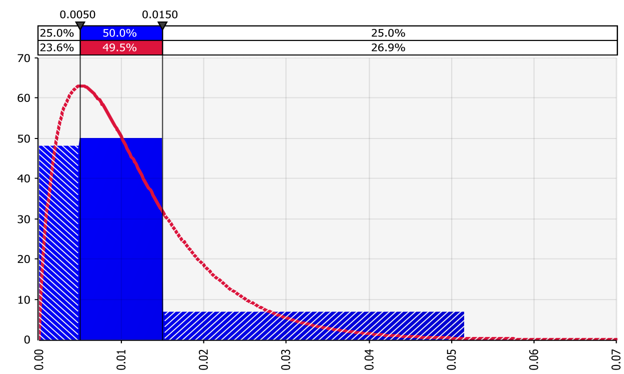
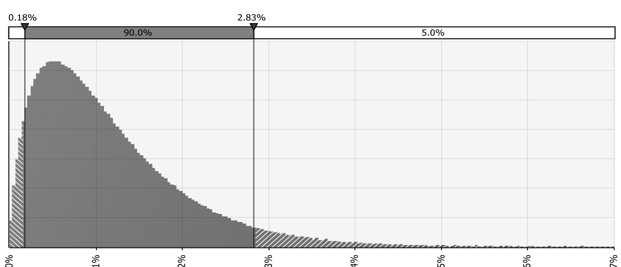


Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on lettuce.



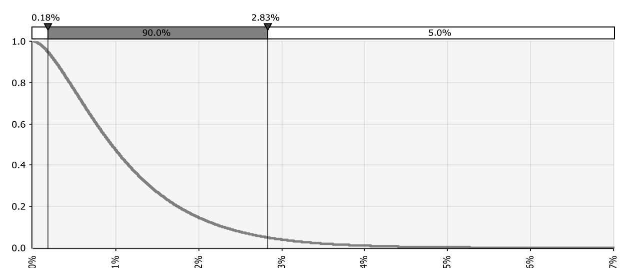


Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on lettuce.

3.1.6. Elicited values for yield losses on ornamentals

What is the percentage yield loss in ornamentals production under the scenario assumptions in the area of the EU under assessment for *T. palmi*, as defined in the Pest Report?

The five elicited values on yield loss on ornamentals on which the group agreed are reported in the table below.

Table 10: The 5 elicited values on yield loss (%) on ornamentals

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0%	0.5%	1%	2%	5%

3.1.6.1. Justification for the elicited values for yield loss on ornamentals

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

The IPM programs in place against other thrips would be not so effective against *T. palmi*. In addition, there are no reports on the damage caused by this pest on ornamentals. The results from Japan do not provide substantial evidence of the damage to chrysanthemum.

Based on the type of damage to the flowers, Chrysanthemum could be a model for highly susceptible plants as well as orchids. This high value is influenced by the expected impact on orchids (where the impact is expected to be higher) together with the insufficient effectiveness of current IPM and the development of insecticide resistance.

The greenhouse conditions and duration of the productive cycle (longer than for leafy vegetables) mean that the impact on these hosts is expected to be higher than for lettuce or other leafy vegetables.

The upper values take into account the use of IPM and biocontrol.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

The current IPM regime is effective, damage to orchids is not expected to be higher than on chrysanthemum and is not expected to be high in either species.

In the UK outbreak, there was no real loss of production or marketability of flowers, the plants could still be sold.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

Overall, the pest is likely to find favourable conditions since most of the ornamental production is in greenhouses.

The median is mainly driven by observations on chrysanthemum.

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

The precision is given by the uncertainty around values below the median while the group is quite confident that values close to the upper limit are not so likely.

