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Pest risk assessment of *Radopholus similis* for the EU territory

EFSA Panel on Plant Health (PLH),
Michael Jeger, Claude Bragard, David Caffier, Thierry Candresse, Elisavet Chatzivassiliou, Katharina Dehnen-Schmutz, Gianni Gilioli, Jean-Claude Grégoire, Josep Anton Jaques Miret, Alan MacLeod, Maria Navajas Navarro, Björn Niere, Stephen Parnell, Roel Potting, Trond Rafoss, Vittorio Rossi, Ariena Van Bruggen, Wopke Van Der Werf, Jonathan West, Stephan Winter, Jan Schans, Svetla Kozelska, Olaf Mosbach-Schulz and Gregor Urek

Abstract

The Panel on Plant Health performed a pest risk assessment on *Radopholus similis*, the burrowing nematode for the EU. The quantitative assessment focused on entry, establishment, spread and impact on tropical and subtropical ornamental host plants, the main pathways for entry of *R. similis* into the EU. Infested consignments are expected to enter the risk assessment area on ornamentals under all scenarios. For citrus, which is a closed pathway for entry, outdoor establishment was assessed. Establishment may only take place after successful transfer from ornamental plants to citrus production systems. This event is called 'shift' in this assessment, to indicate that this is an unusual transfer. It has been estimated that establishment of this nematode in the open field in the EU citrus production areas under current temperatures is possible in most parts of the citrus production area in the EU. Temperature conditions will prevent the nematode from establishing only in the northernmost citrus areas and at higher altitudes in the south. Host plants for planting originating from infested places of production (greenhouses) within the risk assessment area are considered the main pathway for spread within the risk assessment area. Under current climatic conditions, the population of *R. similis* is not expected to reach damaging population levels in the open field. In case of increased temperatures due to global warming, the nematode population may reach damaging levels in very few places outdoors. Currently, main impact is considered for ornamental greenhouse production in the risk assessment area. Impact will be either caused by direct plant growth reductions or loss due to phytosanitary measures applied on regulated plants. Despite the fact that *R. similis* is globally considered as one of the most destructive plant parasitic nematodes, the impact in the risk assessment area is considered low.

Keywords: *Radopholus similis*, burrowing nematode, European Union, quantitative pest risk assessment, risk reduction options

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Correspondence: alpha@efsa.europa.eu

Panel members: Claude Bragard, David Caffier, Thierry Candresse, Elisavet Chatzivassiliou, Katharina Dehnen-Schmutz, Gianni Gilioli, Jean-Claude Grégoire, Josep Anton Jaques Miret, Michael Jeger, Alan MacLeod, Maria Navajas Navarro, Björn Niere, Stephen Parnell, Roel Potting, Trond Rafoss, Vittorio Rossi, Gregor Urek, Ariena Van Bruggen, Wopke Van Der Werf, Jonathan West and Stephan Winter.

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1. Introduction

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

The European Food Safety Authority (EFSA) is requested, pursuant to Article 22(5.b) and Article 29 (1) of Regulation (EC) No 178/2002[1], to provide a scientific opinion in the field of plant health. Specifically, as a follow up to the request of 29 March 2014 (Ares(2014)970361) and the pest categorisations (step 1) delivered in the meantime for 38 regulated pests, EFSA is requested to complete the pest risk assessment (PRA), to identify risk reduction options (RROs) and to provide an assessment of the effectiveness of current European Union (EU) phytosanitary requirements (step 2) for (1) *Ceratocystis platani* (Walter) Engelbrecht et Harrington, (2) *Cryphonectria parasitica* (Murrill) Barr, (3) *Diaporthe vaccinii* Shaer, (4) *Ditylenchus destructor* Thorne, (5) *Eotetranychus lewisi* (McGregor), (6) Grapevine Flavescence dorée and (7) ***Radopholus similis* (Cobb) Thorne.**

During the preparation of these opinions, EFSA is requested to take into account the recommendations, which have been prepared on the basis of the EFSA pest categorisations and discussed with Member States in the relevant Standing Committee. In order to gain time and resources, the recommendations highlight, where possible, some elements which require further work during the completion of the PRA process.

Recommendation of the Working Group on the Annexes of the Council Directive 2000/29/EC – Section II – Listing of Harmful Organisms as regards the future listing of *Radopholus similis* (Cobb) Thorne

Considering the great damage potential, and the limited distribution of this pest in only four MS within the European Union and only to greenhouses, the Working Group suggests listing this pest as a Union Quarantine pest.

The PRA initiated by EFSA needs to continue. In particular, further information is needed as regards the probability of establishment, as well as RROs in both greenhouse and open field conditions. Furthermore, information is also needed as regards the impact of the pest on the relevant host plants (citrus and banana), including an analysis of the potential spread pathways from ornamentals to banana and citrus.

The Working Group highlights that in case of outdoors establishment the possibilities for control under open field conditions are very limited.

1.2. Interpretation of Terms of Reference

1.2.1. *Radopholus similis* pest categorisation

In 2014, the Panel on Plant Health performed a pest categorisation of the *Radopholus similis* and *Radopholus citrophilus*. *R. similis* is regulated in Annex II, Part A, Section II of Council Directive 2000/29/EC[2] as a harmful organism known to occur in the EU. *R. citrophilus* is regulated in Annex II, Part A, Section I of Council Directive 2000/29/EC as a harmful organism not known to occur in the EU. This pest characterisation applies only to *R. similis*, because *R. citrophilus* has been recognised as an invalid species designation and is considered as a junior synonym of *R. similis*. *R. similis* is a distinct taxonomic entity that is absent in the field production sites (citrus, bananas) of the risk assessment area and can cause significant losses in citrus production. Moreover, various susceptible hosts other than citrus species are present in the EU under climatic conditions that are suitable for the development of *R. similis*. The pest has a sporadic presence on ornamental plants (under protected cultivation) in a few EU countries. Plants for planting are a pathway for introduction and spread of *R. similis*. The pest is observed to cause impacts on ornamentals in some Member States (hereinafter referred to as MSs) and further impacts are expected should further spread happen in the EU.

Based on the pest categorisation of *R. similis* and *R. citrophilus*, and in the context of the revision of the listing of harmful organisms of the Annexes of the Council Directive 2000/29/EC – Section II –, the Standing Committee on Plants, Animals, Food and Feed (PAFF Committee) – section Plant health –, provided recommendations to EFSA to take into account in the risk assessment of *Radopholus similis.*

[1] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 1.2.2002, p. 1–24.

[2] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169, 10.7.2000, p. 1–112.

1.2.2. Interpretation of the Terms of Reference and recommendations

The Panel on Plant Health (hereinafter referred to as Panel) interprets the Terms of Reference (ToR) as a request to conduct a full Pest Risk Assessment (PRA), to identify RROs and to provide an assessment of the effectiveness of current EU phytosanitary requirements for *R. similis* and to reply to following additional questions:

1) Probability of establishment,
2) RROs in greenhouses and field conditions,
3) Impact of the pest on relevant host plants (citrus and banana),
4) Analysis of the potential spread pathways from ornamentals to banana and citrus.

In view of the recommendations provided by the PAFF Committee to continue the risk assessment process, several objectives and related questions have been defined for performing the assessment:

1) assess the probability of establishment of *R. similis* focusing on climate and soil conditions and availability of host plants (ornamentals, citrus and banana)
    a) in green houses on ornamental plants,
    b) in the open field area where citrus plants are grown,
    c) in area where banana plants are grown (open field or protected area);
2) evaluate the RROs in greenhouses and open field conditions separately for ornamentals, citrus and banana;
3) assess the impact of the pest for citrus, banana and ornamentals;
4) analyse the potential spread pathways from ornamentals to banana and citrus focusing in particular,
    a) if citrus is a host for *R. similis* populations from ornamentals,
    b) potential pathways from greenhouses in northern EU to citrus production area in Mediterranean area.

In this scientific opinion, the risk assessment (RA) area is defined as the territory of the EU with 28 MSs, restricted to the area of application of Council Directive 2000/29/EC, which excludes Ceuta and Melilla, the Canary Islands and the French overseas departments.

2. Data and methodologies

2.1. Pilot phase

EFSA recommends that efforts should be made to work towards more quantitative expression of both risk and uncertainty whenever possible (EFSA Scientific Committee, 2012), i.e. where possible, the expression of the probability of the negative effect and the consequences of the effect should be reported quantitatively.

The method used in this assessment seeks to address the call for increased quantitative reporting of risk. The first iteration of the method was applied to four case study pests (EFSA PLH Panel, 2016a–d). Feedback from users has been taken into account to refine the method and the revised method is being used in a further series of tests on four more pilot case studies. This is one of these second phase pilot studies. Following feedback received from the second series of pilot case studies, it is anticipated that further refinements may be made to the method before it is published in 2018 as a new guidance document for the EFSA PLH Panel.

2.2. Data

EFSA conducted an extensive literature search for the pest categorisation of *R. similis* (EFSA PLH Panel, 2014). Further references and information were obtained from experts and from citations within the references. The same strategy was followed to retrieve relevant papers that had appeared since the publication of the pest categorisation (EFSA PLH Panel, 2014).

Trade data have been collected and used from different sources:

- Dutch trade inspection data,[3] (hereinafter referred to as NL-NPPO, 2017).
- European Commission, Statistical Office of the European Communities (EUROSTAT, online).
- ISEFOR trade data (Increasing Sustainability of European Forests: Modelling for security against invasive pests and pathogens under climate change).
- International Statistics on Flowers and Plants 2016 (AIPH, 2016).

The EUROPHYT (online) database, which collects notifications of interceptions of plants or plant products that do not comply with EU legislation, was consulted searching for pest-specific notifications on interceptions.

Information provided from the literature and online databases on pest distribution, damage and management was complemented with information obtained from a short questionnaire (hereinafter referred to as MS Questionnaire) that was sent by the PLH Panel to the National Plant Protection Organization (NPPO) of all EU MSs in 2014 (EFSA PLH Panel, 2014). This questionnaire aimed to clarify the current distribution of *R. similis* at country level and update information available in the European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval (EPPO PQR, online). In 2016, some MSs performed a survey for *R. similis* and provided EFSA with updated information on the distribution of the nematode. A summary table on the pest status, based on EPPO PQR (online) and MSs replies, is presented in Appendix A (Section A.4, Table A.27).

2.3. Methodologies

The Panel performed the risk assessment for *R. similis* following the guiding principles presented in the EFSA Guidance on a harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures (ISPM) No. 11 (FAO, 2013).

When conducting this PRA, the Panel took also into consideration the following EFSA horizontal guidance documents:

- Guidance of the Scientific Committee on Transparency in the Scientific Aspects of risk assessments carried out by EFSA. Part 2: General Principles (EFSA, 2009).
- Guidance on the structure and content of EFSA's scientific opinions and statements (EFSA Scientific Committee, 2014).
- Guidance on Statistical Reporting (EFSA, 2014).
- Guidance on uncertainty (EFSA Scientific Committee, 2016).

A specific quantitative assessment model was used to perform the risk assessment. The specification of the model is described in Section 2.4.

The assessment follows a quantitative approach, in which the steps of entry and establishment, are elaborated quantitatively for four pathways (PW1, PW2, PW3 and PW4), under three RRO scenarios, identified as A0–A2, and the steps of spread and impact are elaborated quantitatively for two pathways (PW1 and PW2), under the three RRO scenarios, according to the ToR. Within each step, sub-steps are distinguished to quantitatively assess the underlying component processes. The sub-steps are detailed in Appendix A. An overall summary description of the four steps is provided in Section 2.4, which describes the overall risk assessment model.

The outcome of these models is expressed in a number of glasshouses infested, and for open fields in number of citrus orchards infested. The impact is expressed as production loss in terms of number of plants.

Uncertainty involved in estimating entry, establishment, spread and impact, is represented using a probability distribution which expresses the estimates of the variables provided by the experts considering both available data and judgement. The distribution is characterised by a median value and four additional percentiles of the distribution. The median is the value for which the probability of over- or under-estimation of the actual true value is judged as equal. Calculations with the model are made by stochastic simulation, whereby values are drawn randomly from the distribution specified for each parameter. The stochastic simulations are repeated 20,000 times to generate a probability distribution of outcomes, i.e. the outcome of the entry, establishment, spread and impact process in a given period in the future.

[3] Data were kindly provided by the Dutch National Plant Protection Organisation.

In the model calculation, the uncertainty of each component is passed through the model equation, so that its contribution to the uncertainty of the final result can be shown. The decomposition of uncertainty calculates the relative contribution of each individual input to the overall uncertainty of the result. The sensitivity analysis is performed for the A0 scenario and has similar results also for the other scenarios.

Section 3 on Assessment reports the outcomes of these stochastic simulations. The distributions given in this section characterise the possible range of outcomes in a future year, under a certain scenario.

The distributions of variables are characterised by different values and ranges:

The median is a central value with equal probability of over- or underestimating the actual value.

The quantiles divide the uncertainty distribution into classes, each containing a certain fraction of the possible outcome. Quartiles are quantiles subdividing the uncertainty distribution in four classes, whilst percentiles are quantiles subdividing it in 100 classes.

The interquartile range is an interval around the median, where it is as likely that the actual value is inside as it is likely that the actual value is outside that range. The interquartile range is bounded by the 1st and 3rd quartile (the 25th and 75th percentile) of the distribution. This range expresses the precision of the estimation of interest. The wider the interquartile range, the greater is the uncertainty on the estimate. In this opinion, we refer to the interquartile range by using the term '50%-uncertainty interval'.

For experimental designs, it is common to report the mean (m) and the standard error ($\pm$ s) for the precision of the estimate of a measured parameter. The interval: $m \pm s$ ($[m - s, m + s]$) is used to express an interval of likely values. This estimation concept is based on replicated measurements. In the context of uncertainty, it is not reasonable to assume replicated judgements. Therefore, the median and interquartile range is used instead of the mean and the interval $m \pm s$, but the interpretation as the precision of judgements is similar.

In addition to the median and interquartile range, a second range is reported: the probability range. The probability range is formally defined as the range between the 1st and 99th percentile of the distribution allowing the interpretation that it is extremely unlikely that the actual value is outside this range. In this opinion, we refer to the probability range by using the term '98%-uncertainty interval'.

Further intervals with different levels of coverage could be calculated from the probability distribution, but these are not reported as standard in this opinion.

The methodology used for this risk assessment is quantitative and produces quantitative results (Gilioli et al., 2017). As in all quantitative science, the results are reported in a manner that appropriately reflects the degree of precision or approximation of the data used. Plant health risk assessment data are often limited and some input parameters have been assessed by expert judgement, which is necessarily approximate in nature. The risk assessment outputs are thus also approximate. Therefore, outputs have been rounded to an appropriate degree to reflect the degree of approximation that is present in the assessment.

Please note that the number of significant figures used to report the characteristics of the distribution does not imply the precision of the estimation. For example, the precision of a variable with a median of 13 could be reported using the associated interquartile range, perhaps 3–38, which means that the actual value is below a few tens. In the opinion, an effort was made to present all results both as a statement on the model outcome in numerical expressions, and as an interpretation in verbal terms.

The procedure for assessment of phytosanitary RROs in risk reduction scenarios is provided in Appendix B, the RROs for application in the EFSA quantitative risk assessment framework for Plant Health are listed in Appendix C and the data used in the opinion are provided in Appendix D. The model calculation performed for this opinion is shown in Annex A.

2.3.1. Specification of the scenarios

The different scenarios of the pest risk assessment are:

- **A0:** Current regulation in place: specific requirements according to the Council Directive 2000/29/EC for the pest (see Section 2.3.1.1 and Appendix B).
- **A1**: Current regulation without specific requirements according to the Council Directive 2000/29/EC for *R. similis* (see Section 2.3.1.2 and Appendix B).
- **A2**: Current regulation in place + enforced measures (see Section 2.3.1.3 and Appendix B).
- **A3**: Current regulation in place: specific requirements according to the Council Directive 2000/29/EC for the pest + climate change of +2°C.

2.3.1.1. Scenario A0

Scenario A0 represents the situation with all current regulations and phytosanitary measures in place.

Note: Current regulations treat *R. similis* and *R. citrophilus* as separate species. Only *R. citrophilus* is regarded as pest of citrus not present in the EU in the current legislation and therefore is listed in Annex IIAI and IVAI, whereas *R. similis* is listed in Annex IIAII and IVAII of the Council Directive 2009/EC. *R. citrophilus* is an obsolete species and all phytosanitary measures to *R. citrophilus* are considered as measures to *R. similis* (EFSA PLH Panel, 2014). In summary as specified in Annex IVAI.18 of the Council Directive 2009/EC, this implies that for the specified plant genera only import is allowed from pest-free areas or, if the pest is present, the production places are tested for the presence of the pest (guarantee of pest-free production place).

2.3.1.2. Scenario A1

Scenario A1 represents a hypothetical situation where the existing phytosanitary measures, specific to *R. similis* and *R. citrophilus* (obsolete species) (as specified in Annex IIAI, IIAII, IIIA, IVAI and IVAII of Council Directive 2000/29/EC), are withdrawn. All other phytosanitary measures remain in place. This means:

- no host plant species are listed as 'subject of contamination' for *R. similis* (and *R. citrophilus*) in Annex II,
- the specific requirements concerning *R. similis* (and *R. citrophilus*) of Annex IV A I (18) and Annex IV A II (11) are removed,
- the requirements for listed host plants of *R. similis* in Annex V A (2.3) are removed.

As a consequence, *R. similis* is then no longer listed as a quarantine pest, but measures aimed at other pests or groups of pests may still affect its entry into or spread within the EU.

2.3.1.3. Scenario A2

Scenario A2 represents a situation where more strict phytosanitary measures are in place to prevent entry, establishment and spread of *R. similis*:

In scenario A2, it is recognised that it is not possible to make a complete list of all hosts of *R. similis*. Therefore, *R. similis* is listed as a quarantine pest, regardless of the material potentially carrying the pest, to prevent entry into and spread within all MSs of the EU. Since *R. similis* is known to occur in the EU, the species is now listed in Annex I A II of the Council Directive 2000/29/EC. The special requirements for specified host plants of *R. similis* in scenario A0 are replaced by a new special requirement improving a Pest-Free Place of Production by specifying the growing conditions/procedures of the plants by, e.g. sterile soil, pest-free starting material. This is to recognise that plants may become infested with *R. similis* if they are grown in infested growing medium, or if the plants are grown from infested planting material (e.g. cuttings taken from infested plants) regardless of the presence of *R. similis* in the growing medium. The measure applies to plants for planting from all origins (outside and within the EU and products).

Scenario A2 is completed with a more stringent control procedure at import, requiring a test for presence of *R. similis* for each imported consignment of plants for planting.

2.3.1.4. Scenario A3

Scenario A3 represents a situation under a climate warming of + 2°C increase in average air temperature, but with all the other current regulations and phytosanitary measures of the baseline scenario (A0) in place.

2.3.2. Definitions for the scenarios

2.3.2.1. Definitions of the pathways for entry and spread of *R. similis*

Radopholus similis is a migratory endoparasitic nematode species. It is a highly polyphagous nematode parasitising more than 250 plant species belonging to a wide variety of families (Duncan and Moens, 2006; Brooks, 2008; EPPO, 2008a; Moens and Perry, 2009; CAB International, 2014). For more detailed data on biology, see the pest categorisation and for host plants specifically see Tables 8 and 9 of the pest categorisation (EFSA PLH Panel, 2014).

R. similis cannot move actively over very long distances but its virulent behaviour and a very wide host range may result to its effective local spread of up to 15 m per year (Duncan and Moens, 2006). Although this nematode is not present only within host plants but also in the soil and run-off water, it can be disseminated over short distances through infested plants for planting, soil adhering to agricultural machinery, feet or paws of wild animals (e.g. deer, rabbits, foxes etc.), run-off water and also through flooding events and wind erosion. This nematode can survive for about 6 months in the soil without host plants (Inserra et al., 2005; Brooks, 2008; Chabrier et al., 2010) and for several weeks in water (Chabrier et al., 2009, 2010). According to Chabrier et al. (2010), it is possible that this nematode can be disseminated by run-off water not only over short (within one field, between fields of one farmer and from farm to farm) but also over long distances.

Infested host plants for planting (corms, roots and rhizomes of host plants) are major long distance pathway of *R. similis* resulting in its worldwide occurence (Duncan and Moens, 2006); this nematode is now widespread in tropical and subtropical areas (O'Bannon, 1977; Elbadri et al., 2001).

Because *R. similis* is a migratory root endoparasite (invading also rhizomes), only rooted plants are considered. Because plants within pathways PW1, PW2, PW3 and PW4 are highly diverse a subdivision has been made according to size of plants which is possible according to their combined nomenclature codes (CN codes) used for classification of goods (see Section 2.3.2.1) into plants smaller than 1 m with an assumed main designation for greenhouse and indoor use and plants larger than 1 m with an assumed main designation for outdoor use. Both categories include several genera of host plants of *R. similis*.

The Panel identified following pathways for entry and spread of *R. similis* from infested areas:

1) Regulated plants for planting such as rooted ornamental plants (including rhizomes, plants for planting including cuttings) of the families Araceae, Marantaceae, Musaceae, Strelitziaceae, Heliconiaceae and the genus *Persea* spp., *Musa* spp. or *Citrus* spp. The Panel assumes that this type of planting material (less than 1 m) are mainly produced in glass houses and used as indoor plants (= **under A0 regulated small plants (PW1)**).
2) Non-regulated rooted host plants for planting (including rhizomes plants for planting including cuttings) not listed in the pathways 1, 5, 6 and 7 originating from areas where the pest occurs. The Panel assumes that this type of planting material (less than 1 m) are mainly produced in glass houses and used as indoor plants (= **under A0 non-regulated small plants** (**PW2**)).
3) Regulated plants for consumer end-use such as rooted ornamental potted plants of the families Araceae, Marantaceae, Musaceae, Strelitziaceae, Heliconiaceae and the genus *Persea* spp., *Musa* spp. or *Citrus* spp. The Panel assumes that this type of plant material (above 1 m) are mainly used as outdoor plants (= **under A0 regulated large plants** (**PW3**)).
4) Non-regulated plants for consumer end-use such as rooted host potted plants not listed in the pathways 1, 5, 6 and 7 (e.g. from the family Arecaceae) originating from areas where the pest occurs. The Panel assumes that this type of plant material (above 1 m) are mainly used as outdoor plants (= **under A0 non-regulated large plants** (**PW4**)).
5) Aquatic plants (e.g. *Anubias, Vallisneria spiralis*).
6) Citrus plants; plants of *Citrus*, *Fortunella*, *Poncirus* and their hybrids for planting (seedlings, rootstocks).
7) Banana family plants (Musaceae) for planting (corms: suckers, bits).
8) Soil or growing media attached to host or non-host plants for planting with roots from areas where the pest occurs.
9) Soil adhering to machinery or packaging material, tools, shoes and animals from countries/areas where the pest occurs.
10) Soil and growing media from countries/areas where the pests occur.
11) Water-related pathways.

A. Plant-related pathways

Pathways 1–4. Rooted ornamental plants (including rhizomes, plants for planting and potted plants)

The use of contaminated planting material over a long period is the most important reason for the widespread prevalence of *R. similis.* The probability of the presence of *R. similis* in the roots of ornamental host plants originated from the production sites where this nematode is present is high. These plants are therefore recognised by the Panel as a principal means by which this nematode enters new areas.

The importation into RA area of many ornamental plants that are hosts of *R. similis* and belong to families of Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae is highly restricted (Council Directive 2000/29/EC, Annex IVAI.18).

However, the above-mentioned import restrictions do not apply to all host plants of *R. similis*.

Many not regulated palm tree species (Arecaceae) that are regularly imported into the EU with roots have been reported as hosts of *R. similis* (Griffith et al., 2005; Dixon and Anderson, 2013) and have also been frequently intercepted in recent years (*Areca, Caryota, Howea, Licuala, Livistona*).

Pathway 5. Aquatic plants

R. similis has a broad host range and is able to parasitise rhizomes, petioles and leaves of some commercial aquatic plants (e.g. *Anubias barteri* var. *nana*) (Lehman et al., 2000). In addition to *A. barteri* var. *nana*, this nematode was also detected in the roots of *A. barteri* var. *coffeefolia*, *A. barteri* var. *glabra* and *Anubias gigantea* and based on greenhouse studies also demonstrated as a parasite of *Anubias afzelii*, *A. barteri* var. *caladiifolia* and *A. gracilis* (Lehman et al., 2000). If host species are grown in the infested production sites, the probability of *R. similis* being associated with them is considered as high. Following the interceptions in recent years, aquatic plants (*Anubias* spp.) are considered by the Panel as second important pathway.

Pathway 6. Citrus plants

The importation of *Citrus, Fortunella* and *Poncirus* plants for planting (and their hybrids) into RA area is prohibited by Council Directive 2000/29/EC, Annex III, point 16. For this pathway, the entry of *R. similis* into EU is considered as very unlikely. It is unlikely that phytosanitary regulations considering citrus plants for planting will be withdrawn as this pathway could allow the entry of several other harmful organisms that are listed in the Annexes to the Council Directive 2000/29/EC.

Pathway 7. Banana family plants (Musaceae) for planting (corms, suckers, bits)

In general, banana family plants for planting represent an efficient way of transmission and spread of *R. similis.* However, *Musa* plants for planting for commercial banana fruit production in the EU is not considered relevant because of the very low acreage of banana production in the RA area.

Musa plants that are not used for commercial banana fruit production are considered under ornamental plants less than 1 m high (indoor plants).

B. Soil-related pathways

Although *R. similis* is migratory endoparasite and is mainly present inside the roots of host plants, it may be present in soil in the absence of host roots for several months (Duncan, 2005). Plants for planting (host or non-host) may be imported in containers with soil or soil may be attached to their below-ground parts. If the production site is infested with *R. similis*, the nematode may be present and transported with plants, soil or growing media originating from such sites.

The following pathways are soil related pathways:

Pathway 8. Soil or growing media attached to host or non-host plants for planting with roots from areas where the pest occurs

See the pathway no 9.

Pathway 9. Soil adhering to machinery or packaging material, tools, shoes and animals from countries where the pest occurs

Soil adhering to agricultural machinery was not considered as an important pathway for entry because the volume of trade of used machinery is considered low. Soil attached to agricultural machinery as well as to tools and worker's shoes may contribute to spread but this may be mostly relevant for within field spread or spread to adjacent fields. More important is long distance spread which will require infested host plants.

Pathway 10. Soil and growing media from countries/areas where the pests occur

The Council Directive 2000/29/EC provides the following safeguards to prevent the introduction of pests with soil.

Annex IIIA of Council Directive 2000/29/EC prohibits the introduction of soil from Third countries to prevent movement with, e.g. machinery. Although Annex IVA1, Section 34, does allow the movement of 'soil . . . attached to or associated with plants . . . intended to sustain the vitality of the plants', there must also be an official statement that:

a) 'the growing medium, at the time of planting, was:

- either free from soil, and organic matter,

or

- found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms,

or

- subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and

b) since planting:

- either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms,

or

- within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a)'.

These measures reduce the chance that *R. similis* is introduced with soil transported with hosts/non-hosts from Third countries.

C. Water-related pathway

Pathway 11. Movement of surface water (run-off rain) in fields and through ditches, streams and rivers

The probability of *R. similis* being disseminated by runoff water over long distances depends on the nematode's ability to survive in water (*R. similis* can survive in water for several weeks) and is closely related to soil moisture which should be between field capacity and water saturation (Chabrier et al., 2009). In banana growing areas, favourable conditions for the spread of *R. similis* by runoff water occur during tropical showers accompanied by wind gusts. Due to soggy soil and gusts of wind, it is very likely that banana trees are tipping over. Nematodes consequently leave the roots of fallen trees and may be subject to the spread by runoff water over long distances (Chabrier et al., 2009).

In case that the environmental conditions facilitate establishment of *R. similis* in the RA area, the probability of the nematode being disseminated with this pathway would be limited to fields in the vicinity of the contaminated field and therefore to the local growing area of infested host plants of this nematode. Currently, the probability of the nematode being associated with this pathway in the RA area is considered as negligible.

D. Selection of relevant pathways for assessment

The selection of the most important of the pathways listed above for further assessment in this document has been based on the EFSA guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options (EFSA PLH Panel, 2010). The guidance document states that: 'the most relevant pathways should be selected using expert judgement and, where there are different origins and end uses, it is sufficient to consider only realistic worst-case pathways'.

For selection of the entry pathways, the number of interceptions and the trade volume were taken into consideration. Therefore, pathways 1–4 (rooted ornamental plants) are considered for quantitative risk assessment. Because there is a general import prohibition for citrus plants for planting (Annex III of Council Directive 2000/29/EC), which is not expected to be withdrawn, citrus pathway (the pathway 6) is considered closed.

Regarding the banana pathway, the Panel estimates that the majority of the EU farmers that cultivated bananas are using tissue culture seedlings as propagating material therefore the possibility of *R. similis* entering the EU via *Musa* plants for planting is considered as negligible. For aquatic plants, the Panel considers the transfer/shift from very specific environment (e.g. aquariums) to citrus nurseries and citrus orchard as not likely.

For spread and shift, the pathways 1–4 were considered in the assessment.

2.3.2.2. Definitions of different units used

Production unit in the assessment area: greenhouse

Pathway unit: consignment. In the entry part, consignment means pack, and in the spread part, consignment means production of one greenhouse.

Transfer unit: consignment

Spatial unit: greenhouse

Time unit: year.

2.3.2.3. Definitions of abundance of the pest

Scientific literature on surveys on the pest typically reports abundance of the pest as the average number of nematodes per unit of soil sample (e.g. 250 mL soil) and/or unit of host plant root tissue (e.g. 30 g root samples). In addition, the frequency of occurrence of the pest in the samples is reported. All tropical countries are considered to be infested at the same level. However, in this risk assessment, we only classify the abundance of the pest as infested or non-infested units.

Production unit in the assessment area: number of greenhouse, number of citrus orchards

Pathway unit: consignment. Consignment is considered infested when one infested plant is present in that consignment.

Transfer unit: consignment

Spatial unit: greenhouse

Time unit: year.

2.3.2.4. Potential RROs of the steps and identification of the RROs for the sub-steps

According to ToR, it is important to describe and evaluate the RROs in greenhouses and open field conditions separately for ornamentals, citrus and banana. Separate section is provided at the end of the assessment (Section 4). Potential RROs for implementation in the Risk Assessment steps are selected from Appendix C.

Potential RROs for sub-steps of Entry:

Sub-step E1 (starts with pre-planting preparations and ends with storage of the harvested product, resulting in a level of pest abundance in the harvested product, before preparation of consignment):

RRO 1.01: Growing plants in isolation
RRO 1.05: Cleaning and disinfection of facilities, tools and machinery
RRO 1.06: Soil treatment
RRO 1.07: Use of non-contaminated water
RRO 1.12: Roguing and pruning
RRO 2.01: Inspection
RRO 2.02: Laboratory testing
RRO 2.03: Sampling scheme
RRO 2.05: Certified and approved premises
RRO 2.06: Certified production of reproductive material
RRO 2.08: Surveillance.

Sub-step E2 (starts with handling of the harvested product and ends with a prepared consignment ready for transport, resulting in a level of pest abundance in consignment, before transport):

RRO 1.05: Cleaning and disinfection of facilities, tools and machinery
RRO 1.08: Physical treatments on consignments or during processing
RRO 1.14: Heat and cold treatments
RRO 2.01: Inspection
RRO 2.02: Laboratory testing
RRO 2.03: Sampling scheme
RRO 2.04: Phytosanitary Certificate.

Sub-step E3 (starts with transport of the consignment from the packing house and ends with arrival at the point of entry in the area of destination, resulting in a level of pest abundance before entry in area of destination):

No RROs selected.

Sub-step E4 (starts with inspection at the point of entry of the consignment and ends with release of the commodity units from the consignment, resulting in a level of pest abundance after entry, before transfer to host plants):

RRO 2.01: Inspection
RRO 2.02: Laboratory testing
RRO 2.03: Sampling scheme.

Sub-step E5 (starts with handling of commodity units at the place of destination and ends with transfer of the pest to host plants originally present in the place of destination, resulting in a level of pest abundance after transfer to host plants):

RRO 1.17: Post-entry quarantine.

Potential RROs for Establishment:

No sub-steps are distinguished.

RRO 1.01: Growing plants in isolation
RRO 1.05: Cleaning and disinfection of facilities, tools and machinery
RRO 1.06: Soil treatment
RRO 1.07: Use of non-contaminated water
RRO 1.11: Use of resistant and tolerant plant species/varieties.

Potential RROs for Spread:

No sub-steps are distinguished.

RRO 1.01: Growing plants in isolation
RRO 1.05: Cleaning and disinfection of facilities, tools and machinery
RRO 1.06: Soil treatment
RRO 1.07: Use of non-contaminated water
RRO 1.08: Physical treatments on consignments or during processing
RRO 1.11: Use of resistant and tolerant plant species/varieties
RRO 1.12: Roguing and pruning
RRO 2.01: Inspection
RRO 2.02: Laboratory testing
RRO 2.03: Sampling scheme
RRO 2.04: Plant Passport
RRO 2.05: Certified and approved premises
RRO 2.06: Certified production of reproductive material
RRO 2.08: Surveillance.

2.3.2.5. Ecological factors and conditions in the chosen scenarios

The reproduction rate of *R. similis* is temperature dependent (Elbadri et al., 2001) and the nematode is sensitive to low temperatures but thrives at higher temperatures and under moist soil conditions. Based on a review of presence/absence information for the pest in the literature, the Panel derived simple temperature sum thresholds for temperature suitability of the environment for *R. similis* establishment and impact.

Under scenario A3, the Panel considered the potential effect of climate warming on the potential for pest establishment.

2.3.2.6. Temporal and spatial scales

The resolution of the risk assessment with regard to time and space is defined for entry, establishment, spread and impact as follows:

Temporal scale: (time resolution and temporal horizon for the steps):

The temporal resolution is 1 year and the temporal horizon of the assessment is 10 years.

Spatial scale (spatial resolution and spatial extent for the steps):

The spatial extent of this PRA is the EU and the spatial resolution are greenhouses, citrus production area and citrus orchards.

2.3.3. Summary of different scenarios

The overview of the scenarios considered in the opinion is shown in Table 1.

Table 1: Overview of the scenarios

Scenarios		PW1	PW2	PW3	PW4	Considered in section
Baseline scenario						
A0	Baseline scenario: current regulations	x[(a)]	x	x	x	All sections
Deregulation scenario						
A1	All current regulations specific for *R. similis* and *R. citrophilus* are withdrawn	x	x	x	x	All sections
Scenario with additional regulation						
A2	Stricter measures, based on *R. similis* listed as harmful organism for any plant or product	x	x	x	x	All sections
Scenario under a climate warming of + 2°C increase in average air temperature						
A3	Climate warming of +2°C	x	x	x	x	Establishment Spread

(a): Scenario is applicable to the pathway.

2.4. Model formulation and formalisation

2.4.1. Notation

The following steps are defined

E = entry
B = establishment
S = spread
I = Impact
The steps are linearly ordered in a sequence E → B → S → I.
The letter A defines an assessment, the relevant scenario is defined by an integer number *j* (j = 0, 1, 2). A0 represents the current scenario.

2.4.2. Model for entry

2.4.2.1. Conceptual model for entry

The conceptual model for entry is shown in Figure 1.

The sub-steps E1–E3, as distinguished for the identification and operation of RROs (see Appendix B), are merged into one step represented by 'Trade volume', because steps E1–E3 are performed in exporting countries and details for the individual sub-steps are not available. Sub-step E4 is represented by 'Import inspection'. The potential founder populations represent sub-step E5.

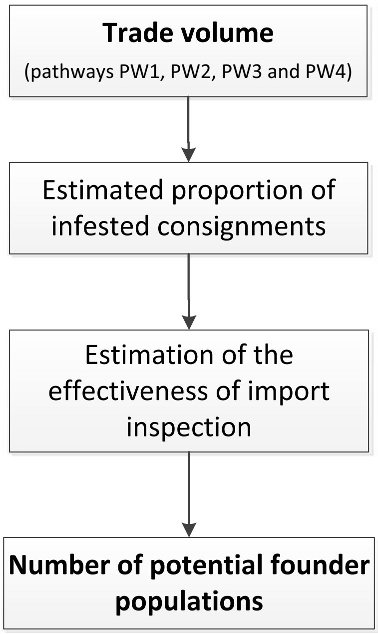

Figure 1: Conceptual model for entry

2.4.2.2. Formal model for entry

The parameters of the entry model are summarised in the Table 2.

Table 2: Parameters of the entry model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/ subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model (see Table D.9 in Appendix D)	
N0	Imp_Path	Total yearly import from countries class I [100 kg] by pathway	EUROSTAT by CN8
e1	Conv_Pcs2kg_Path	Conversion from weight [in kg] to number of plants [–] by pathway	CN Manual[(a)]
e2	Prop_Host_Path	Proportion of host plants [%] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [–] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
e4	Prop_Inf_Path	Proportion of infested packs exported to Europe [%] by pathway	Expert Knowledge Elicitation
e5	Surv_Insp_Path	Proportion of infested packs passing the EU border inspection [%] by pathway	Expert Knowledge Elicitation
N1	Packs_Inf_p, Packs_Inf_Path	Infested packages entering EU [–] by pathway no/pathway	Calculated by Monte Carlo simulation

(a): Commission Implementing Regulation (EU) 2016/1821 of 6 October 2016 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff. OJ L 294, 28.10.2016, p. 1–956.

<u>The equation of the entry model:</u>

The Entry model calculates the number of infested packs entering the EU from third countries of class I for different pathways N = 1, 2, 3, 4.

$$\text{Packs}_{\text{Inf,p}} = \sum\nolimits_{\text{path\_p}} \text{Packs}_{\text{Inf, Path}} = \sum\nolimits_{\text{Path\_p}} [\text{Imp}_{\text{Path}} \times 100/\text{Conv}_{\text{Pcs2kg, Path}} \times \text{Prop}_{\text{Host;Path}} / \text{Conv}_{\text{Packs2pcs, Path}} \times \text{Prop}_{\text{Inf, Path}} \times \text{Surv}_{\text{Insp, Path}}]$$

(1st step) Starting point of the Entry Model are the annual imports of different kinds of plants for planting into the EU (Imp) from tropical/subtropical countries with known pest reports or interceptions of *R. similis*. Annual trade volumes (in 100 kg) of the recent years 2010–2015 are used and converted to total numbers of imported plants (2nd step) by dividing through the average unit weights as defined in the CN manual (Conv_Pcs2kg).

To estimate the number of infested packages with *R. similis* entering the EU (Packs_inf), several multiplication factors are applied.

To correct for the possible host plants, the number of plants for planting is multiplied by the proportion of host plants in the different categories of planting material (3rd step). Proportions of the years 2010, 2012–2014 are used from the Dutch trade inspection database (NL-NPPO, 2017). Infestations are recognised on the level of packages. Therefore, the number of plants is converted to number of packs (4th step) by dividing by the average numbers of plants per package, which is also reported in the Dutch database.

Further multiplication factors take into account the infestation rate (Prop_Inf) of planting material (5th step), and the part, which will (6th step) not be detected at the import control (Surv_Insp).

2.4.3. Model for establishment

2.4.3.1. Conceptual model for establishment

Conceptual model for establishment is shown in Figure 2.

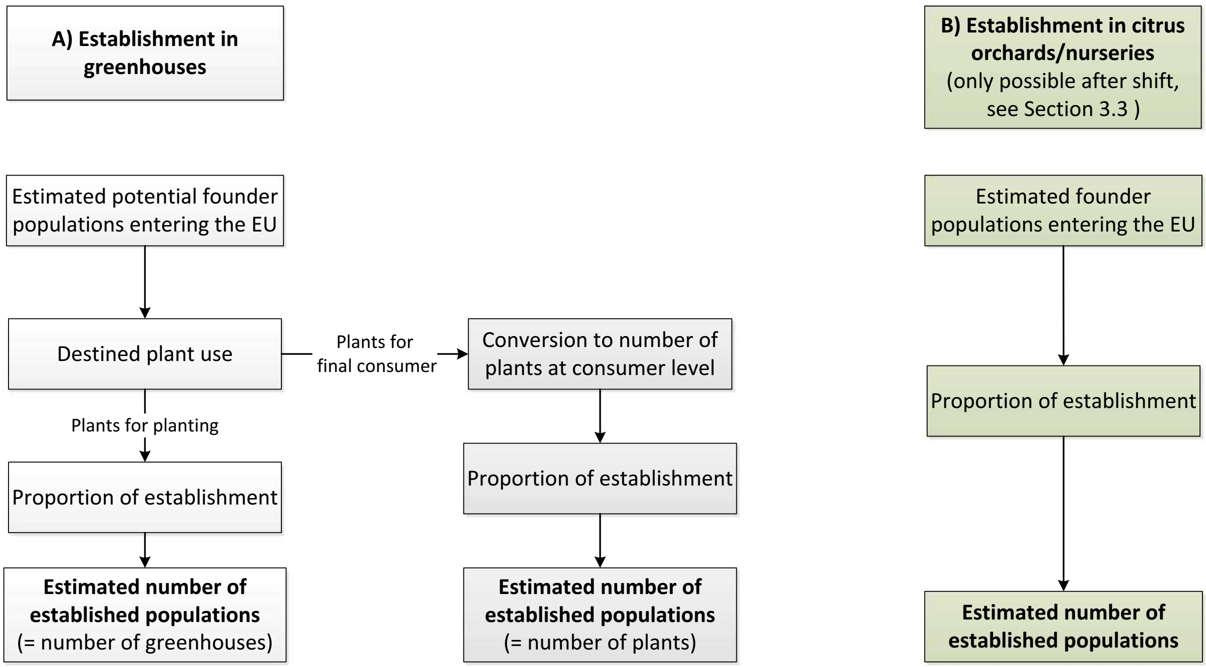

Figure 2: Conceptual model for establishment in greenhouses (A) and citrus nurseries or orchards (B)

2.4.3.2. Formal model for establishment

The parameters of the establishment model are summarised in the Table 3.