3.1.6.2. *Estimation of the uncertainty distribution for yield loss on ornamentals*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 11: Fitted values of the uncertainty distribution on the yield loss (%) on ornamentals

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0%					0%		1%		2%					5%
Fitted distribution	0.03%	0.06%	0.11%	0.20%	0.33%	0.48%	0.65%	1.04%	1.57%	1.94%	2.45%	3.08%	3.93%	4.77%	5.87%

Fitted distribution: Gamma(1.2133,0.011556), @RISK7.5

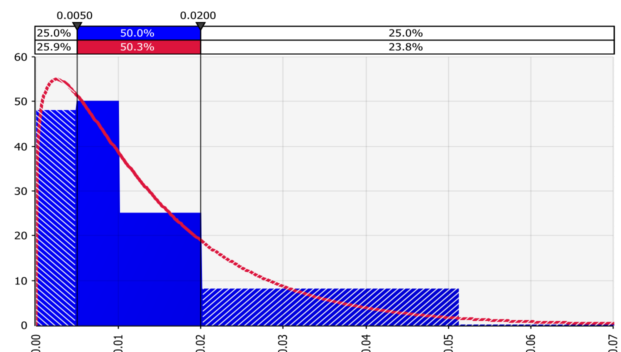


Figure 11 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on ornamentals.

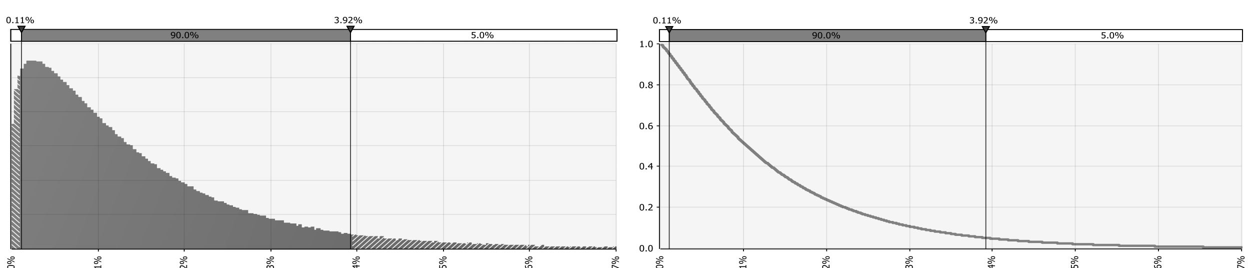


Figure 12 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on ornamentals.

3.1.7. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the percentage of yield losses are estimated to be:

- 6% (with a 95% uncertainty range of 2.1 – 16.1%) for eggplant, pepper and cucurbit
- 1% (with a 95% uncertainty range of 0.12 – 3.35%) for leafy vegetables
- 1% (with a 95% uncertainty range of 0.06 – 4.77%) for ornamentals

Based on the general and specific scenarios considered in this assessment, the percentage of quality losses is estimated to be:

- 5% (with a 95% uncertainty range of 0.3 – 21.9%) for pepper and cucurbit
- 10% (with a 95% uncertainty range of 1.4 – 35.0%) for eggplant

3.2. Spread rate

3.2.1. Structured expert judgement

3.2.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.2.1.2. Specific scenario assumptions

- Spread in glasshouses is assessed by considering a situation where continuous glasshouse production occurs (e.g. Almeria).
- Human assisted spread is considered to occur within sites of about 1000 m in diameter. Longer distances of spread by human assistance are not considered within this scenario although it could play an important role in the dispersal of the pest.

3.2.1.3. Selection of the parameter(s) estimated

The spread rate has been assessed as the number of metres per year.

3.2.1.4. Defined question(s)

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

3.2.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. A few points were made:

- *Thrips palmi* is mostly carried with fruits, seedlings or packing materials. Its natural dispersal potential is low.

- Cannon et al. (2007b) noted that *T. palmi* does not readily leave greenhouses and the favourable conditions (humidity, temperature, etc) indoors. This is confirmed by observations in the Netherlands by Vierbergen (1996).
- Boumier (1987) indicates that *T. palmi* can move long distances with the help of winds.

3.2.1.6. Uncertainties identified

- The effect of wind
- The efficacy of control measures

3.2.2. Elicited values for the spread rate

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

The five elicited values on time to detection on which the group agreed are reported in the table below.