Table 3: Variables and parameters involved in the establishment model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model (see Table D.9 in Appendix D)	
N1	Packs_Inf_Path	Infested packages entering EU [−] by pathway	Calculated by Monte Carlo simulation
b1	Prop_P4P_Path	Proportion of packs used as plants for planting [%]	Dutch trade inspection data (NL-NPPO, 2017)
b2	Prop_Est_Path	Proportion of individual plants establishing a founder population ()	Expert Knowledge Elicitation
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [−] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
N2_GH	Est_GH_p, Est_GH_Path	Established greenhouses [−] by pathway	Calculated by Monte Carlo simulation
N2_Plants	Est_Plants_p, Est_Plants_Path	Established populations at consumer level (incl. plants finally produced) [−] by pathway	Calculated by Monte Carlo simulation
	Plants_Cons_Path	Established populations at consumer level from finally produced plants (see impact)	Calculated by Monte Carlo simulation

The equation of the establishment model:

The Establishment model calculates the number of greenhouses with established founder populations in the EU, and the number of individual plants with established founder populations at consumer level (including plants finally produced) for different pathways N = 1, 2, 3, 4.

$$\mathrm{Est}_{\mathrm{GH,p}} = \sum\nolimits_{\mathrm{Path\_p}} \mathrm{Est}_{\mathrm{GH,\,Path}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Packs}_{\mathrm{Inf,\,Path}} \times \mathrm{Prop}_{\mathrm{P4p,\,Path}} \times \mathrm{Prop}_{\mathrm{Est,\,Path}}\right]$$

$$\mathrm{Est}_{\mathrm{Plants,p}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Est}_{\mathrm{Plants,\,Path}} + \mathrm{Plants}_{\mathrm{Cons,\,Path}}\right] = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Packs}_{\mathrm{Inf,\,Path}} \times (1 - \mathrm{Prop}_{\mathrm{P4P,\,Path}}) \times \mathrm{Prop}_{\mathrm{Est,\,Path}} \times \mathrm{Conv}_{\mathrm{Packs2pcs,\,Path}} + \mathrm{Plants}_{\mathrm{Cons,\,Path}}\right]$$

The establishment model distinguishes the use of the infested packs (Packs_inf) for further propagation or direct transfer to the consumer.

The number of infested packs (Packs_inf) is multiplied by the proportion for use for further propagation (1st step), and the proportion of infested packs (2nd step). It is assumed that infestation is seldom, and a single infested pack has the potential to infest a greenhouse. Therefore, each infested pack, which will establish a founder population and is used for further propagation, will cause the infestation of a total greenhouse (Est_GH).

The remaining part of the planting material will be distributed to the consumer. The number of packs is multiplied by the number of plants per pack, because at consumer level each plant has the potential to establish a founder population.

Finally, the total number of established plants (Est_plant) is calculated by summing the direct transfer to the consumer and the indirect via infested plants after propagation (see impact for Plants_Cons).

The formal model for establishment in EU citrus growing areas.

Annual Tsum = ∑(Ti− Tbase), where T is monthly average temperature $i = 1 \cdots 12$ and Tbase = 21°C. Tsum from 0° to 40° days: unsuitable for *R. similis* establishment, Tsum 40–992 day degrees: suitable for *R. similis* establishment with low population densities, Tsum > 992 day degrees: *R. similis* may establish with high population densities.

2.4.4. Model for spread

2.4.4.1. Conceptual model for spread

Conceptual model for spread is shown in Figure 3.

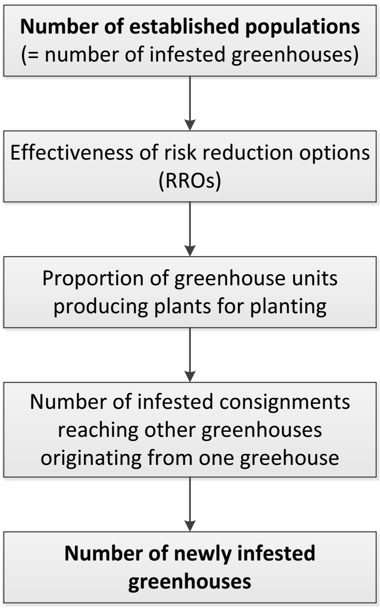

Figure 3: Conceptual model for spread

2.4.4.2. Formal model for spread

The parameters of the spread model are summarised in the Table 4.

Table 4: Variables and parameters involved in the spread model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model (see Table D.9 in Appendix D)	
N2_GH	Est_GH_Path	Established greenhouses [–] by pathway	Calculated by Monte Carlo simulation
s1	Surv_RRO_Path	Proportion of infested greenhouses after application of usual mitigation measures [%]	Expert Knowledge Elicitation
s2	Prop_GHP4P	Proportion of greenhouses producing further plants for planting [%]	Expert Knowledge Elicitation
s3	Fact_GHP4P	Multiplication factor for spread via production of plants for planting [–]	Dutch trade inspection data (NL-NPPO, 2017)
N3_GH	GH_spread	Infested greenhouses after spread [–] by pathway	Calculated by Monte Carlo simulation

The equation of the spread model:

The spread model calculates the number of greenhouses with established founder populations after spread via planting material for different pathways N = 1, 2, 3, 4.

$$GH_{Spread,p} = \sum\nolimits_{Path\_p} GH_{Spread,\ Path} = \sum\nolimits_{Path\_p} \left[Est_{GH,\ Path} \times Surv_{PRO,\ Path} \times \left(Prop_{GHP4P,\ Path} \times Fact_{GHP4P,\ Path} + \left(1 - Prop_{GHP4P,\ Path}\right)\right)\right]$$

The spread model calculates the number of infested greenhouses after spread via propagation material. The number of greenhouses before spread is corrected by the proportion of greenhouses, which will be detected by regular RRO (Surv_RRO).

Two cases are distinguished for spread: (1) The greenhouse produces intermediate products and sends these to additional greenhouses (Fact_GHp4p); (2) the greenhouse produces already for the final consumer. In the first case, additional greenhouses are infested; in the latter, only the original greenhouse will be infested.

The estimator (GH_Spread) is the sum of both cases weighted by the proportion of greenhouses for further propagation.

2.4.5. Model for impact

2.4.5.1. Conceptual model for impact

Conceptual model for impact is shown in Figure 4.

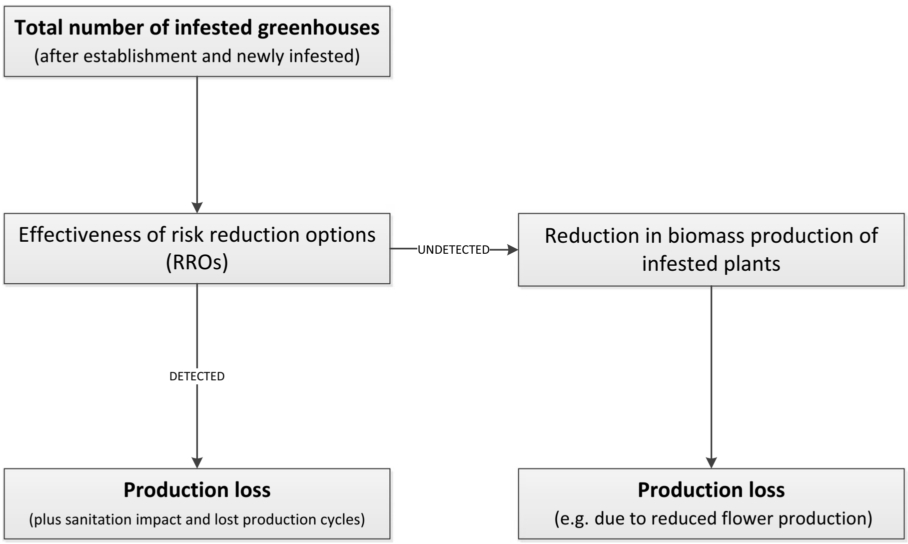

Figure 4: Conceptual model for impact

2.4.5.2. Formal model for impact

The parameters of the impact model are summarised in the Table 5.

Table 5: Variables and parameters involved in the impact model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model (see Table D.9 in Appendix D)	

Abbreviation	Name	Description	Evidence
N3_GH	GH_spread_p	Infested greenhouses after spread [−] by pathway	Calculated by Monte Carlo simulation
i1	Surv_Cert_Path	Proportion of greenhouses passing control programs [%] by pathway	Expert Knowledge Elicitation
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [−] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
i3	Red_all_Path	Reduction in plant material due to the infestation [%]	Expert Knowledge Elicitation
b2	Prop_Est_Path	Proportion of individual plants establishing a founder population [%]	Expert Knowledge Elicitation
N4_GH	GH_det_p, GH_det_Path	Infested greenhouses detected [−] by pathway	Calculated by Monte Carlo simulation
N4_Plants	Plants_imp_p, Plants_imp_Path	Plants impacted [−] by pathway by pathway	Calculated by Monte Carlo simulation
N4_Cons	Plants_Cons_Path	Established populations at consumer level from finally produced plants (see establishment)	Calculated by Monte Carlo simulation

The equation of the impact model:

The impact model calculates the number of greenhouses with detected infestation in the EU, and the loss in plants due to undetected infestation, and finally the number of infested, established plants at the consumer for different pathways N = 1, 2, 3, 4. The latter is reported in the establishment section.

$$GH_{det,p} = \sum_{Path\_p} GH_{det,\ Path} = \sum_{Path\_p} \left[GH_{spread,\ Path} \times \left(1 - Surv_{Cert,\ Path}\right)\right]$$

$$Plants_{imp,p} = \sum_{Path\_p} Plants_{imp,\ Path} = \sum_{Path\_p} \left[GH_{spread,\ Path} \times Surv_{Cert,\ Path} \times Conv_{Packs2pcs,\ Path} \times Red_{all,\ Path}\right]$$

$$Plants_{cons,p} = \sum_{Path\_p} Plants_{cons,\ Path} = \sum_{Path\_p} \left[GH_{spread,\ Path} \times Surv_{Cert,\ Path} \times Conv_{Packs2pcs,\ Path} \times \left(1 - Red_{all,\ Path}\right) Prob_{Est,\ Path}\right)\right]$$

The impact model estimates three kinds of impacts separately. First, the number of greenhouses after spread is corrected by the proportion of greenhouses, which will not be detected by certification schemes as infested. This results in the number of detected infested greenhouses (GH_det).

If the infestation is not recognised, *R. similis* will reduce the amount of plants (Plants_imp). Here, a conversion back to plants (Conv_Packs2pcs) and the reduction of plant material (Red_all) is used in the estimation.

Finally, a number of infested plants will reach the consumer and establish (Plants_cons). The latter is reported in the establishment section.

3. Assessment

3.1. Entry

The aim of this section is to estimate quantitatively the number of potential founder populations of *R. similis* that enter each year the RA area from Third countries (i.e. outside the EU) with infested plants for planting. The assessment of entry is made separately for the four main pathways described above in Section 2.3.2.1 and the assessments are made under different scenarios describing situations with varying phytosanitary regulations as specified above in Sections 2.3.1 and 2.3.2.

3.1.1. Assessment of entry for the different scenarios

Radopholus similis has a very wide host range and a number of plants that may carry the nematode are imported into the EU. Virulence difference of *R. similis* has led to the designation of races and description of a new (now invalid) species. The extent and relevance of these differences among nematode populations as well as aspects of the host range of *R. similis* are described in Appendix A. For some hosts plants, such as, e.g. citrus plants, importation is not allowed. The importation of citrus plants for planting from Third countries into the EU is banned by Council Directive 2000/29/EC, Annex III, point 16. Entry of *R. similis* into the RA area with citrus plants is very unlikely and therefore citrus is considered a closed pathway. Potential pathways for entry are therefore restricted to small or large ornamental plants (including banana).

Although banana plants are imported into the EU, the importation of banana plants for the production of banana fruits ('commercial production') is considered negligible by the Panel. This is due to the fact that (i) commercial banana production is of only local relevance in the RA area, (ii) the acreage is very low (few hundred hectares only) and (iii) commercial production is based on the use of tissue cultured banana plants. As the banana pathway is of minor importance (or negligible), it will not be considered in the model.

Aquatic plants, specifically *Anubias* spp., infested with *R. similis* are frequently intercepted. The reasons for this are not clear; Anubias are only reported relatively recently as a host plant of *R. similis* (Lehman et al., 2000). Since the transfer from aquatic environments to, e.g., citrus orchards or nurseries, is unclear and because the Panel considers transfer from aquatic plants in tropical aquariums to terrestrial plants not likely, the aquatic plants pathway will not be quantitatively assessed.

Ornamentals – large or small – are therefore the most relevant pathway and are quantitatively assessed. However, ornamentals are also a highly diverse pathway. Because of this huge diversity and for the purpose of this PRA, a subdivision of this pathway is necessary. A subdivision has been made according to size of plants which is possible according to their combined nomenclature codes (CN-codes) used for classification of goods (see Section 2.3.2.1) into plants smaller than 1 m with an assumed main designation for greenhouse and indoor use and plants larger than 1 m with an assumed main designation for outdoor use. Both categories include several genera of host plants of *R. similis*. Imported palm trees may be used as indoor plants but larger palms may also be planted outdoors areas that are also suitable for citrus production. A distinction will also be made for the regulatory status of the plants. Details on host plant species, including the non-regulated group of palm species are found in Appendix A.

For the entry section, only the scenarios A0, A1 and A2 are relevant. The Panel considers that climate change which – is considered in scenario A3 – does not immediately affect entry of the pest because the pest will most likely enter from either tropical/subtropical regions where outdoors conditions are already suitable for the pest or the pest enters via plants produced in greenhouses; in both cases, an increase in temperature is not likely to affect pest abundance leading to an increase in infested consignments.

For the quantitative assessment, data on imports of plants from tropical and subtropical countries to the EU from 2010 to 2015 from the EUROSTAT database (EUROSTAT, online) were considered and adjusted by trade category as described in Appendix D.

Only countries in which the pest is known to be present and is classified as subtropical/tropical and from which infested consignment were intercepted are considered in the assessment. The Panel considers that all before mentioned countries are equally infested by *R. similis.* The infestation rates of consignments originating from these countries are assumed to be equal. Details on country selection can be found in Appendix D.

The trade categories were then allocated to the following four pathways:

- under scenario A0 regulated small plants **(PW1)**
- under scenario A0 non-regulated small plants **(PW2)**
- under scenario A0 regulated large plants **(PW3)**
- under scenario A0 non-regulated large plants **(PW4).**

To illustrate these pathways, the Panel provide more detailed descriptions of the production for one species or group of species representing the small and large plants pathways in Appendix A.

The results of the entry assessment for the four relevant pathways are shown in Figures 5–8. The Panel assumes that the number of infested consignments entering the EU will result in the equivalent number of potential founder populations of *R. similis* in 1 year.

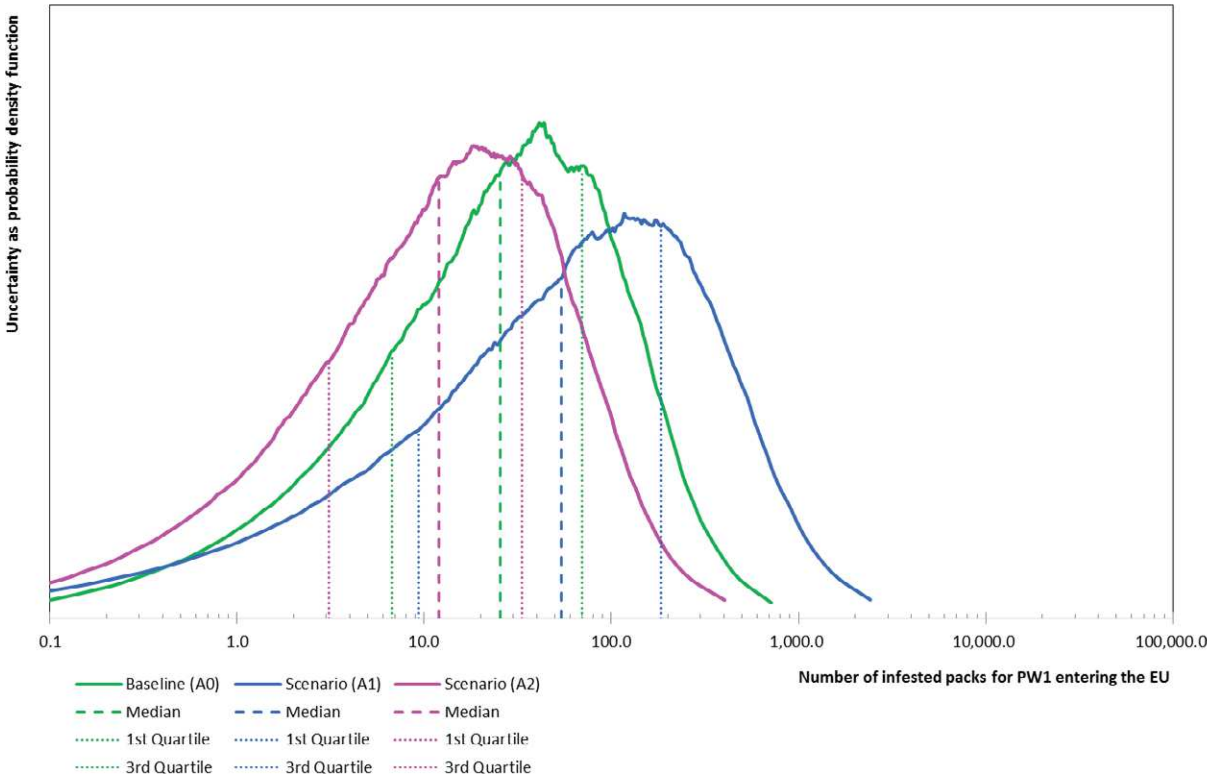

Figure 5: Uncertainty distribution of the number of potential founder populations of *Radopholus similis* expected per year due to new entries of infested consignments into the EU for pathway PW1 under the scenarios A0, A1 and A2

Consignments infested with *R. similis* are expected to enter the EU in PW1 despite the regulations (i.e. guarantee of exporting country that plants originate from a pest-free area or a pest-free production place) in place. However, median numbers are relatively low under all scenarios with values between 12 and 54 per year, and a 50% uncertainty interval between around 10 and not more than 200 infested consignments per year (Figure 5).

Highest numbers of infested consignments are estimated for the PW2 in scenarios A0 and A1 with a median number of infested consignments around 300 per year and a 50% uncertainty interval between 60 and 1,200 infested consignments. No differences between scenarios A0 and A1 will be expected due to the fact that this pathway is not regulated as regards *R. similis* (Figure 6).

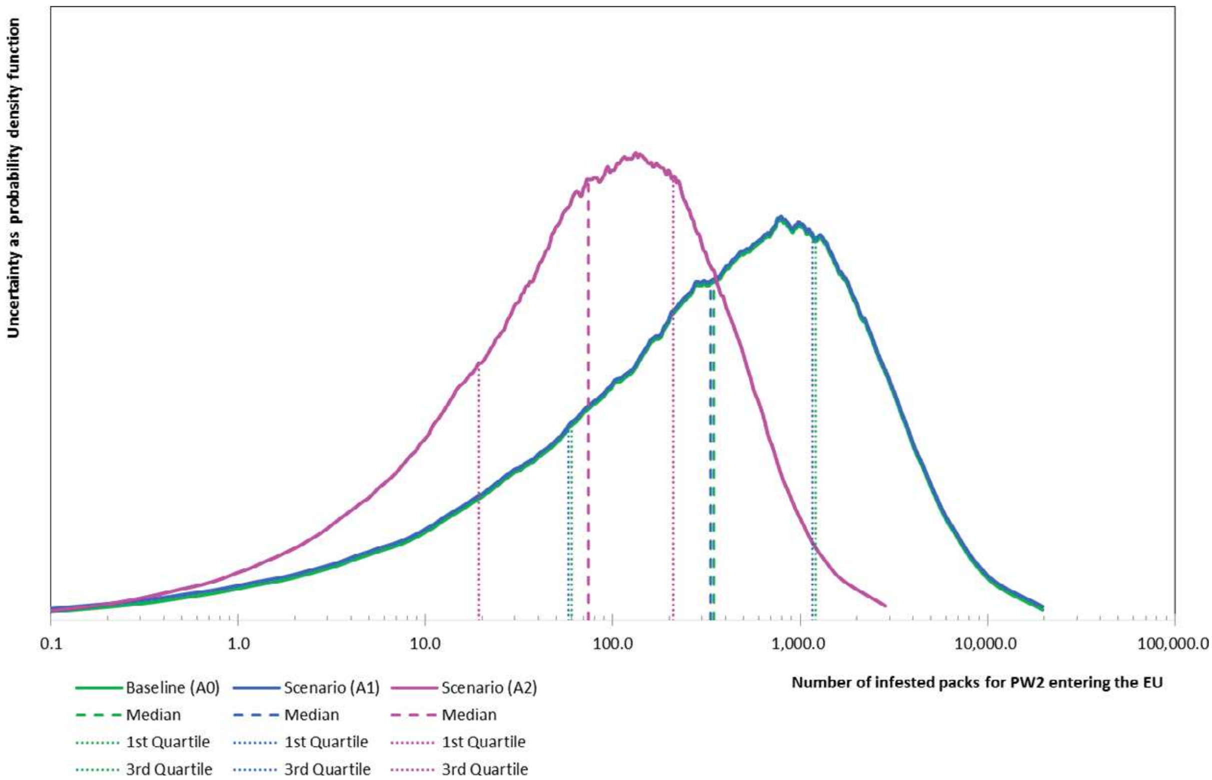

Figure 6: Uncertainty distribution of the number of potential founder populations of *Radopholus similis* expected per year due to new entries of infested consignments into the EU for pathway PW2 under the scenarios A0, A1 and A2

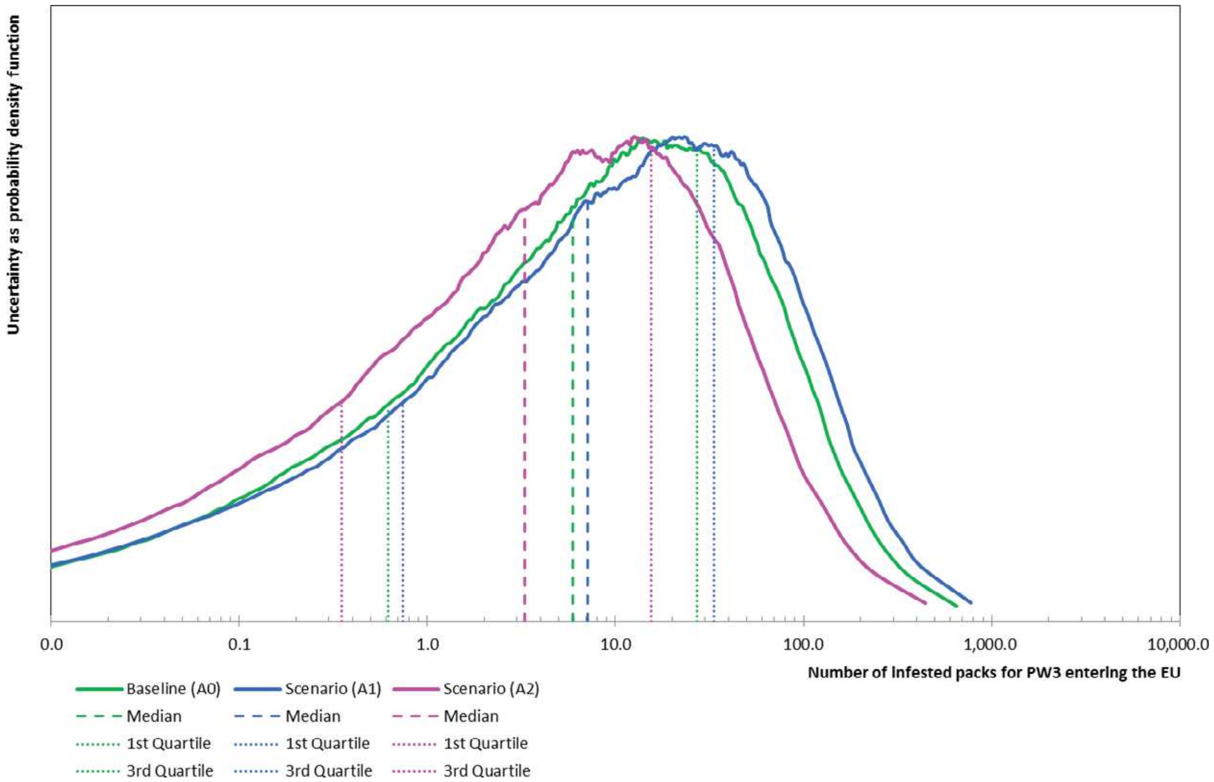

Figure 7: Uncertainty distribution of the number of potential founder populations of *Radopholus similis* expected per year due to new entries of infested consignments into the EU for pathway PW3 under the scenarios A0, A1 and A2

Lowest numbers of *R. similis*-infested consignments are expected for the regulated large plants with median values of less than 10 infested consignments per year under all scenarios (Figure 7).

The pest may also enter with large non-regulated plants (PW4), the second most important pathway for entry of *R. similis*. For this pathway, the median number of infested consignments is estimated to be below 100 and is estimated to be in the same order of magnitude as for PW2. However, the uncertainty interval is lower than for PW2, ranging between 10 and 400 infested consignments per year (Figure 8). Again, as this pathway is not regulated at present, no differences between A0 and A1 are expected.

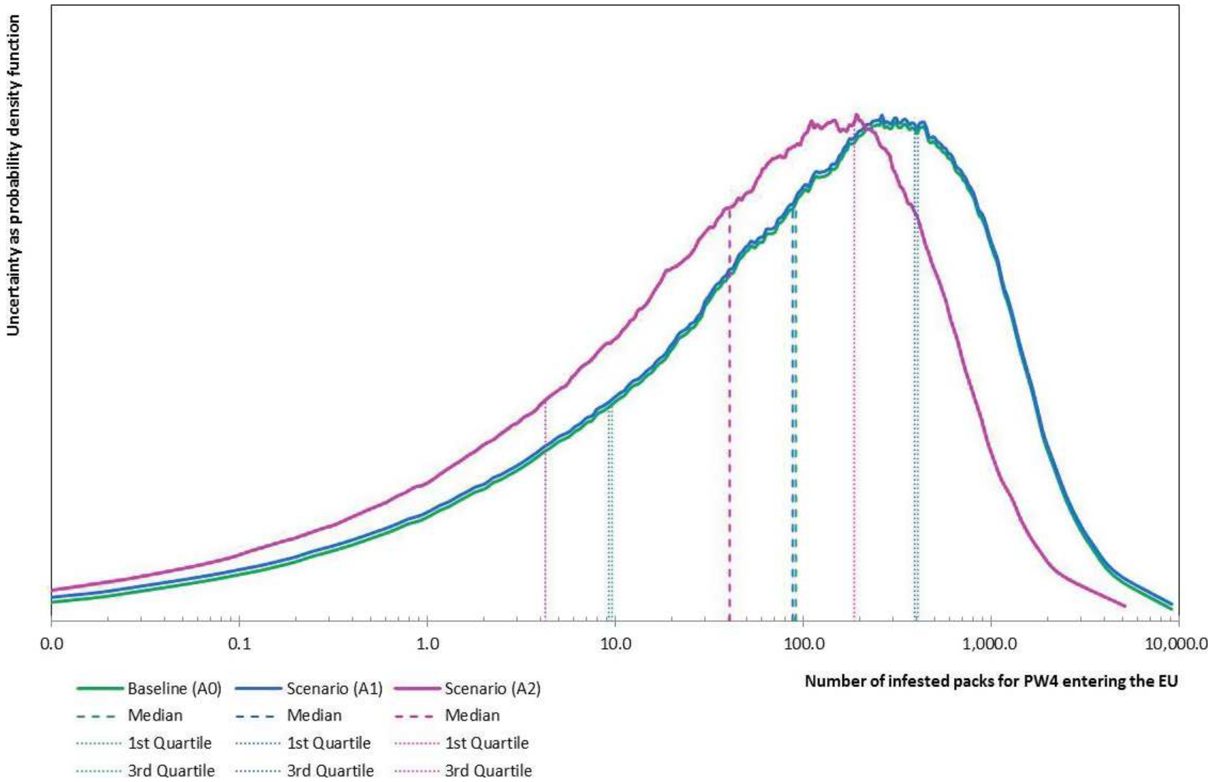

Figure 8: Uncertainty distribution of the number of potential founder populations of *Radopholus similis* expected per year due to new entries of infested consignments into the EU for pathway PW4 under the scenarios A0, A1 and A2

In general, under scenario A1 (without current pest specific regulations, where *R. similis* is *de facto* not a regulated pest), numbers of infested consignments entering the RA area are not expected to change considerably except for the currently regulated small ornamental plants. For those, a small increase in numbers of infested consignments is estimated under scenario A1 vs A0 due to a reduced effectiveness (or absence) of import inspections. However, the estimated median values range in the same order of magnitude as under scenario A0. A slightly larger 50% uncertainty interval for this pathway is expected under scenario A1 (between 10 and 200 infested consignments) as compared to scenario A0 (between less than 10 and 70 infested consignments).

Lower median numbers of infested consignments are estimated for all pathways under scenario A2 with stricter phytosanitary measures. Under this scenario, the currently non-regulated pathways (PW2 and PW4) are estimated to have highest numbers of infested consignments with a slightly wider uncertainty interval as compared to the regulated pathways. For the regulated small plants, the reduction under scenario A2 is entirely attributed to the mandatory testing of consignments at import for the presence of *R. similis*.

3.1.2. Uncertainties affecting the assessment of entry

The contribution of the various factors to uncertainty considered in the entry assessment quantified for each pathway and scenarios are shown in Figures 9–12 (for the legend to the figures see Table 2 where the factors are specified) and in Appendix A (see Tables A.13–A.16). The contributions are expressed as standardised regression coefficients.

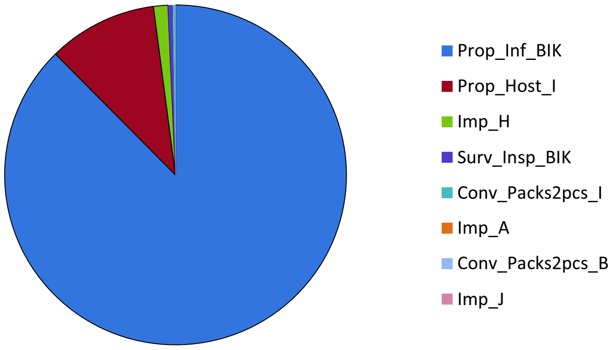

Figure 9: Contribution of the uncertainty in each of the factors to the overall uncertainty on the entry of *R. similis* in the EU by PW1

In the case of infested consignments of pathway PW1 entering the RA area, 88% of the uncertainty is due to uncertainty in the proportion of consignments infested with *R. similis*. Another 10% of the uncertainty is attributed to uncertainty in the proportion of indoor rooted cuttings and young plants of regulated families (10%) and the total imports (1%).

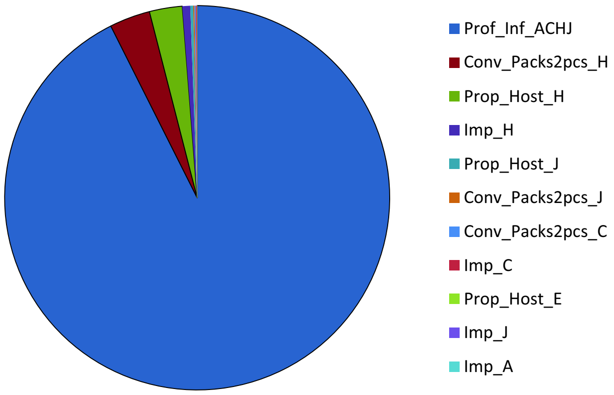

Figure 10: Contribution of the uncertainty in each of the factors to the overall uncertainty on the entry of *R. similis* in the EU by PW2

In the case of infested consignments of pathway PW2 entering the RA area, 93% of the uncertainty is due to uncertainty in the proportion of consignments of unrooted cuttings and slips of non-regulated families infested with *R. similis*. Another 3% of the uncertainty is attributed to uncertainty in conversion of kilograms to pieces for rooted indoor cuttings of non-regulated families and the proportion of rooted indoor cuttings of non-regulated families, respectively, while 1% is due to the total imports.

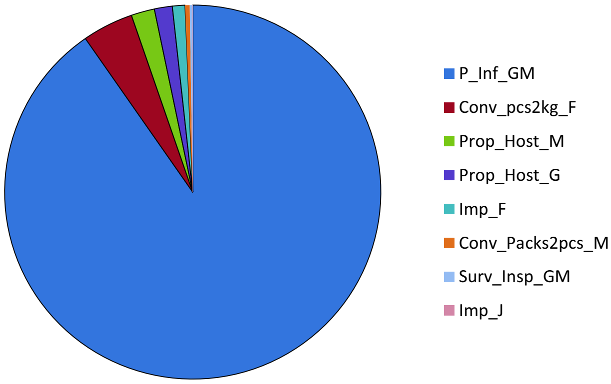

Figure 11: Contribution of the uncertainty in each of the factors to the overall uncertainty on the entry of *R. similis* in the EU by PW3

In the case of infested consignments of pathway PW3 entering the RA area, 90% of the uncertainty is due to uncertainty of the proportion of infested units of live outdoor plants, including their roots of regulated families. Another 4% of the uncertainty is attributed to uncertainty in conversion of kilograms to pieces for live outdoor plants, including their roots of non-regulated families. All other factors contribute 2% or less to uncertainty.

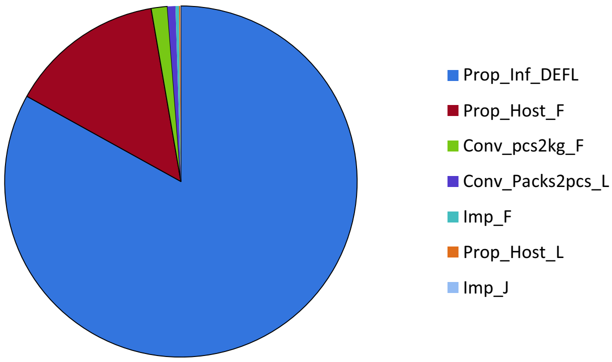

Figure 12: Contribution of the uncertainty in each of the factors to the overall uncertainty on the entry of *R. similis* in the EU by PW4

In the case of infested consignments of pathway PW4 entering the RA area, 83% of the uncertainty is due to uncertainty of the proportion of consignments of large non-regulated plants infested with *R. similis*. Another 14% of the uncertainty is attributed to uncertainty in the proportion of *R. similis* host plants consignments of live outdoor plants, including their roots of non-regulated families. All other factors contribute 1% or less to overall uncertainty.

Additional uncertainties affecting the entry assessment but no quantified within the assessment model are listed in Table 6.

Table 6: List of additional uncertainties affecting the entry assessment but not quantified within the assessment model

No.	Description of source of additional uncertainties	Description of effect on assessment of entry
1	Pest abundance at place of origin	Pest abundance at place of origin was not assessed because a lack of survey data (pest abundance in country or place of production). This might affect pest abundance at consignment level but is considered in the overall estimation of infestation rates. In all countries, the infestation rate was estimated at the same level
2	Only official data were used	Illegal trade (e.g. import by tourists, internet trade). Illegal trade was not considered in the model

3.1.3. Conclusion on the assessment of entry for the different scenarios

The risk assessment concludes that *R. similis* is able to enter the RA area on all four main pathways. Highest numbers of infested consignments are expected to enter as currently non-regulated plants for planting with a median estimate for small non-regulated plants (PW2) around 300 infested consignments per year with a 50% uncertainty interval between 60 and 1,200 infested consignments. For large non-regulated plants (PW4), the median estimate is slightly below 100 infested consignments per year with a 50% uncertainty interval ranging between 10 and 400. No differences between scenarios A0 and A1 will be expected due to the fact that this pathway is not regulated as regards *R. similis*.

The median values of infested consignments of regulated plants for planting are estimated to be approximately ten times lower (pathways PW1 and PW3). Therefore, the unregulated pathways (PW2 and PW4) in terms of volume are much more important than the regulated pathways (PW1 and PW3) as approximately 10 times more plants are imported. The estimated proportion of infested consignments is for all pathways less than 1%. Lifting the current pest-specific regulations for the currently regulated pathways (PW1 and PW3) is estimated to lead to a doubling or tripling of infested consignments entering the RA area (scenario A1). On the other hand, stricter pest-specific regulations for the already regulated pathways are expected to reduce the number of infested consignments entering by 50%. When considering strict pest-specific regulations under scenario A2 for the non-regulated pathways (PW2 and PW4), a substantial reduction in number of infested consignments is estimated by the Panel. The median number of infested consignments is estimated to be reduced to approximately 20% (PW2) or even to approximately 5% (PW4) of the number of infested consignments without pest specific regulations. Uncertainties in the Entry assessment are mainly due to a lack of data on the proportion of infested consignments. Although the proportion of infested consignments is estimated for all pathways at between 0.5% and 2% (median values), much higher infestation rates (up to 90%) are possible taking into account the 98%-uncertainty interval.

3.2. Establishment

For the assessment of the potential of *R. similis* to establish in the EU, the Panel considers subcategories of plants from all four entry pathways (PW1–PW4) that are either (1) directly planted or cultivated in greenhouses for further multiplication or (2) are directly planted outdoors such as palm trees. Plants that are sold directly to consumers through retailers for indoor use are not considered although they may later be relevant for the 'shift' (see Section 3.3 on Spread). Plants from PW1 and PW2 will be used for the assessment of establishment under protected environments, i.e. greenhouses, and the second category will be used for the assessment of establishment in the open, i.e. citrus orchards. Banana cultivation is very limited in the EU, only 12.6% of total EU consumption of bananas is covered by bananas produced in the EU and only about 1% of bananas produced in the EU originates from the RA area – Cyprus, Greece and continental Portugal (European Commission, 2013); therefore, banana cultivation is not included in the assessment. The potential for *R. similis* to establish in citrus cultivation areas is also included although entry of *R. similis* on citrus plants is a closed pathway. Transfer of *R. similis* entering the EU to citrus cultivation has to happen through a host shift, which is dealt with as a spread event (see Section 3.3 on Spread).

3.2.1. Assessment of establishment for the different scenarios

The estimated potential for *R. similis* to establish in the EU territory is shown in Figures 13 and 14. The figures present the uncertainty distribution for establishment in terms of number of greenhouses becoming infested with *R. similis* in the EU per year and how the different scenarios (A0, A1 and A2) are expected to affect pest establishment under protected cultivation.

The assessment is done separately for protected environments (greenhouses) and outdoor conditions. Furthermore, the number of populations establishing under protected environments, i.e. the number of greenhouses becoming infested by *R. similis*, is estimated separately for the four pathways (PW1–PW4) assessed in the Section 3.1 on Entry.

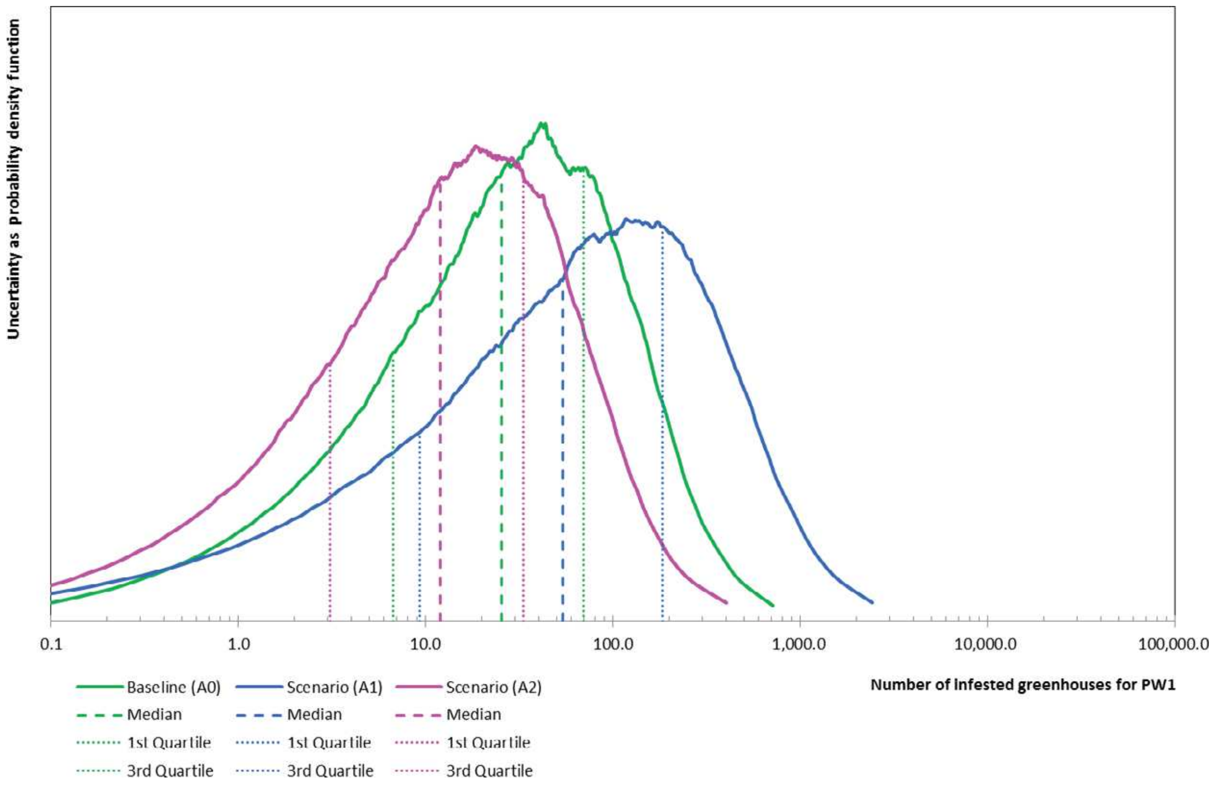

Figure 13: Uncertainty distribution of the number of greenhouses expected to become infested per year through pathway PW1 under the scenarios A0, A1 and A2

In the case of pathway PW1, the effect of the various scenarios is that the number of greenhouses becoming infested is estimated to have a median around 50 greenhouses per year under A1. However, under the current regime (A0) the estimated median will be half of that, i.e. around 25 greenhouses becoming infested per year, and under the stricter measures of the A2 scenario, another further halving of that estimate again with just above 10 greenhouses becoming infested per year.