Table 12: The 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	100	500	800	1500	5000

3.2.2.1. Justification for the elicited values of the spread rate

Reasoning for a scenario which would lead to wide spread (99th percentile / upper limit)

The upper limit is supported by the following scenario:

- Human spread is within sites of about 1000 m in width
- Thrips are known to be wind dispersed organisms. Possible wind events may transport the adults and therefore play a role in the extreme scenarios.
- Several life cycles can occur in one year.
- Control measures are not well applied or work properly.
- The pest population is high and may be increasing.

Reasoning for a scenario, which would lead to limited spread (1st percentile / lower limit)

The lower limit is supported by the following scenario:

- Spread is limited by the size of the production sites.
- No local human assisted movement occurs.
- Good crop hygiene and pest control.
- Low pest population.

Reasoning for a central scenario, equally likely to over- or underestimate the spread (50th percentile / median)

The median is supported by the following scenario:

- Wind is considered to be a key factor defining the median. In Almeria: the pest can move to the next glasshouse roughly every month.
- Most of the spread is expected to occur inside one farm site with a smaller probability of long distance spread due to wind.
- Crop production methods are relatively effective against thrips.

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

Uncertainty is mainly in the low part, while the upper part shows more confidence in the median.

3.2.2.2. *Estimation of the uncertainty distribution for the spread rate*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 13: Fitted values of the uncertainty distribution on the spread rate (m/y)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	100					500		800		1,500					5,000
Fitted distribution	124.6	168.2	217.6	293.0	378.8	481.4	587.7	836.0	1,189.2	1,451.6	1,844.8	2,385.4	3,211.2	4,155.6	5,608.2

Fitted distribution: Lognorm(1168.3,1140.6), @RISK7.5

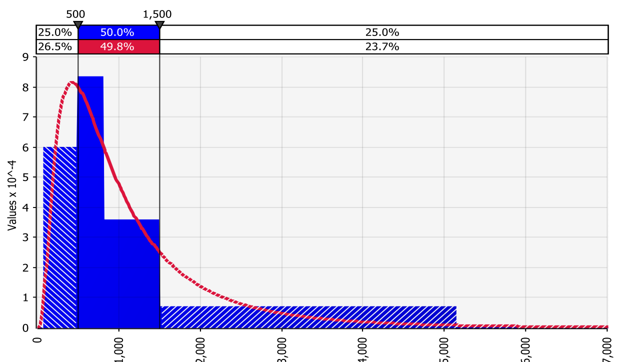


Figure 13 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

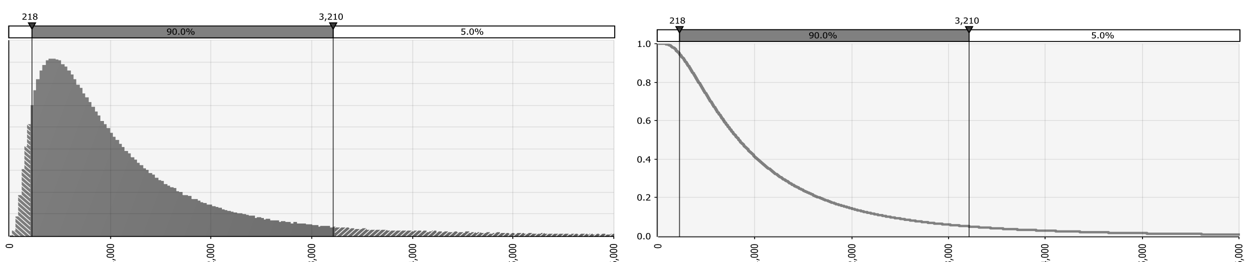


Figure 14 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

3.2.3. Conclusions on the spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *T. palmi* is approximately 800 m (with a 95% uncertainty range of 168 – 4155 m).

3.3. Time to detection

3.3.1. Structured expert judgement

3.3.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.3.1.2. Specific scenario assumptions

No specific assumptions are introduced for the assessment of the time to detection.

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of months between the first event of pest transfer to a suitable host and its detection.

3.3.1.4. Defined question(s)

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

3.3.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on the time to detection.

- Symptoms are not specific to this thrips species
- Not easy for growers to distinguish this thrips from other species
- *Thrips palmi* can quickly build-up populations at high temperatures. Low-level infestations and the presence of eggs within the plant tissue may hamper the detection by phytosanitary authorities.

3.3.1.6. Uncertainties identified

Overall awareness of growers of emerging species.

3.3.2. Elicited values for the time to detection

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

The five elicited values on time to detection on which the group agreed are reported in the table below.

Table 14: The 5 elicited values on time to detection (months)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	6	15	24	36	48

3.3.2.1. *Justification for the elicited values of the time to detection*

Reasoning for a scenario which would lead to a long time for detection (99th percentile / upper limit)

The upper limit is supported by the following scenario:

- The pest needs a high population to develop in order to be noticed.
- Detection in outdoor crops will be more difficult since this is less intense and frequent, and scouting methods are not well established.
- This species can be easily confused with other pests.
- Outbreaks starting in the natural environment or private gardens will take even longer to detect.
- If starting in a private garden, 2 years may be needed to build up a population to a density where it is noticed, while another 2 years could be necessary to report and identify *T. palmi*.

Reasoning for a scenario which would lead to a short time for detection (1st percentile / lower limit)

The lower limit is supported by the following scenario:

- High inspection rate at entry points, at the locations receiving planting material would be expected.
- High awareness of growers about new and emerging pests.
- Detection would be more likely during peaks of population growth and low population dispersal rate so that visible symptoms could appear. A lapse of time might be still needed for the population to build up.
- Some differences, e.g. damage caused to particular crops from other pests observed.

Reasoning for a central scenario, equally likely to over- or underestimate the time for detection (50th percentile / median)

The median is supported by the following scenario:

- Awareness moderate: noticeable when there is a more rapid increase.
- When the pest reaches crops, where thrips damage is noticeable, it will not necessarily be identified as caused by *T. palmi* given the coexistence of many other thrips species.

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

This distribution indicates a maximum uncertainty for both sides of the curve.

3.3.2.2. *Estimation of the uncertainty distribution for the time to detection*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 15: Fitted values of the uncertainty distribution on the time to detection (months)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	6					15		24		36					48
Fitted distribution	6.0	6.6	7.4	9.2	11.6	14.7	17.9	24.5	31.7	35.5	39.5	43.1	46.1	47.8	48.9