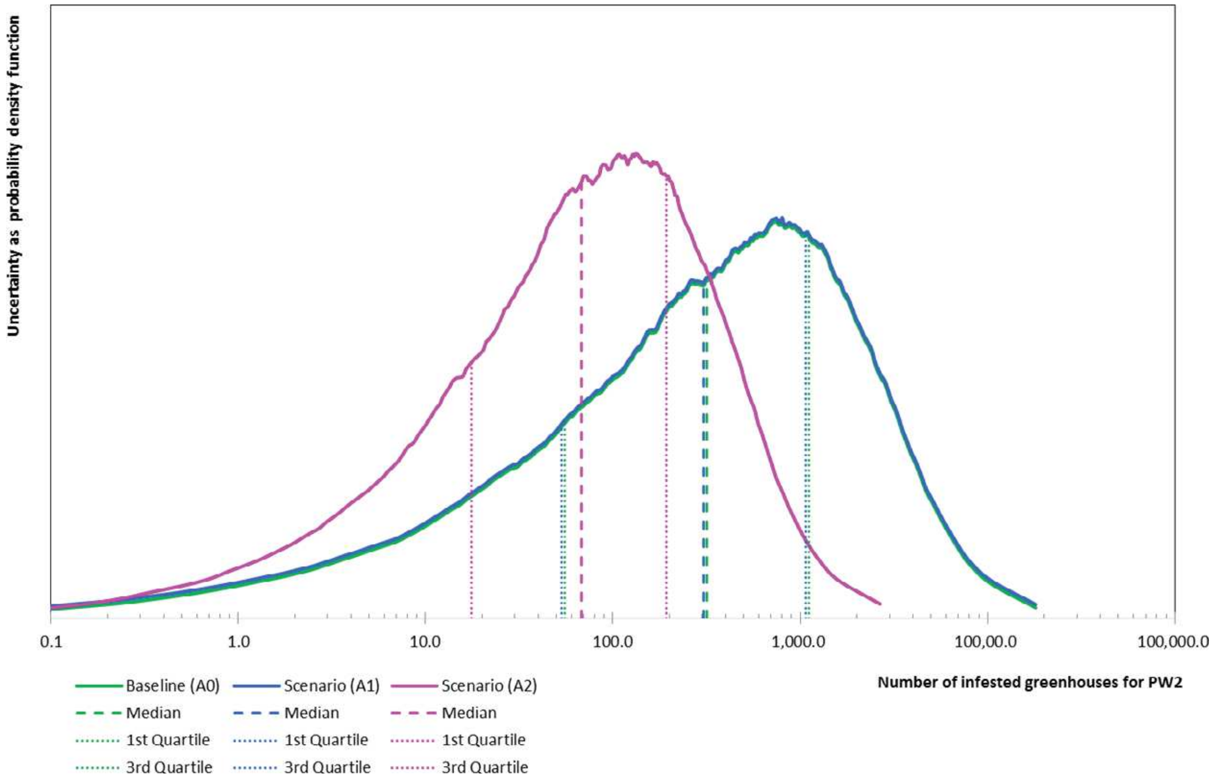

Figure 14: Uncertainty distribution of the number of greenhouses expected to become infested per year through pathway PW2 under scenario A0, A1 and A2

The combined effect of the RROs under scenario A2 reduces the number of new greenhouses becoming infested through pathway PW2 from a median of about 300 to less than 100 per year. The uncertainty associated with these estimates are in the range from 20 to 200 according to the 50% uncertainty interval under scenario A2, and 50–1,000 under scenarios A0 and A1.

For both the pathways of regulated and non-regulated outdoor plants (PW3 and PW4), these will not lead to new infested greenhouses.

As establishment at the consumer level (see Figures 15–18) is actually dealing with one infested plant in a pot, which is not expected to be used for reproduction, it is only relevant for the 'shift', i.e. that the infested soil and or the infested plant is planted outdoor in a way that can result in transfer of the nematode to another host, e.g. an adjacent citrus orchard, this is regarded as a spread event, and therefore not dealt with further in this section on establishment. The number of establishments at the consumer level is therefore an endpoint. However, it is relevant for the 'shift' (see Section 3.3 on Spread). The more infested plants going to the consumer level, the more frequent there might happen shifts to other hosts, e.g. Citrus.

At the consumer level, it is estimated for pathway PW2 that they under the scenarios A0 and A1 will lead to a median of around 100,000 populations established per year in the EU, while under A2 the estimated median is five times less, i.e. around 20,000 populations brought in.

This information relies on the assumption that one infested plant will not give rise to more than the one population of *R. similis* that is present on that infested consumer plant.

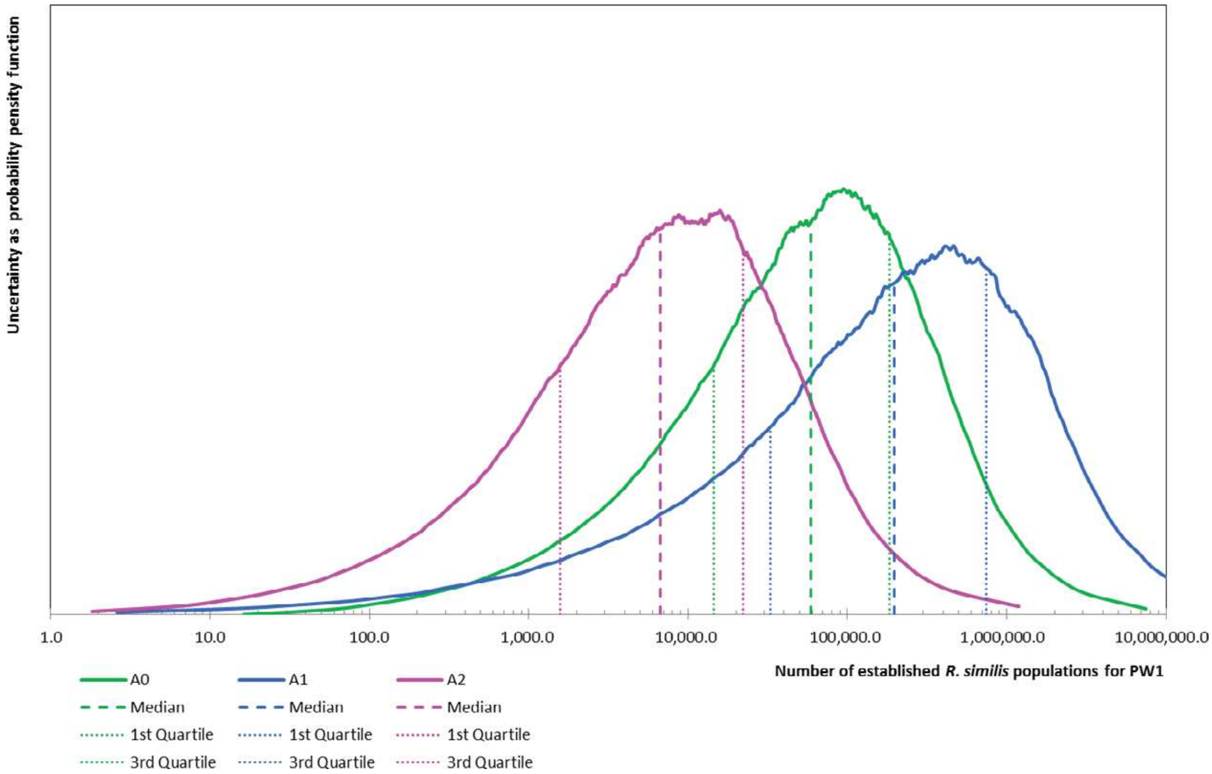

Figure 15: Uncertainty distribution of the number of *R. similis* populations becoming established at the consumer level per year in the EU through PW1 under scenarios A0, A1 and A2

Furthermore, at the consumer level, for PW1 indoor regulated plants, they are expected to bring in a median number just above 50,000 nematode populations per year under A0, while under A1 the median estimate increases four times to 200,000. Under the stricter scenario A2 the median estimate is less than 10,000 populations brought in per year.

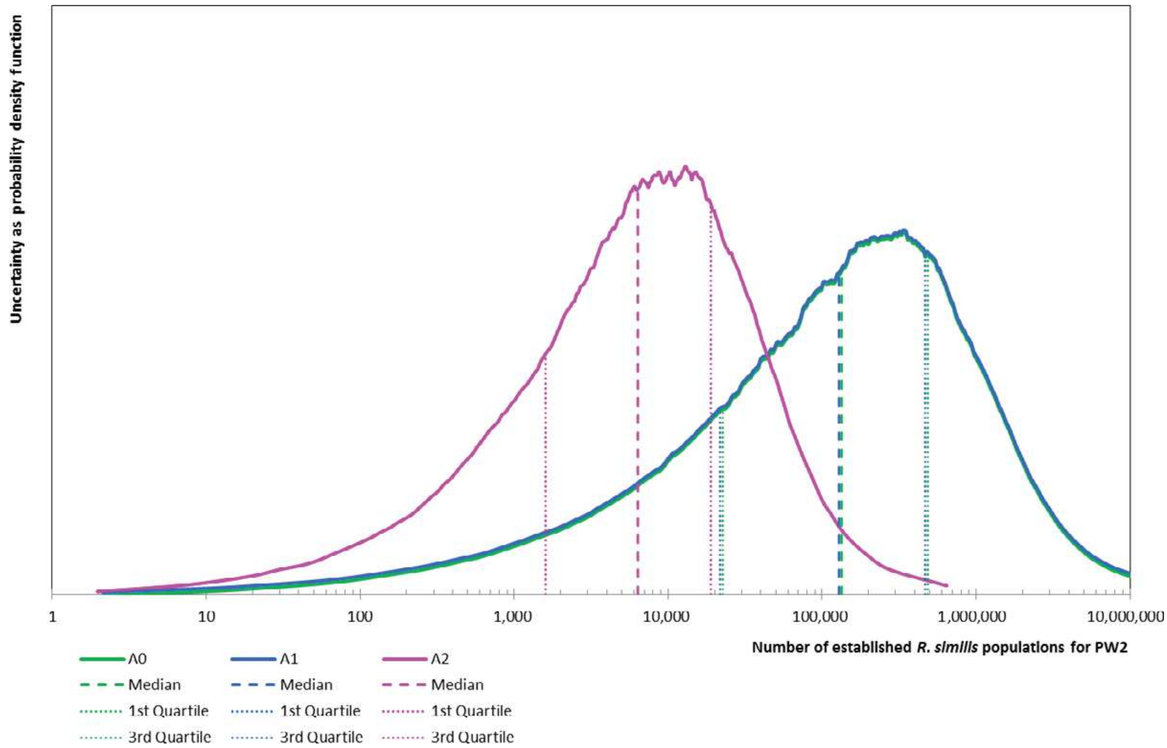

Figure 16: Uncertainty distribution of the number of *R. similis* populations becoming established at the consumer level per year in the EU through PW2 under scenarios A0, A1 and A2

In the case of indoor non-regulated plants (PW2), the estimated median number of populations is under both A0 and A1 also somewhat above 100,000 populations brought in at the consumer level per year, while it under A2 will be more than 10 times lower with an annual median number of populations just above 6,000.

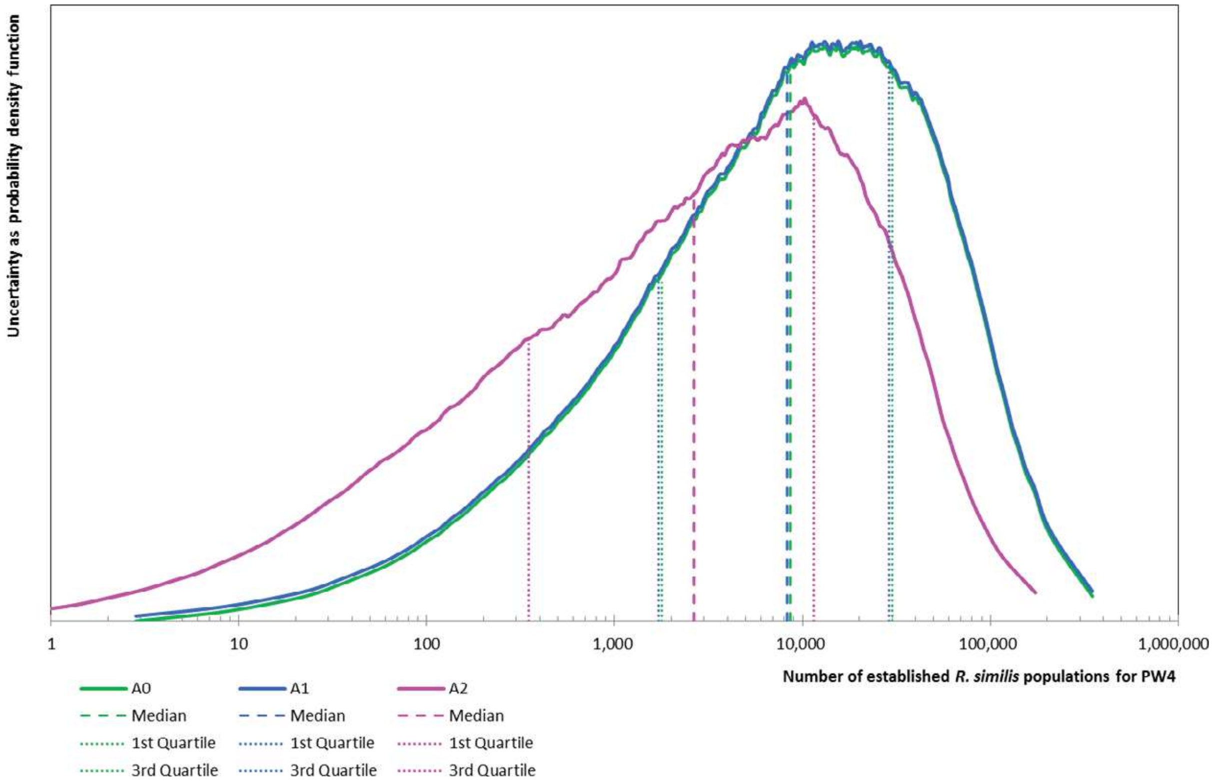

Figure 17: Uncertainty distribution of the number of *R. similis* populations becoming established at the consumer level per year in the EU through PW4 under scenarios A0, A1 and A2

For outdoor non-regulated plants (PW4) at the consumer level, a median estimate of less than 10,000 infested plants is expected per year under both A0 and A1. Under the stricter A2 scenario, the median is estimated to be less than 3,000 populations brought in.

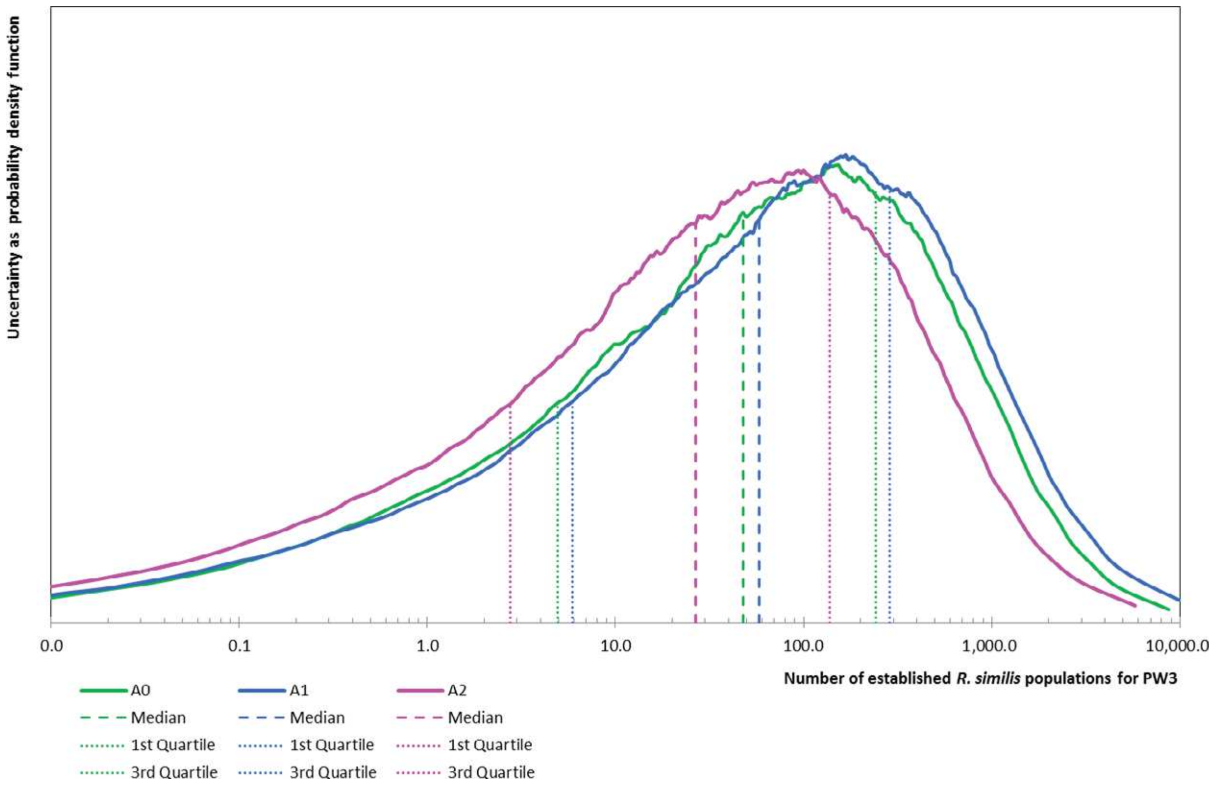

Figure 18: Uncertainty distribution of the number of *R. similis* populations becoming established at the consumer level per year in the EU through PW3 under scenarios A0, A1 and A2

Outdoor regulated plants (PW3) are estimated to result in very few populations of *R. similis* overall. There effect of the different RRO scenarios is also very small.

For *R. similis* to establish on EU citrus, infested material other than citrus has to bring the pest into citrus production as citrus plants for planting is a closed pathway. Nevertheless, the Panel has estimated that *R. similis* can establish in around 80% of the citrus cultivation areas while the remaining 20% citrus cultivation area will be too cold for the *R. similis* to establish.

3.2.2. Uncertainties affecting the assessment of establishment

Uncertainties on establishment in greenhouses

The contribution of the various factors to uncertainty considered in the assessment of establishment in greenhouses quantified for the pathways PW1 and PW2 and each scenarios are shown in Figures 19 and 20 (for the legend to the figures see Table 2 and 3 where the factors are specified) and in Appendix A (see Tables A.20 and A.21).

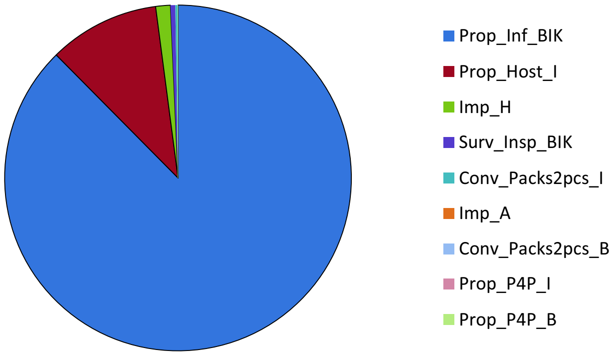

Figure 19: Contribution of the uncertainty in each of the factors, to the overall uncertainty on the potential for establishment of *R. similis* in the EU greenhouses by PW1

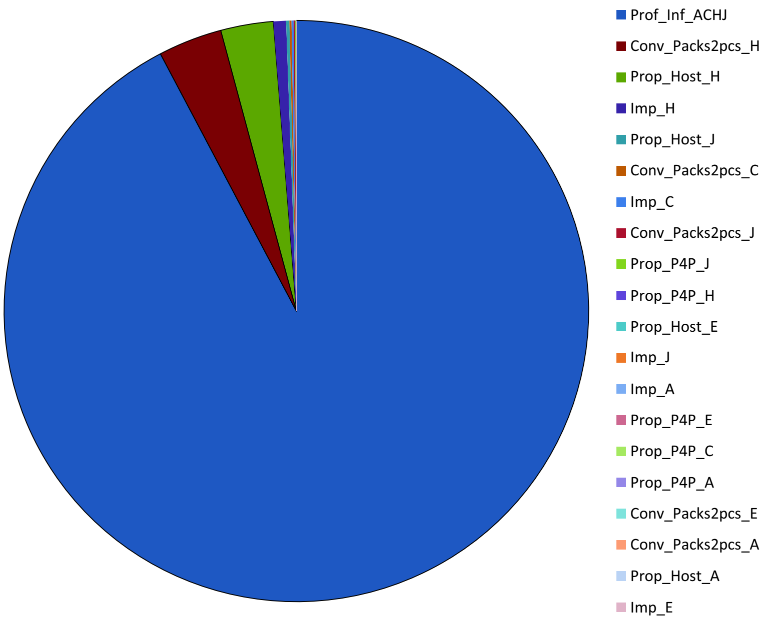

Figure 20: Contribution of the uncertainty in each of the factors to the overall uncertainty on the potential for establishment of *R. similis* in the EU greenhouses by PW2

The uncertainty in the estimate for the number of populations of *R. similis* under protected environments in the EU (i.e. the number of infested greenhouses) is mainly due to uncertainty infestation rate, but also trade volume. In the case of PW1, 88% of the uncertainty is due to uncertainty in the proportion of consignments infested with *R. similis*. Another 10% of the uncertainty is attributed to uncertainty in the proportion of host plants in the trade. All other factors of uncertainty are of minor importance. Under PW2, more than 90% of uncertainty is referred to uncertainty in the proportion of consignments of unrooted cuttings and slips of non-regulated families infested with *R. similis*. All other factors contribute 4% or less to overall uncertainty.

Uncertainties on establishment at consumer level

The contribution of the various factors to uncertainty considered in the assessment of establishment at consumer level quantified for each pathway and each scenario are shown in Figures 21–24 (for the legend to the figures see Table 2 and 3 where the factors are specified) and in Appendix A (see Tables A.22–A.25). The contributions are expressed as standardised regression coefficients.

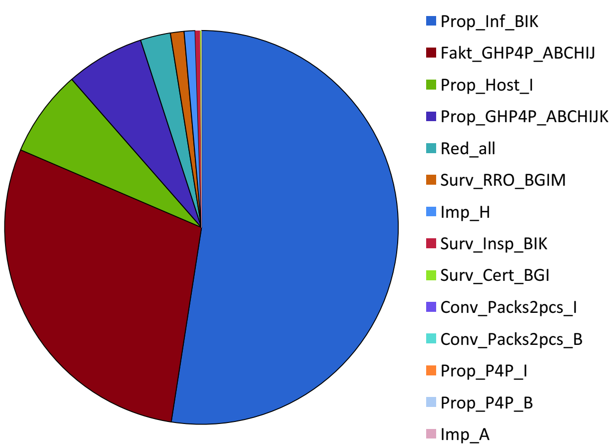

Figure 21: Contribution of the uncertainty in each of the factors to the overall uncertainty on the potential for establishment of *R. similis* at the consumer level in the EU by PW1

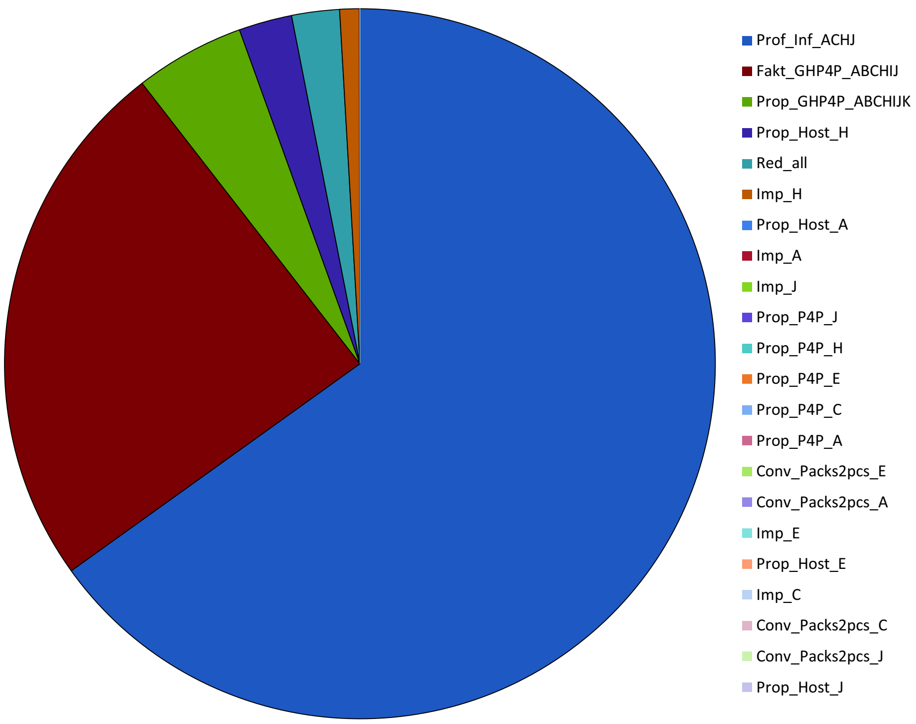

Figure 22: Contribution of the uncertainty in each of the factors to the overall uncertainty on the potential for establishment of *R. similis* at the consumer level in the EU by PW2

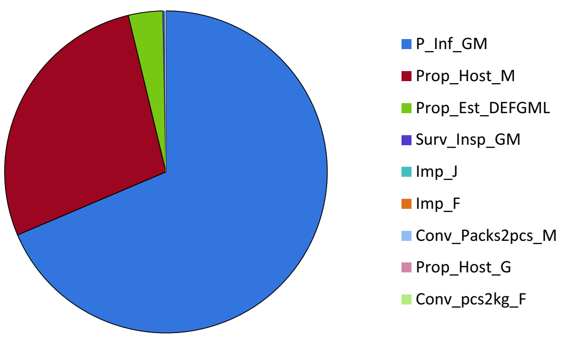

Figure 23: Contribution of the uncertainty in each of the factors to the overall uncertainty on the potential for establishment of *R. similis* at the consumer level in the EU by PW3

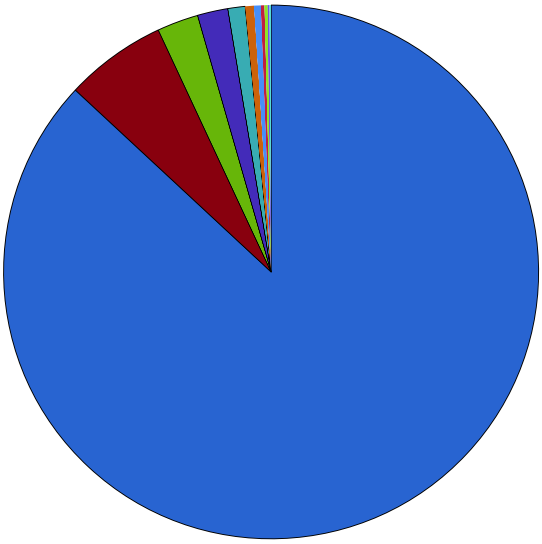

Figure 24: Contribution of the uncertainty in each of the factors to the overall uncertainty on the potential for establishment of *R. similis* at the consumer level in the EU by PW4

Assessment of establishment of *R. similis* at consumer level is affected by substantial uncertainties regarding the proportion consignments infested with *R. similis* for PW1 (52%), PW2 (65%), PW3 (69%) and PW4 (87%). In addition, there are considerable uncertainties due to the uncertainty in the number of units reached by other units under PW1 (29%) and PW2 (24%) and the proportion of live indoor plants and cacti, larger than 1 m, regulated families (28%) under PW3. All other factors contribute less to the uncertainty.

Overall, the main contributing factors to uncertainty considered in the calculation of the number of *R. similis* populations that can establish per year is the infestation rate in the trade bringing in new entries of the pest into the EU.

Additional uncertainties affecting the establishment assessment but not quantified within the assessment model are listed in Table 7.

Table 7: List of additional uncertainties affecting the establishment assessment but not quantified within the assessment model

No.	Description of source of additional uncertainties	Description of effect on assessment of establishment
1	Soil type	Different soil types may have an influence on establishment and development of *R. similis* but have not been assessed within this opinion. The disease 'spreading decline' only occurs in a very specific area in Florida (deep sandy soils of the central ridge) and there is no information available if such conditions exist in the EU
2	Climate	Choice of climate period can affect risk estimates Only air temperatures are considered within this opinion, because no data about soil temperatures that are relevant for *R. similis* development are available. Soil data is not considered an appropriate meteorological element due to its site specific dependencies on a whole range of soil characteristics like structure, albedo and humidity, etc.
3	Temperature thresholds for development and multiplication of *R. similis*	Temperature thresholds for development (basal temperature), multiplication and for mortality of *R. similis* vary among populations
4	Host preferences of *R. similis* populations	Different populations of *R. similis* show also host preferences which may have an impact on the establishment of this nematode in the RA area. Due to difficulties in determining host preferences of *R. similis* populations, they were not considered in this pest risk assessment

3.2.3. Conclusions on establishment for the different scenarios including the area of potential establishment

The nematode is able to establish under conditions present in greenhouses for the production of tropical ornamental crops. Therefore, *R. similis* can be expected to establish in protected cultivation (greenhouses) throughout the EU territory with an estimate for the median rate of 25 greenhouses per year under the current regulations (A0), with a doubling to about 50 greenhouses if the regulations are lifted (A1). Introduction of stricter measures (A2 scenario) is estimated to reduce the number of newly infested greenhouses compared to scenario A0; under scenario A2 around 10 greenhouses are expected to become infested per year.

The assessment of climatic conditions (temperature) estimates the environment to be favourable for the development and reproduction of *R. similis* outdoors in the majority of the citrus production areas of the EU. Climate will only prevent the nematode from establishing in the northernmost citrus areas and at higher altitudes in the south. Host plant species (e.g. citrus trees) are also present throughout the entire Mediterranean basin. There is some uncertainty regarding differences in host preference of nematode populations but this was not assessed.

Temperature increases due to climate change were simulated in scenario A3. It is expected that this will allow the nematode to establish in more regions around the Mediterranean. It will also favour nematode development in regions in which the nematode could already establish under present conditions resulting in higher population levels.

3.3. Spread

3.3.1. Assessment of spread for the different scenarios

The volume of trade flow is a key factor for introduction (entry and establishment) of the pest in the RA area. New introductions from import of infested tropical ornamental host plants for planting (regulated and non-regulated) from Third countries is far more important than spread from the populations already present/established in the EU. This is supported by a relatively large number of *R. similis* interceptions from Third countries (EUROPHYT, on line, accessed on 5 December 2016, see Table A.2) and the very low number of outbreaks of the nematode in greenhouses within the EU in last years (e.g. the Netherlands and Belgium) (see EFSA questionnaire, Table A.27 in Appendix A).

Because the transfer of *R. similis* from ornamental plants or greenhouse production of ornamentals to citrus nurseries or orchards might only occur as a rare event or 'accident' as direct links are not evident, only the risks by the ornamental pathway has been considered quantitatively for this PRA. The potential transfer from ornamental plants or greenhouse production to citrus nurseries or orchards is subsequently called 'shift' (see Section 3.3.3).

The main pathways for spread within the RA area therefore considered are small plants for planting: PW1 and PW2. The pathways of large plants, PW3 and PW4, refer to plants intended for final consumers and will be considered in Section 3.3.3 on shift.

The spread of *R. similis* via regulated and non-regulated small plants from infested to non-infested greenhouse is assessed in the context of the following successive steps:

- Number of established *R. similis* populations = number of infested greenhouses.
- Proportion of greenhouse units producing plants for planting for other greenhouse producers.
- Number of consignments reaching other greenhouse units.
- Effectiveness of phytosanitary measures.
- Number of newly infested greenhouses.

The estimated number of infested greenhouses after spread represents the number of newly established populations of *R. similis* in the RA area per year. For pathway PW1, the number of newly established populations after spread under scenario A0 ranges up to 800 with a median number around 20. However, the Panel estimates that only one of these populations (median number) will be detected (in the range from 0 to 60) annually, which in fact may be justified by a very low positive findings/outbreaks of the pest in greenhouses in the Netherlands and Belgium in the last years.

Under scenario A1, the most probable annual number of newly established populations of *R. similis* after spread for PW1 is estimated to be around 80, ranging between 0 and 3,700. Because no phytosanitary measures (no inspections) are foreseen against *R. similis* under scenario A1*,* the newly established populations will remain undetected. Under scenario A2, the estimated number of newly established *R. similis* populations after spread for small regulated plants is reduced to 6.

The number of newly established populations after spread for pathway PW2 under scenario A0 is estimated up to 23,000 with a median number around 400 which is considerably more than in the case of regulated small plants (PW1). None of these populations will however be detected under scenario A1. The number of newly established populations of *R. similis* after spread for PW2 under scenario A2 is estimated to be in the range of up to 1,560 with a median number around 40; however, none of these populations will be detected.

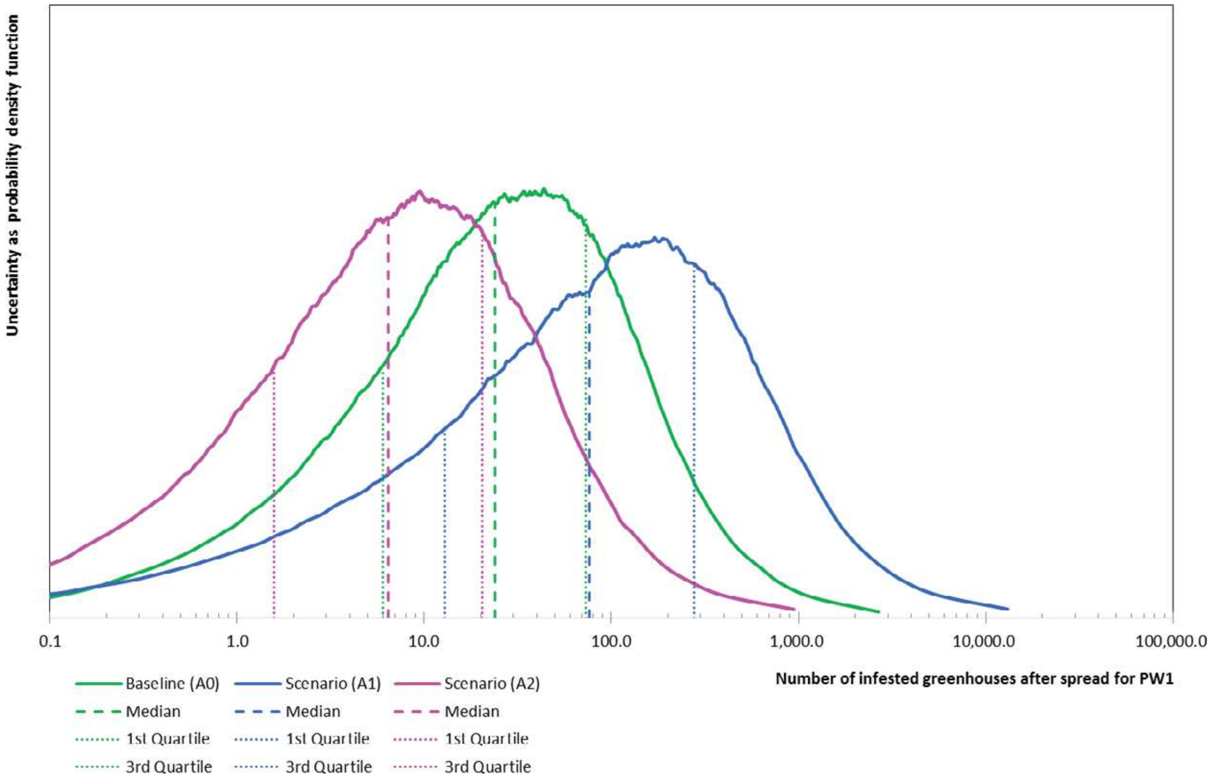

Figure 25: Uncertainty distribution of the number of newly established populations of *R. similis* per year after spread for pathway PW1 in the RA area under the scenarios A0, A1 and A2

The median number of newly established populations of *R. similis* after spread via regulated indoor plants for planting (PW1) each year is around 20 with a 50% uncertainty interval from 6 to 70 newly established populations after spread under scenario A0 (Figure 25).

Reduction in the number of newly established *R. similis* populations after spread for small regulated plants is attained in the scenarios A2 requiring an official statement that:

- the plants have been grown in nurseries, the plants originate from certified planting material produced in accordance with a certified production scheme and which was tested and found free from *R. similis,*
- the plants originate in an area, established by the national plant protection service of the Member State of origin, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures,

  or

  that the plants originate in a place of production, established by the national plant protection service of the Member State of origin, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures,

  or that the plants have been grown in sterile growing medium in pots on shelves at least 50 cm above the ground and the growing medium has been maintained free from harmful organisms.

Scenario A1 results in an increase of the number of newly established populations of *R. similis* because no phytosanitary measures (no inspections) are foreseen against the nematode and newly established populations will remain undetected.

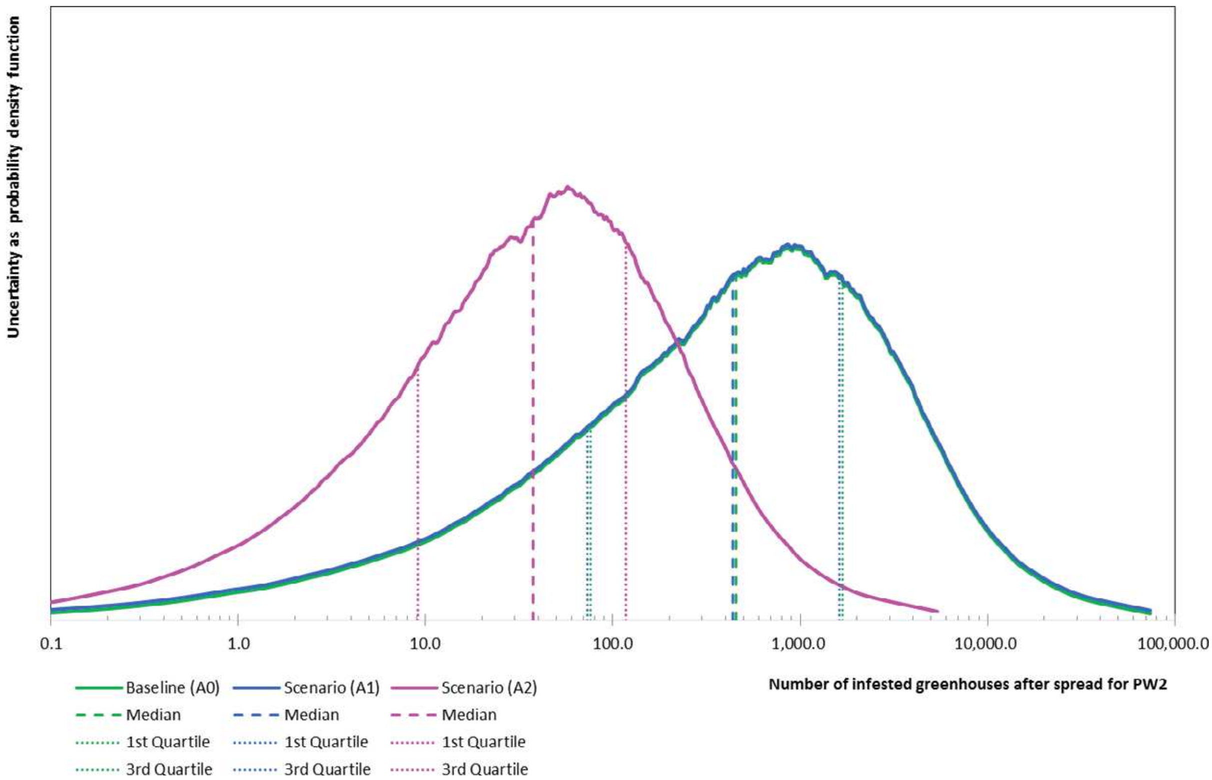

Figure 26: Uncertainty distribution of the number of newly established populations of *R. similis* per year after spread for pathway PW2 in the risk assessment area under the scenarios A0, A1 and A2

The median number of newly established populations of *R. similis* after spread via PW2 each year is around 400 with a 50% uncertainty interval from 70 to 1,600 newly established populations after spread under scenario A0 (Figure 26 above). Results for the scenario without regulations for *R. similis* (scenario A1) are identical to those of the baseline (scenario A0). The median number of newly established populations of *R. similis* after spread via PW2 each year is reduced under scenario A2 and is around 40 with a 50% uncertainty interval from 10 to 120 newly established populations after spread due to special requirements for the movement of plants for planting (all plant species) produced in EU MSs within the RA area.

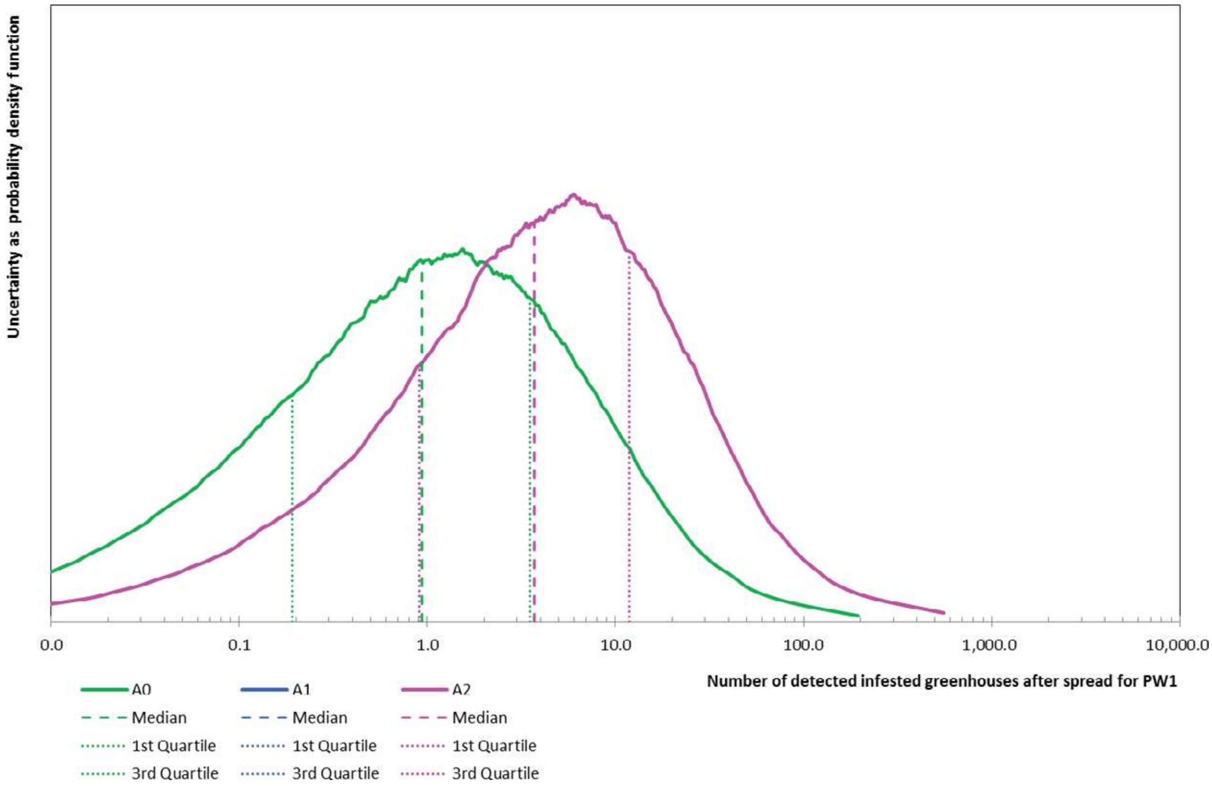

Figure 27: Uncertainty distribution of the number of detected newly established populations of *R. similis* after spread for pathway PW1 in the risk assessment area under the scenarios A0, A1 and A2

The median number of newly detected established populations of *R. similis* after spread via pathway PW1 each year is 1 with a 50% uncertainty interval from 0 to 3 newly detected established populations after spread under scenario A0 (Figure 27). None of these populations will however be detected under scenario A1 where all regulations including inspections are lifted. The median number of newly detected established populations of *R. similis* after spread via PW1 each year is increased under scenario A2 and is around 4 with a 50% uncertainty interval from 1 to 12 newly established populations after spread.

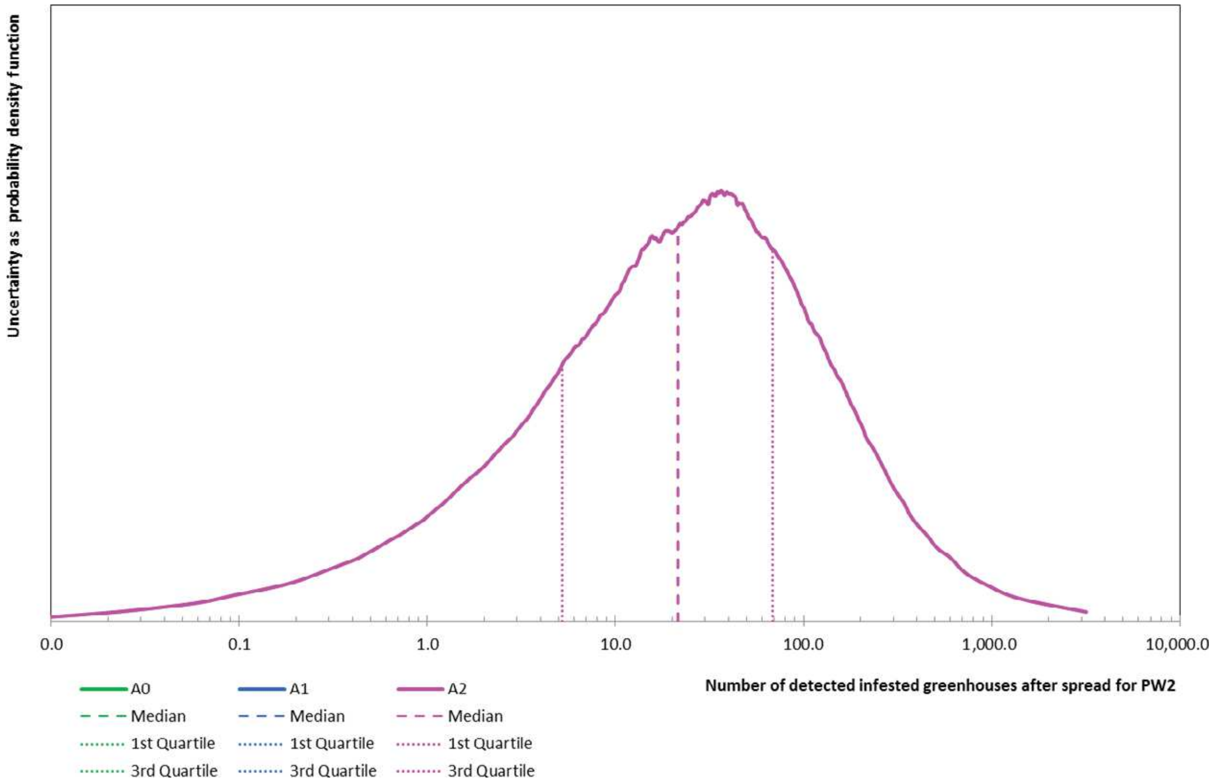

Figure 28: Uncertainty distribution of the number of detected newly established populations of *R. similis* after spread for pathway PW2 in the risk assessment area under the scenario A0, A1 and A2

For PW2, the detections are zero in scenarios A0 and A1 where no inspections are required, however, in scenario A2 the RROs specified include inspections and outbreaks are detected. The median number of newly detected established population of *R*. *similis* after spread for pathway PW2 each year is around 20 with 50% uncertainty interval from 4 to 70 newly detected established populations after spread (Figure 28 above).

3.3.2. Uncertainties affecting the assessment of spread

The contribution of the various factors to uncertainty considered in the spread assessment quantified for each spread pathway and scenario is shown in Figures 29–31 (for the legend to the figures see Tables 2, 3 and 4 where the factors are specified) and in Appendix A (see Tables A.33–A.35) showing regression coefficients and partition.

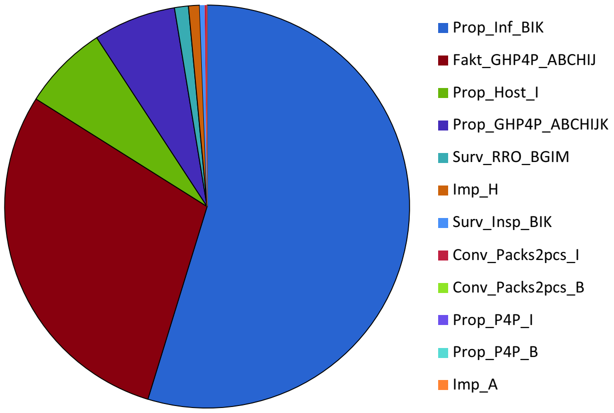

Figure 29: Contribution of the uncertainty in each of the factors, to the overall uncertainty for the number of infected greenhouses in pathway PW1 for scenario A0

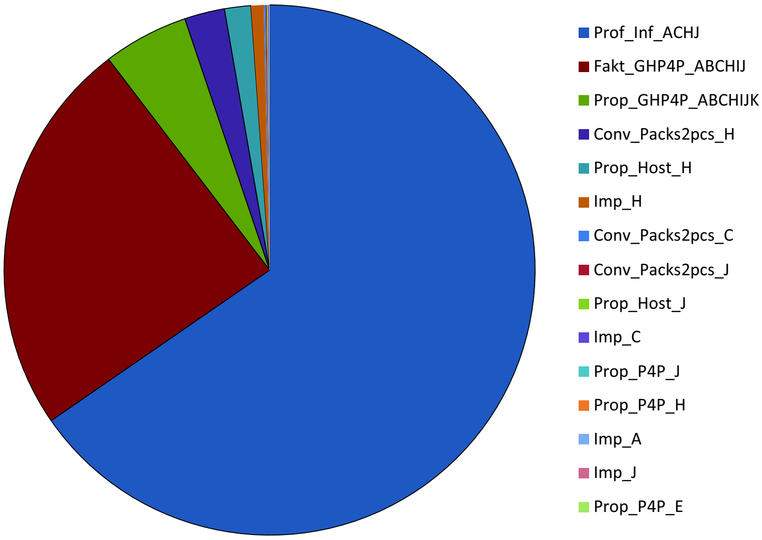

Figure 30: Contribution of the uncertainty in each of the factors, to the overall uncertainty for the number of infected greenhouses in pathway PW2 for scenario A0

In the case of the intra-European trade in PW1, more than 50% of the uncertainty is due to uncertainty in the proportion of infested regulated indoor plants for planting (PW1) that are spread from greenhouses that are infested with *R. similis.* Twenty-nine per cent of the uncertainty is attributed to uncertainty in the number of units reached by other units, 7% is due to the proportion of host plants and 7% is due to uncertainty in the proportion of greenhouses producing plants for planting. A further 1% is due to uncertainty in the survival of the RROs and the total imports.

Uncertainty in the predictions in PW2 is for 65% attributable to uncertainty in the proportion of consignments of unrooted cuttings and slips of non-regulated families infested with *R. similis* and for 24% to the number of units reached by other units. All other factors contribute 5% or less to uncertainty.

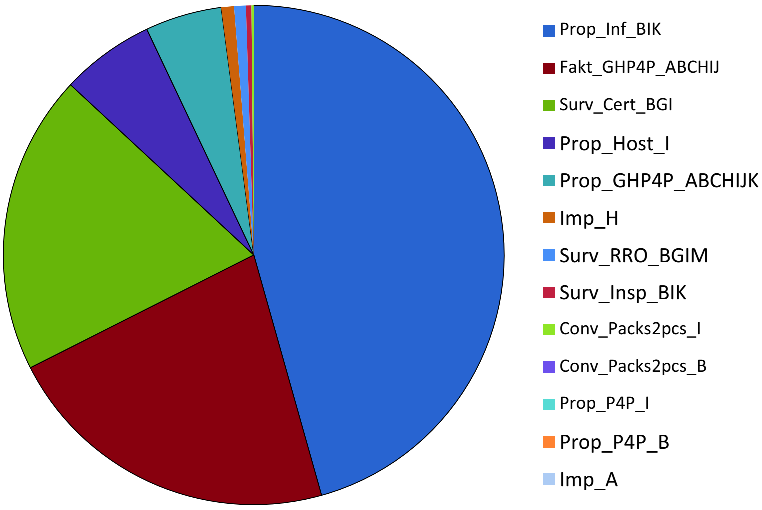

Figure 31: Contribution of the uncertainty in each of the factors, to the overall uncertainty for the number of detected infested greenhouses in pathway PW1 for scenario A0

In the case of detected *R. similis* infestations of greenhouses, almost 50% of the uncertainty refers to uncertainty in the proportion of infested units, more than 20% to the number of units reached by other units and 19% to effectiveness of inspection. All other factors are less important.

No uncertainty analysis was performed for PW2 because under scenario A0 no greenhouses are expected to be detected as infested with *R. similis*.

Additional uncertainties affecting the spread assessment but no quantified within the assessment model are listed in Table 8.

Table 8: List of additional uncertainties affecting the spread assessment but not quantified within the assessment model

No.	Description of source of additional uncertainties	Description of effect on assessment of spread
1	Already established populations in the RA area	The model is taking as starting point only greenhouses newly infested by imported plant material from Third countries and does not consider potentially existing established populations in greenhouses within the EU. The numbers of such outbreaks reported have been very low (e.g. in the Netherlands and Belgium) and are not expected to have significant impacts on spread
2	Infected larger plants sold to final consumer	Ornamental plants with roots including non-regulated host plants (e.g. palm trees) more than 1 m high are considered mainly for consumers, either for indoor use or outdoor plantation. No further spread is assumed, however, it is a place where a shift of *R. similis* into outdoor citrus production might happen. This is considered in a separate Section 3.3.3. »Shift to citrus production«
3	Commercial producers of plants for planting based in the RA area	The Panel assumes that commercial producers in the RA are not using plant material imported from outside the RA area for the production of plants for planting. Instead it is assumed that they will use their own material, as in the example for Anthurium, where the biggest producer uses tissue culture techniques for propagation and does not import any plant material for propagation
4	Pest abundance	Pest density within an infected greenhouse was not quantified because of the lack of data. The Panel assumes that all plants in a greenhouse receiving an infected consignment will be infected and the nematode will be spread with any plant material leaving and infected greenhouse
5	Use of small plants outdoors	Part of the greenhouse grown plants are garden plants and plants used for indoor in north-EU can be used as garden plant in south-EU

3.3.3. Shift to citrus production

The shift or transfer of *R. similis* to citrus production areas is considered either directly into orchards for example through infected ornamental plants planted in the vicinity of orchards or to a citrus production nursery subsequently supplying plants to commercial citrus growers. The estimation of the establishment potential is presented in detail in Section A.4.2 in the Appendix A.

The following pathways of infested material for the shift are considered:

- ornamental plants
- aquatic plants
- growing media/soil
- waste
- water.

The selection of these pathways is justified by the fact that all of these pathways can carry *R. similis* but only in few cases evidence for a transfer exists. This is the case for the transfer from ornamental plantations in a private property to a citrus orchard as documented in California (CDFA, 2016). Also, Marin et al. (1998) consider that it is possible that burrowing nematodes were introduced to banana growing areas with ornamental plants.

Similar situations could also arise in citrus nurseries where for example infested palms could be planted close to the citrus production sites, or nurseries use fields for ornamental plant production subsequently for citrus production Although most citrus nurseries in Spain are considered to be specialised to produce for commercial citrus growers only, citrus plants are also sold to consumers by retailers and ornamental nurseries that could sell ornamental hosts plants of *R. similis* as well. In these situation, a shift could take place through contaminated tools, growing media, waste or irrigation water.

The probabilities of the shift happening for each of the above pathways has been estimated by expert judgement (see Table A.36 in Appendix A) under the conditions of scenario A0. Overall, these estimations show that the probability of an outbreak of *R. similis* in a nursery within the RA area is 5.5%; this shift might happen once in 18 years. For citrus orchards, the probability of an outbreak of *R. similis* infection is estimated to be three times higher (15%). In an orchard, an outbreak may not be recognised due to the lack of symptoms. Outbreaks will be noted only in case of symptoms.

Infested nurseries and orchards are potential starting points for further spread in the RA area, either by long or short distance spread, for example by machinery, irrigation water or natural spread of the nematode depending on suitable establishment conditions (see Section 3.2 on Establishment). However, this further spread was not assessed by the Panel.

3.3.4. Conclusions on spread for the different scenarios

The nematode is not able to move actively over distances more than a few metres. Spread rates in soil may depend on soil type and soil water movement. Over short distances, this nematode might also be spread with agricultural activities (e.g. with irrigation water). Spread – long or short distances – is facilitated by the movement of infested plants for planting within or between greenhouses. The main pathways for spread of *R. similis* within the EU that contribute to long distance as well as short distance spread are regulated and non-regulated plants for planting originating from infested places of production (i.e. greenhouses).

There is no direct link between ornamental plant production to citrus production systems and hence transfer from ornamentals plants to citrus is not evident. However, it cannot be excluded and may be the result of an accidental introduction or other failure of the systems. For the purpose of this PRA, this event is called 'shift' (between production systems) and needs to take place before this nematode may enter the citrus production system in the RA area. Further spread may occur after an accidental shift to citrus nurseries.

3.4. Impact

3.4.1. Assessment of impact for the different scenarios

Radopholus similis is one of the most destructive endoparasitic nematode species (Duncan and Moens, 2006) which causes a decline of many plant species. Symptoms are most pronounced in banana and plantain (*Musa* spp.), citrus (*Citrus* spp.) and black pepper (*Piper nigrum*) (Brooks, 2008).

It can also cause damage to several tropical ornamental plants and palms that are grown in the RA area mainly indoors. Numerous other economically important annual crops including strawberries and many vegetable and field crops have also been reported to be susceptible to *R. similis* (see Pest categorisation, EFSA PLH Panel, 2014). There are no reports of *R. similis* under outdoors conditions in the RA area. Furthermore, due poor survival in soil for longer periods and adverse soil temperatures in most regions in general this nematode is not considered as a major pest of aforementioned plant species (Chabrier et al., 2009). The Panel therefore assesses the impact of *R. similis* on outdoor and indoor plants that are specified in the Chapter 3.4.2 (strawberries, vegetable and field crops) of the Pest characterisation (EFSA PLH Panel, 2014) as insignificant.

As mentioned above, *R. similis* has not been reported outdoors in the RA area and was only sporadically reported from the greenhouses in individual EU countries (France, Italy, the Netherlands and Belgium). Due to unsuitable environmental conditions (too low temperatures), establishment of *R. similis* outdoors in the EU temperate regions is not very likely, but is likely in countries of Mediterranean area where temperatures are higher. So far, no MS reported impact of *R. similis* on indoor or outdoor plants grown in the RA area and it is justified to assume that there is currently no damage caused by this pest in the RA area.

Although the establishment of *R. similis* is considered possible in Mediterranean area under current climatic conditions, the potential impact is at the moment not very likely, because temperatures do not allow the nematode to reach damaging population levels. In case of global warming due to climate change, it is expected that temperatures will increase in some locations of the Mediterranean area to a level which is more favourable for *R. similis* development than at present. Under such conditions, possibly established *R. similis* population densities may then reach damaging levels to outdoor EU banana and citrus production. However, there are additional uncertainties besides temperature: other environmental factors (e.g. soil moisture, soil type, precipitation) that are suspected to contribute to the impact caused by *R. similis* could not be assessed. Citrus spreading decline apparently only occurs in Florida, USA under very specific environmental conditions and banana toppling disease is of little relevance due to the insignificant production in the RA area.

In case the nematode is found in greenhouse where regulated plants for planting are grown, all plants in that greenhouse are considered in feed because of the potential of the nematode to spread with irrigation water. Those plants cannot be used for further propagation and production loss is therefore considered as 100%. In addition to the production loss, it is necessary to take into account also losses due to interruption of the production cycle and costs of sanitation and cleaning of the infested greenhouse to eliminate *R. similis* from the entire production system. Overall impact on the production of plants for planting may therefore be considerable.

The estimated impact in terms of yield loss is reported in Figures 32 and 33 and in Table A.39 in Appendix A. For regulated small plants (PW1), the loss under scenario A0 ranges up to 1.25 million plants with a median loss around 30,000 plants annually. This loss emerges from the sanitation measures following detection. Impact in the case of non-regulated small plants (PW2) is estimated to range up to three and a half million, with a median loss around 60,000 plants per year.

Under scenario A1, the median annual loss for regulated small plants is estimated to be around 100,000 plants, the 50% uncertainty interval is between 16,000 and 400,000. Under scenario A2, the estimated annual loss for PW1 is significantly reduced to a median loss of 3,000 plants (see Table A.39 in the Appendix A).

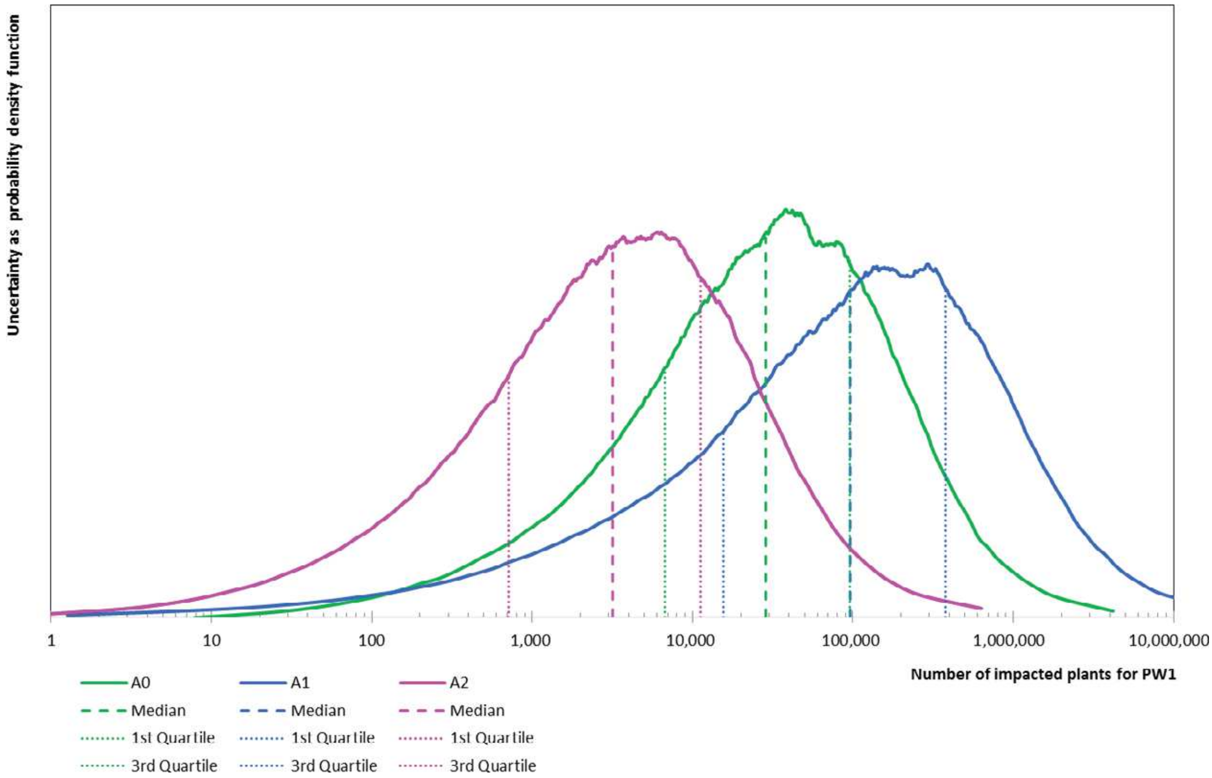

Figure 32: Uncertainty distribution of the number of impacted plants in PW1 in the risk assessment area under the scenarios A0, A1 and A2

The impact of *R. similis* on regulated small plants for planting (PW1) under the baseline scenario A0 is estimated at median value of 30,000 with a 50% uncertainty interval ranging from 6,500 to 92,000 impacted plants. Reductions in the impact of *R. similis* on regulated indoor plants for planting are achieved by implementing more strict phytosanitary measures (sampling and laboratory testing is mandatory) in the scenario A2 where a median value is estimated at around 3,000 impacted plants with 50% uncertainty interval of (700; 11,000). Under scenario A1, the median value is more than three times higher than under baseline scenario with uncertainty interval ranging from 16,000 to 380,000 impacted plants.

For non-regulated small plants (PW2), the two regulation scenarios (A0 and A1) have identical quantiles for loss as pest is not regulated and there is no need to take actions. The annual loss under these two scenarios is estimated to range up to three and a half million, with a most likely loss around 60,000 plants per year. Under scenario A2, the estimated annual loss is significantly reduced because of the implementation of phytosanitary measures related to the issuing of the plant passport, registration of place of production and phytosanitary inspection (planting material has to be inspected – sampling and laboratory testing is required) that are taken against this pest and is most likely 5,000 plants as shown in Table A.42 in the Appendix A.

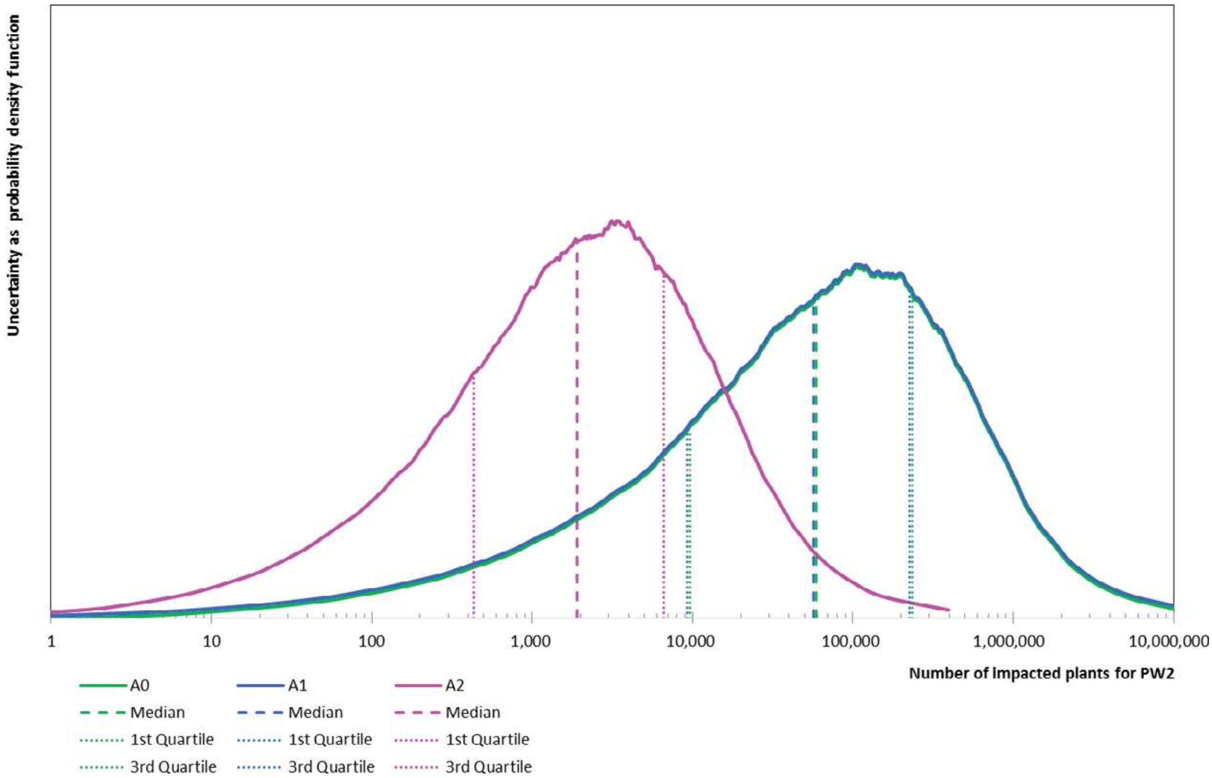

Figure 33: Uncertainty distribution of the number of impacted plants in PW2 in the risk assessment area under scenarios A0, A1 and A2

The impact of *R. similis* on production of non-regulated indoor plants for planting (PW2) is estimated at a median value of 60,000 under scenario A0, with a 50% uncertainty interval ranging from 9,000 to 226,000 impacted plants. In scenario A1 (deregulation), the number of impacted non-regulated indoor plants for planting each year is equal to the baseline scenario (A0). Scenario A2 results in a significant reduction in median impact (5,000 impacted plants).

3.4.2. Uncertainties affecting the assessment of impact

The contribution of the various factors to uncertainty considered in the impact assessment quantified for each scenario are shown in Figures 34 and 35 (for the legend to the figures see Tables 2,3,4 and 5 where the factors are specified) and in Appendix A (see Tables A.40 and A.43) in the same way as done for the other steps of the risk assessment.

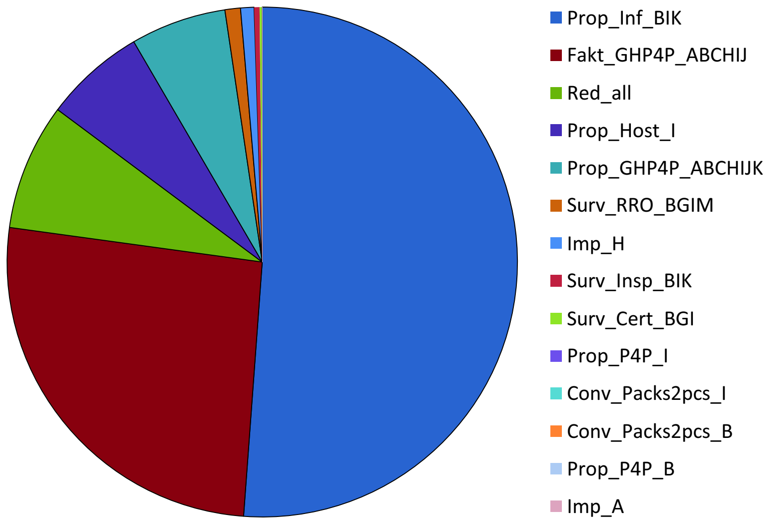

Figure 34: Contribution of the uncertainty in each of the factors, to the overall uncertainty for production loss in pathway PW1 for scenario A0

More than 50% of uncertainty in the case of the impact on regulated indoor plants for planting refers to proportion of infested units and 26% to the number of units reached by other units. For additional 8% of uncertainty is responsible reduction in plant production. Six per cent of the uncertainty refers to the proportion of host plants and additional 6% to the proportion of greenhouses producing plants for planting. Smaller contributions to uncertainty are due to uncertainties in total import of indoor rooted cuttings and young plants and survival ability of the nematode due to implemented RROs (phytosanitary measures).

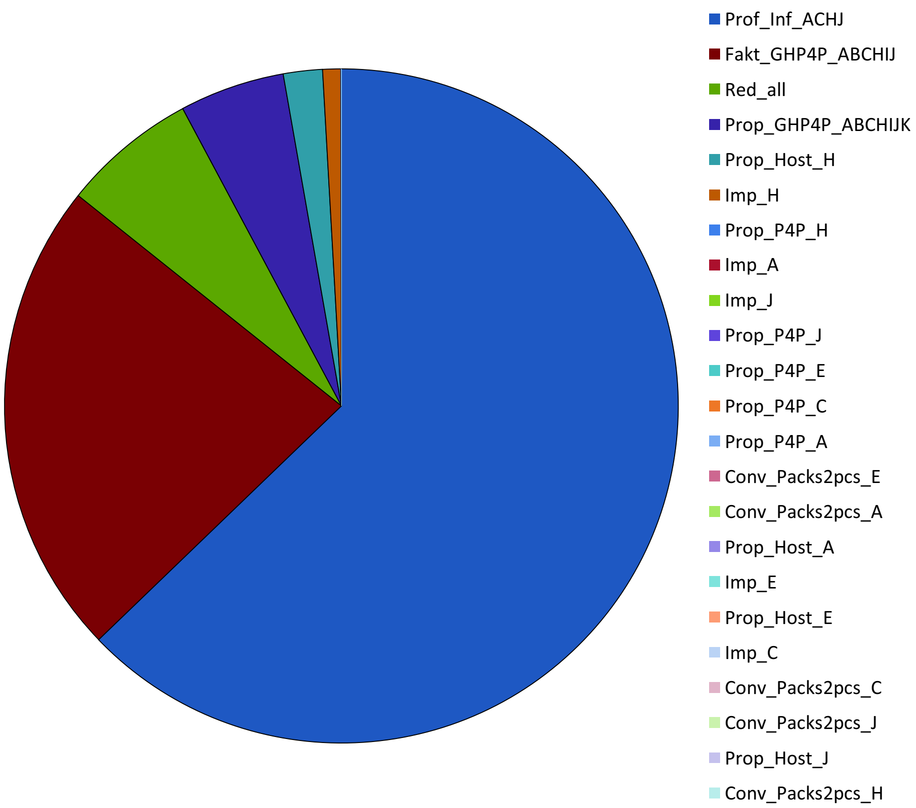

Figure 35: Contribution of the uncertainty in each of the factors, to the overall uncertainty for production loss in pathway PW2 for scenario A0

In case of non-regulated indoor plants for planting, 63% of the uncertainty is due to uncertainty in the proportion of infested units and 23% of the uncertainty is attributed to uncertainty in the number of units reached by other units. Six per cent of the uncertainty is due to reduction in plant production and 5% due to uncertainty in a proportion of greenhouses producing plants for planting. Other factors are of minor influence on uncertainty.

Additional uncertainties affecting the impact assessment but not quantified within the assessment model are listed in Table 9.

Table 9: List of additional uncertainties affecting the impact assessment but not quantified within the assessment model

No.	Description of source of additional uncertainties	Description of effect on assessment of spread
1	Pest density that can cause damage to host plants	The population density of *R. similis* that could cause significant damage to host plants is not defined Not all host plants are equally endangered Initial impact can be overlooked
2	Soil characteristics in the RA area	Pest density may be affected not only by temperatures, but also by soil characteristics and moisture and this were not quantified within the assessment model. It is known that *R. similis* causes problems to citrus trees only in sandy soils of the central Florida ridge area. If similar soil conditions exist also in RA area, the impact caused by this nematode is possible in case of climate changes

3.4.3. Conclusions on impact for the different scenarios

Radopholus similis is considered to be one of the ten most devastating plant parasitic nematodes in the world. Under tropical and subtropical environmental conditions, the nematode seriously affects the production of many important plants (e.g. bananas, citrus, black pepper, several ornamental plants, etc.) in areas located at approximately 40° north and south latitude, respectively. Due to the very limited banana production in the RA area, the globally most important host plant (banana) is not considered quantitatively in this assessment.

In heated greenhouses where tropical and subtropical (ornamental) plants are produced in the RA area, the environmental conditions are suitable for the development of *R. similis*. There may be impact of the nematode on the production of ornamental host plants in greenhouses in the RA area, however, so far, no MS reported impact of *R. similis* on indoor or outdoor plants grown in the RA area as a results of reduced plant growth (e.g., flower production).

Although outdoor establishment of *R. similis* is possible in the Mediterranean area under current climatic conditions, current temperature conditions do not allow nematode populations to reach damaging levels. In case of temperature increases due to climate change, the nematode populations may reach damaging levels. This is only expected to occur in very few places. However, there are additional uncertainties besides temperature: other environmental factors (e.g. soil moisture, soil type, precipitation) that are suspected to contribute to the impact caused by *R. similis* could not be assessed. Citrus spreading decline apparently only occurs in Florida, USA under very specific environmental conditions and banana toppling disease is of little relevance due to the insignificant production in the RA area. Main impact is therefore considered for ornamental greenhouses production in the RA area.

4. Reply to the ToR question on risk reduction options

Based on the request which is reflected in the interpretation of ToR, the Panel described and evaluated the RROs in greenhouses and open field conditions for ornamentals, citrus and banana (see Table 10 below). Details on the RROs are described in Appendix B and in EFSA PLH Panel (2014).

Table 10: Overview of all identified RROs for greenhouse and open field conditions

			Effectiveness	Uncertainties	Feasibility
Control measures					
RRO	**Before start of production cycle**				
1.06	Soil treatment	Greenhouse: To establish a growing medium free from *R. similis*: • unused growing medium, • sterilised soil or sterilised growing medium may be required Pots must be new or sterilised	High	Low	High
		Open field: To establish a field free from *R. similis*, the field should be located in a pest-free area (FAO, 1995 - ISPM No.4)	High	Low	High
		Open field: In an area where *R. similis* is known to occur, infestation by *R. similis* in a field may be reduced by chemical or physical treatment	Moderate	Moderate	Moderate
1.13	Crop rotation, associations and density, weed/ volunteer control	Open field: In an area where *R. similis* is known to occur, infestation by *R. similis* in a field may be reduced by leaving the field fallow (bare) for > 6 months	High	Moderate	Moderate
2.06	Certification of reproductive material	Greenhouse and open field: To prevent infestation of a field or greenhouse by *R. similis*, it may be required to use certified and tested plants for planting derived from certified production schemes	High	Low	High
1.05	Cleaning and disinfection of facilities tools and machinery	Greenhouse and open field: To prevent infestation of a field or greenhouse by *R. similis*, the use of pest-free (new, or thoroughly cleaned or disinfected) tools, machinery, equipment, clothing and shoes may be required	Moderate	Moderate	Low to Moderate
RRO	**During production including harvest**				
1.05	Cleaning and disinfection of facilities tools and machinery	Greenhouse and open field: To prevent infestation by *R. similis* during production, the use of pest-free (new, or thoroughly cleaned or disinfected) tools, machinery, equipment, clothing and shoes may be required	Moderate	Moderate	Low to Moderate

			Effectiveness	Uncertainties	Feasibility
Control measures					
1.01	Growing plants in isolation	Greenhouse: To prevent infestation by *R. similis* during production it may be required to: • Grow plants in pots • Maintain absence of other host plants than the produced plants in the greenhouse • Establish compartmentalisation (pots on tables, division of greenhouse in physically separated sections) • Prevent run-off of irrigation water to other tables and other compartments	High	Low	Moderate
		Open field: To prevent infestation by *R. similis* during production it may be required to: • Maintain absence of other host plants than the produced plants in the field • Establish buffer zones to separate between fields • Prevent run-off of irrigation water to other fields with *R. similis* host plants	High	Moderate	Moderate
1.11	Use of resistant cultivars/grafts	Greenhouse and open field: To reduce population development of *R. similis* resistant cultivars may be required for host plant production	High	Moderate	Low
1.07	Use of non-contaminated water	Greenhouse and open field: To prevent infestation by *R. similis* during production it may be required to use only pest-free water on the field or in the greenhouse	High	Low	Moderate
1.12	Roguing and pruning	Open field: To reduce population development of *R. similis* it may be required to remove plants showing symptoms including removal of surrounding symptom-free plants	Moderate	High	Moderate
RRO	**Consignment preparation**				
1.05	Cleaning and disinfection of facilities tools and machinery	Greenhouse and open field: To prevent infestation by *R. similis* during consignment preparation, the use of pest-free (new, or thoroughly cleaned or disinfected) tools, machinery, equipment, clothing and shoes may be required	Moderate	Moderate	Low to Moderate
1.08	Physical treatments on consignments or during processing	Greenhouse and open field: To reduce the abundance of units infested by *R. similis*, plants showing signs or symptoms of possible infestation should be removed before packing into the consignment	Low	Moderate	Moderate

			Effectiveness	Uncertainties	Feasibility
Control measures					
1.14	Heat and cold treatments	Greenhouse and open field: To reduce the abundance of units infested by *R. similis*, plants to be packed in to a consignment may treated with hot water. Hot water treatment has been reported as an effective measure to control *R. similis* with some limitations (Tsang et al., 2004). It requires careful monitoring of achieved temperatures and exposure time to avoid the adverse effects on treated plants	Moderate	Moderate	Moderate
2.01	Inspection and trapping	Greenhouse and open field: Inspection of consignment prior to shipping	Low	Moderate	High
2.02	Laboratory testing	Greenhouse and open field: Laboratory testing of consignment prior to shipping (e.g. export inspection)	Moderate	Moderate	High
RRO	**Supporting Measures**				
2.01	Inspection and trapping	Greenhouse and open field: • Inspection may be performed at several stages of production and trade to verify the absence of *R. similis.*	Low	Moderate	High
2.02	Laboratory testing	Greenhouse and open field: • testing may be performed at several stages of production and trade to verify the absence of *R. similis*	Moderate	Moderate	High
2.03	Sampling	Greenhouse and open field: • sampling according to a sampling plan may enhance the effectiveness of inspection or testing for detection of *R. similis*	Moderate	Moderate	High
2.04	Phytosanitary Certificate and Plant Passport	Greenhouse and open field: An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO, 2016 – ISPM No. 5). If the phytosanitary certificate is issued solely on the basis of a visual inspection of the consignment, the effectiveness of this measure is considered low to moderate, because symptomless infested plants would escape detection. The effectiveness of this measure may be improved in case additional requirements, e.g. sampling and laboratory testing, for issuing phytosanitary certificates are required	Moderate	Moderate	High

			Effectiveness	Uncertainties	Feasibility
Control measures					
2.05	Certified and approved premises	Greenhouse and open field: Mandatory/voluntary certification/approval of premises is a process including a set of procedures and of actions implemented by producers, conditioners and traders contributing to ensure the phytosanitary compliance of consignments. Key property of certified or approved premises is the traceability of activities and tasks (and their components) inherent the pursued phytosanitary objective	Moderate	Moderate	Moderate
2.08	Surveillance	Greenhouse and open field: The verified information acquired by surveillance may be used to determine the presence or distribution of pests in an area, or on a host or commodity, or their absence from an area, in the establishment and maintenance of pest-free areas (FAO, 1997 - ISPM No. 6). The effectiveness depends strongly on the intensity of survey and review techniques employed	Moderate	Moderate	Moderate

5. Conclusions

The risk assessment concludes that *R. similis* is able to enter the RA area on all four main pathways. Highest numbers of infested consignments are expected to enter as currently non-regulated plants for planting with a median estimate for small non-regulated plants (PW2) around 300 infested consignments per year with a 50% uncertainty interval between 60 and 1,200 infested consignments. For large non-regulated plants (PW4), the median estimate is slightly below 100 infested consignments per year with a 50% uncertainty interval ranging between 10 and 400. No differences between scenarios A0 and A1 will be expected due to the fact that this pathway is not regulated as regards *R. similis*.

The median values of infested consignments of regulated plants for planting are estimated to be approximately ten times lower (pathways PW1 and PW3). Therefore, the unregulated pathways (PW2 and PW4) in terms of volume are much more important than the regulated pathways (PW1 and PW3) as approximately 10 times more plants are imported. The estimated proportion of infested consignments is for all pathways less than 1%. Lifting the current pest-specific regulations for the currently regulated pathways (PW1 and PW3) is estimated to lead to a doubling or tripling of infested consignments entering the RA area (scenario A1). On the other hand, stricter pest-specific regulations for the already regulated pathways are expected to reduce the number of infested consignments entering by 50%. When considering strict pest-specific regulations under scenario A2 for the non-regulated pathways (PW2 and PW4), a substantial reduction in number of infested consignments is estimated by the Panel. The median number of infested consignments is estimated to be reduced to approximately 20% (PW2) or even to approximately 5% (PW4) of the number of infested consignments without pest specific regulations. Uncertainties in the Entry assessment are mainly due to a lack of data on the proportion of infested consignments. Although the proportion of infested consignments is estimated for all pathways at between 0.5% and 2% (median values) much higher infestation rates (up to 90%) are possible taking into account the 98%-uncertainty interval.

The nematode is able to establish under conditions present in greenhouses for the production of tropical ornamental crops. Therefore, *R. similis* can be expected to establish in protected cultivation (greenhouses) throughout the EU territory with an estimate for the median rate of 25 greenhouses per year under the current regulations (A0), with a doubling to about 50 greenhouses if the regulations are lifted (A1). Introduction of stricter measures (A2 scenario) is estimated to reduce the number of newly infested greenhouses compared to scenario A0; under scenario A2 around 10 greenhouses are expected to become infested per year.

The assessment of climatic conditions (temperature) estimates the environment to be favourable for the development and reproduction of *R. similis* outdoors in the majority of the citrus production areas of the EU. Climate will only prevent the nematode from establishing in the northernmost citrus areas and at higher altitudes in the south. Host plant species (e.g. citrus trees) are also present throughout the entire Mediterranean basin. There is some uncertainty regarding differences in host preference of nematode populations but this was not assessed.

Temperature increases due to climate change were simulated in scenario A3. It is expected that this will allow the nematode to establish in more regions around the Mediterranean. It will also favour nematode development in regions in which the nematode could already establish under present conditions resulting in higher population levels.