Fitted distribution: BetaGeneral(0.98496,1.2314,5.7000,50), @RISK7.5

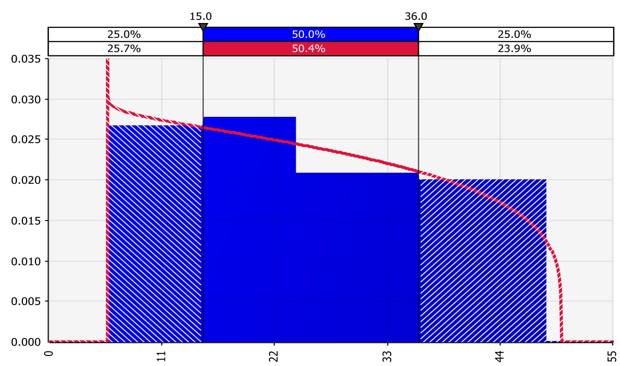


Figure 15 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

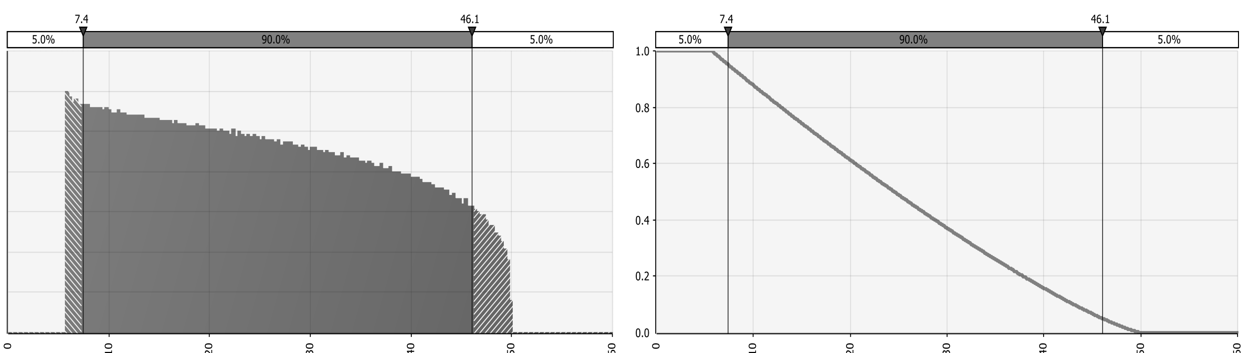


Figure 16 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

3.3.3. Conclusions on the time to detection

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be approximately 2 years (with a 95% uncertainty range of 6.6 – 47.8 months).

4. Conclusions

Host selection

The hosts on which the impact is assessed are:

- eggplants, peppers (sweet and chili), cucurbits, both in open air and under glass growing conditions
- leafy vegetables
- ornamentals (chrysanthemum and orchids)

Area of potential distribution

A careful evaluation of the published temperature thresholds for survival and development and thermal sums for completing a generation led to the conclusion that most of southern Europe is suitable for the establishment of *T. palmi*, particularly: the Iberian peninsula, the Mediterranean area of France, Italy, the coastal part of the Balkan peninsula and the whole Greece.

The pest is unable to survive the low winter temperatures typical of central and northern European climates, but the pest can overwinter in infested glasshouses here and throughout the EU.

Since outdoor transient populations have not been taken into account, the assessment is limited to the area of potential establishment.

Expected change in the use of plant protection products

The most suitable PPP indicator is Case "C" and the category is "1", with high uncertainty since this scenario will not be appropriate in all the different growing conditions.

Yield and quality loss

Based on the general and specific scenarios considered in this assessment, the percentage of yield losses are estimated to be:

- 6% (with a 95% uncertainty range of 2.1 – 16.1%) for eggplant, pepper and cucurbit
- 1% (with a 95% uncertainty range of 0.12 – 3.35%) for leafy vegetables
- 1% (with a 95% uncertainty range of 0.06 – 4.77%) for ornamentals

Based on the general and specific scenarios considered in this assessment, the percentage of quality losses is estimated to be:

- 5% (with a 95% uncertainty range of 0.3 – 21.9%) for pepper and cucurbit
- 10% (with a 95% uncertainty range of 1.4 – 35.0%) for eggplant

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *T. palmi* is approximately 800 m (with a 95% uncertainty range of 168 – 4155 m).

Time for detection after entry

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be approximately 2 years (with a 95% uncertainty range of 6.6 – 47.8 months).

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Appendix A – CABI/EPPO host list

The following list, defined in the Methodology Report (EFSA, 2019) as the full list of host plants, is compiled merging the information from the most recent PRAs, the CABI Crop Protection Compendium and the EPPO Global Database. Hosts from the CABI list classified as 'Unknown', as well as hosts from the EPPO list classified as 'Alternate', 'Artificial', or 'Incidental' have been excluded from the list.

Genus	**species**
Allium	*cepa*
Benincasa	*hispida*
Capsella	*bursa-pastoris*
Capsicum	
Capsicum	*annuum*
Cerastium	*glomeratum*
Chrysanthemum	
Citrullus	*lanatus*
Citrus	
Cucumis	*melo*
Cucumis	*sativus*
Cucurbita	*moschata*
Cucurbita	*pepo*
Cucurbitaceae	
Cyclamen	*persicum*
Dendranthema	*grandiflorum*
Fabaceae	
Ficus	
Glycine	*max*
Gossypium	
Gossypium	*hirsutum*
Helianthus	*annuus*
Herbaceous	*ornamental*
Lactuca	*sativa*
Mangifera	*indica*
Nicotiana	*tabacum*
Orchidaceae	
Oryza	*sativa*
Persea	*americana*
Phaseolus	
Phaseolus	*vulgaris*
Pisum	*sativum*
Sesamum	*indicum*
Solanaceae	
Solanum	*lycopersicum*
Solanum	*melongena*
Solanum	*tuberosum*
Vegetable	*plants*
Vicia	*sativa*
Vigna	*unguiculata*