The nematode is not able to move actively over distances more than a few metres. Spread rates in soil may depend on soil type and soil water movement. Over short distances this nematode might also be spread with agricultural activities (e.g. with irrigation water). Spread – long or short distances – is facilitated by the movement of infested plants for planting within or between greenhouses. The main pathways for spread of *R. similis* within the EU that contribute to long distance as well as short distance spread are regulated and non-regulated plants for planting originating from infested places of production (i.e. greenhouses).

There is no direct link between ornamental plant production to citrus production systems and hence transfer from ornamentals plants to citrus is not evident. However, it cannot be excluded and may be the result of an accidental introduction or other failure of the systems. For the purpose of this PRA, this event is called 'shift' (between production systems) and needs to take place before this nematode may enter the citrus production system in the RA area. Further spread may occur after an accidental shift to citrus nurseries.

R. similis is considered to be one of the ten most devastating plant parasitic nematodes in the world. Under tropical and subtropical environmental conditions, the nematode seriously affects the production of many important plants (e.g. bananas, citrus, black pepper, several ornamental plants etc.) in areas located at approximately 40° north and south latitude, respectively. Due to the very limited banana production in the RA area, the globally most important host plant (banana) is not considered quantitatively in this assessment.

In heated greenhouses where tropical and subtropical (ornamental) plants are produced in the RA area, the environmental conditions are suitable for the development of *R. similis*. There may be impact of the nematode on the production of ornamental host plants in greenhouses in the RA area; however, so far no MS reported impact of *R. similis* on indoor or outdoor plants grown in the RA area as a results of reduced plant growth (e.g. flower production).

Although outdoor establishment of *R. similis* is possible in the Mediterranean area under current climatic conditions, current temperature conditions do not allow nematode populations to reach damaging levels. In case of temperature increases due to climate change, the nematode populations may reach damaging levels. This is only expected to occur in very few places. However, there are additional uncertainties besides temperature: other environmental factors (e.g. soil moisture, soil type, precipitation) that are suspected to contribute to the impact caused by *R. similis* could not be assessed. Citrus spreading decline apparently only occurs in Florida (USA) under very specific environmental conditions and banana toppling disease is of little relevance due to the very limited production in the RA area. Main impact is therefore considered for ornamental greenhouses production in the RA area.

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Abbreviations

AQIM	Agriculture Quarantine Inspection Monitoring
CDF	Cumulative Distribution Functions
CDF-R	Cumulative Distribution Functions of the Ratio
CN code	Combined nomenclature codes used for classification of goods
EPPO	European and Mediterranean Plant Protection Organization
ISEFOR database	database developed within the FP7 Project 'Increasing Sustainability of European Forests: Modelling for Security Against Invasive Pests and Pathogens under Climate Change'
ISPM	International Standards for Phytosanitary Measures
MS(s)	Member State(s)
NPPO	National Plant Protection Organization
PAFF Committee	Standing Committee on Plants, Animals, Food and Feed
PDF	Probability Density Functions
PDF-R	Probability Density Functions of the Ratio
PLH	Plant Health
PRA	Pest risk assessment
PW	pathway
PW1	pathway for under A0 regulated small plants
PW2	pathway under A0 non-regulated small plants
PW3	pathway under A0 regulated large plants
PW4	pathway under A0 non-regulated large plants
RA	risk assessment
RRO	risk reduction option
ToR	Terms of Reference

Appendix A – Formal model and parameters estimates

A.1. Host status of citrus, banana, ornamentals and palms to *Radopholus similis* and possibilities for transfer from one host to another

The host range of *R. similis* is very wide as specified in the pest categorisation for this pest (EFSA PLH Panel, 2014). Two races of the pest have been reported each with a specific but also partially overlapping host range. *Radopholus citrophilus* was described as a new species in 1984 (Huettel et al., 1984) based on physiologic differences but this species is now considered a junior synonym of *R. similis* (Kaplan et al., 2000). However, the existence of races or more generally differences in physiology may still have to be considered. The banana race[4] (or populations originating from banana roots) of *R. similis* is able to reproduce on banana but not on citrus (DuCharme and Birchfield, 1956; Huettel et al., 1982; Marin et al., 1999). The citrus race (or populations originating from citrus roots) of *R. similis* may affect – among others – citrus and banana (EFSA PLH Panel, 2014).

The host range of the nematode, the regulatory status of the species – which is currently different for *R. similis* and *R. citrophilus* – as well as the different pathways and possibilities to transfer to susceptible hosts need to be considered in this PRA.

As indicated above, a number of reports indicate that *R. similis* from banana will not affect (or multiply on) citrus. *Radopholus similis* populations from potted ornamentals plants may also not be able to parasitise citrus. Marin et al. (1999) report that *R. similis* populations from *Anthurium* sp. did not affect citrus or banana. Kaplan and Opperman (1997) indicate that such populations do not affect citrus. In a survey conducted by Kaplan and Opperman (1997), *R. similis* could not be isolated from citrus even if anthuriums that were grown in close proximity were infested. The authors conclude that these populations from *Anthurium* sp. lack the genetic potential to infect citrus. According to a single report (Huettel et al., 1982), however, *R. similis* from *Anthurium* sp. may be able to parasitise citrus.

According to Marin et al. (1999), populations from banana and citrus from Florida are closely related according to RAPD analyses and are morphologically similar. The authors therefore conclude that the populations have a common origin. Marin et al. (1999) speculate that the citrus race may have evolved in Florida under special conditions. However, they do not specify the conditions under which they evolved. It appears that populations can be genetically grouped according to their origin, but not according to their host range (Fallas et al., 1996). Different palm species are listed as hosts of *R. similis* (see Table A.1). The host preference of these populations from palms in most cases is not known. However, Koshy and Jasy (1991) have investigated the host range of 28 Indian populations from different hosts and found that none of these were able to infest citrus. Anthuriums on the other hand were good hosts for these populations. Another unusual group of host plants for *R. similis* are aquatic plants. *R. similis* populations from *Anubias* spp. reproduced on sour orange and Duncan grapefruit under laboratory conditions (Lehman et al., 2000). Under greenhouse conditions, *R. similis* from citrus and from *Anubias barteri* reproduced on *Anubias* spp. Although infection of aquatic plants with nematodes from terrestrial plants and vice versa may be possible, this is not likely to happen under natural conditions due to the different lifestyles of plants and associated nematode populations.

Overall, there is some uncertainty concerning the pathogenicity of *R. similis* populations of different origins towards different host plants. The problem of host range assignments to (now invalid) species or races illustrates the difficulties in determining host preferences of *R. similis* populations. Due to the lack of a clear host race designation, all nematode populations need to be considered potentially virulent, however, not all to the same extent. However, due to a general lack of information these differences are not considered in the model.

The indicative list of palm hosts of *R. similis* is presented in the Table A.1.

[4] The term race may be used in this PRA as a term indicating the plant from which the nematode population was isolated; e.g. the citrus race was isolated from citrus roots.

Table A.1: Indicative list of palm hosts of *Radopholus similis*

Palms (genus/species) reported to be:	
Good hosts of *Radopholus similis*	**Evidence**
Areaca	Interception; Pest categorisation (EFSA PLH Panel, 2014)
Catyota	Interception
Chamaedorea	Pest categorisation (EFSA PLH Panel, 2014)
Cocos	Pest categorisation (EFSA PLH Panel, 2014)
Howea	Interception
Licuala	Interception
Livistona	Interception
Phoenix canariensis (Canary Island date palm)	Dixon and Anderson (2013), Griffith et al. (2005)
Phoenix reclinata (Senegal date palm),	Dixon and Anderson (2013)
Phoenix dactylifera (date palm)	Dixon and Anderson (2013)
Phoenix roebellinii	Goo and Sipes (1997)
Chamaedorea seifrizii	Goo and Sipes (1997), Tsang et al. (2003)
Chamaedorea neathebella	Goo and Sipes (1997)
Chamaedorea cataractarum Martius	Griffith et al. (2005)
Chamaedorea elegans Martius (parlour palm or Neanthebelia	Griffith et al. (2005)
Cocos nucifera L. (coconut)	Griffith et al. (2005)
Elaeis guineensis Jacq. (African oil palm)	Griffith et al. (2005)
Archontophoenix cunninghamiana	Griffith et al. (2005)
Areca (Actinorhytis) calapparia	Griffith et al. (2005)
Areca catechu L. (Betel-nut palm)	Griffith et al. (2005)
Areca normanbyii	Griffith et al. (2005)
Areca triandra Roxb.	Griffith et al. (2005)
Areca macrocalyx Beec.	Griffith et al. (2005)
Areca langlosiana	Griffith et al. (2005)
Rhapis excelsa (Thunb.) Henry (large lady palm)	Goo and Sipes (1997)
Roystonea regia (H.B.K.) Cook. (royal palm)	Griffith et al. (2005)
Syagrus romanzoffiana (Cham.) Glassman (queen palm)	Griffith et al. (2005)
Poor hosts of *Radopholus similis*	**Evidence**
Caryota mitis	Goo and Sipes (1997), Tsang et al. (2003)
Cycas revoluta	Goo and Sipes (1997)
Ravenea spp.	Goo and Sipes (1997)
Howea forsteriana	Goo and Sipes (1997)

A.2. Entry

Within this section, the number of infested consignments entering each year in the risk assessment area from Third countries (i.e. outside the EU) was estimated following a quantitative approach. Based on the EFSA guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options (EFSA PLH Panel, 2010) the Panel selected the most relevant pathways for further assessment.

The conceptual model for the entry is shown in Figure A.1.

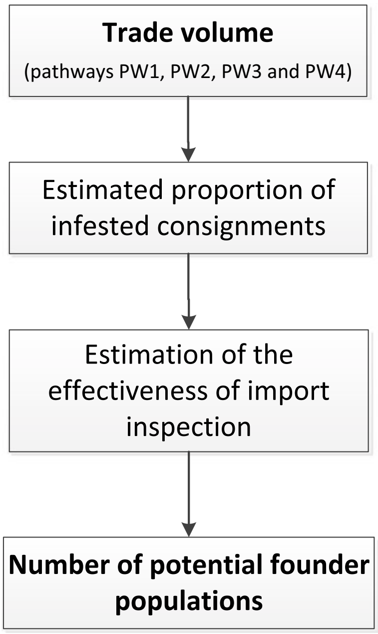


Figure A.1: Conceptual model for entry

Radopholus similis has been frequently intercepted on consignments from third countries (see Table A.2).

Table A.2: *Radopholus similis* interceptions on consignments from Third countries reported in EUROPHYT, online (data extracted from EUROPHYT, online, accessed on 5 December 2016)

Year	Reference country	Country of origin	Plant name
1995	NL	Costa Rica	*Calathea* sp.
1996	NL	Malaysia	*Heliconia* sp.
1997	NL	Sri Lanka	*Philodendron* sp.
1997	NL	Jamaica	*Calathea* sp.
1997	NL	Jamaica	*Calathea* sp.
1998	NL	Brazil	*Marantha* var. *prata*
1998	NL	Sri Lanka	*Musa* sp.
2001	NL	Sri Lanka	*Epipremnum pinnatum*
2002	NL	Thailand	*Anthurium* sp.
2003	DE	Singapore	*Acorus* sp.
2003	FR	Cote d'Ivoire	*Schefflera* sp.
2003	FR	Cote d'Ivoire	*Pothos* sp.
2003	FR	Cote d'Ivoire	*Schefflera* sp
2003	FR	Cote d'Ivoire	*Syngonium* sp.
2003	FR	Cote d'Ivoire	*Schefflera* sp
2003	FR	Cote d'Ivoire	*Pothos* sp.
2003	FR	Cote d'Ivoire	*Syngonium* sp.
2003	FR	Cote d'Ivoire	*Schefflera* sp
2003	FR	Cote d'Ivoire	*Syngonium* sp.
2003	NL	Israel	*Philodendron* sp.
2003	FR	Cote d'Ivoire	*Pothos* sp.
2003	FR	Cote d'Ivoire	*Syngonium* sp.
2003	FR	Cote d'Ivoire	*Schefflera* sp
2003	FR	Cote d'Ivoire	*Syngonium* sp.

Year	Reference country	Country of origin	Plant name
2003	FR	Cote d'Ivoire	*Syngonium* sp.
2004	DE	Canary Islands	*Anubias* sp.
2005	FR	Sri Lanka	*Areca catechu*
2005	FR	Sri Lanka	*Areca* sp.
2005	FR	Sri Lanka	*Caryota* sp.
2005	FR	Sri Lanka	*Howea forsteriana*
2005	FR	Sri Lanka	*Licuala grandis*
2005	FR	Sri Lanka	*Livistona* sp.
2005	DE	Philippines	*Cryptocoryne*
2005	FR	Singapore	*Anubias barteri*
2007	NL	Thailand	*Anubias* sp.
2007	NL	Thailand	*Anubias barteri*
2007	NL	USA	*Anubias* sp.
2008	NL	Malaysia	*Anubias barteri*
2008	NL	Thailand	*Anubias* sp.
2007	FR	Singapore	*Anubias barteri*
2008	NL	Thailand	*Anubias* sp.
2008	NL	Thailand	*Calathea* sp.
2008	FR	Singapore	*Anubias barteri*
2008	FR	Singapore	*Anubias barteri*
2008	NL	Costa Rica	*Heliconia* sp.
2008	NL	Thailand	*Anubias* sp.
2008	NL	Malaysia	*Anthurium* sp.
2008	NL	Malaysia	*Philodendron* sp.
2008	NL	Thailand	*Anubias* sp.
2008	NL	Thailand	*Anubias* sp.
2008	NL	Thailand	*Anubias* sp.
2009	NL	Singapore	*Anubias* sp.
2008	NL	Thailand	*Anubias* sp.
2009	NL	Thailand	*Anubias* sp.
2008	FR	Singapore	*Anubias barteri*
2009	NL	Thailand	*Anubias sp.*
2009	NL	Malaysia	*Anubias* sp.
2008	FR	Thailand	*Anubias barteri*
2009	NL	Thailand	*Anubias* sp.
2009	FR	Singapore	*Anubias barteri*
2009	NL	Thailand	*Anubias* sp.
2009	NL	Sri Lanka	*Scindapsus* sp.
2010	FR	Thailand	*Anubias barteri*
2010	NL	Thailand	*Heliconia* sp.
2012	NL	USA	*Alocasia* sp.
2012	NL	USA	*Anthurium* sp.
2012	NL	USA	*Anthurium* sp.
2012	NL	USA	*Colocasia* sp.
2012	NL	USA	*Heliconia* sp.
2012	NL	USA	*Philodendron* sp.
2013	NL	Malaysia	*Anubias barteri*
2013	NL	Malaysia	*Musa* sp.
2014	NL	Sri Lanka	*Epipremnum* sp.
2014	NL	Sri Lanka	*Epipremnum* sp.

Year	Reference country	Country of origin	Plant name
2015	NL	Costa Rica	*Anthurium* sp.
2015	NL	Costa Rica	*Calathea* sp.
2015	NL	Costa Rica	*Dieffenbachia* sp.
2015	NL	Costa Rica	*Heliconia* sp.
2015	NL	Costa Rica	*Philodendron* sp.
2016	NL	Malaysia	*Anthurium* sp.
2016	NL	Thailand	*Calathea lutea*
2016	NL	Thailand	*Philodendron* sp.
2016	NL	Thailand	*Ravenala madagascariensis*
2016	IT	Malaysia	*Vallisneria spiralis*

To estimate the number of infested ornamental plants with roots entering the EU each year, the entry was assessed in the following successive steps:

- Total trade flow of tropical ornamental plants from Third countries (Section A.2.1.1).
- Estimation of effectiveness of RROs implemented during Entry in different scenarios (Section A.2.1.2).
- Estimation of the proportion of infested consignments in the trade flow, taking into account the effect of RROs in scenarios A0, A1 and A2 (Section A.2.1.3).
- Estimation of effectiveness of import inspection (Section A.2.1.4).

The proportion of infested consignments in the trade flow of host plants, before performance of import inspection, is affected by measures implemented during sub-steps E1–E3 of the entry process (see Sections A.2.1.2 and A.2.1.3). Data are not available for the individual sub-steps; therefore, no estimation of pest abundance can be made per sub-step. However, phytosanitary measures implemented in the scenarios A0, A1 and A2 affect the proportion of infested consignments in the trade flow and their effectiveness will be evaluated (Section A.2.1.2) and taken into account when estimating this proportion.

The import inspection is part of sub-step E4 of the Entry process (Sections A.2.1.2 and A.2.1.4). In scenarios A0, A1 and A2, import inspection is implemented in different ways. The effectiveness of import inspection in the different scenarios is evaluated in Section A.2.1.4.

A.2.1. Entry by tropical ornamental plants

A.2.1.1. Trade flow of tropical ornamental plants from Third countries

For the quantitative assessment, data on imports of plants from tropical and subtropical countries infested by *R. similis* to the EU from 2010 to 2015 from the EUROSTAT database (EUROSTAT, online) were considered. Countries are assumed to be infested, when interceptions were detected or pest reports on *R. similis* were given. Pest prevalence in (sub)tropical countries is assumed to be higher. Countries are classified as subtropical/tropical when parts of their area are between 40° North latitude and 40° South latitude (for details see Appendix D). Only (sub)tropical countries (class I) is considered in the model.

The relevant trade categories were allocated to the following four pathways (PW1, PW2, PW3 and PW4) from the class 1 countries (subtropical countries with known infestation, for more details see the Appendix D) as shown in Table A.3. The number of consignment was calculated based on EUROSTAT data, percentiles of host plants per pathway derived from the ISEFOR database (Eschen et al., 2017) conversion factor (for more detailed information see Appendix D).

Table A.3: Volume of tropical ornamental plants imported into the EU

Volume of tropical ornamental plants imported into the EU (number of consignments*)				
Quantile (percentile)[(a)]	**PW1**	**PW2**	**PW3**	**PW4**
Lower (1%)	2,737	16,062	100	2,582
Q1 (25%)	5,482	33,636	332	4,538
Median (50%)	7,397	46,352	532	5,914
Q3 (75%)	10,029	64,282	851	8,145
Upper (99%)	21,560	152,316	2,746	32,603

*: See definition in the Section 2.3.2.2. Definitions of different units used.
(a): Five percentiles are used to characterise uncertainty about the true value of the parameter: 1%, 25%, 50%, 75% and 99%. The 1 percentile is labelled as 'Lower', the 25 percentile as 'Q1' (first quartile), the 50 percentile as 'Median', the 75 percentile as 'Q3' (third quartile) and the 99 percentile as 'Upper'.

To illustrate these pathways, the Panel provide more detailed descriptions of the production for one species or group of species representing the small and large plants pathways. The Panel chose *Anthurium* as an example for the small regulated plants (< 1 m) and ornamental palms for the large non-regulated plants.

Production of *Anthurium*

The genus *Anthurium* consists of about 900 species native in the tropics of Central and South America. *Anthurium* spp. are one of the most important ornamental tropical plants used as cut flowers, pot plants as well as for ornamental foliage production. Cut flower production is mainly based on hybrids referred to as *A. andreanum* Hort. (Gantait and Mandal, 2010) but other species are used as well although more commonly as pot plants.

The high demand for *Anthurium* plants and flowers has resulted in the establishment of production facilities in many tropical countries for example in Taiwan, Mexico, Costa Rica, Mauritius and India. However, globally, the Netherlands are the largest producer and supplier of *Anthurium* with 87 ha of greenhouse production (Pizano, 2005). As direct sunlight can damage the plants, production in tropical countries takes place in shade houses using a fertigation system (Ministry of Agriculture and Agro-based industry, Malaysia, 2004). Flower harvest for cut flowers begins about one and a half years after planting and continues for 5 years (Ministry of Agriculture and Agro-based industry, Malaysia, 2004).

Propagation of *Anthurium* spp. is mainly vegetatively with micropropagation through tissue culture but also through cuttings of side shoots and suckers whereas propagation by seeds is rarely used as it takes up to 3 years until flowers are produced and flowers are non-homogenous (Desai et al., 2015). For example, production in Florida is almost entirely from tissue culture (Chen et al., 2015) and it is believed that this is also the case in the EU. Specialised propagation companies sell *Anthurium* spp. mainly as plugs (8–10 cm tall, 4 months old plants derived from microcuttings from tissue culture, grown in a polyphenol foam) which growers have to grow on in pots before planting out or as small plants that are suitable for planting directly in their final position (Anthura/IMAC 2007a). For imported cuttings, the growing on to transplantable size could be done by specialised nurseries selling plants to cut flower producers. For cut flower production, plants are planted directly in the ground, in beds, pots or gutters with the latter three recommended to growers for better disease control (Anthura/IMAC 2007a). The maintenance of the plants for cut flower production requires the regular removal of leaves to encourage more flowers. Plant spacing also determines flower production but varies according to cultivars. In beds of 1.20 m, usually four rows are planted with the distance between plants in the row 10–20 cm (Anthura/IMAC 2007a). Pot plants for indoor use need regular respacing and in some cases repotting as plants grow, and depending on final pot size density varies from 49 to 8 pots/m^2 (Anthura/IMAC 2007b).

However, pot plants are in most cases produced for domestic markets due to high shipping costs cut flowers are traded internationally. Propagation material (mainly plugs) are also traded at the global scale with some countries entirely dependent on imports (Ministry of Agriculture and Agro-based industry, Malaysia, 2004). One company in the Netherlands, Anthura B.B., is the main supplier of plugs within the EU as well as globally. Nevertheless, *Anthurium* plants are still introduced with about 1.6 million plants imported to the Netherlands between 2000 and 2010 (ISEFOR database, Eschen et al., 2017).

Over the last 20 years, *Anthurium* spp. production has become increasingly industrialised. For example, just recently a record flower production of up to 140 flowers per m^2/year with a plant density of 30 plants/m^2 was achieved by a grower in the Netherlands (Anthura, 2016). These systems also employ high levels of phytosanitary measures which have become increasingly necessary since a bacterial blight (*Xanthomonas axonopodis* pv. *dieffenbachiae*) had devastating impacts on the *Anthurium* spp. production in Hawaii and subsequently spread to other important Anthurium producing countries in the 1980s and 1990s (Alvarez et al., 2006).

Palm production

The palm plant family (Arecaceae) consists of about 2,600 species in 181 genera native in tropical areas globally (Baker and Dransfield, 2016). Many palm species are popular as ornamental plants, both for outdoor and indoor use. Palm production takes place in tropical and subtropical countries but also in Mediterranean areas. In Europe, Spain produces about 2 million palm trees annually (Armengol et al., 2005), and ornamental palm nurseries are also of high economic importance in the Marche region of Italy (Nardi et al., 2009).

Propagation of ornamental palms is typically by seeds and while the most efficient and economical way to grow them in tropical countries is in field nurseries, production in containers is also common (Broschat et al., 2014). For some species, e.g. date palms, propagation from offshoots and by tissue culture is practiced (Chao and Krueger, 2007). Palms grown in the open field are usually dug up and put into containers only before they are sold if destined for outdoor use, whereas palms for indoor use will be moved into a shadehouse for acclimatisation about a year before marketing (Broschat et al., 2014). Even large specimens of palms are easy to transplant.

According to the ISEFOR database (database developed within the FP7 Project 'Increasing Sustainability of European Forests: Modelling for Security Against Invasive Pests and Pathogens under Climate Change') (Eschen et al., 2017), between the year 2000 and 2011, 45 million plants of the nine genera on which interceptions of *R. similis* have been detected (EUROPHYT, online, see Table A.2) have been imported into countries included in the ISEFOR database (the Netherlands, the Czech Republic, Belgium, Germany, Italy and France) (Eschen et al., 2017). The most important countries of origin were Honduras, Australia and Costa Rica with more than 10 million plants each. The three genera that account for 95% of the introductions, *Chrysalidocarpus, Areca* and *Howea*, may be marketed as indoor plants. However, these data do not provide evidence if these plants were destined for indoor or outdoor use.

A.2.1.2. Effectiveness of RROs implemented during entry in different scenarios

The formal entry process is divided in five sub-steps (E1–E5; see Section 2.3.2.4). The abundance of *R. similis* in each sub-step is affected by implemented RROs.

A.2.1.2.1. Effectiveness of RROs for entry in scenario A0

Sub-step E1 (starting with preplanting preparations and ending with storage of the harvested product, resulting in a level of pest abundance in the harvested product, before preparation of consignment):

For regulated host plants (small plants):

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free country for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the surveillance activities to confirm the pest absence in the country.

The alternative implementation of RROs 2.02 and 2.03 to establish a pest-free place of production for *R. similis* can also be effective in preventing the association of *R. similis* with the pathway. However, the requirements take into account both soil and roots from the place of production, but other requirements for a pest-free place of production, such as those concerning hygienic measures, are not specified. The effectiveness is limited by sampling scheme, timing, frequency and sampling size.

The additional implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production.

For regulated host plants (trees and shrubs):

The additional implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries, and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production.

For non-regulated host plants:

There are no specific requirements (i.e. pest freedom) for non-regulated host plants. However, general requirements for growing media are in place. The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting may contribute to prevention of association of *R. similis* with the pathway. However, the effectiveness of this combination of RROs is limited because it refers to the growing medium only. It does not preclude that plants or cuttings infested with *R. similis* may be planted in nematode-free growing medium (incl. soil).

For non-regulated host plants (trees and shrubs):

The implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes is not effective because it is insufficient to detect infestation of growing plants by *R. similis* and to ensure pest freedom of the production site.

Sub-step E2 (starts with handling of the harvested product and ends with a prepared consignment ready for transport, resulting in a level of pest abundance in the consignment before transport):

For regulated and non-regulated host plants:

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.

The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

For regulated and non-regulated host plants (trees and shrubs):

The implementation of RROs 2.01 and 1.14, subjecting trees and shrubs with signs or symptoms of harmful nematodes (here: *R. similis)* to appropriate treatment to eliminate such organisms, is not effective, because visual inspection will not detect trees and shrubs infected with *R. similis*, and heat treatments may not be effective for trees and shrubs.

Sub-step E3 (starts with transport of the consignment from the warehouse and ends with arrival at the point of entry in the area of destination, resulting in a level of pest abundance in the consignment before entry in area of destination):

For regulated and non-regulated host plants:

No RROs implemented in scenario A0.

Sub-step E4 (starts with inspection of the consignment, ends with release of the commodity units from the consignment, resulting in a level of pest abundance after entry, before transfer to host plants):

For regulated host plants:

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production. Moreover, inspection is unlikely to detect the presence of *R. similis*.

For non-regulated host plants:

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, is performed only to determine that the plants and attached soil are not contaminated by organisms listed in Annex I A, or by organisms that are listed in Annex II A for the plants in the consignment (Article 13 of the Council Directive 2000/29/EC).

Therefore, the effectiveness of import inspection to intercept *R. similis* is zero for plants that are not listed as 'object of contamination' for *R. similis* in Annex II A of the Council Directive 2000/29/EC.

Sub-step E5 (starts with handling of commodity units at the place of destination and ends with transfer of the pest to host plants originally present in the place of destination, resulting in a level pest abundance after transfer to host plants):

For regulated and non-regulated host plants:

No RROs implemented in scenario A0.

A.2.1.2.2. Effectiveness of RROs for entry in scenario A1

Sub-step E1 (starting with pre-planting preparations and ending with storage of the harvested product, resulting in a level of pest abundance in the harvested product, before preparation of consignment):

For all host plants (all plants are non-regulated in scenario A1):

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting may contribute to prevention of association of *R. similis* with the pathway. However, the effectiveness of this combination of RROs is limited because it refers to the growing medium only. It does not preclude that plants or cuttings infested with *R. similis* may be planted in nematode-free growing medium (incl. soil).

For all host plants (trees and shrubs):

The implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, is not effective because it is insufficient to detect infestation of growing plants by *R. similis* and to ensure pest freedom of the production site.

Sub-step E2 (starts with handling of the harvested product and ends with a prepared consignment ready for transport, resulting in a level of pest abundance in the consignment before transport):

For all host plants (all plants are non-regulated in scenario A1):

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.

The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

Sub-step E3 (starts with transport of the consignment from the warehouse and ends with arrival at the point of entry in the area of destination, resulting in a level of pest abundance in the consignment before entry in area of destination):

For all host plants:

No RROs implemented in scenario A1.

Sub-step E4 (starts with inspection of the consignment, ends with release of the commodity units from the consignment, resulting in a level of pest abundance after entry, before transfer to host plants):

For all host plants:

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, is performed only to determine that the plants and attached soil are not contaminated by organisms listed in Annex I A, or by organisms that are listed in Annex II A for the plants in the consignment (Article 13 of the Council Directive 2000/29/EC). Since *R. similis* is not a listed pest in scenario A1, the effectiveness of import inspection to intercept *R. similis* is zero.

Sub-step E5 (starts with handling of commodity units at the place of destination and ends with transfer of the pest to host plants originally present in the place of destination, resulting in a level pest abundance after transfer to host plants):

For all host plants:

No RROs implemented in scenario A1.

A.2.1.2.3. Effectiveness of RROs for entry in scenario A2

Sub-step E1 (starting with pre-planting preparations and ending with storage of the harvested product, resulting in a level of pest abundance in the harvested product, before preparation of consignment):

For all host plants (all host plants are regulated in scenario A2):

Pest-free area.

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free area for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the surveillance activities to confirm the pest absence in the area.

Pest-free production place.

The alternative implementation of RROs 2.02, 2.03 and 2.08 to establish a pest-free place of production for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the activities to confirm the pest absence in the production place.

Pest-free production site combined with Pest-free crop.

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting contributes to prevention of association of *R. similis* with the pathway. The combination with RRO 1.01 to establish that the plants are grown in isolation, and with RROs 2.02 and 2.03, requiring that the plants are grown from certified plants for planting that have been produced according to a certification scheme and tested for the absence of *R. similis*, results in a very effective prevention of association of *R. similis* with the pathway.

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective and does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production.

For all host plants (trees and shrubs):

The additional implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries, and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, does not provide additional prevention to the level already obtained by the requirement for a pest-free country, pest-free place of production or pest-free production site combined with pest-free crop.

Sub-step E2 (starts with handling of the harvested product and ends with a prepared consignment ready for transport, resulting in a level of pest abundance in the consignment before transport):

For all host plants (all host plants are regulated in scenario A2):

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.

The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

Sub-step E3 (starts with transport of the consignment from the warehouse and ends with arrival at the point of entry in the area of destination, resulting in a level of pest abundance in the consignment before entry in area of destination):

For all host plants:

No RROs implemented in scenario A2.

Sub-step E4 (starts with inspection of the consignment, ends with release of the commodity units from the consignment, resulting in a level of pest abundance after entry, before transfer to host plants):

For all host plants:

The implementation of RROs 2.01, 2.02, 2.03 and 2.04 to establish that all consignments of plants with roots need to be sampled and tested for the presence of *R. similis* at import, rather than visually inspected, is effective for intercepting infested consignments and a great improvement over visual inspection. The effectiveness may be reduced if sampling and testing protocols are insufficiently accurate for *R. similis* detection.

In this scenario A2, R. *similis* is listed in Annex I A II; therefore, any consignment where *R. similis* is detected will be rejected. This is in contrast with the baseline scenario A0, where only consignments of the host plants that are listed as subject of contamination for *R. similis* in Annex II A I/II A II are rejected (Article 13 of the Council Directive 2000/29/EC).

Sub-step E5 (starts with handling of commodity units at the place of destination and ends with transfer of the pest to host plants originally present in the place of destination, resulting in a level pest abundance after transfer to host plants):

For all host plants:

No RROs implemented in scenario A2.

A.2.1.3. Estimation of the proportion of infested consignments (plants) in the trade flow

The Panel assumes that:

1) infestation rates for the small plants are considered lower than for the large plants because it is assumed that they are produced in protected areas where the presence of *R. similis* can be reduced or excluded;
2) infestation rates are higher for the large plants than for the small plants because it is assumed that they are produced in open fields where the infestation with the nematode is expected to be high (the pest may also not be present in an area therefore uncertainty should be expressed).

According to Quénéhervé (1997), *R. similis* was the dominant nematode species found on *Anthurium andreanum* grown outdoors in soil during a survey conducted in 1993 in Martinique. The nematode was detected in more than 27% of soil samples and in 40% of root samples. This may be relevant for all plants grown outdoors, such as palm trees.

Although the growing conditions and number of locations were not specified in this study, it was also found that 80% of roots sampled from plants grown in soilless culture were infested by this nematode. Re-infestation of otherwise clean soilless culture substrates has been described and may occur if the media are in contact with infested soil or contaminated water is used for irrigation.

In Trinidad and Tobago, Bala and Hosein (1996) conducted a survey in shade houses in which *Anthurium* sp. was grown in troughs lined with a plastic sheet and filled with coconut fibres. They found in 69% of root samples from *Anthurium* plants *R. similis*. This indicates that nematodes may be present at high frequencies, particularly if no appropriate control measures are carried out.

According to Liebhold et al. (2012), 81 out of 856,423 (0.01%) shipments (plants for planting) were infested with Q plant parasitic nematodes imported into the United States in fiscal years 2003-2010. Based on the Agriculture Quarantine Inspection Monitoring (AQIM), programme to monitor the effectiveness of the inspections, it has been found that approximately one quarter (28%) of actual infestations were detected by standard inspection procedures (Liebhold et al., 2012). The nematode infestation level of shipments that enter USA is therefore four times higher, about 0.04%. According to Martin (1978), *R. similis* was found in 0.3% of ornamental plants originating in areas not known to be infested by the nematode in the USA and Canada. Therefore, the Panel adjusted the median by one order of magnitude as shown in the Tables 4–7. Particularly because the pest is present in most tropical countries and therefore higher infestation rates under natural conditions are expected.

Soilless culture systems in combination with clean planting material such as tissue culture derived plants should guarantee that ornamental plant production is nematode free. However, this also depends on the source of planting material as cuttings of *Anthurium* spp. may harbour the nematode (Wang et al., 1999). If such planting material is used in a soilless production system, then the nematode could spread within such a soilless system as has been shown for other nematodes (Hallmann et al., 2005).

In case of production of outdoor plants, the infestation is considered higher because the production may not be as strictly controlled as in the case for indoor plants production. Therefore, the values for outdoor plants are higher than for indoor plants.

In case the certification scheme under which the plants are produced does not have an effect on the nematode, the values under A1 are expected to be higher than in scenario A0 specifically for indoor plants. For outdoor plants, the values for the scenarios A0 and A1 are the same because outdoor plants (mainly palm trees) are not regulated specifically with respect to *R. similis.*

This evidence has some uncertainty:

- The studies from Martinique and Trinidad and Tobago are more than 20 years old (surveys conducted in 1992 and 1988-91, respectively) and considerable changes in production systems may have occurred.
- It is not clear on how many production sites the high infestation rate of 80% on artificial soil (coco peat) was observed.
- Proportion of plants grown in the open air and exported to the EU is not known.
- Infestation rates (percentage of production systems infested) in soilless cultures is not known.

Taking into account the above evidence and uncertainty and the effectiveness of RROs in the various scenarios, the Panel estimated the percentage of infested plants in the total trade flow for the relevant pathways as shown in Tables A.4–A.7.

Table A.4: Expert judgement on percentage of infested units in the total trade flow for pathway PW1

Percentage of infested units in the total trade flow for PW1				
Quantile (percentile)[(a)]	**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.0001%	0.0001%	0.0001%	Not considered
Q1 (25%)	0.1%	0.1%	0.1%	Not considered
Median (50%)	0.5%	1%	0.5%	Not considered
Q3 (75%)	1%	2%	1%	Not considered
Upper (99%)	60%	80%	60%	Not considered

(a): Five percentiles are used to characterise uncertainty about the true value of the parameter: 1%, 25%, 50%, 75% and 99%. The 1 percentile is labelled as 'Lower', the 25 percentile as 'Q1' (first quartile), the 50 percentile as 'Median', the 75 percentile as 'Q3' (third quartile) and the 99 percentile as 'Upper'.

Table A.5: Expert judgement on percentage of infested plants in the total trade for PW2

Percentage of infested plants in the total trade flow for PW2				
Quantile (percentile)[(a)]	**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.0001%	0.0001%	0.0001%	Not considered
Q1 (25%)	0.1%	0.1%	0.1%	Not considered
Median (50%)	1%	1%	0.5%	Not considered
Q3 (75%)	2%	2%	1%	Not considered
Upper (99%)	80%	80%	60%	Not considered

(a): Five percentiles are used to characterise uncertainty about the true value of the parameter: 1%, 25%, 50%, 75% and 99%. The 1 percentile is labelled as 'Lower', the 25 percentile as 'Q1' (first quartile), the 50 percentile as 'Median', the 75 percentile as 'Q3' (third quartile) and the 99 percentile as 'Upper'.

Table A.6: Expert judgement on percentage of infested plants in the total trade flow for PW3

Percentage of infested plants in the total trade flow for PW3				
Quantile (percentile)[(a)]	**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.0001%	0.0001%	0.0001%	Not considered
Q1 (25%)	0.1%	0.1%	0.1%	Not considered
Median (50%)	2%	2%	2%	Not considered
Q3 (75%)	5%	5%	5%	Not considered
Upper (99%)	80%	90%	80%	Not considered

(a): Five percentiles are used to characterise uncertainty about the true value of the parameter: 1%, 25%, 50%, 75% and 99%. The 1 percentile is labelled as 'Lower', the 25 percentile as 'Q1' (first quartile), the 50 percentile as 'Median', the 75 percentile as 'Q3' (third quartile) and the 99 percentile as 'Upper'.

Table A.7: Expert judgement on percentage of infested plants in the total trade flow for PW4

Percentage of infested plants in the total trade flow for PW4				
Quantile (percentile)[(a)]	**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.0001%	0.0001%	0.0001%	Not considered
Q1 (25%)	0.1%	0.1%	0.1%	Not considered
Median (50%)	2%	2%	2%	Not considered
Q3 (75%)	5%	5%	5%	Not considered
Upper (99%)	90%	90%	80%	Not considered

(a): Five percentiles are used to characterise uncertainty about the true value of the parameter: 1%, 25%, 50%, 75% and 99%. The 1 percentile is labelled as 'Lower', the 25 percentile as 'Q1' (first quartile), the 50 percentile as 'Median', the 75 percentile as 'Q3' (third quartile) and the 99 percentile as 'Upper'.

The percentage of infested plants will be lowered not only by the inclusion in the regulation but also by the possibility to have special requirements for regulated plats (such as production under certification scheme).

A.2.1.4. Effectiveness of import inspection

According to Liebhold et al. (2012), the efficacy of import inspection for plant material in the USA is approximately 28%. This result based on study where the records of pest interception done by standard inspections in 2009 are compared with specifically organised AQIM. In average, each USA inspector checks 43 million plants per year. Comparable studies for the EU are not known.

A study in the UK (Calleja et al., 2013) found for a specific pest (*Colletotrichum acutatum*) that border inspections intercepted about 50% of infested strawberry plants using data of traceable outbreaks on farms. The FVO (2011) carried out an audit in 2011 in a Member State and reported that the inspections cannot in all cases be considered to be based on representative samples. The FVO (2011) also states that inspections were often not as meticulous as required by Article 13a(1)(a) of the Council Directive 2000/29/EC. This is also supported by the fact that only 10–15 min are allocated for the inspection of one consignment. The overall statistics on interceptions indicate that for planting material, the Member State under report harmful organisms as stated in the report: 'E.g. in 2010, NL received some 70% of the EU imports of planting material (excl. seeds, tubers and bulbs) but reported only some 10% of the harmful organism interceptions on such material'. Effectiveness of inspection of large plants might be lower but there is some uncertainty on the sampling effectiveness.

Most of the plant imports (ca 70%) are not regulated at import, and therefore, the effectiveness of import inspection is considered to be low as no sampling is required (and therefore the value of 0 was chosen). For those plants, scenarios A0 and A1 are identical.

This evidence has some uncertainty:

- the USA situation may not be fully comparable to the situation in the EU,
- the UK study deals with one fungal disease and a specific host plant. The detection rate may be overestimated in case of undetected outbreaks,
- the FVO report (FVO, 2011) does not provide detailed figure on the effectiveness of the import inspections,

- the EU legislation does not specify the conditions required for establishing phytosanitary requirements (pest-free area, inspection of growing plants and inspection of consignments), such as sampling schemes, sampling size and accuracy of surveillance. The effectiveness of each phytosanitary measure is limited by the methods and procedures used. For the detection of *R. similis* as a first step during the inspection process, root would need to be washed free of adhering soil and roots need to be split longitudinally in order to detect necrotic lesions caused by *R. similis*. If necrotic tissue is found, sample should be send to the laboratory to verify the presence/absence of the pest.

Taking into account the above uncertainty, the Panel estimated the effectiveness of import inspection to detect a host plant infested with *R. similis* to be lower than the unspecific rates from the literature, see Tables A.8–A.11.

Table A.8: Effectiveness of import inspection in the scenarios A0, A1 and A2 for PW1

Effectiveness of phytosanitary import inspection for PW1									
Quantile (percentile)	**Reduction factor[(a)]**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.02	0	0.2	Not considered	Upper (99%)	0.98	1	0.8	Not considered
Q1 (25%)	0.15	0	0.5	Not considered	Q3 (75%)	0.85	1	0.5	Not considered
Median (50%)	0.2	0	0.6	Not considered	Median (50%)	0.8	1	0.4	Not considered
Q3 (75%)	0.3	0	0.7	Not considered	Q1 (25%)	0.7	1	0.3	Not considered
Upper (99%)	0.5	0	0.75	Not considered	Lower (1%)	0.5	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Table A.9: Effectiveness of import inspection in the scenarios A0, A1 and A2 for PW2

Effectiveness of phytosanitary import inspection for PW2									
Quantile (percentile)[(a)]	**Reduction factor**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0	0	0.2	Not considered	Upper (99%)	1	1	0.8	Not considered
Q1 (25%)	0	0	0.5	Not considered	Q3 (75%)	1	1	0.5	Not considered
Median (50%)	0	0	0.6	Not considered	Median (50%)	1	1	0.4	Not considered
Q3 (75%)	0	0	0.7	Not considered	Q1 (25%)	1	1	0.3	Not considered
Upper (99%)	0	0	0.75	Not considered	Lower (1%)	1	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Table A.10: Effectiveness of import inspections in the scenarios A0, A1 and A2 for PW3

Effectiveness of phytosanitary import inspections for PW3									
Quantile (percentile)[(a)]	**Reduction factor**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.02	0	0.2	Not considered	Upper (99%)	0.98	1	0.8	Not considered
Q1 (25%)	0.15	0	0.4	Not considered	Q3 (75%)	0.85	1	0.6	Not considered
Median (50%)	0.18	0	0.5	Not considered	Median (50%)	0.82	1	0.5	Not considered
Q3 (75%)	0.25	0	0.65	Not considered	Q1 (25%)	0.75	1	0.35	Not considered
Upper (99%)	0.5	0	0.7	Not considered	Lower (1%)	0.5	1	0.3	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Table A.11: Effectiveness of import inspections in the scenarios A0, A1 and A2 for PW4

Effectiveness of phytosanitary import inspections for PW4									
Quantile (percentile)[(a)]	**Reduction factor**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0	0	0.2	Not considered	Upper (99%)	1	1	0.8	Not considered
Q1 (25%)	0	0	0.4	Not considered	Q3 (75%)	1	1	0.6	Not considered
Median (50%)	0	0	0.5	Not considered	Median (50%)	1	1	0.5	Not considered
Q3 (75%)	0	0	0.65	Not considered	Q1 (25%)	1	1	0.35	Not considered
Upper (99%)	0	0	0.7	Not considered	Lower (1%)	1	1	0.3	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

A.2.2. Entry by other pathways

Aquatic (ornamental pond and aquarium) plants are a popular commodity in the EU. Those plants mainly originate from tropical areas but are also produced in large quantities in the EU. Most imported species belong to the families Araceae, Alismataceae, Hydrocharitaceae, Acanthaceae and Lytraceae. Most of imported aquatic plants (65%) are used specifically in aquaria, while some others are used outdoors, as garden plants (e.g. in ponds), or indoors as house plants (Brunel, 2009). The Netherlands is a major importer of aquatic plants in Europe, followed by France, the Czech Republic and Germany (Brunel, 2009). Some aquatic plants have been reported to be a host of *R. similis* and represent a significant pathway for the introduction of this pest into the RA area. *R. similis* has been frequently intercepted on *Anubias* spp., *Vallisneria spiralis* (EUROPHYT, online, accessed on 5 December 2016 or see Table A.2 in Appendix A). Given that ornamental aquatic plants are related to specific aquatic environments, the Panel considers the possibility of the transfer of *R. similis* from infested aquatic plants to commercially producing outdoor host plants as extremely low or negligible.

Based on interceptions data, the Panel considers a similar level of infestations in aquatic plants entering the EU.

Although the EU is one of the most important bananas consumers worldwide importing approximately 27% (4,488 thousand tonnes) of all bananas traded internationally (FAO, 2014), only 12.6% of total EU consumption of bananas is covered by bananas produced in the EU (European Commission, 2013). The majority of EU banana production takes place in the outside the RA area (the Canary Islands, the French overseas departments of Guadeloupe and Martinique, Madeira, and marginally, the Azores) and only about 1% of bananas produced in the EU originates from the RA area – Cyprus, Greece and continental Portugal (European Commission, 2013). The Panel estimates that the majority of the EU farmers that cultivate bananas are using tissue culture seedlings as propagating material (personal communication, 24 April 2017, Spiros M. Lionakis, PhD, Emeritus Professor of Horticulture, Technological Educational Institute of Crete, Greece, Former Researcher at the Olive Tree and Subtropical Plants Institute of Chania-Crete, replying to a specific query with regard to banana planting material in Greece) and that no sucker-derived material (infested with *R. similis*) enters the EU. Banana plants for planting are for these reasons not quantitatively assessed in this RA.

A.2.3. Number of infested consignments (plants) entering the EU

The results of the entry assessment are shown in Table A.12 for all pathways (PW1–PW4). The table reports five quantile values (1st, 25th, 50th, 75th and 99th) of infested consignments entering the RA area per year for scenarios A0, A1 and A2.

Table A.12: Selected quantiles of the uncertainty distribution for the number of consignments infested by *Radopholus similis* expected per year due to new entries in the EU for scenarios A0–A2 (all pathways are presented separately)

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
PW1 Number of infested consignments for scenario **A0**	**0**	**6**	**24**	**67**	**380**
PW2 Number of infested consignments for scenario **A0**	**0**	**58**	**333**	**1,163**	**8,783**
PW3 Number of infested consignments for scenario **A0**	**0**	**1**	**6**	**26**	**275**
PW4 Number of infested consignments for scenario **A0**	**0**	**9**	**87**	**389**	**3,407**
PW1 Number of infested consignments for scenario **A1**	**0**	**9**	**54**	**184**	**1,270**
PW2 Number of infested consignments for scenario **A1**	**0**	**58**	**333**	**1,163**	**8,783**
PW3 Number of infested consignments for scenario **A1**	**0**	**1**	**7**	**33**	**336**
PW4 Number of infested consignments for scenario **A1**	**0**	**9**	**87**	**389**	**3,407**
PW1 Number of infested consignments for scenario **A2**	**0**	**3**	**12**	**33**	**208**
PW2 Number of infested consignments for scenario **A2**	**0**	**19**	**74**	**210**	**1,343**
PW3 Number of infested consignments for scenario **A2**	**0**	**0**	**3**	**15**	**175**
PW4 Number of infested consignments for scenario **A2**	**0**	**4**	**40**	**186**	**1,784**

A.2.4. Uncertainties affecting the assessment of entry

The contribution of the various factors to uncertainty considered in the entry assessment quantified for each pathway and scenarios are shown in Tables A.13–A.16. The contributions are expressed as standardised regression coefficients.

Table A.13: Sensitivity of the baseline scenario A0 for PW1 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_BIK	0.85	0.72	88
Prop_Host_I	0.29	0.09	10
Imp_H	0.11	0.01	1
Surv_Insp_BIK	0.06	0.00	0
Conv_Packs2pcs_I	–0.05	0.00	0

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Imp_A	0.01	0.00	0
Conv_Packs2pcs_B	–	–	0
Imp_J	–	–	0
	R^2 =	0.82	100

Table A.14: Sensitivity of the baseline scenario A0 for PW2 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_ACHJ	0.82	0.68	93
Conv_Packs2pcs_H	−0.16	0.02	3
Prop_Host_H	0.14	0.02	3
Imp_H	0.07	0.00	1
Prop_Host_J	0.04	0.00	0
Conv_Packs2pcs_J	−0.03	0.00	0
Conv_Packs2pcs_C	−0.03	0.00	0
Imp_C	0.03	0.00	0
Prop_Host_E	0.01	0.00	0
Imp_J	0.01	0.00	0
Imp_A	–	–	0
Conv_Packs2pcs_E	–	–	0
Conv_Packs2pcs_A	–	–	0
Prop_Host_A	–	–	0
Imp_E	–	–	0
	R^2 =	0.73	100

Table A.15: Sensitivity of the baseline scenario A0 for PW3 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
P_Inf_GM	0.70	0.50	90
Conv_pcs2kg_F	−0.16	0.02	4
Prop_Host_M	0.11	0.01	2
Prop_Host_G	0.09	0.01	2
Imp_F	0.08	0.01	1
Conv_Packs2pcs_M	−0.05	0.00	0
Surv_Insp_GM	0.04	0.00	0
Imp_J	–	–	0
	R^2 =	0.55	100

Table A.16: Sensitivity of the baseline scenario A0 for PW4 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_DEFL	0.67	0.44	83
Prop_Host_F	0.28	0.08	14
Conv_pcs2kg_F	−0.09	0.01	1
Conv_Packs2pcs_L	−0.06	0.00	1
Imp_F	0.04	0.00	0
Prop_Host_L	0.03	0.00	0
Imp_J	0.02	0.00	0
	R^2 =	0.54	100

A.3. Establishment

The population dynamics of *R. similis* is closely linked to the phenology of the host plant, but is also affected by environmental factors, mainly temperature and soil humidity.

The purpose of this section is to estimate the number of *R. similis* populations that will establish after entering the RA area.

The conceptual model for the establishment is shown in Figure A.2.

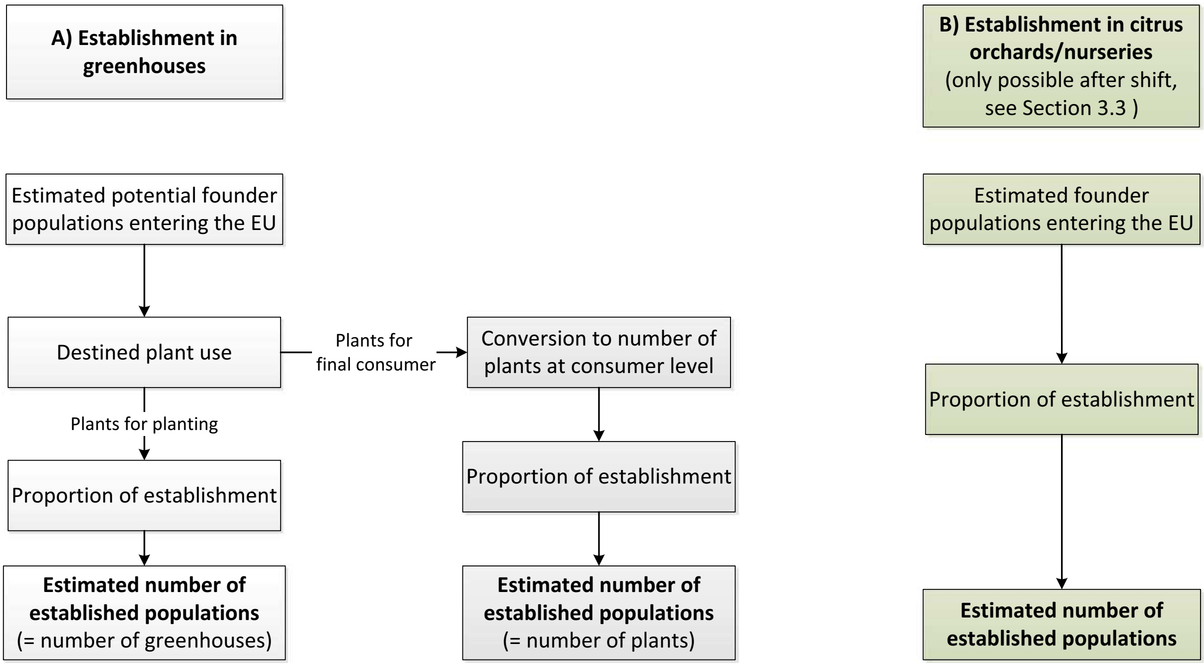


Figure A.2: Conceptual model for establishment in greenhouses (A) and citrus nurseries or orchards (B)

The Panel considers that the following three categories of plants entering the EU may be infested with *R. similis*:

I. Plants directly planted or cultivated in greenhouses for further multiplication.
II. Plants directly planted outdoors such as e.g. palm trees.
III. Plants that are sold directly to consumers through retailers for indoor use.

Category III is not considered in the assessment because it is not expected to be reproduced or planted out-doors. The assessment of the risk of establishment of *R. similis* in the EU, therefore considers only the first two. Plants directly planted or cultivated for further multiplication in greenhouses will be used for the assessment of establishment under protected environments, i.e. greenhouses and the second category will be used for the assessment of establishment in the open, i.e. citrus orchards. Banana cultivation is very limited in the EU, only 12.6% of total EU consumption of bananas is covered by bananas produced in the EU and only about 1% of bananas produced in the EU originates from the RA area – Cyprus, Greece and continental Portugal (European Commission, 2013), therefore banana cultivation is not included in the assessment.

A.3.1. Establishment in greenhouses

If plants infested with *R. similis* are planted directly, or by other means cultivated for further multiplication, in greenhouses, it is estimated that *R. similis* will establish in the greenhouse with 100% probability.

A.3.1.1. Estimation of establishment in greenhouses

Table A.17: Probability of establishment of *R. similis* in greenhouses

Probability of establishment of *R. similis* in greenhouses				
Quantile (percentile)	**Probability of establishment**			
	A0	**A1**	**A2**	**A3**
Lower (1%)	1	1	1	Not considered
Q1 (25%)	1	1	1	Not considered
Median (50%)	1	1	1	Not considered
Q3 (75%)	1	1	1	Not considered
Upper (99%)	1	1	1	Not considered

A.3.1.2. Number of established populations

One greenhouse becoming infested with *R. similis* is regarded as one established population of *R. similis*. Table A18 presents the estimated number of greenhouses/established populations of *R. similis* under protected environment in the EU per year.

Table A.18 presents, in terms of quantile estimates, the uncertainty distributions describing expectations on the number of new populations that will establish per year as a result of the pest entering with each of the pathways assessed quantitatively.

Table A.18: Estimated quantiles of the uncertainty distribution for the number of established pest populations of *Radopholus similis* expected per 1 year due to founder populations in the EU in the chosen time horizon for scenarios A0–A2

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
PW1 Number of established pest populations **in greenhouses** in scenario **A0**	**0.03**	**6.44**	**24.42**	**66.89**	**380.05**
PW2 Number of established pest populations **in greenhouses** in scenario **A0**	**0.03**	**53.20**	**305.22**	**1,070.37**	**8,137.29**
PW3 Number of established pest populations **in greenhouses** in scenario **A0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW4 Number of established pest populations **in greenhouses** in scenario **A0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW1 Number of established pest populations **in greenhouses** in scenario **A1**	**0.00**	**9.29**	**53.93**	**183.50**	**1,264.84**
PW2 Number of established pest populations **in greenhouses** in scenario **A1**	**0.03**	**53.20**	**305.22**	**1,070.37**	**8137.29**
PW3 Number of established pest populations **in greenhouses** in scenario **A1**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW4 Number of established pest populations **in greenhouses** in scenario **A1**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW1 Number of established pest populations **in greenhouses** in scenario **A2**	0.01	**3.09**	**11.96**	**33.20**	207.63
PW2 Number of established pest populations **in greenhouses** in scenario **A2**	**0.07**	**17.59**	**67.94**	**193.13**	**1,251.73**

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
PW3 Number of established pest populations **in greenhouses** in scenario **A2**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW4 Number of established pest populations **in greenhouses** in scenario **A2**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Table A.19 reports five quantile values (1st, 25th, 50th, 75th and 99th) of the estimated number of established pest populations of *R. similis* emerging from infested imported plants reaching the consumer level per year in the EU for scenarios A0–A2.

Table A.19: Selected quantiles of the uncertainty distribution for the expected number of established pest populations of *Radopholus similis* emerging from infested imported plants reaching the consumer level per year in the EU for scenarios A0–A2

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
PW1 Number of established pest populations **at consumer level** in scenario **A0**	**58**	**13,941**	**56,758**	**176,684**	**2,152,167**
PW2 Number of established pest populations **at consumer level** in scenario **A0**	**11**	**21,755**	**128,821**	**466,889**	**5,912,902**
PW3 Number of established pest populations **at consumer level** in scenario **A0**	**0**	**5**	**46**	**233**	**3,339**
PW4 Number of established pest populations **at consumer level** in scenario **A0**	**8**	**1,715**	**8,286**	**28,906**	**194,548**
PW1 Number of established pest populations **at consumer level** in scenario **A1**	**15**	**32,859**	**197,034**	**744,243**	**10,614,174**
PW2 Number of established pest populations **at consumer level** in scenario **A1**	**11**	**21,755**	**128,821**	**466,889**	**5,912,902**
PW3 Number of established pest populations **at consumer level** in scenario **A1**	**0**	**6**	**58**	**287**	**4,279**
PW4 Number of established pest populations **at consumer level** in scenario **A1**	**8**	**1,715**	**8,286**	**28,906**	**194,548**
PW1 Number of established pest populations **at consumer level** in scenario **A2**	**7**	**1,576**	**6,707**	**22,141**	**293,863**
PW2 Number of established pest populations **at consumer level** in scenario **A2**	**6**	**1,600**	**6,363**	**18,954**	**192,703**
PW3 Number of established pest populations **at consumer level** in scenario **A2**	**0**	**3**	**27**	**138**	**2,058**
PW4 Number of established pest populations **at consumer level** in scenario **A2**	**1**	**349**	**2,645**	**11,495**	**93,167**

A.3.1.3. Uncertainty on establishment in greenhouses and at the consumer level

The uncertainty in the estimate for the number of populations of *R. similis* under protected environments in the EU (i.e. number of infested greenhouses) is due to change in both infestation rate and trade volume.

Infested plants reaching the consumer, i.e. the category II, which is plants intended for direct planting out-doors such as, e.g. palm trees, is considered resulting in one new population of *R. similis* for each infested plant.

A.3.1.3.1. Uncertainties on establishment in greenhouses

The contribution of the various factors to uncertainty considered in the assessment of establishment in greenhouses quantified for the pathways PW1 and PW2 and each scenarios are shown in Tables A.20 and A.21. The contributions are expressed as standardised regression coefficients.

Table A.20: Sensitivity of the baseline scenario A0 for establishment in greenhouses for PW1 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_BIK	0.85	0.72	88
Prop_Host_I	0.29	0.09	10
Imp_H	0.11	0.01	1
Surv_Insp_BIK	0.06	0.00	0
Conv_Packs2pcs_I	−0.05	0.00	0
Imp_A	0.01	0.00	0
Conv_Packs2pcs_B	–	–	0
Prop_P4P_I	–	–	0
Prop_P4P_B	–	–	0
	R^2 =	0.82	100

Table A.21: Sensitivity of the baseline scenario A0 for establishment in greenhouses for PW2 (Regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_ACHJ	0.82	0.67	92
Conv_Packs2pcs_H	−0.16	0.03	4
Prop_Host_H	0.15	0.02	3
Imp_H	0.07	0.01	1
Prop_Host_J	0.04	0.00	0
Conv_Packs2pcs_C	−0.03	0.00	0
Imp_C	0.03	0.00	0
Conv_Packs2pcs_J	−0.02	0.00	0
Prop_P4P_J	−0.02	0.00	0
Prop_P4P_H	−0.01	0.00	0
Prop_Host_E	0.01	0.00	0
Imp_J	0.01	0.00	0
Imp_A	–	–	0
Prop_P4P_E	–	–	0
Prop_P4P_C	–	–	0
Prop_P4P_A	–	–	0
Conv_Packs2pcs_E	–	–	0
Conv_Packs2pcs_A	–	–	0
Prop_Host_A	–	–	0
Imp_E	–	–	0
	R^2 =	0.72	100

A.3.1.3.2. Uncertainties on establishment at consumer level

The contribution of the various factors to uncertainty considered in the assessment of establishment at consumer level quantified for each pathway and each scenario are shown in Tables A.22–A.25. The contributions are expressed as standardised regression coefficients.

Table A.22: Sensitivity of the baseline scenario A0 for establishment at consumer level for PW1 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_BIK	0.41	0.16	52
Fakt_GHP4P_ABCHIJ	0.30	0.09	29
Prop_Host_I	0.15	0.02	7
Prop_GHP4P_ABCHIJK	0.14	0.02	6
Red_all	−0.09	0.01	2
Surv_RRO_BGIM	0.06	0.00	1
Imp_H	0.05	0.00	1
Surv_Insp_BIK	0.04	0.00	0
Surv_Cert_BGI	0.02	0.00	0
Conv_Packs2pcs_I	–	–	0
Conv_Packs2pcs_B	–	–	0
Prop_P4P_I	–	–	0
Prop_P4P_B	–	–	0
Imp_A	–	–	0
	R^2 =	0.31	100

Table A.23: Sensitivity of the baseline scenario A0 for establishment at consumer level for PW2 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_ACHJ	0.50	0.25	65
Fakt_GHP4P_ABCHIJ	0.31	0.09	24
Prop_GHP4P_ABCHIJK	0.14	0.02	5
Prop_Host_H	0.10	0.01	2
Red_all	−0.09	0.01	2
Imp_H	0.06	0.00	1
Prop_Host_A	0.01	0.00	0
Imp_A	–	–	0
Imp_J	–	–	0
Prop_P4P_J	–	–	0
Prop_P4P_H	–	–	0
Prop_P4P_E	–	–	0
Prop_P4P_C	–	–	0
Prop_P4P_A	–	–	0
Conv_Packs2pcs_E	–	–	0
Conv_Packs2pcs_A	–	–	0
Imp_E	–	–	0
Prop_Host_E	–	–	0
Imp_C	–	–	0
Conv_Packs2pcs_C	–	–	0
Conv_Packs2pcs_J	–	–	0
Prop_Host_J	–	–	0

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Conv_Packs2pcs_H	–	–	0
	R^2 =	0.38	100

Table A.24: Sensitivity of the baseline scenario A0 for establishment at consumer level for PW3 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
P_Inf_GM	0.59	0.35	69
Prop_Host_M	0.37	0.14	28
Prop_Est_DEFGML	0.13	0.02	3
Surv_Insp_GM	0.03	0.00	0
Imp_J	0.02	0.00	0
Imp_F	0.01	0.00	0
Conv_Packs2pcs_M	–	–	0
Prop_Host_G	–	–	0
Conv_pcs2kg_F	–	–	0
	R^2 =	0.51	100

Table A.25: Sensitivity of the baseline scenario A0 for establishment at consumer level for PW4 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_DEFL	0.75	0.56	87
Prop_Est_DEFGML	0.20	0.04	6
Prop_Inf_ACHJ	0.13	0.02	2
Prop_Host_E	0.11	0.01	2
Fakt_GHP4P_ABCHIJ	0.08	0.01	1
Prop_P4P_E	−0.06	0.00	1
Prop_Host_L	0.05	0.00	0
Prop_GHP4P_ABCHIJK	0.04	0.00	0
Imp_J	0.04	0.00	0
Red_all	−0.03	0.00	0
Imp_E	0.03	0.00	0
Conv_Packs2pcs_E	−0.01	0.00	0
Conv_Packs2pcs_L	–	–	0
Prop_Host_F	–	–	0
Conv_pcs2kg_F	–	–	0
Imp_F	–	–	0
	R^2 =	0.65	100

A.3.2. Establishment in EU citrus production areas

The Panel decided to estimate the potential for establishment of *R. similis* in the open fields only for citrus production areas of the EU. This is because citrus is regarded as the main category of hosts for *R. similis* might pose a risk in the EU in open fields. However, the other suitable hosts, such as palm trees, only thrive in the Mediterranean area of the EU. Therefore, the citrus growing areas are assumed as a proxy also for other outdoor host plants of *R. similis* in the EU.

Entry by infested citrus is not possible because this is a closed pathway into the EU. Therefore, establishment in citrus can only happen through entry of *R. similis* on other species of host plants, e.g. those species and pathways dealt with in the Section A.2 on Entry and Section A.4 on Spread.

In general, areas suitable for citrus production according to Duncan (2005) can be described as a belt within 35° latitude north or south of the equator where citrus is grown in more than 125 countries. The major limiting factor to citrus production is a requirement that the occurrence of freezing temperatures must be of very short duration.

In the EU, the production sites are located mainly in Mediterranean areas under semiarid climates with less than 500 mm per year and with clay alkaline soils. In the Mediterranean basin, citrus has been irrigated, with flood or drip irrigation. Drip irrigation is increasingly used due to higher water efficiency. Compared to the EU in Florida, citrus production takes place under humid subtropical conditions with more than 1,500 mm per year, mostly in sandy acid soils so rootstocks like swingle citrumelo or rough lemon can be used (personal communication, 7 January 2017, Dr Antonio Vicent, researcher, Valencian Institute for Agricultural Research, Plant Protection and Biotechnology Centre, Moncada, Valencia 46113, Spain, replying to a specific query with regard to citrus production).

The evidence from Florida (US) where *R. similis* have been observed to cause severe damage on citrus is regarded as a worst case scenario for the risk posed by *R. similis* to EU citrus.

Citrus is grown in California under similar climate conditions as in the EU, but *R. similis* has not established in there despite occasionally interceptions (CDFA, 2016). However, *R. similis* has been detected in an established *R. similis* population in a residential property in Huntington Beach in 1996 but was eradicated from the infested region (CDFA, 2016).

In order to estimate the potential for establishment of *R. similis* in EU citrus growing areas, the Panel decided to perform an analysis comparing the environmental conditions in areas of the world where *R. similis* is known to occur with EU conditions.

Although the Panel is aware that there exist studies, e.g. Wang and Xie (2007) to estimate the potential for establishment of *R. similis* in China, that are applying generic tools like MAXENT (Phillips et al., 2006) and GARP (Stockwell and Peters, 1999) to predict the potential geographic distribution of this nematode, the Panel is of the opinion that there might be less complex approaches that can provide equally or even more useful results.

A.3.2.1. Estimation of establishment in open fields in EU citrus production areas

The reproduction rate of *R. similis* is temperature dependent (Elbadri et al., 2001) and the nematode is sensitive to low temperatures but thrives at higher temperatures and under moist soil conditions. According to the scientific literature, the optimal temperature range for nematode multiplication is 24–32°C (Tarjan and O'Bannon, 1984; Gowen and Quénéhervé, 1990). Generally, this nematode does not reproduce at temperatures below 16–17°C (Pinochet et al., 1995; Sarah et al., 1996) or above 33°C (Sarah et al., 1996). However, populations exposed to lower temperatures for a long period could adapt to the cooler conditions and reproduce at 15°C (Elbadri et al., 2001).

The occurrence of populations of *R. similis* is known to have an elevation limit in East Africa (Talwana et al., 2000; Elsen et al., 2004). It appears that *R. similis* does not occur at altitudes higher than 1,400 masl in Uganda. This might be relevant for other parts in the world as well and may be due to the effect of temperature on nematode development. Elsen et al. (2004) found that at Ryeru (Bushenyi district, Uganda) located at 1,340–1,420 masl) and at Kalongo (Mubende district, Uganda) located at 1,210–1,280 masl, *R. similis* was not present. At these locations, *Pratylenchus goodeyi* was present in high densities; this species was not present at the lower altitudes of the East African highlands. Similarly, Talwana et al. (2000) did not detect *R. similis* in roots of banana in Ntungamo (Ntungamo district, Uganda) at 1,450 masl. Elsewhere on the African continent, nematode surveys have been conducted in the three main banana-producing areas of South Africa, namely Onderberg and Hazyview (both in Mpumalanga Province), and the South Coast of Kwazulu-Natal Province found that *R. similis* was present in all areas both in soil- and banana root samples (Daneel et al., 2015). However, the population densities of *R. similis* were at these locations too low to cause any damage. Interestingly, and specifically in the context of the assessment of the risk posed by *R. similis* to citrus cultivation, these areas in South Africa are also important citrus cultivation areas. However, despite its presence, there are no reports that *R. similis* causes problems for citrus cultivation neither in Mpumalanga nor in Kwazulu-Natal provinces. Daneel et al. (2015) discussed this information in the light of the results from a phylogenetic study by Kaplan et al. (2000) who determined which pathotypes were able to infect citrus among a large number of *R. similis* populations from distant geographical areas. The study of Kaplan et al. (2000) included two isolates from Mpumalanga, South Africa, which were found to belong to the *R. similis* pathotype that does not parasitise citrus. However, as in the case of Van den Berg et al. (2005), *R. similis* damage in South Africa might be similar to what they found for *Pratylenchus coffeae*, which never increased to dramatic levels due to cool winter and periods of abundant rainfall. South Africa also has a cool, dry winter period, which might be in part responsible for preventing dramatic *R. similis* levels in banana plantations.

Inspired by the information in the scientific literature, both from laboratory experiment data on the temperature dependence of the multiplication rate of *R. similis*, and from field reports on its presence and absence, the Panel conducted a simple analysis for estimation of establishment potential for *R. similis* in the EU based on temperature information.

The Panel used the information on the presence/absence of the pest and compared the temperature conditions in these locations with temperature conditions in EU citrus growing areas. The literature reports on the presence and absence of *R. similis* in the field are summarised in Table A.26.

Table A.26: Locations selected for further study of the relationship between temperature and population density or presence/absence of the pest

Location	Status of *R. similis*	Latitude	Longitude	Altitude	Reference
Polk county, Florida, USA	Present Severe impact on citrus	81.69	−27.94	39	Suit (1947)
Kyadondo, central Uganda	Present Impact on banana	0.41	32.58	1,152	Elsen et al. (2004)
Bushenyi, central Uganda	Absent	−0.41	30.08	1,412	Elsen et al. (2004)
Onderberg, Mpumalanga, South Africa	Present, low density No impact	−25.48	31.51	325	Daneel et al. (2015)
Hazyview, Mpumalanga, South Africa	Present, low density No impact	−25.052	31.13	530	Daneel et al. (2015)
South Coast of Kwazulu-Natal, South Africa	Present, low density No impact	−30.87	30.35	30	Daneel et al. (2015)
Huntington beach, California, USA	Eradicated (previously present) No impact	33.67	−117.00	10	Chitambar (2007)

In order to ease the comparison of temperature conditions for the locations in Table A.26, the Panel decided to use the WorldClim dataset version 1.4 (Hijmans et al., 2005) which is a climate data set with a global coverage, but with monthly data only. The average monthly air temperatures of these locations as extracted from WorldClim are displayed in Figure A.3, with the addition of one EU location, Messina, Italy.

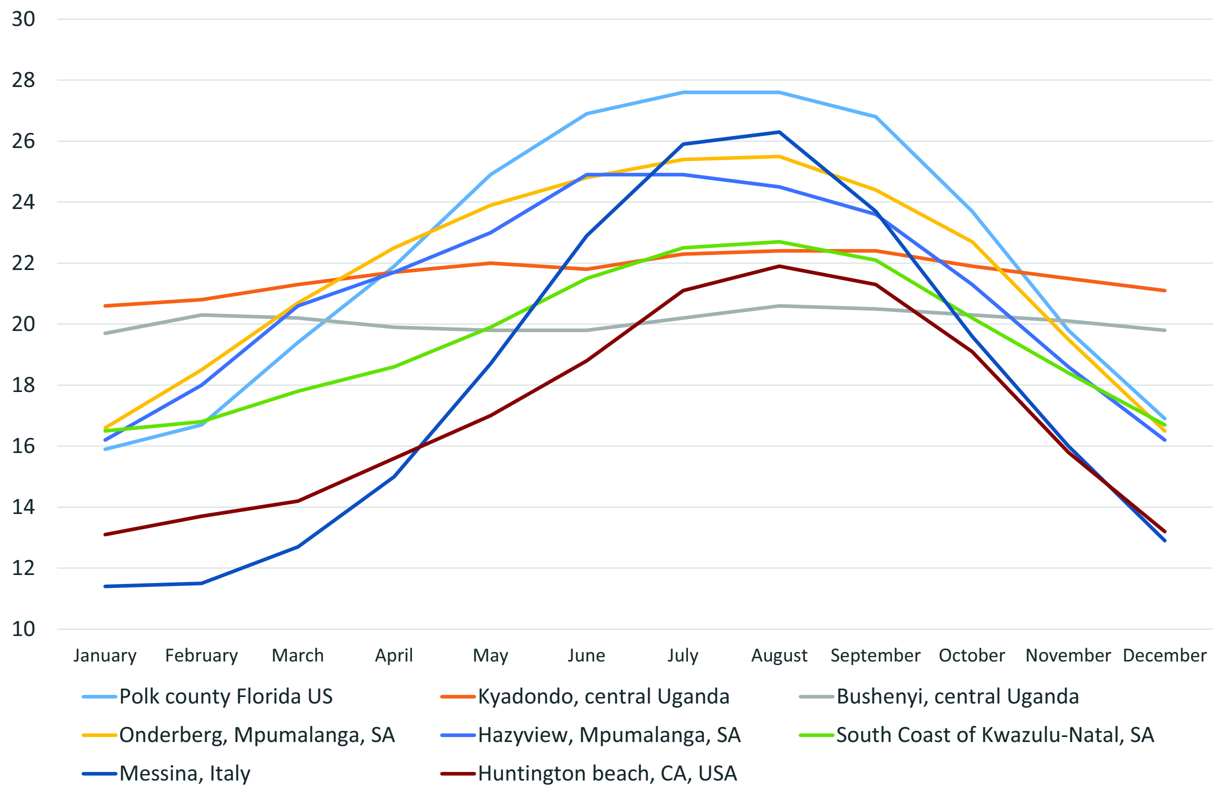


Figure A.3: Average monthly temperatures for locations in Table A.26 with the addition of one EU location Messina, Italy. The southern hemisphere locations are seasonally shifted 6 months for ease of comparison

Notably is the fact that the reported presence of *R. similis* in one location in Uganda (at an altitude of about 1,100 masl) only differs, on average, less than 2°C from another nearby location (at an altitude of about 1,400 masl) where *R. similis* was not able to establish, suggesting that marginal differences in temperature may determine the establishment potential for *R. similis*. Generally, the information in the relatively stable year-round temperature profile of the tropical locations like the two Ugandan locations in Figure A.3, where the pest is, respectively, present and absent, lend themselves to support the estimation of a threshold temperature for development of *R. similis* populations under field conditions. The laboratory studies, as already mentioned, reports an optimal temperature range for nematode multiplication for *R. similis* of 24–32°C (Tarjan and O'Bannon, 1984; Gowen and Quénéhervé, 1990) and that the nematode generally does not reproduce at temperatures below 16–17°C (Pinochet et al., 1995; Sarah et al., 1996). Nevertheless, the study of Elbadri et al. (2001) showed that populations exposed to lower temperatures for longer periods could also adapt and reproduce at 15°C.

For non-tropical locations, the temperature might be suitable for nematode multiplication only during the warmest periods of the year and with little or no population growth during the rest of the year. This will result in low population densities.

Inspired by this information, the Panel calculated simple temperature sums for a whole range of threshold temperatures from 14°C to 21°C (Figure A.4) using the same WorldClim data. The underlying idea of this approach was to derive a simple temperature-based classification rule that might be used for estimation establishment potential of *R. similis*.

The results of the temperature sum calculations are displayed in Figure A.4. It is only the highest temperature threshold of 21°C that yields a temperature sum of zero for the Bushenyi location in central Uganda, where the nematode was not able to establish. Based on the results from this simple analysis, the Panel decided to use the temperature of 21°C as the threshold in the temperature-sum calculation approach based on monthly data.

Although the WorldClim data only consist in monthly averages, the Panel is of the opinion that monthly data on air temperature will suffice as a proxy for soil temperature at the scale of comparison conducted in this risk assessment for *R. similis* as the pest is a soil residing organism that also thrive deep into the soil where temperatures normally are very stable. This approach deviate from a standard approach where calculation of temperature sums normally will require data with minimum a daily temporal resolution.

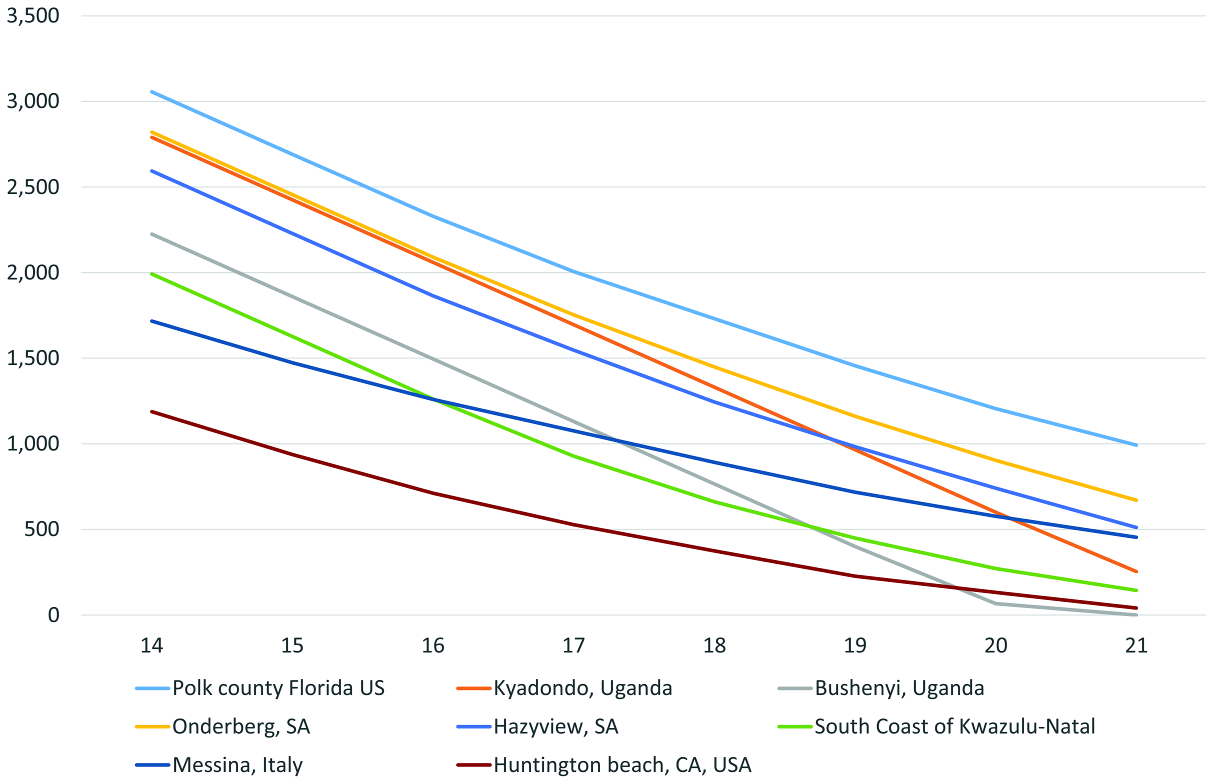


Figure A.4: Temperature sums calculated for various threshold temperatures for locations in Table A.26

Following the analysis of temperature data for the locations in Table A.26, the Panel calculated the temperature sum above 21°C for all EU citrus growing areas. This calculation was done in the same way, but using the gridded agro-meteorological data for Europe from the Joint Research Centre, taking the average of the data from the last decade (2007–2016).

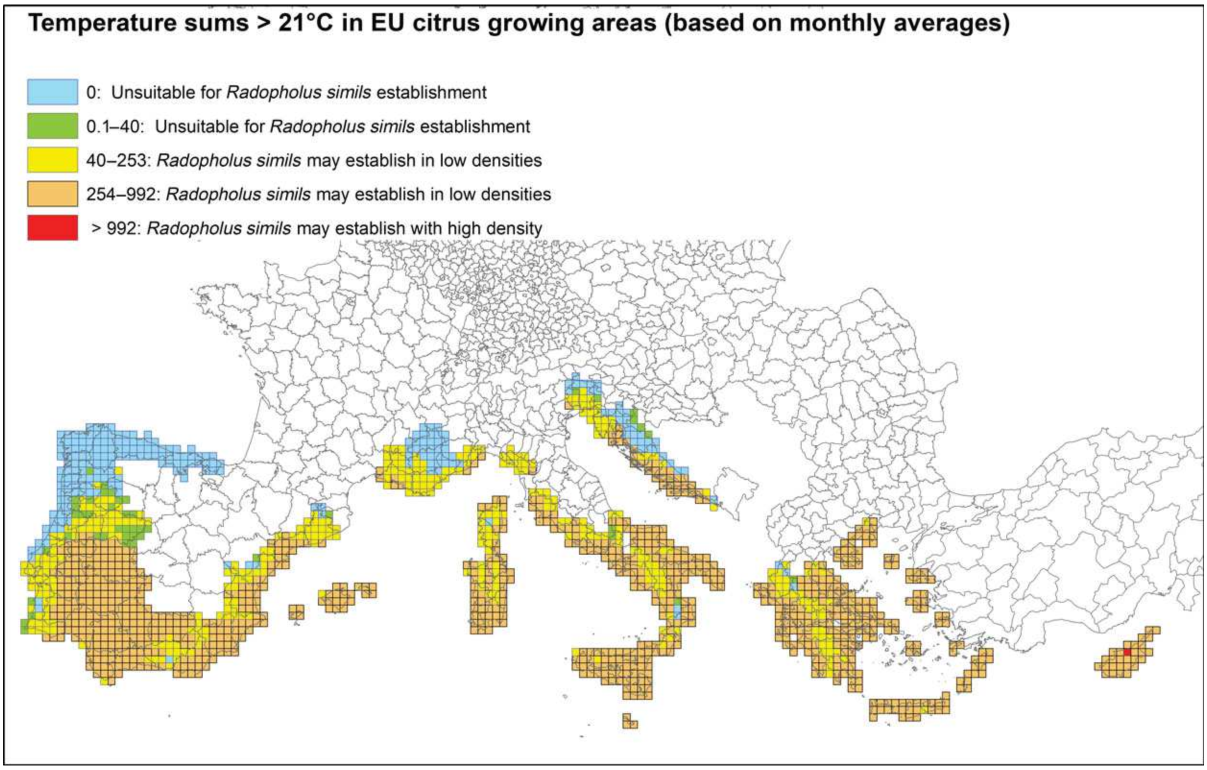


Figure A.5: Citrus growing areas of the EU classified according to temperature sum intervals based on monthly average temperatures from locations surveyed for the presence of *R. similis*, see JRC (2017) for the data used to create the map

Figure A.5 shows the results from the temperature sum calculations for estimation of the establishment potential of *R. similis* in EU citrus growing areas. The results suggest that the temperature conditions will prevent the nematode from establishing only in the northernmost citrus areas and in higher altitude areas in the south.

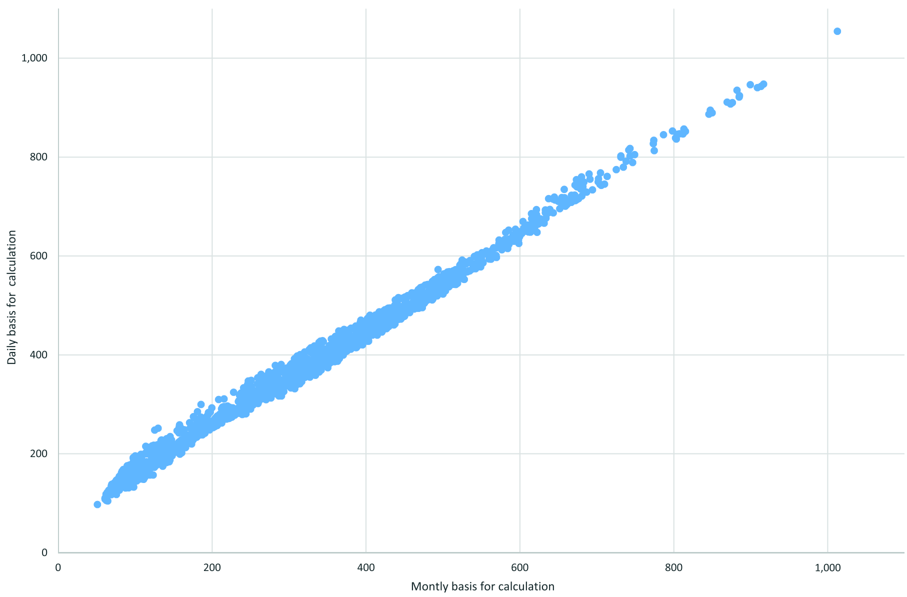


Figure A.6: Plot of temperature sums in EU citrus growing areas calculated, respectively, based on monthly data versus daily data

In order to be transparent on the relationship between temperature sums calculated from monthly versus daily data, a simple scatterplot is provided in Figure A.6.