Appendix B – Evidence tables

B.1 Summary on the evidence supporting the elicitation of yield and quality losses

Susceptibility	Infection	Symptoms	Impact	Additional information	Reference
	Incidence	***Severity***	***Losses***		
Watermelon			80%	Philippines, 1977	Medina, 1980
Eggplant		80% of fruits unmarketable			Guyot, 1988
Eggplant and cucumber	from 300 to 700 thrips/leaf		50-90%	Trinidad. Infestations of 300-700 *T. palmi*/leaf	Cooper, 1991
Cucumber			Yield losses: • 43.6 % at 62.2 thrips-days/cm^2 71% at 32.8 thrips-days/cm^2	5.3 adults per leaf for the total fruit yield and 4.4 adults per leaf for the yield of uninjured fruit	Kawai, 1986
Cucumber			45.8% total fruit weight losses at 35 thrips-days/cm^2 54.2% total fruit weight losses at final harvest observed at 45 thrips-days/cm^2 No detectable reduction in overall mean fruit quality	Mean thrips numbers were calculated for each week and multiplied by the number of days between samples, thus providing the number of thrips-days accumulated each week.	Welter et al., 1990
Snap beans			30% losses	Colombia	Bueno and César Cardona, 2003

B.2 Summary on the evidence supporting the elicitation of the spread rate

Spread	Additional information	Reference	Uncertainty
20 km/year	Easterly spread following westerly winds	Layland et al., 1994	Data just mentioned in the introduction. No reference.
0 km/year	18 months period	Cannon et al., 2007b	Thrips were studied inside greenhouses.

B.3 Summary on the evidence supporting the elicitation of the time to detection

Reference	Case	Aspect	Results / evidence
Detection methods			
EPPO, 2001 Vierbergen et al., 2012 FAO, 2016	Identification	Morphological examination	
Layland et al., 1994	Sampling techniques	Blue-sticky-board traps and water-tray traps	Australia, Norther Territory
Bacci et al., 2008	Sampling techniques	• Leaf beating on a plastic tray • Direct counting of insects on the lower leaf surface Whole leaf collection in bags	The best sampling technique for *T. palmi* was the leaf beating on a tray using one leaf of the apical third per plant and 35 plants per field.
Brunner et al., 2002; Toda & Komazaki, 2002	Identification	PCR and restriction fragment length polymorphism (PCR–RFLP)	
Walsh et al., 2005; Kox et al., 2005	Identification	Real-time polymerase chain reaction (PCR)	
Kumar et al, 2014	Identification	Scanning Electron Microscopy (SEM) followed by DNA extraction	
Seepiban et al., 2015	Identification	Polymerase chain reaction (PCR) on RNA extract	
Nakahara and Minoura, 2015; Sabahi et al., 2017; Yeh et al., 2014	Identification	Multiplex polymerase chain reaction (PCR) assay	
Przybylska et al., 2015	Identification	Loop-mediated isothermal amplification (LAMP)	rDNA regions from crushed *T. palmi* (no DNA isolation step needed)
Blaser et al., 2018	Identification	Loop-mediated isothermal amplification (LAMP)	Test efficiency of 99%
Tyagi et al., 2017; Chakraborty et al., 2018	Identification	DNA barcoding	
Przybylska et al., 2018	Identification	Duplex polymerase chain reaction assay	