Applying the same approach, the Panel also considered the effect of an overall + 2°C climate warming, and what the temperature sums for EU citrus growing areas would look like under such a scenario. The result is shown in Figure A.7 which indicates that there will be some areas (red coloured grids) reaching temperature sums for *R. similis* multiplication equal to the Florida situation where the nematode cause severe damage on citrus.

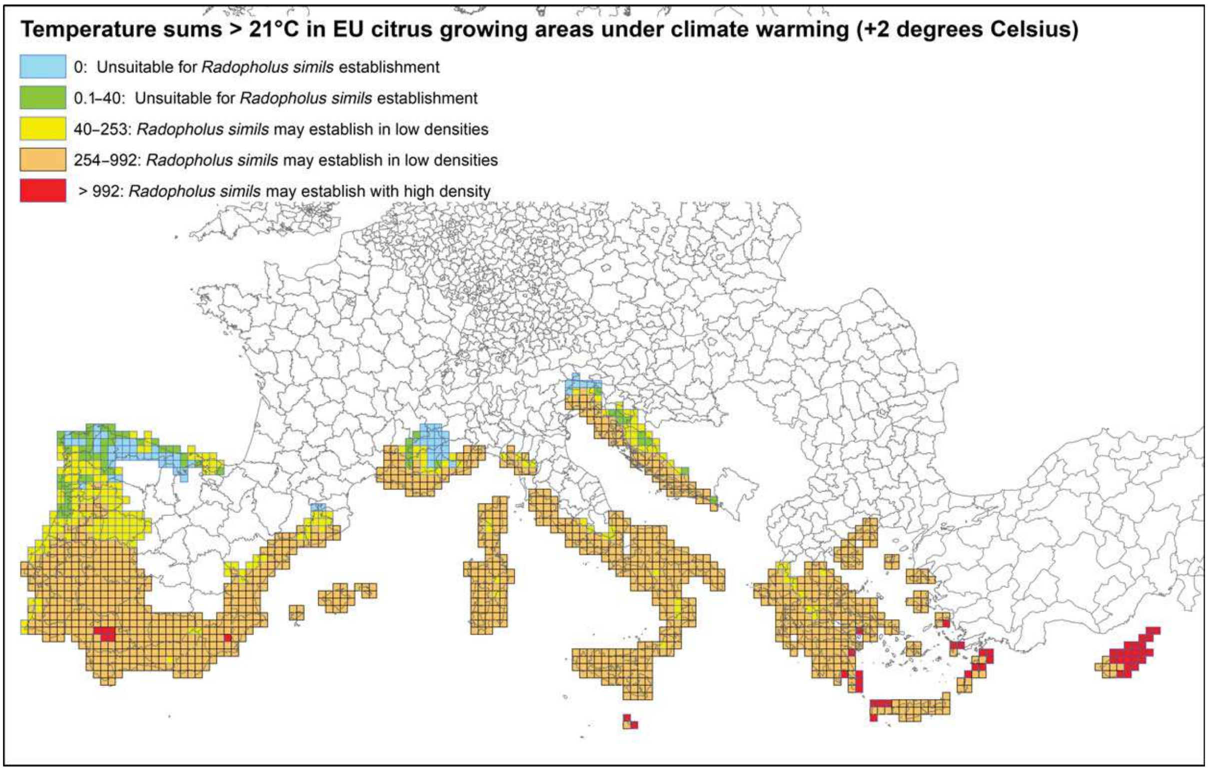


Figure A.7: Citrus growing areas of the EU classified for temperature suitability for *Radopholus similis* establishment according to temperature sum intervals under climate warming, see JRC (2017) for the data used to create the map

A.3.2.2. Uncertainty on establishment in open fields

The Panel identified following uncertainties:

- Physiological differences between populations of *R. similis* have been reported (Fallas and Sarah, 1995); therefore, the situation analysed using climatic data may not be transferred for all populations.
- Different soil types may have an influence on establishment and development of *R. similis* but have not been assessed within this opinion. The disease 'spreading decline' only occurs in a very specific area in Florida (deep sandy soils of the central ridge) and there is no information available if such conditions exist in the EU.
- Temperature thresholds for development (basal temperature), multiplication and for mortality of *R. similis* vary among populations (Fallas and Sarah, 1995; Elbadri et al., 2001).
- The reported presence of *R. similis* in one location in Uganda (at an altitude of ca 1,100 masl) only differed in mean temperature of less than 2°C from another location in Uganda (at altitude of ca 1,400 masl) where the establishment of *R. similis* was not possible (Elsen et al., 2004). This shows that marginal differences of temperature may decide about the establishment of *R. similis*.
- Only air temperatures are considered within this opinion, because no data about soil temperatures that are relevant for *R. similis* development are available. Soil data is not considered an appropriate meteorological element due to its site specific dependencies on a whole range of soil characteristics like structure, albedo and humidity, etc.
- Not all host plants for *R. similis* are known so far.

A.4. Spread

Conceptual model for spread is shown in Figure A.8.

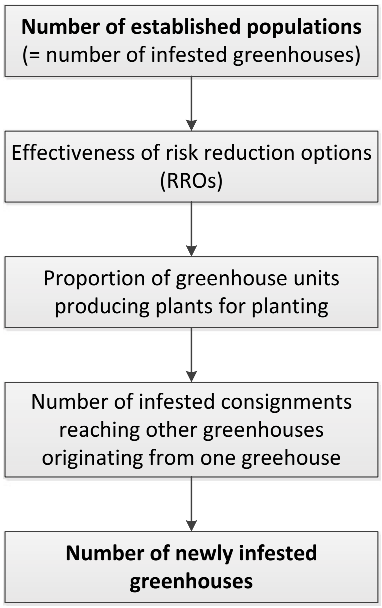


Figure A.8: Conceptual model for spread

As indicated in the Pest characterisation (EFSA PLH Panel, 2014), information on the presence of *R. similis* in the risk assessment area is only available at national level because it is not known in which areas within a specific MS the pest is present or absent. Based on answers to an EFSA Questionnaire that was sent by the PLH Panel to the National Plant Protection Organizations (NPPO) of all EU MSs in 2014 (EFSA PLH Panel, 2014), this nematode is currently established indoors in some EU countries (France, Belgium, Italy and the Netherlands) at low prevalence (see Table A.27 in Appendix A). In this assessment, the Panel focused on the spread of *R. similis* from infested to non-infested greenhouses based on movement of planting material. The main pathways for spread that are considered for this PRA are plants for planting: PW1 (under AO regulated small plants) and PW2 (under A0 non-regulated small plants).

PW3 and PW4, ornamental plants with roots including non-regulated host plants (e.g. palm trees) more than 1 m high, are considered mainly for outdoor use and for this reason the Panel will not assess the spread part for these pathways because it assumes that these plants are intended for the final consumer who will keep the plants either indoor or will plant them outside. Final consumer is regarded as end point for further spread of host plants of *R. similis* but is also considered as a place where shift of this nematode to the outdoor citrus production might happen. This is considered in a separate Section A.4.2. Shift to citrus production.

The spread of *R. similis* via regulated and non-regulated small plants from infested to non-infested greenhouses is assessed in the context of the following successive steps:

- Number of established *R. similis* populations = number of infested greenhouses.
- Proportion of greenhouse units producing plants for planting for other greenhouse producers.
- Number of consignments reaching other greenhouse units.
- Effectiveness of phytosanitary measures.
- Number of newly infested greenhouses.

Currently, *R. similis* is not widespread in the RA area and has only been sporadically reported from some EU countries (see Table A.27 below).

Table A.27: The current distribution of *R. similis* in the risk assessment area, based on answers received from the 28 EU Member States, Iceland and Norway in 2014 and 2016 (or based on EPPO PQR, online if no answers were received)

Member State	Current situation as for 2014*	Updated information as for 2016
Austria	Absent, no pest records	Targeted surveys to detect the pest have not been conducted in Austria. However, general surveillance (targeted to detect other pests on the host plants) indicated no symptoms of *Radopholus similis.* The official status of the three species in Austria can therefore be described as: Absent, no pest records
Belgium	Present, restricted distribution (only under protected cultivation)	Survey on *R. similis* was performed in 2014 and 2015 as part of a research programme. No findings were reported
Bulgaria	Absent, no pest records	–[(a)]
Croatia	Absent, no pest records	*R. similis* was not found in 2016 (1/1/2016–1/11/2016) survey
Cyprus	Absent, no pest records	No surveys were carried out in Cyprus on *R. similis*
Czech Republic	Absent, no pest records	A survey for *R. similis* was not carried out in the CZ neither in 2016 nor in last years. The pest status of *R. similis* in the territory of CZ can be declared as:Absent, no pest records
Denmark	Absent, pest eradicated	*R. similis* was not included in DK survey programme 2016
Estonia	Absent, no pest records	*R. similis* were not included in surveys of 2016
Finland	Absent, no pest records	Survey on *R. similis* has not been done because its host plants are not grown in Finland
France	Present, restricted distribution	–
Germany	Absent, intercepted only	In the period from May to December 2016, a survey of *R. similis* was conducted in two Federal States of Germany. Three greenhouses and 12 wholesaler or retailers were inspected. Fifteen samples were analysed. *R. similis* was not detected
Greece	No data (EPPO PQR, online)	–
Hungary	Absent, no pest records	–
Ireland	No data (EPPO PQR, online)	–
Italy	Present, restricted distribution (EPPO PQR, online)	–
Latvia	No data (EPPO PQR, online)	No inspections for *R. similis* performed in 2016
Lithuania	No data (EPPO PQR, online)	*Radopholus similis* was not involved in the official survey in 2016 because climatic conditions for *R. similis* to survive in Lithuania are unfavourable
Luxembourg	No data (EPPO PQR, online)	No survey for *R. similis* performed in 2016; no information about a presence of the pest in Luxembourg
Malta	Absent, no pest records	–
Netherlands	Present, only in restricted cultivation, at low prevalence	Findings in 2016: One finding in *Rhapis* from Malaysia. No measures were taken because the organism is not regulated on *Rhapis* Four findings in plants of Marantaceae (rooted and/or with growing medium attached or associated). Measures: plants were not allowed to be marketed as propagation material
Poland	Absent, pest eradicated	In 2016 surveillance conducted for *R. similis*, 175 inspections performed, one sample taken, no positive sample
Portugal	Absent, pest eradicated	–
Romania	No data (EPPO PQR, online)	–
Slovakia	Absent, no pest records	–
Slovenia	Absent, pest records invalid	No survey has been conducted in Slovenia for *R. similis.* The pest status confirmed as: Absent: pest records invalid

Member State	Current situation as for 2014*	Updated information as for 2016
Spain	Absent, no pest records	–
Sweden	Absent, pest eradicated	No survey for *R. similis* performed in 2016
United Kingdom	Absent, pest eradicated	–
Iceland	No data (EPPO PQR, online)	–
Norway	No data (EPPO PQR, online)	–

*: When no information was made available to EFSA, the pest status in the EPPO PQR (2014) was used.
(a): updated information as for 2016 not available.

A.4.1. Spread by ornamental plants in protected areas (greenhouses)

Only populations entering the EU from Third countries are considered in the spread model.

A.4.1.1. Number of established populations

The starting point for the spread assessment is the number of established populations of *R. similis* in greenhouses after entering the RA area (see results of establishment). The number of greenhouse units getting infected from these existing established populations in 1 year represents the newly established populations. Assessing the number of established populations, the Panel considers the proportion of plants for planting for spread between greenhouse units separately for pathways PW1 and PW2. Plants for end-users are only considered in the Section A.4.2 on shift to citrus production.

A greenhouse unit is defined as production unit with closed irrigation system where the nematodes can move from plant to plant within the greenhouse either via natural active spread (nematode will move only short distances in soil) or via irrigation water, by flooding, or by run-off water.

Once one infested plant is discovered in the greenhouse unit, the whole unit and all plants originating from this unit are considered infested representing a source for nematode spread within the RA area.

Assessment of spread is influenced by substantial uncertainty regarding the knowledge gap about greenhouses/companies organisation (e.g. number of greenhouse units per company) and technological processes of plant production within various greenhouses across the RA area.

A.4.1.2. Effectiveness of the RROs (phytosanitary measures)

Here, a reduction factor is estimated which determines the proportion of infested greenhouse units that will escape detection and consequently performed phytosanitary measures.

A.4.1.2.1. Effectiveness of RROs for spread in scenario A0

In the baseline scenario (A0), RROs 2.01, 2.03 and 2.08 are implemented for host plants with roots or with growing medium attached, produced in the EU territory, to confirm the absence of *R. similis* in the growing crop. The procedure to establish this requirement is not specified. The effectiveness of observations, rather than testing, to detect *R. similis* is low. An alternative requirement for host plants with roots or with growing medium attached, produced in the EU territory, is implemented with RROs 2.01, 2.02, 2.03 and 2.08 to confirm the absence of *R. similis* in the growing crop by testing soil and roots from suspected plants. The effectiveness of this requirement is low, because it is not specified how suspected plants are to be detected.

Consignments of host plants with roots or with growing medium attached, produced in EU Member States, may be moved within the EU only if the plants have been grown at registered nurseries and if a plant passport for the consignment is issued based on a general plant health inspection. The effectiveness is low, because a general inspection is not effective for detection of *R. similis*.

A.4.1.2.2. Effectiveness of RROs for spread in scenario A1

In scenario A1, *R. similis* is not a listed harmful organism, and the category of 'regulated host plants' does not exist. There is only one category of plants: non-regulated host plants.

For non-regulated host plants produced in EU Member States, consignments of plants for planting may be moved within the EU only if the plants have been grown at registered nurseries and if a general plant health inspection is performed before a plant passport for the consignment is issued

(RROs 2.01, 2.03, 2.04 and 2.05). The effectiveness is low, because a general inspection is not effective for detection of *R. similis*.

A.4.1.2.3. Effectiveness of RROs in A2

In scenario A2, it is recognised that it is not possible to make a complete list of all hosts of *R. similis*. To prevent entry into and spread within all Member States of the EU, *R. similis* is therefore listed as a harmful organism, regardless of the material carrying the pest.

In scenario A2, the category of non-regulated host plants' does not exist; there is only the category of 'regulated host plants'. Since *R. similis* is known to occur in the EU, the species is now listed in Annex I A II of the Council Directive 2000/29/EC.

A new special requirement for the movement within in the EU of plants for planting (all plant species), produced in Member States of the EU, is formulated as follows:

'For plants with roots, planted or intended for planting:

Official statement:

that the plants have been grown in nurseries,

And

that the plants originate from certified planting material produced in accordance with a certified production scheme and which was tested and found free from *R. similis*,

And

that the plants originate in an area, established by the national plant protection service of the Member State of origin, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures,

Or

that the plants originate in a place of production, established by the national plant protection service of the Member State of origin, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures,

Or

That the plants have been grown in sterile growing medium in pots on shelves at least 50 cm above the ground and the growing medium has been maintained free from harmful organism'.

Pest-free production area

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free area for *R. similis*, for plants with roots produced within the EU, is very effective in preventing spread within the EU. The effectiveness may be limited by the accuracy of the surveillance activities to confirm the pest absence in the area.

Pest-free production place

The alternative implementation of RROs 2.02, 2.03 and 2.08 to establish a pest-free place of production for *R. similis*, for plants with roots produced within the EU, is very effective in preventing spread of *R. similis* within the EU. The effectiveness may be limited by the accuracy of the activities to confirm the pest absence in the production place.

Pest-free production site

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting, for plants with roots produced within the EU, is effective to prevent spread of *R. similis*. The combination with RRO 1.01 to establish that the plants are grown in isolation, and with RROs 2.02 and 2.03, requiring that the plants are grown from certified plants for planting that have been produced according to a certification scheme and tested for the absence of *R. similis*, results in a very effective prevention of spread of *R. similis*.

Human-assisted spread

For regulated and non-regulated host plants, consignments of plants for planting may be moved within the EU only if the plants have been grown at registered nurseries and if a general plant health inspection is performed before a plant passport for the consignment is issued (RROs 2.01, 2.03, 2.04 and 2.05).

The implementation of these RROs has a low effectivity and has little added value to the other measures to prevent spread, because the probability to detect *R. similis* by a general plant health inspection is low.

For these reasons, the Panel considers the following distribution of the values estimating the effectiveness of phytosanitary measures on pest abundance in regulated plants for planting in the EU.

Table A.28: Effectiveness of the RROs (phytosanitary measures) for PW1[(a)]

Effectiveness of the RROs (phytosanitary measures) for PW1									
Quantile (percentile)	**Reduction factor[(a)]**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.1	0	0.2	Not considered	Upper (99%)	0.9	1	0.8	Not considered
Q1 (25%)	0.2	0	0.5	Not considered	Q3 (75%)	0.8	1	0.5	Not considered
Median (50%)	0.3	0	0.6	Not considered	Median (50%)	0.7	1	0.4	Not considered
Q3 (75%)	0.4	0	0.7	Not considered	Q1 (25%)	0.6	1	0.3	Not considered
Upper (99%)	0.7	0	0.75	Not considered	Lower (1%)	0.3	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

The Panel considers the following distribution of the values estimating the effectiveness of phytosanitary measures on pest abundance in non-regulated plants for planting in the EU.

Table A.29: Effectiveness of the RROs (phytosanitary measures) for PW2[(a)]

Effectiveness of the RROs (phytosanitary measures) for PW2									
Quantile (percentile)	**Reduction factor[(a)]**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0	0	0.2	Not considered	Upper (99%)	1	1	0.8	Not considered
Q1 (25%)	0	0	0.5	Not considered	Q3 (75%)	1	1	0.5	Not considered
Median (50%)	0	0	0.6	Not considered	Median (50%)	1	1	0.4	Not considered
Q3 (75%)	0	0	0.7	Not considered	Q1 (25%)	1	1	0.3	Not considered
Upper (99%)	0	0	0.75	Not considered	Lower (1%)	1	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Many host plant species of *R. similis* that are not listed in the Council Directive 2000/29/EC (e.g. Arecaceae) are regularly imported into the EU with roots (Griffith et al., 2005; Dixon and Anderson, 2013) and have been frequently intercepted in recent years (*Areca, Caryota, Howea, Licuala, Livistona*). Because *R. similis* in this case is not regulated, no action is taken, therefore values for scenarios A0 and A1 are zero.

A.4.1.3. Proportion of greenhouse units producing plants for planting for other greenhouse producers (vs. sale to final consumers or cut flower production)

For the purpose of this risk assessment, the following assumptions/distribution of values are considered:

- Most imported cuttings/plants for planting will be used for final production of cut flowers or end-users.
- Some cuttings might be just rooted and sold to another producer/company.
- Commercial producers based in the risk assessment area will not use imported cuttings for the production of plants for planting but use tissue culture plants.

Uncertainty in knowledge about the proportion of greenhouse units producing plants for planting for other greenhouse producers is expressed by using quantiles. The median value determined by expert judgement is at 10% and the upper value at 50%.

Table A.30: Proportion of greenhouse units producing plants for planting for other greenhouse producers (vs sale to final consumers or cut flower production)

Proportion of greenhouse units producing plants for planting for other greenhouse producers (vs sale to final consumers or cut flower production)	
Quantile (percentile)	**Proportion of greenhouse units producing plants for planting for other greenhouse producers (vs sale to final consumers or cut flower production)**
Lower (1%)	0%
Q1 (25%)	5%
Median (50%)	10%
Q3 (75%)	20%
Upper (99%)	50%

A.4.1.4. Number of consignments reaching other greenhouse units originating from one greenhouse in 1 year

The spread of *R. similis* from one greenhouse to other greenhouses is determined by the number of other growers a producer is selling infected planting material to. All planting material leaving a greenhouse that received at least one infected consignment previously is assumed infected. There are no data available on the movement of plants between greenhouses. Expert judgement was therefore used to estimate these numbers with a median of ten greenhouses reached (Table A.31). Similar figures were used to model the spread of diseases in trade networks, for example Moslonska-Lefebvre et al. (2009) work in their simulations with up to ten trade links in networks of 100 nodes and with up to 20 connections in networks with 500 nodes. Similar, Nelson and Bone (2015) in a horticultural trade network model use between four and eight average trade links. The expert judgement is illustrated by the example of *Anthurium* growers, where one large company is supplying about 60% of the market with plugs and small plants. In 2013, the area of *Anthurium* production in the Netherlands was 65 hectares (AIPH, 2016); with an average size of 1.7 ha under glass for flowers and ornamental growers in the Netherlands (derived from EUROSTAT, online) which was assumed corresponding to about 38 *Anthurium* growers. In this case, the upper limit of 50 is justified given that for cut-flower production plants need to be replanted about every 5 years and that the market of this one grower is not limited to the Netherlands

Table A31: Number of consignments reaching other greenhouse units originating from one greenhouse in 1 year

Number of consignments reaching other greenhouse units originating from one greenhouse in 1 year (multiplication factor)	
Quantile (percentile)	**Number of consignments reaching other greenhouse units (multiplication factor)**
Lower (1%)	1
Q1 (25%)	8
Median (50%)	10
Q3 (75%)	15
Upper (99%)	50

A.4.1.5. Number of infested greenhouses after spread

The results of the spread assessment for pathways PW1 and PW2 are shown in Table A.32. The Table A.32 reports five quantile values (1st, 25th, 50th, 75th and 99th) of the number of infested greenhouses after spread and the number of detected infested greenhouses after spread by *R. similis* per 1 year for scenarios A0, A1 and A2.

Table A.32: Selected quantiles of the uncertainty distribution for the number of infested greenhouses after spread by *Radopholus similis* in the EU in the time horizon of 1 year for scenarios A0–A2 (scenario A.3 was not considered) for the pathways PW1 and PW2

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
PW1 Number of infested greenhouses after spread for scenario **A0**	**0.02**	**5.78**	**22.94**	**70.19**	**795.35**
PW1 Number of **DETECTED** infested greenhouses after spread for scenario **A0**	**0.00**	**0.18**	**0.90**	**3.37**	**53.63**
PW2 Number of infested greenhouses after spread for scenario **A0**	**0.04**	**73.09**	**437.04**	**1,618.51**	**23,386.75**
PW2 Number of **DETECTED** infested greenhouses after spread for scenario **A0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW1 Number of infested greenhouses after spread for scenario **A1**	**0.01**	**12.87**	**76.25**	**276.55**	**3,684.41**
PW1 Number of **DETECTED** infested greenhouses after spread for scenario **A1**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW2 Number of infested greenhouses after spread for scenario **A1**	**0.04**	**73.09**	**437.04**	**1,618.51**	**23,386.75**
PW2 Number of **DETECTED** infested greenhouses after spread for scenario **A1**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
PW1 Number of infested greenhouses after spread for scenario **A2**	**0.01**	**1.57**	**6.43**	**20.40**	**249.20**
PW1 Number of **DETECTED** infested greenhouses after spread for scenario **A2**	**0.00**	**0.91**	**3.71**	**11.84**	**150.25**
PW2 Number of infested greenhouses after spread for scenario **A2**	**0.04**	**9.10**	**37.51**	**117.24**	**1,566.29**
PW2 Number of **DETECTED** infested greenhouses after spread for scenario **A2**	**0.02**	**5.21**	**21.48**	**68.47**	**945.80**

A.4.1.6. Uncertainty on spread by ornamental plants in protected areas (greenhouses)

Assessment of spread of *R. similis* is affected by considerable uncertainty regarding the proportion of greenhouse units producing plants for planting for other greenhouse producers and the number of consignments reaching other greenhouse units originating from one greenhouse. These uncertainties are due to the lack of information about how many companies produce plants for planting which are sold/distributed to other producers of plants for planting (e.g. no precise information how many companies are supplied by Anthura company which is one of the largest producers of Anthuriums). There is also no precise information about how many companies producing plants for planting exists in the RA area. Some uncertainties are also related to the uncertainties associated with effectiveness of RROs under scenarios A0 and A2.

Sensitivity analysis for infested greenhouses after spread

Table A.33: Sensitivity of the baseline scenario A0 for infested greenhouses after spread (regression coefficients and partition) in PW1

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_BIK	0.44	0.19	55
Fakt_GHP4P_ABCHIJ	0.32	0.10	29
Prop_Host_I	0.15	0.02	7
Prop_GHP4P_ABCHIJK	0.15	0.02	7
Surv_RRO_BGIM	0.06	0.00	1
Imp_H	0.06	0.00	1
Surv_Insp_BIK	0.04	0.00	0
Conv_Packs2pcs_I	−0.03	0.00	0
Conv_Packs2pcs_B	–	–	0
Prop_P4P_I	–	–	0
Prop_P4P_B	–	–	0
Imp_A	–	–	0
	R^2 =	0.35	100

Table A.34: Sensitivity of the baseline scenario A0 for infested greenhouses after spread (regression coefficients and partition) in PW2

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_ACHJ	0.49	0.24	65
Fakt_GHP4P_ABCHIJ	0.30	0.09	24
Prop_GHP4P_ABCHIJK	0.14	0.02	5
Conv_Packs2pcs_H	−0.09	0.01	2
Prop_Host_H	0.08	0.01	2
Imp_H	0.05	0.00	1
Conv_Packs2pcs_C	−0.02	0.00	0
Conv_Packs2pcs_J	−0.02	0.00	0
Prop_Host_J	0.02	0.00	0
Imp_C	0.02	0.00	0
Prop_P4P_J	−0.01	0.00	0
Prop_P4P_H	−0.01	0.00	0
Imp_A	–	–	0
Imp_J	–	–	0
Prop_P4P_E	–	–	0
Prop_P4P_C	–	–	0
Prop_P4P_A	–	–	0
Conv_Packs2pcs_E	–	–	0
Conv_Packs2pcs_A	–	–	0
Prop_Host_A	–	–	0
Imp_E	–	–	0
Prop_Host_E	–	–	0
	R^2 =	0.36	100

Sensitivity analysis for number of detected infested greenhouses after spread

Table A.35: Sensitivity of the baseline scenario A0 for detected infested greenhouses after spread (regression coefficients and partition) in PW1

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_BIK	0.32	0.10	46
Fakt_GHP4P_ABCHIJ	0.22	0.05	22
Surv_Cert_BGI	−0.21	0.04	19
Prop_Host_I	0.12	0.01	6
Prop_GHP4P_ABCHIJK	0.11	0.01	5
Imp_H	0.04	0.00	1
Surv_RRO_BGIM	0.04	0.00	1
Surv_Insp_BIK	0.03	0.00	0
Conv_Packs2pcs_I	−0.02	0.00	0
Conv_Packs2pcs_B	–	–	0
Prop_P4P_I	–	–	0
Prop_P4P_B	–	–	0
Imp_A	–	–	0
	R^2 =	0.22	100

No uncertainty analysis was performed for PW2 because under scenario A0 no greenhouses are expected to be detected as infested with *R. similis*.

A.4.2. Shift to citrus production

The shift of the nematode from ornamental plants to citrus nurseries is considered possible as ornamentals and citrus could coexist in a few greenhouses, although not very often. They certainly coexist at retailer level, in garden centres, etc. Fields for outdoor production of citrus plants could be sequentially planted with citrus and ornamentals (personal communication, 7 January 2017, Dr Antonio Vicent, researcher, Valencian Institute for Agricultural Research, Plant Protection and Biotechnology Centre, Moncada, Valencia 46113, Spain, replying to a specific query with regard to citrus production). Although the shift is considered possible, its probability is extremely low because the coexistence of ornamentals and citrus in certified nurseries is rare and sequential plantings outdoors is also not very common.

The probability of the shift to citrus production was assessed by expert judgement. Table A.36 shows for the different pathways identified for the two shift scenarios (to citrus nurseries and to citrus orchards) a likelihood estimate of the shift to happen both as a probability as well as an estimate of the shift happening once in a certain number of years. The table also provides a justification for these estimations for each pathway.

Table A.36: Overview and estimation of possible shifts

Shift to	Via infested pathway	Justification (under the assumption that the pathway is infested)	Yes (1) No (0) estimate	One single event in xx years
Citrus nurseries	Infested ornamental plants small	Most nurseries are highly specialised but mixed production systems cannot be excluded, the small plants are moved, may share the same water system, the reuse of growing media, use of contaminated tools	0.02	50
	Infested ornamental plants big	Most nurseries are highly specialised but mixed production systems cannot be excluded, big plants are not moved	0.01	100
	Infested aquatic plants	Completely different production systems but owner could have an aquarium/pond on his premises (on site)	0.005	200
	Infested growing media/soil	Growing media originate in the EU (import into EU is regulated = not allowed). EU media are considered pest-free. They are produced under certification schemes	0.01	100
	Infested waste	Generally, organic waste is treated or is stored for a period of several weeks/ months, (EPPO, 2008b, national standards, EU Commission Decision on waste, etc.), it is considered that organic waste is usually used locally	0.01	100
	Infested water	The pest is not known to be present in the EU, and therefore, the pest is not known to be present in the open water courses in the EU. It is considered that the irrigation water of even mixed production systems is independent from the citrus nurseries	0	Not considered as pathway
Summary of the shift to Citrus nurseries			Overall probability 0.055	18 years
Citrus orchards	Infested ornamental plants small	If adjacent/neighbouring gardens and retail nurseries are infected (birds, small animals, shoes, machinery, tools, flooding events, etc.)	0.04	25
	Infested ornamental plants big	If adjacent/neighbouring gardens and retail nurseries are infected (birds, small animals, shoes, machinery, tools, flooding events, etc.). We assume that the level of phytosanitary is security is higher in the nurseries	0.04	25
	Infested aquatic plants	Completely different production systems but owner could have an aquarium/pond on his premises (on site). We assume that the level of phytosanitary is security is higher in the nurseries	0.02	50
	Infested growing media/soil	Growing media originate in the EU (import into EU is regulated = not allowed). EU media are considered pest-free. They are produced under certification schemes. The orchards usually do not use growing media	0.01	100

Shift to	Via infested pathway	Justification (under the assumption that the pathway is infested)	Yes (1) No (0) estimate	One single event in xx years
	Infested waste	Generally, organic waste is treated or is stored for a period of several weeks/ months, (EPPO, 2008b, national standards, EU Commission Decision on waste, etc.), it is considered that organic waste is usually used locally. The Orchards may apply larger quantities of compost (e.g. as fertiliser), and the phytosanitary security could be lower than in the nurseries	0.04	25
	Infested water	The pest is not known to be present in the EU, and therefore, does not occur in the open water courses. It is considered that the irrigation water of even mixed production systems is independent from the citrus nurseries	0	Not considered as pathway
Summary of the shift to Citrus orchards			Overall probability 0.15	Average number of 6 years

Further spread from infected nurseries and within and from infected orchards was not formally assessed by the Panel due to the lack of data and time. Factors impacting on the spread after the shift are for example the number of orchards supplied by an infested nursery, if the shift happens in an area suitable for *R. similis* to spread naturally, and the rate and pattern of renewal of citrus trees in orchards.

A.5. Impact

Conceptual model for impact is shown in Figure A.9.

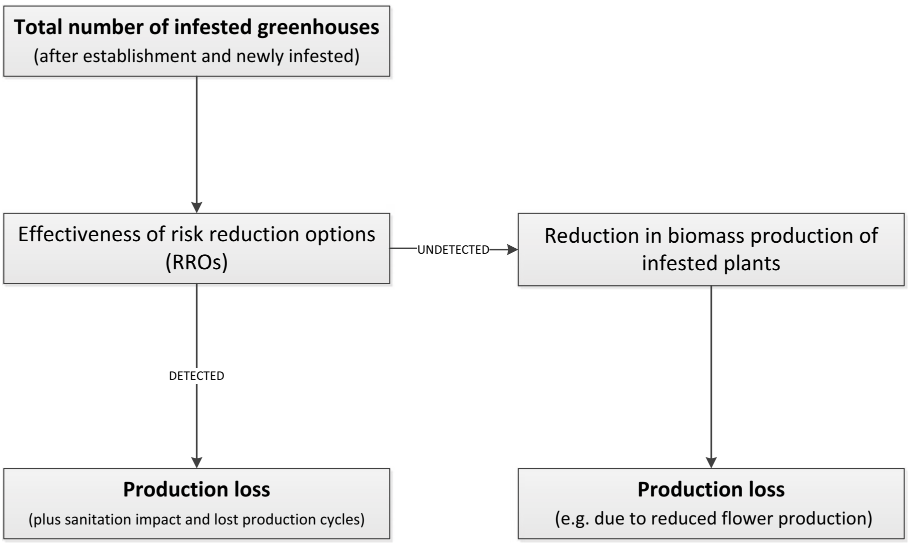


Figure A.9: Conceptual model for impact

Radopholus similis is listed among the 10 most harmful plant parasitic nematodes in the world (Jones et al., 2013). In bananas, it causes root wounds which form cankers and thus adversely affect the uptake of water and nutrients, which results in a reduction of plant growth and development and in the weakening of plant anchorage (Moens, 2004). It is extremely polyphagous and invasive species and is considered the most important pest of bananas worldwide reducing yield of up to 30–60% in many banana producing countries (Brooks, 2004). According to Costa et al. (2008), crop losses among Cavendish bananas in Brazil can be even higher, reaching up to 100% under heavy nematode infestation.

In the mid-1990s, *R. similis* (citrus race) has been reported to cause extensive damage to citrus orchards (spreading decline of citrus) in Florida, which has led to 40–70% and 50–80% of yield losses of oranges and grapefruit, respectively (Brooks, 2008). *R. similis* causes a problem to citrus only on the deep sandy soils of the central ridge. It has been found in the shallow soils of the flatwood regions, but does not cause the disease known as spreading decline in those conditions. Spreading decline results from near complete destruction of the deep root system that occurs only on the central ridge. Roots in shallow soil are not comparably damaged by the nematode; therefore, management focusses on cultural practices to grow trees on shallow root systems. Nonetheless, regardless of management practices, infected trees are not as productive as uninfected trees and they suffer inordinately when other stress conditions occur, most notably freeze events or infection by root pathogens such as the causal agent of citrus greening disease (huanglongbing) (personal communication, 11 January 2017, Larry Wayne Duncan, professor of nematology, University of Florida, Citrus Research and Education Center, Lake Alfred, FL 33850, replying to a specific query with regard to *R. similis*).

Severe yield losses are reported also from black pepper (*Piper nigrum*). Symptoms of infested plants are expressed as poor growth, root necrosis and pale yellowing of leaves that droop and then fall from the vine (Brooks, 2008). On the basis of experiments, yield losses caused by initial *R. similis* populations of 100, 1,000 and 10,000 were estimated as 29%, 50% and 59%, respectively (Mohandas and Ramana, 1991).

R. similis may have negative impact also on flower production, size of potted plants and consequently on market value of many ornamental plants such as *Anthurium, Calathea* and *Dracena* (Uchida et al., 2003; Volcy, 2011). It may also cause small, oblong root lesions of palms which are subsequently aggregated and consequently resulting in extensive rotting of roots (Griffith et al., 2005). As a very serious pest of the parlour palm, *Chamaedorea elegans,* this nematode can very negatively affect their commercial production (NEMAPLEX online, accessed on 13 April 2017).

The Panel assesses the impact of *R. similis* in the RA area in the context of the following categories:

- regulated plants in the greenhouse for the production of plants for planting (quantitative assessment);
- non-regulated plants in the greenhouse for the production of plants for planting and on plants (regulated or not regulated) for the production of flower or potted plants (quantitative assessment);
- citrus nurseries and citrus production (impact described verbally);
- banana production (impact described verbally);
- other crops (impact described verbally).

A.5.1. Impact on regulated plants in the greenhouse for the production of plants for planting

A.5.1.1. Number of infested greenhouses per year

For the assessment of the impact of *R. similis* on regulated plants in the greenhouse for the production of plants for planting, the number of infested greenhouse per year is estimated on the basis of assessments made in the Section A.4 on Spread (see Table A.32).

A.5.1.2. Level of detection (effectiveness of phytosanitary measures)

The following phytosanitary measures for the greenhouse production of regulated plants for planting are required:

- a plant passport has to be issued,
- plants must be grown at a registered places of production,
- plants should be inspected for contamination by *R. similis.*

R. similis is endoparasite that causes symptoms on roots of host plants. As current legislation does not specify sampling and testing procedures to detect *R. similis* in plants for planting, the Panel assumes that only visual inspections are performed under scenario A0. Visual inspections, however, can only detect plants for planting showing symptoms on roots of host plants. Symptomless plants will most likely escape detection by visual inspection. The effectiveness of the detection under scenario A0 is therefore estimated at range from 0.5% to 20% due to the difficulties in sampling and the difficulties in detecting latent infestations. As expressed in Table A.37, 80–99% of the pest population is expected to be overlooked.

In the scenario A1, existing phytosanitary measures (as specified in Annex II A I, II A II, III A, IV A I and IV A II, of Council Directive 2000/29/EC) specific to *R. similis* only are withdrawn. Consequently, regulated plants become non-regulated and no action is taken – all host plants of *R. similis* remain uninspected. The effectiveness of the detection is therefore estimated as zero.

For the scenario A2, the Panel considers that non-regulated plants become regulated and the same values as for the improved phytosanitary measures for the regulated plants (A2) are used. Scenario A2 requires not only visual inspection but also sampling and laboratory testing. The first step for the detection of *R. similis* during the inspection process roots would need to be washed free of adhering soil and roots need to be split longitudinally in order to detect necrotic lesions caused by *R. similis*. If necrotic tissue is found, sample should be send to the laboratory to verify the presence/absence of the pest.

The lower percentile for the effectiveness of the detection is estimated at 20% because latent infections may be overlooked. The median for the effectiveness of the detection under scenario A2 is estimated at 60% due to the difficulties in sampling and the difficulties in detecting latent infestations. The upper percentile for the effectiveness of the detection is estimated at 75%. In this case, detection level is considered highly effective and almost three quarters of infested plants will be detected and only 25% of infested host plants of *R. similis* are expected to remain undetected; this is expressed as the upper percentile in effectiveness in Table A.37.

Table A.37: Level of detection (effectiveness of phytosanitary measures) in the scenarios A0, A1 and A2 for PW1

Level of detection (effectiveness of phytosanitary measures) for PW1									
Quantile (percentile)[(a)]	**Reduction factor**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0.005	0	0.2	Not considered	Upper (99%)	0.995	1	0.8	Not considered
Q1 (25%)	0.02	0	0.5	Not considered	Q3 (75%)	0.98	1	0.5	Not considered
Median (50%)	0.05	0	0.6	Not considered	Median (50%)	0.95	1	0.4	Not considered
Q3 (75%)	0.08	0	0.7	Not considered	Q1 (25%)	0.92	1	0.3	Not considered
Upper (99%)	0.2	0	0.75	Not considered	Lower (1%)	0.8	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Table A.38: Level of detection (effectiveness of phytosanitary measures) in the scenarios A0, A1 and A2 for PW2

Level of detection (effectiveness of phytosanitary measures) for PW2									
Quantile (percentile)[(a)]	**Reduction factor**				**Quantile (percentile)**	**Multiplier**			
	A0	**A1**	**A2**	**A3**		**A0**	**A1**	**A2**	**A3**
Lower (1%)	0	0	0.2	Not considered	Upper (99%)	1	1	0.8	Not considered
Q1 (25%)	0	0	0.5	Not considered	Q3 (75%)	1	1	0.5	Not considered
Median (50%)	0	0	0.6	Not considered	Median (50%)	1	1	0.4	Not considered
Q3 (75%)	0	0	0.7	Not considered	Q1 (25%)	1	1	0.3	Not considered
Upper (99%)	0	0	0.75	Not considered	Lower (1%)	1	1	0.25	Not considered

(a): Expert judgement was used to estimate five quantiles of the reduction factor expressing effectiveness. The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness (reduction) factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

A.5.1.3. Production loss on plants for planting

Production loss on regulated plants in the greenhouse for the production of plants for planting is presented in Table A.39.

Table A.39: Quantile values of the distribution of the number of impacted regulated small plants (PW1) at the time horizon of 1 year for the scenarios A0, A1 and A2

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
The number of impacted plants for scenario **A0**	**25**	**6,479**	**27,537**	**92,035**	**1,247,136**
The number of impacted plants for scenario **A1**	**6**	**15,590**	**96,248**	**377,850**	**5,908,241**
The number of impacted plants for scenario **A2**	**3**	**715**	**3180**	**11,229**	**171,895**

A.5.1.4. Uncertainty on impact on production for plants for planting

Following uncertainties related to the impact on production of regulated plants for planting were identified by the Panel:

- Many host plants are considered in the assessment with different production cycles (from less than 1 year to 3–4 years)
- The host plants represent also different type of plants for planting (unrooted cuttings, indoor rooted cuttings and small plants, live indoor plants and cacti smaller than 1 m)
- Effectiveness of inspection/detection of *R. similis* may differ between greenhouses/countries.

Table A.40: Sensitivity of the baseline scenario A0 for impacted plants per year in pathway PW1 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
Prop_Inf_BIK	0.40	0.16	51
Fakt_GHP4P_ABCHIJ	0.29	0.08	26
Red_all	0.16	0.03	8
Prop_Host_I	0.14	0.02	6
Prop_GHP4P_ABCHIJK	0.14	0.02	6
Surv_RRO_BGIM	0.06	0.00	1
Imp_H	0.05	0.00	1
Surv_Insp_BIK	0.03	0.00	0
Surv_Cert_BGI	0.02	0.00	0
Prop_P4P_I	–0.01	0.00	0
Conv_Packs2pcs_I	–	–	0
Conv_Packs2pcs_B	–	–	0
Prop_P4P_B	–	–	0
Imp_A	–	–	0
	R^2 =	0.32	100

A.5.2. Impact on non-regulated plants in the green house for the production of plants for planting and on plants (regulated or not regulated) for the production of flower or potted plants

A.5.2.1. Reduction factor for the plant production (flowers or volume of plants)

Flowers but also leaves and potted plants for final consumers are the harvested products of *Anthurium*. In *Anthurium* plants, *R. similis* might cause 'anthurium decline'. Leaves will yellow and plants will also be generally stunted. According to Aragaki et al. (1984), damage can be as high as 50%. Sipes and Lichty (2002) investigated the effect of varying population densities of *R. similis* on *Anthurium* production. Depending on initial nematode densities and duration of cultivation, leaf development and height of plants was reduced. Flower production is directly linked to leaf production. At the highest nematode population density, leaf production was reduced by 75% (Sipes and Lichty, 2002). According to the same authors, flower production was reduced by a maximum of 50%. At lower nematode densities, flower production was still reduced by around 25–30%. Shoot weight reductions were in a similar range. Therefore, the following values for general reduction factor for the production of ornamental plants were considered by the Panel:

Table A.41: Reduction factor for the plant production (flowers or volume of plants)

Reduction factor for the plant production (flowers or volume of plants)	
Quantile (percentile)	
Lower (1%)	2%
Q1 (25%)	25%
Median (50%)	30%
Q3 (75%)	50%
Upper (99%)	75%

A.5.2.2. Production loss of plants in greenhouses

Impact on non-regulated plants in the greenhouse for the production of plants for planting and on plants (regulated or not regulated) for the production of flower or potted plants is presented in Table A.41.