Biology of the pest			
Vljaya Lakshmi, 1994	Life cycle	Mean generation time	20-30 days in Southern Taiwan (peaks in December – mid January)
Tsai et al., 1995	Life cycle	Longevity	Female: 13- 24 days Male: 11.1 – 13.7 days
EPPO, 1996	Life cycle	Egg-to-adult developmental time	At 25°C, the life cycle from egg to egg lasts only 17.5 days
McDonald et al., 1999	Life cycle	Egg-to-adult developmental time	Preimaginal development period 40.2 days at 15°C 16.6 days at 21°C 15.2 days at 23°C 10.1 days at 30°C
McDonald et al., 1999	Life cycle	Development threshold temperature/ Thermal constant	Development threshold temperature: between 10.1°C and 35°C Egg: 9.4°C Larva: 11.5°C Propupa: 7.2°C Pupa: 10.1°C Thermal constant: 194 degree-days above threshold
McDonald et al., 2000	Life cycle	Lethality temperature	$LTime_{50S}$ • 0°C: 85 - 120 h • -5°C: 53 - 64 h • -10°C: 8 – 48 h $LTime_{90S}$ • 0°C: 170 - 280 h • -5°C: 66 - 125 h • -10°C: 14 – 107 h Adults resist better than larvae to cold temperatures (2°C difference).
Kakei and Tsuchida, 2000	Life cycle	Lethality humidity	Mortality from the prepupal stage to adulthood decreased with increasing relative humidity. No survivals were recorded at relative humidity percentages below 78% after 24 hours.
Murai, 2002	Life cycle	Cold temperatures lethality	Duration before all pupae die: • 8 days at 0°C • 255min at -5°C 35min at -10°C

Murai, 2002	Life cycle	Mean generation time	15°C: 80.2 days 20°C: 40.7 days 25°C: 24.8 days 30°C: 20.5 days
Zhang and Brown, 2008	Life cycle	Egg-to-adult developmental time	10-12 days at 30°C 14-16 days at 25°C
Park et al., 2010	Life cycle	Development threshold temperature/ Thermal constant	Cucumber 10.6°C for egg 10.6°C for larva 9.1°C for pre-pupa 10.7°C for pupa 10.6°C for total Thermal constant (degree-days) 71.7 for egg 59.2 for larva 18.1 for prepupa 36.8 for pupa 183.3 degree-days total Larval and pupal mortality was lowest at 30°C, and prepupal mortality was lowest at 27.5°C.
Park et al., 2010	Life cycle	Egg-to-adult developmental time	Cucumber 64.2 days at 12.5°C 9.2 days at 32.5°C
Yadav and Chang, 2012	Life cycle	Mean generation time	47.52 days at 16°C 38.33 days at 19°C 29.52 days at 22°C 19.81 days at 25°C 13.88 days at 31°C The developments of pre-adult and adult stages were faster in males than in females
Park et al., 2014	Life cycle	Cold temperatures lethality	• 0°C for 4 hours: not lethal • -15°C for 1 hour: 100% lethal • -5°C: average survival time of 18 minutes (egg), 10.8 minutes (larva), 11.4 minutes (pupa), 38.4 minutes (adult)

			A brief exposure to 4°C significantly increased the cold tolerance of *T. palmi* from eggs to adults. Furthermore, the brief exposure significantly increased supercoiling capacity in all stages.
Yadav and Chang, 2014	Life cycle	Optimal developmental temperature	Eggplant (*Solanum melongena*) Highest survival rate of first instar larvae: 97.5% at 25°C Highest survival rate of pupae: 86.1% at 28°C
Yadav and Chang, 2014	Life cycle	Longevity	<u>Male</u> 15.5 days at 31°C 50.7 days at 16°C <u>Female</u> 18.7 days at 31°C 56.7 days at 16°C
Yadav and Chang, 2014	Life cycle	Development threshold temperature/ Thermal constant	Eggplant (*Solanum melongena*) <u>Development threshold temperature</u> 11.25°C on average 13.91°C for adult pre-oviposition period 11.82°C for total pre-oviposition period 9.36°C for female longevity 10.45°C for male longevity 11.81°C for egg 13.14°C for first-instar larvae 9.9°C for second-instar larvae 10.07°C for pupae <u>Thermal constant</u> (degree-days) 196.1 degree-days on average 29.3 for adult pre-oviposition period 227.3 for total pre-oviposition period 454.6 for female longevity 344.8 for male longevity
Yadav and Chang, 2014	Life cycle	Egg-to-adult developmental time	35.7 days at 16°C 26.9 days at 19°C 19.3 days at 22°C

Yadav and Chang, 2012			14.1 days at 25°C 12.2 days at 28°C 9.6 days at 31°C Maximum life span of female adults: 56.67 days at 16°C Maximum life span of female adults: 50.66 days at 16°C
Capinera, 2015	Life cycle	Egg-to-adult developmental time	<u>Total</u> 42 days at 15°C 16.5 days at 25°C Eggs 16 days at 15°C 7.5 days at 26°C 4.3 days at 32°C Larvae 14 days at 15°C 5 days at 26°C 4 days at 32°C Pupae (combined prepupal + pupal stages) 12 days at 15°C 4 days at 26°C 3 days at 32°C Adult 20 days at 15°C 17 days at 26°C 12 days at 32°C
Capinera, 2015	Life cycle	Egg-to-adult developmental time	<u>Total</u> 80 days at 15°C 20 days at 30°C <u>Eggs</u> 16 days at 15°C 7.5 days at 26°C 4.3 days at 32°C <u>Larvae</u> 14 days at 15°C 5 days at 26°C 4 days at 32°C <u>Pupae (combined prepupal + pupal stages)</u>

			12 days at 15°C 4 days at 26°C 3 days at 32°C <u>Adult</u> 20 days at 15°C 17 days at 26°C 12 days at 32°C
Capinera, 2015	Life cycle	Longevity	Female: 10 - 30 days Male: 7- 20 days
Hirano et al., 1993	Behaviour	Spatial distribution	Adult females do not use airborne phytochemical cues, attractants and/or repellents to search for food.
Castineiras et al., 1997	Behaviour	Spatial distribution	On eggplants, *T. palmi* was more abundant on leaves than on fruits and flowers. Preference was shown for oldest leaves, specifically the adaxial surface.
EPPO, 2009	Behaviour	Feeding	Adults: Mostly along midrib and veins Propupae and pupae: relative sedentary, non-feeding stages
EPPO, 2009	Behaviour	Habitat	Propupae and pupae: soil, growing substrates, plant debris, occasionally on host plants in closed environments
Cho et al., 2000	Behaviour	Spatial distribution	On potatoes, most of individuals identified in the top one-third of the plant. Aggregated spatial distribution.
EFSA PLH Panel, 2019	Reproduction	Fecundity	Mated females lay a maximum of 200 eggs during their lifespan
Tsai et al., 1995	Reproduction	Fecundity	29 eggs/female
Zhang and Brown, 2008	Reproduction	Fecundity	Up to 100 eggs/female
Yadav and Chang, 2014 Yadav and Chang, 2012	Reproduction	Fecundity	64.2 eggs/female at 25°C 23.4 eggs/female at 16°C Maximum egg laying temperature: 27.33°C
Capinera, 2015	Reproduction	Fecundity	Up to 200 eggs/female. Average of 50 eggs/female.
Bernardo, 1991	Various	Various parameters	On watermelon, highest levels of fecundity (15.6 eggs) and longest adult lifespan (17.4 days) were recorded in Philippines
Cermeli and Montagne, 1993	Various	Various parameters	Bean (*Phaseolus vulgaris*) Life cycle: 11.5 days Net reproduction rate: 18.3 Generation time: 27.3 days Intrinsic rate of natural increase: 0.125 individuals/ female/ day
Murai, 2002	Various	Net reproduction rate	15°C: 16.5 20°C: 25.9

			25°C: 28.0 30°C: 19.1
Murai, 2002	Various	Reproductive rate/month	15°C: 2.9 20°C: 11.0 25°C: 55.7 30°C: 75.2
Yadav and Chang, 2014	Various	Population trend	31.3 at 25°C 7.6 at 16°C
Zhang and Brown, 2008; Capinera, 2015	Various	Size	0.8 – 1 mm (adult) 0.5 mm (first stage nymph)
Weather factor			
Katti et al., 2011	Relation between weather conditions and *T. palmi*	• Positive correlation with maximum temperature, wind speed and bright sunshine • Negative correlation with rainfall and morning/evening relative humidity Total influence of weather factors on *T. palmi* population: 50%	
Akashe et al., 2016		• Positive correlation with maximum temperature Negative correlation with relative humidity and rainfall	