Table A.42: Quantile values of the distribution of the number of impacted non-regulated small plants (PW2) at the time horizon of 1 year for the scenarios A0, A1 and A2

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
The number of impacted plants for scenario **A0**	**5**	**9,270**	**56,865**	**225,821**	**3,509,160**
The number of impacted plants for scenario **A1**	**5**	**9,270**	**56,865**	**225,821**	**3,509,160**
The number of impacted plants for scenario **A2**	**2**	**433**	**1,911**	**6,618**	**99,533**

A.5.2.3. Uncertainty on impact on production for plants for planting

Following uncertainties related to the impact on production of plants for planting and plants (regulated or not regulated) for the production of flower or potted plants in the greenhouse were identified by the Panel:

- No specific data on the impact of *R. similis* for the non-regulated species available therefore the available data on *Anthurium* spp. were extrapolated also to the non-regulated species.
- Many host plants are considered in the assessment with different production cycles (from less than 1 year to 3–4 years).
- The host plants represent also different type of use (potted green plants, cut flower production, etc.).
- Pest density that can cause damage to host plants is not known; not all host plants are equally endangered.
- Effectiveness of inspection/detection of *R. similis* may differ between greenhouses/countries.

Table A.43: Sensitivity of the baseline scenario A0 for impacted plants per year in pathway PW2 (regression coefficients and partition)

Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty (%)
Prop_Inf_ACHJ	0.48	0.23	63
Fakt_GHP4P_ABCHIJ	0.29	0.08	23
Red_all	0.15	0.02	6
Prop_GHP4P_ABCHIJK	0.14	0.02	5
Prop_Host_H	0.08	0.01	2
Imp_H	0.06	0.00	1
Prop_P4P_H	−0.01	0.00	0
Imp_A	–	–	0
Imp_J	–	–	0
Prop_P4P_J	–	–	0
Prop_P4P_E	–	–	0
Prop_P4P_C	–	–	0
Prop_P4P_A	–	–	0
Conv_Packs2pcs_E	–	–	0
Conv_Packs2pcs_A	–	–	0
Prop_Host_A	–	–	0
Imp_E	–	–	0
Prop_Host_E	–	–	0
Imp_C	–	–	0
Conv_Packs2pcs_C	–	–	0
Conv_Packs2pcs_J	–	–	0
Prop_Host_J	–	–	0
Conv_Packs2pcs_H	–	–	0
	R^2 =	0.37	100

A.5.3. Impact on citrus nurseries and citrus production

Environmental conditions (temperatures) in the EU citrus production area will not prevent establishment of *R. similis* in the open field as shown in Section A.3 on Establishment. However, the Panel estimates that for the moment (scenario A0) no impact on citrus production is expected in the RA area because *R. similis* is not present yet there (no reports about the presence of this nematode in the open field in the EU exist) or the population density of this nematode is very likely not high enough to be detected or to cause damage to citrus orchards.

Based on temperature data under scenario A3, the impact on citrus production could be possible in some locations of RA area in the future, however there are some ambiguities regarding other environmental factors such as humidity, soil conditions, etc. that may contribute to the impact of *R. similis* and possible development of citrus spreading decline that need to be taken into consideration. It is known for example that *R. similis* causes a problem to citrus only on the deep sandy soils of the central ridge (personal communication, 11 January 2017, Larry Wayne Duncan, professor of nematology, University of Florida, Citrus Research and Education Center, Lake Alfred, FL 33850, replying to a specific query with regard to *Radopholus similis*).

A.5.4. Impact on banana production

The Panel estimates that banana production in the RA area is currently not at risk despite the fact that *R. similis* has been recognised as the most devastating banana pest in subtropical and tropical areas causing toppling disease of *Musa* plants.

As shown in the Section A.2 on Entry, the acreage of banana production in continental EU is very low (see also Table A.44 below representing the whole EU banana production area from 2010 to 2015), which is reflected in the fact that only about 1% of bananas produced in the EU originates from the RA area – Cyprus, Greece and continental Portugal (European Commission, 2013). As it has been shown already in the Section A.2 on Entry, the Panel beliefs that the majority of the EU farmers are using tissue culture seedlings as propagating material (personal communication, 24 April 2017, Spiros M. Lionakis, PhD, Emeritus Professor of Horticulture, Technological Educational Institute of Crete, Greece, Former Researcher at the Olive Tree and Subtropical Plants Institute of Chania-Crete, replying to a specific query with regard to banana planting material in Greece); therefore, the possibility of *R. similis* entering the EU is very low. As presented in Section A.3 on Establishment, environmental conditions (temperature) in the Mediterranean area will not prevent establishment of *R. similis* in the open field. In case that *R. similis* would nonetheless establish in certain locations, the nematode population density would not be high enough to cause significant damage to bananas. The Panel therefore estimates the impact on banana production in the RA area as not likely.

In case that air and soil temperatures will increase due to climate changes as presented in scenario A3, the Panel estimates that production of bananas in the Mediterranean area could be impacted. Such an impact will however not be very large due to extremely small production acreage of bananas in the RA area. Taken into account, the possibility of establishment and spread of *R. similis* in the RA area as well as climate changes as illustrated in the Section A.3 on Establishment and in the Section A.4 on Spread, the Panel estimates that the impact on the production of bananas may increase in case of increasing of production acreage in the next few years.

The following uncertainties influencing the assessment of the impact on citrus and banana production in the RA area have been recognised by the Panel:

- It is not known how drastically will climatic changes influencing air/soil temperatures in the Mediterranean area.
- There are uncertainties regarding pest survival/establishment in the areas where citrus/banana production takes place in the continental EU (Greece, Cyprus, Continental Portugal).
- The population density of *R. similis* that could cause significant damage to host plants is not defined and may be affected not only by temperatures, but also by soil characteristics and moisture which were not considered in the assessment.
- Initial impact can be overlooked.
- Soil characteristics in the RA area have not been considered.

Table A.44: The whole EU banana production area (Source: EUROSTAT, accessed on 28.10.2016)

Country	Banana production area (1,000 ha)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Austria	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	0.00	0.00	0.00	0.00	0.00
Bulgaria	0.00	0.00	0.00	0.00	0.00	0.00
Croatia	0.00	0.00	0.00	0.00	0.00	0.00
Cyprus	0.23	0.24	0.23	0.21	0.22	0.20
Czech Republic	0.00	0.00	0.00	0.00	0.00	0.00
Denmark	0.00	0.00	0.00	0.00	0.00	0.00
Estonia	0.00	0.00	0.00	0.00	0.00	0.00
Finland	0.00	0.00	0.00	0.00	0.00	0.00
France	10.07	10.03	10.15	10.16	9.78	9.36
Germany	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.06	0.08	0.08	0.08	0.08	0.08
Hungary	0.00	0.00	0.00	0.00	0.00	–[(a)]
Ireland	0.00	0.00	0.00	0.00	0.00	0.00
Italy	–	–	–	–	–	0.00
Latvia	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00

Country	Banana production area (1,000 ha)					
	2010	2011	2012	2013	2014	2015
Poland	0.00	0.00	0.00	0.00	0.00	0.00
Portugal	1.01	1.01	1.02	1.01	1.03	1.03
Romania	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	0.00	0.00	0.00	0.00	0.00	0.00
Slovenia	0.00	0.00	0.00	0.00	0.00	0.00
Spain	9.12	9.14	9.15	9.13	9.13	8.98
Sweden	0.00	0.00	0.00	0.00	0.00	0.00
United Kingdom	0.00	0.00	0.00	0.00	0.00	0.00

(a): Data not available.

Table A.45: The whole EU banana production (Source: EUROSTAT, accessed on 28.10.2016)

Country	Banana harvested production (1,000 tonnes)					
	2010	2011	2012	2013	2014	2015
Austria	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	0.00	0.00	0.00	0.00	0.00
Bulgaria	0.00	0.00	0.00	0.00	0.00	0.00
Croatia	0.00	0.00	0.00	0.00	0.00	0.00
Cyprus	6.01	6.00	6.00	5.75	6.01	5.46
Czech Republic	0.00	0.00	0.00	0.00	0.00	0.00
Denmark	0.00	0.00	0.00	0.00	0.00	0.00
Estonia	0.00	0.00	0.00	0.00	0.00	0.00
Finland	0.00	0.00	0.00	0.00	0.00	0.00
France	279.93	260.64	269.62	249.08	286.75	282.59
Germany	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.90	3.31	3.31	3.31	3.31	3.12
Hungary	0.00	0.00	0.00	0.00	0.00	–(a)
Ireland	0.00	0.00	0.00	0.00	0.00	0.00
Italy	–	–	–	–	–	0.00
Latvia	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	0.00	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00
Poland	0.00	0.00	0.00	0.00	0.00	0.00
Portugal	20.94	20.92	22.53	21.20	24.21	24.26
Romania	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	0.00	0.00	0.00	0.00	0.00	0.00
Slovenia	0.00	0.00	0.00	0.00	0.00	0.00
Spain	396.59	346.51	371.21	360.99	365.27	381.98
Sweden	0.00	0.00	0.00	0.00	0.00	0.00
United Kingdom	0.00	0.00	0.00	0.00	0.00	0.00

(a): Data not available.

A.5.5. Impact on other crops

Radopholus similis can parasitise a wide range of economically important annual crops including strawberries and many vegetable and field crops (see Pest categorisation, EFSA PLH Panel, 2014). Due to inferior ability of moving over longer distances and relatively poor survival ability in soil, this nematode is however not considered as a major pest of aforementioned plant species (Chabrier et al., 2009). The Panel assesses the impact of *R. similis* on outdoor and indoor plants that are specified in the Chapter 3.4.2 (strawberries, vegetable and field crops) of the Pest characterisation (EFSA PLH Panel, 2014) as insignificant.

Appendix B – Procedure for the assessment of phytosanitary risk reduction options in risk reduction scenarios

B.1. Introduction

This document describes a procedure for the assessment of phytosanitary risk reduction options (RROs) implemented in risk reduction scenarios for a particular pest. This is a generic procedure developed as part of this opinion using the nematode *Radopholus similis* as an example, and should be read in conjunction with the opinion. A 'baseline risk reduction scenario' (A0) consisting of the RROs currently implemented in phytosanitary legislation of the European Union (Council Directive 2000/29/EC) is compared with two hypothetical alternative scenarios. One scenario (A1) represents the situation where all RROs, specifically implemented against *R. similis*, are lifted. The other scenario (A2) represents a situation where the strength of measures against *R. similis* is increased.

The level of risk reduction in a risk reduction scenario is assessed by the following procedure.

Stage 1:

The often complex linguistic formulation of each implemented phytosanitary measure (e.g. as described in Council Directive 2000/29/EC) is expressed in terms of RROs). This will result in the set of RROs that make up the baseline scenario for the pest (*R. similis*).

Stage 2:

For each RRO included in the baseline scenario, the 'RA sub-step' (step in the process of entry establishment and spread of the pest), where abundance of the pest is modified by the RRO, is identified. 'RA sub-steps' are distinguished in the EFSA Risk assessment framework (EFSA Journal, in preparation). The result is presented in tables demonstrating the relation between RROs and 'RA sub-steps'.

For 'Entry', the following sub-steps are distinguished:

Sub-step E1 starts with preplanting preparations and ends with storage of the harvested product, resulting in a level of pest abundance in the harvested product.

Sub-step E2 starts with handling of the harvested product and ends with a prepared consignment ready for transport, resulting in a level of pest abundance in the consignment before transport.

Sub-step E3 starts with transport of the consignment from the packing house and ends with arrival at the point of entry in the area of destination, resulting in a level of pest abundance in the consignment before entry in area of destination.

Sub-step E4 starts with inspection at the point of entry of the consignment and ends with release of the commodity units from the consignment, resulting in a level of pest abundance after entry, before transfer to host plants.

Sub-step E5 starts with handling of commodity units at the place of destination and ends with transfer of the pest to host plants originally present in the place of destination, resulting in a level pest abundance after transfer to host plants.

For 'Spread', three mechanisms are distinguished: S1 (human assisted spread), S2 (spread by vectors) and S3 (natural spread). Eradication measures are grouped in S4 as the most advanced measures for prevention of spread.

Stage 3:

For each 'RA sub-step', the effect on pest abundance of each individual RRO operating at that sub-step is described in detail.

Stage 4:

For each 'RA step', the combined effect of all RROs operating at one 'RA sub-step' is expressed quantitatively as one overall multiplication factor (between 0 and 1) for pest abundance. As a result, there will be 4 multiplication factors for the scenario: one for entry, one for establishment, one for spread and one for impact. If insufficient data or information is available for this level of detail, one or more RA sub-steps may be combined and an aggregated parameter can be estimated.

The results are used in the opinion to quantify the pest risk by *R. similis* in the three risk reduction scenarios.

B.2. The baseline scenario for risk assessment (A0)

The 'baseline risk reduction scenario' (A0) for a pathway consists of the phytosanitary measures, implemented in plant health legislation at the time of preparation of the assessment to reduce the probability of entry, establishment, spread and/or the level of impact of *R. similis.* Here, A0 is described for *R. similis* and the pathway of 'rooted ornamental plants'.

B.2.1. Stage 1: phytosanitary measures corresponding to RROs

Several phytosanitary measures implemented in Council Directive 2000/29/EC may limit the introduction into and the movement within the EU of host plants for *R. similis*. Some measures are targeted specifically at *R. similis*. Some other measures are targeted primarily at other pests, but these may also affect *R. similis*. For this assessment, groups of host plants have been identified according to the scope of the measures to prevent entry and of measures to prevent spread in the Council Directive 2000/29/EC. These host plant groups correspond with the different types of rooted ornamental plants identified in the Risk Assessment for *R. similis* (PW1, PW2, PW3 and PW4).

Table B.1: Groups of host plants identified according to the scope of the measures to prevent entry and of measures to prevent spread in the Council Directive 2000/29/EC

Host plant group	Affected pathway	With respect to measures preventing entry	With respect to measures preventing spread
1	PW1 PW2 PW3 PW4	'Plants intended for planting other than seeds' with or without 'soil or growing medium attached or associated'	'Plants intended for planting other than seeds' with or without 'soil or growing medium attached or associated'
2	PW3 PW4	'Trees or shrubs' N.B. this group includes Palmae	Plants belonging to genera of Palmae listed in Annex V A I (2.3.1)
3	PW1 PW3	Host plants specifically listed as 'subject of contamination' for *R. similis* in Annex II A	Host plants specifically listed as 'subject of contamination' for *R. similis* in Annex II A N.B. This group includes plant species, the import of which is prohibited when originating outside the EU
4	PW1 PW3	Host plants produced outside the EU, for which the introduction into the EU is prohibited in Annex III	–

The measures for group 1 also apply to groups 2 and 3. For each of these groups, the phytosanitary measures in the Council Directive 2000/29/EC and the corresponding combination of RROs are specified as follows.

B.2.1.1. Host plants group 1

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis.*

- originating outside the EU:

Table B.2: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 1 originating outside the EU in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex V B I (1): Plants intended for planting, other than seeds	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex V B I (2): Parts of plants, other than fruits and seeds, of *Phoenix* spp.	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex V B I (7b): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances specified in Annex V B I (7a), or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine • non-European countries other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex IV A I (34a): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine • non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia Official statement that: the growing medium, at the time of planting, was: (a) either free from soil, and organic matter or found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms or subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b): since planting: either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms or within 2 weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a)	Conditions for the growing medium: a *pest-free production site, inspection and testing,* and *soil treatment* Maintaining the absence of pest: *cleaning and disinfection of tools*, *use of non-contaminated water* Preparation of consignment: *physical treatment of consignment*	2.01 and 2.02 and 2.03 and 1.06 1.05 and 1.07 1.08

- originating within the EU:

Table B.3: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for Host plants group 1 originating within the EU in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.1): Plants intended for planting, other than seeds, of herbaceous species, [. . .] other than bulbs, corms, rhizomes, seeds and tubers, produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A, which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.2.1.2. Host plant group 2

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis.*

- originating outside the EU:

Table B.4: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating outside the EU in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex IV A I (39): For trees and shrubs, intended for planting, other than seeds and plants in tissue culture, originating in Third countries other than European and Mediterranean countries, official statement that the plants:	The 'official statement' requires a *Phytosanitary Certificate*, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
• are clean (i.e. free from plant debris) and free from flowers and fruits	'plants are clean': physical treatment of consignment	1.08
• have been grown in nurseries • have been inspected at appropriate times and prior to export and found free from symptoms of harmful bacteria, viruses and virus-like organisms, and either found free from signs or symptoms of harmful nematodes, insects, mites and fungi, or have been subjected to appropriate treatment to eliminate such organisms	For the statement: 'have been *inspected* . . . and . . . either found free from signs or symptoms For the statement '. . . or have been subjected to *treatments*. . .'	2.01 and 2.03 1.14

- originating within the EU:

Table B.5: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating within the EU in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.3.1): Plants of Palmae, intended for planting, having a diameter of the stem at the base of over 5 cm and belonging to the following genera: *Brahea* Mart., *Butia* Becc., *Chamaerops* L., *Jubaea* Kunth, *Livistona* R. Br., *Phoenix* L., *Sabal* Adans., *Syagrus* Mart., *Trachycarpus* H. Wendl., *Trithrinax* Mart., *Washingtonia* Raf., produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.2.1.3. Host plant group 3

Official listing of *R. similis* as a regulated pest: Annex II A I 23 and Annex II A II 7 of the Council Directive 2000/29/EC. Measures that are specifically implemented for *R. similis*.

R. similis and the now invalid *R. citrophilus* are listed as pests, whose introduction into, and spread within, all Member States shall be banned if present on plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf. and their hybrids, other than fruit and seeds, and plants of Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae, rooted or with growing medium attached or associated (Annex II A I 23/Annex II A II 7 of the Council Directive 2000/29/EC). Corresponding with this listing, special requirements for the introduction into and movement within all Member States are formulated for these listed plants with respect to *R. similis*:

- For plants, plant products and other products originating outside the EU:

Table B.6: Measures that are specifically implemented for *R. similis* for plants, plant products and other products originating outside the EU for host plant group 3 in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex IV A I (18): For plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds, and plants of Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae, rooted or with growing medium attached or associated, official statement that: The plants originate in countries known to be free from *R. similis*, or in places of production where the absence of *R. similis* is demonstrated by official nematological testing of samples of soil and roots from the place of production, since the beginning of the last complete cycle of vegetation	The 'official statement' requires a *Phytosanitary Certificate*, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample* At import (Article 13 (1) of the Council Directive 2000/29/EC), the consignment must be *inspected* for contamination by organisms listed in Annex I A and *R. similis*, which is generally based on a *sample* For the statement of '*pest-free country*' For the statement: 'official nematological *testing* of *samples* [...] place of production'	2.01 and 2.03 and 2.04 2.01 and 2.03 2.08 2.02 and 2.03

- For plants, plant products and other products originating in the EU:

Table B.7: Measures that are specifically implemented for *R. similis* for plants, plant products and other products originating in the EU for host plant group 3 in scenario A0

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex IV A II (11): For plants of Araceae, Marantaceae, Musaceae, *Persea* spp. and *Strelitziaceae*, rooted or with growing medium attached or associated, official statement that: The plants originate from a place of production where no contamination by *R. similis* has been observed since the beginning of the last complete cycle of vegetation or soil and roots from suspected plants must have been subjected since the beginning of the last complete cycle of vegetation to official nematological testing for at least *R. similis* and have been found, in these tests, free from that harmful organism	The 'official statement' requires a *Plant Passport*, for which the plants must have been grown at *registered place of production*, and have been *inspected* for contamination by organisms listed in Annex I A and *R. similis*, which is generally based on a *sample* For the statement: 'from a place of production where no contamination of *R. similis* has been observed' For the statement: 'soil and roots from *suspected* plants [. . .] free from harmful organism	2.01 and 2.03 and 2.04 and 2.05 2.01 and 2.03 and 2.08 2.01 and 2.02 and 2.03 and 2.08
Article 6 and Annex V A I (1.4): Plants of *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, [. . .], other than fruit and seeds	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A and by *R. similis,* which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05
Article 6 and Annex V A I (1.6): Plants of *Citrus* L. and their hybrids other than fruit and seeds	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A and by *R. similis* which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05
Article 6 and Annex V A I (2.3): Plants of *Araceae*, *Marantaceae*, *Musaceae*, *Persea* spp. and *Strelitziaceae*, rooted or with growing medium attached or associated, produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A and by *R. similis* which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.2.1.4. Host plant group 4

Table B.8: Phytosanitary measures for host plant group 4 in scenario A0

Phytosanitary measure 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex III A (16): The introduction of plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds, from Third countries, shall be prohibited in all Member States	*Prohibition* of import	1.17
Annex III A (17): The introduction of plants of *Phoenix* spp. other than fruit and seeds, from Algeria and Morocco, shall be prohibited in all Member States	*Prohibition* of import	1.17

B.2.2. Stage 2: Summary tables of the active RROs in each RA sub-step

The baseline risk reduction scenario, expressed in terms of RROs, is structured along the RA sub-steps defined by the risk assessment model.

For explanation of the RA sub-steps for entry, see Section B.1 'Introduction'.

For each pathway, Table B.9 presents the RROs for entry and Table B.10 presents the RROs for spread. The pathways are ordered according to the complexity of implemented RROs. The reference to the relevant section of the Council Directive 2000/29/EC is specified in each cell. The baseline scenario includes only a few control RROs (1.01–1.17) contributing to the absence of *R. similis* at the production site, in the growing crop and in the consignment. A larger number of supporting RROs (2.01–2.09) is implemented covering all RA sub-steps except transport (E3) and transfer (E5).

Table B.9: Scenario A0 – RROs implemented for each pathway per sub-step of entry

RRO	RA sub-steps for ENTRY							
	E1				E2	E3	E4	E5
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Pest-free consignment	Transport	Entry	Transfer
PATHWAY: PW1 (small rooted host plants, regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b			
Supporting measures								
2.01	IV A I (18)		IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.02	IV A I (18)	IV A I (18)	IV I A (34)a					
2.03	IV A I (18)	IV A I (18)	IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (18), IV A I (34)		Article 13 (1)	
2.08	IV A I (18)							
PATHWAY: PW2 (small rooted host plants, not regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b			
Supporting measures								
2.01			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.02			IV I A (34)a					
2.03			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34)		Article 13 (1)	

RRO	RA sub-steps for ENTRY							
	E1				E2	E3	E4	E5
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Pest-free consignment	Transport	Entry	Transfer
PATHWAY: PW3 (large rooted host plants, regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b, IV A I (39)			
1.14					IV A I (39)			
Supporting measures								
2.01	IV A I (18)		IV I A (34)a	IV A I (39)	V B I (1), V B I (7b), IV A I (39)		Article 13 (1)	
2.02	IV A I (18)	IV A I (18)	IV I A (34)a					
2.03	IV A I (18)	IV A I (18)	IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (18), IV A I (34), IV A I (39)		Article 13 (1)	
2.05				IV A I (39)				
2.08	IV A I (18)							
PATHWAY: PW4 (large rooted host plants, not regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b, IV A I (39)			
1.14					IV A I (39)			
Supporting measures								
2.01			IV I A (34)a	IV A I (39)	V B I (1), V B I (7b), IV A I (39)		Article 13 (1)	
2.02			IV I A (34)a					
2.03			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34), IV A I (39)		Article 13 (1)	
2.05				IV A I (39)				

Table B.10: Scenario A0 – RROs implemented for each host group per sub-step of SPREAD

RRO	RA sub-steps for SPREAD							
	Targeted at production (analogous to E1)				S1	S2	S3	S4
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Human assisted	Vector spread	Natural spread	Eradication
PATHWAY: PW1 (small rooted host plants, regulated for *R. similis*)								
Control measures								
1.01–1.17								
Supporting measures								
2.01				IV A II (11a), IV A II (11b)	V A I (2.1), V A I (2.3)			
2.02				IV A II (11b)				
2.03				IV A II (11a), IV A II (11b)	V A I (2.1), V A I (2.3)			
2.04					IV A II (11), V A I (2.1), V A I (2.3)			
2.05					V A I (2.1), V A I (2.3)			
2.08				IV A II (11a)				
PATHWAY: PW2 (small rooted host plants, not regulated for *R. similis*)								
Control measures								
1.02–1.17								
Supporting measures								
2.01					V A I (2.1)			
2.03					V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			
PATHWAY: PW3 (large rooted host plants, regulated for *R. similis*)								
Control measures								
1.03–1.17								
Supporting measures								
2.01				IV A II (11a), IV A II (11b)	V A I (2.1), V A I (2.3), V A I (2.3.1)			
2.02				IV A II (11b)				
2.03				IV A II (11a), IV A II (11b)	V A I (2.1), V A I (2.3)			
2.04					IV A II (11), V A I (2.1), V A I (2.3)			
2.05					V A I (2.1), V A I (2.3)			
2.08				IV A II (11a), IV A II (11b)				

RRO	RA sub-steps for SPREAD							
	Targeted at production (analogous to E1)				S1	S2	S3	S4
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Human assisted	Vector spread	Natural spread	Eradication
PATHWAY: PW4 (large rooted host plants, not regulated for *R. similis*)								
Control measures								
1.04–1.17								
Supporting measures								
2.01					V A I (2.1), V A I (2.3.1)			
2.03					V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			

B.2.3. Stage 3. Descriptive assessment of effectiveness of RROs operating at each sub-step

At each RA sub-step, the effectiveness of the implemented RRO (presented in Tables B.9 and B.10) on reduction of the pest abundance is assessed.

B.2.3.1. ENTRY Sub-step E1 (Table B.9)

For Pathways PW1 and PW3:

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free country for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the surveillance activities to confirm the pest absence in the country.
The alternative implementation of RROs 2.02 and 2.03 to establish a pest-free place of production for *R. similis* can also be effective in preventing the association of *R. similis* with the pathway. However, the requirements take into account both soil and roots from the place of production, but other requirements for a pest-free place of production, such as those concerning hygienic measures, are not specified. The effectiveness is limited by sampling scheme, timing, frequency and sampling size.
The additional implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production.

For Pathway PW3:

The implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production.

For Pathways PW2 and PW4:

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting may contribute to prevention of association of *R. similis* with the pathway. However, the effectiveness of this combination of RROs is limited because it refers to the growing medium only. It does not preclude that plants or cuttings infested with *R. similis* may be planted in nematode-free growing medium (incl. soil).

For Pathway PW4:

The implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, is not effective because it is insufficient to detect infestation of growing plants by *R. similis* and to ensure pest freedom of the production site.

B.2.3.2. ENTRY Sub-step E2 (Table B.9), pest-free consignment

For all pathways PW1, PW2, PW3 and PW4:

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.
The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

For pathways PW3 and PW4:

The implementation of RROs 2.01 and 1.14, subjecting trees and shrubs with signs or symptoms of harmful nematodes (here: *R. similis)* to appropriate treatment to eliminate such organisms, is not effective, because visual inspection will not detect trees and shrubs infected with *R. similis*, and heat treatments may not be effective for trees and shrubs.

B.2.3.3. ENTRY Sub-step E3 (Table B.9), pest abundance during transport, before entry in area of destination

For regulated and non-regulated host plants:

No RROs implemented in scenario A0.

B.2.3.4. ENTRY Sub-step E4 (Table B.9), Import inspection

For pathways PW1 and PW3:

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, does not provide additional prevention to the level already obtained by the requirement for a pest-free country or a pest-free place of production. Moreover, inspection is unlikely to detect the presence of *R. similis*.

For pathways PW2 and PW4:

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, is performed only to determine that the plants and attached soil are not contaminated by organisms listed in Annex I A, or by organisms that are listed in Annex II A for the plants in the consignment (Article 13 of the Council Directive 2000/29/EC). Therefore, the effectiveness of import inspection to intercept *R. similis* is zero for plants that are not listed as 'object of contamination' for *R. similis* in Annex II A of the Council Directive 2000/29/EC.

B.2.3.5. ENTRY Sub-step E5 (pest abundance after transfer to host plants)

For regulated and non-regulated host plants:

No RROs implemented in scenario A0.

<u>Import prohibition:</u>

The prohibition to import *Citrus*, *Fortunella*, *Poncirus* is very effective for reduction of probability of entry of *R. similis* on these host plants.

B.2.3.6. SPREAD Sub-step S1 (Table B.10)

For pathways PW1 and PW3:

Pest-free crop:

The implementation of RROs 2.01, 2.03 and 2.08 to confirm the absence of *R. similis* in the growing crop provides no specification on the procedure to establish this requirement. The effectiveness of mere observations, rather than testing, to detect *R. similis* is low.
The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to confirm the absence of *R. similis* in the growing crop by testing soil and roots from suspected plants is of low effectiveness, because there is no requirement for systematic inspection for *R. similis* as the basis to form a suspicion.

Human-assisted spread:

The implementation of RROs 2.01, 2.03, 2.04 and 2.05 to establish the absence of *R. similis* in the consignment before the plants are moved provides a low effectivity, because the probability to detect *R. similis* by a general plant health inspection is low.

For pathways PW2 and PW4:

Human assisted spread:

The implementation of RROs 2.01, 2.03, 2.04 and 2.05 to establish the absence of *R. similis* in the consignment before the plants are moved has a low effectivity, because the probability to detect *R. similis* by a general plant health inspection is low.

B.2.4. Stage 4. Quantification of RA parameters

Based on the assessment in Stage 3, the parameters for the RA model are estimated in Sections A.2.1.2, A.2.1.4, A.3.1, A.3.2.1 and A.4.1.2 of this opinion.

B.3. Alternative Scenario for Risk Reduction: A1

B.3.1. Stage 1: phytosanitary measures corresponding to RROs in scenario A1

In the hypothetical scenario 'A1', the specific measures for *R. similis* are removed from the Council Directive 2000/29/EC, while all non-specific measures remain unchanged.
This means:

- no host plant species will be listed as 'subject of contamination' for *R. similis* in Annex II,
- the specific requirements concerning *R. similis* of Annex IV A I (18) and Annex IV A II (11) are removed,
- the requirements for listed host plants of *R. similis* in Annex V A (2.3).

As a consequence, *R. similis* is then no longer listed as a quarantine pest, but measures aimed at other pests or groups of pests may still affect its entry into or spread within the EU.
Using the same grouping of host plants as for the baseline risk reduction scenario, the relevant measures are related to the RRO classification as follows.

B.3.1.1. Host plants group 1

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis*

- originating outside the EU:

Table B.11: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 1 originating outside the EU in scenario A1

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex V B I (1): Plants intended for planting, other than seeds	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex V B I (2): Parts of plants, other than fruits and seeds, of *Phoenix* spp.	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex V B I (7b): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances specified in Annex V B I (7a), or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine • non-European countries other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex IV A I (34a): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine • non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia Official statement that: the growing medium, at the time of planting, was: (a) either free from soil, and organic matter or found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms or subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b): since planting: either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms, or within 2 weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a)	Conditions for the growing medium: a *pest-free production site, inspection and testing,* and *soil treatment* Maintaining the absence of pest: *cleaning and disinfection of tools*, *use of non-contaminated water* *Physical treatment of consignment*	2.01 and 2.02 and 2.03 and 1.06 1.05 and 1.07 1.08

- originating within the EU:

Table B.12: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 1 originating within the EU in scenario A1

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.1): Plants intended for planting, other than seeds, of herbaceous species, [...] other than bulbs, corms, rhizomes, seeds and tubers, produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A, which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.3.1.2. Host plant group 2

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis.*

- originating outside the EU:

Table B.13: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating outside the EU in scenario A1

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex IV A I (39): For trees and shrubs, intended for planting, other than seeds and plants in tissue culture, originating in Third countries other than European and Mediterranean countries, official statement that the plants:	The 'official statement' requires a *Phytosanitary Certificate*, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
• are clean (i.e. free from plant debris) and free from flowers and fruits	'plants are clean': physical treatment of consignment	1.08
• have been grown in nurseries • have been inspected at appropriate times and prior to export and found free from symptoms of harmful bacteria, viruses and virus-like organisms, and either found free from signs or symptoms of harmful nematodes, insects, mites	For the statement: 'have been *inspected* ... and ... either found free from signs or symptoms	2.01 and 2.03
and fungi, or have been subjected to appropriate treatment to eliminate such organisms	For the statement '... or have been subjected to *treatments*... '	1.14

- originating within the EU:

Table B.14: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating within the EU in scenario A1

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.3.1): Plants of Palmae, intended for planting, having a diameter of the stem at the base of over 5 cm and belonging to the following genera: *Brahea* Mart., *Butia* Becc., *Chamaerops* L., *Jubaea* Kunth, *Livistona* R. Br., *Phoenix* L., *Sabal* Adans., *Syagrus* Mart., *Trachycarpus* H. Wendl., *Trithrinax* Mart., *Washingtonia* Raf., produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.3.1.3. Host plant group 4:

Table B.15: Phytosanitary measures for host plant group 4 in scenario A1

Phytosanitary measure in the Council Directive 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex III A (16): The introduction of plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds, from Third countries, shall be prohibited in all Member States	*Prohibition* of import	1.17
Annex III A (17): The introduction of plants of *Phoenix* spp. other than fruit and seeds, from Algeria and Morocco, shall be prohibited in all Member States	*Prohibition* of import	1.17

B.3.2. Stage 2: Summary tables of the active RROs in each RA sub-step

Risk reduction scenario A1, expressed in terms of RROs, is structured along the RA sub-steps in the risk assessment model (Table B.16 for entry and Table B.17 for spread). The reference to the relevant section of the Council Directive 2000/29/EC is specified in each cell. The scenario includes only a few control RROs (1.01–1.17) contributing to the absence of *R. similis* at the production site, in the growing crop and in the consignment. A number of supporting RROs are implemented.

Table B.16: Scenario A1 – RROs implemented for each pathway per sub-step of entry

	RA sub-steps for ENTRY							
	E1				E2	E3	E4	E5
RRO	**Pest-free area (FAO, 1995 – ISPM No. 4)**	**Pest-free place of prod (FAO, 1999 – ISPM No. 10)**	**Pest-free prod. site (FAO, 1999 – ISPM No. 10)**	**Pest-free crop**	**Pest-free consignment**	**Transport**	**Entry**	**Transfer**
PATHWAY: PW2 (small rooted host plants, not regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b			
Supporting measures								
2.01			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.02			IV I A (34)a					
2.03			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34)		Article 13 (1)	
PATHWAY: PW4 (large rooted host plants, not regulated for *R. similis*)								
Control measures								
1.05				IV I A (34) b				
1.06			IV I A (34) a					
1.07				IV I A (34) b				
1.08					IV I A (34) b, IV A I (39)			
1.14					IV A I (39)			
Supporting measures								
2.01			IV I A (34)a	IV A I (39)	V B I (1), V B I (7b), IV A I (39)		Article 13 (1)	
2.02			IV I A (34)a					
2.03			IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34), IV A I (39)		Article 13 (1)	
2.05				IV A I (39)				

Table B.17: Scenario A1 – RROs implemented for each host group per sub-step of SPREAD

RRO	RA sub-steps for SPREAD							
	Targeted at production (analogous to E1)				S1	S2	S3	S4
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Human assisted	Vector spread	Natural spread	Eradication
PATHWAY: PW2 (small rooted host plants, not regulated for *R. similis*)								
Control measures								
1.05–1.17								
Supporting measures								
2.01					V A I (2.1)			
2.03					V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			
PATHWAY: PW4 (large rooted host plants, not regulated for *R. similis*)								
Control measures								
1.06–1.17								
Supporting measures								
2.01					V A I (2.1), V A I (2.3.1)			
2.03					V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			

B.3.3. Stage 3. Descriptive assessment of effectiveness of RROs operating at each sub-step

At each RA sub-step, the effectiveness of the implemented RRO (presented in Tables B.16 and B.17) on reduction of the pest abundance is assessed.

B.3.3.1. ENTRY Sub-step E1 (Table B.16)

For Pathways PW2 and PW4 (all host plants):

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting may contribute to prevention of association of *R. similis* with the pathway. However, the effectiveness of this combination of RROs is limited because it refers to the growing medium only. It does not preclude that plants or cuttings infested with *R. similis* may be planted in nematode-free growing medium (incl. soil).

For Pathway PW4 (all host plants: trees and shrubs):

The implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, is not effective because it is insufficient to detect infestation of growing plants by *R. similis* and to ensure pest freedom of the production site.

B.3.3.2. ENTRY Sub-step E2 (Table B.16), pest-free consignment:

For pathways PW2 and PW4 (all host plants):

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.
The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

B.3.3.3. ENTRY Sub-step E3 (pest abundance during transport, before entry in area of destination):

For all host plants:

No RROs implemented in scenario A1.

B.3.3.4. ENTRY Sub-step E4 (Table B.16), Import inspection:

For pathways PW2 and PW4 (all host plants):

The implementation of RROs 2.01, 2.03 and 2.04, subjecting all imported consignments on these pathways to an inspection based on a sample, is performed only to determine that the plants and attached soil are not contaminated by organisms listed in Annex I A, or by organisms that are listed in Annex II A for the plants in the consignment (Article 13 of the Council Directive 2000/29/EC). Since *R. similis* is not a listed pest in scenario A1, the effectiveness of import inspection to intercept *R. similis* is zero.

B.3.3.5. ENTRY Sub-step E5 (pest abundance after transfer to host plants)

For all host plants:

No RROs implemented in scenario A1.

B.3.3.6. SPREAD Sub-step S1 (Table B.17)

In scenario A1, *R. similis* is not a listed harmful organism, and the category of 'regulated host plants' does not exist. There is only one category of plants: non-regulated host plants.

For pathways PW2 and PW4:

Human-assisted spread:

The implementation of RROs 2.01, 2.03, 2.04 and 2.05 to establish the absence of *R. similis* in the consignment before the plants are moved has a low effectivity, because the probability to detect *R. similis* by a general plant health inspection is low.

B.3.4. Stage 4. Quantification of RA parameters

Based on the assessment in stage 3, the parameters for the RA model are estimated in Sections A.2.1.2, A.2.1.4, A.3.1, A.3.2.1 and A.4.1.2 of this opinion.

B.4. Alternative Scenarios for Risk Reduction: A2

B.4.1. Stage 1: phytosanitary measures corresponding to RROs in scenario A2

In the hypothetical risk reduction scenario 'A2', it is recognised that it is not possible to make a complete list of all hosts of *R. similis*. To prevent entry into and spread within all Member States of the EU, *R. similis* is therefore listed as a quarantine pest, regardless of the material carrying the pest. Since *R. similis* is known to occur in the EU, the species is now listed in Annex I A II of the Council Directive 2000/29/EC.

Using the same grouping of host plants as for the baseline risk reduction scenario, the relevant measures are related to the RRO classification as follows.

B.4.1.1. Host plants group 1

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis*

- originating outside the EU:

Table B.18: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 1 originating outside the EU in scenario A2

Phytosanitary measure in 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex V B I (1): Plants intended for planting, other than seeds	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex V B I (2): Parts of plants, other than fruits and seeds, of *Phoenix* spp.	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex V B I (7b): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances specified in Annex V B I (7a), or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine • non-European countries other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	A *Phytosanitary Certificate* is required, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
Annex IV A I (34a): Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, Belarus, Georgia, Moldova, Russia, Ukraine, • non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia Official statement that: the growing medium, at the time of planting, was: (a) either free from soil, and organic matter or found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms or subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b): since planting: either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms or within 2 weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a)	Conditions for the growing medium: a *pest-free production site, inspection and testing,* and *soil treatment* Maintaining the absence of pest: *cleaning and disinfection of tools*, *use of non-contaminated water* *Physical treatment of consignment*	2.01 and 2.02 and 2.03 and 1.06 1.05 and 1.07 1.08

- originating within the EU:

Table B.19: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 1 originating within the EU in scenario A2

Phytosanitary measure in 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.1): Plants intended for planting, other than seeds, of herbaceous species, [. . .] other than bulbs, corms, rhizomes, seeds and tubers, produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A, which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.4.1.2. Host plant group 2

Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis.*

- originating outside the EU:

Table B.20: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating outside the EU in scenario A2

Phytosanitary measure 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex IV A I (39): For trees and shrubs, intended for planting, other than seeds and plants in tissue culture, originating in Third countries other than European and Mediterranean countries, official statement that the plants:	The 'official statement' requires a *Phytosanitary Certificate*,, for which a general plant health *inspection* must be done prior to export, which is generally based on a *sample*	2.01 and 2.03 and 2.04
• are clean (i.e. free from plant debris) and free from flowers and fruits • have been grown in nurseries	'plants are clean': physical treatment of consignment	1.08
• have been inspected at appropriate times and prior to export and found free from symptoms of harmful bacteria, viruses and virus-like organisms, and either found free from signs or symptoms of harmful nematodes, insects, mites and fungi, or have been subjected to appropriate treatment to eliminate such organisms	For the statement: 'have been *inspected* . . . and . . . either found free from signs or symptoms	2.01 and 2.03
	For the statement '. . . or have been subjected to *treatments*. . . '	1.14

- originating within the EU:

Table B.21: Broad ranging (non-specific) measures, targeted at a number of regulated pests possibly affecting *R. similis* for host plants group 2 originating within the EU in scenario A2

Phytosanitary measure 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Article 6 and Annex V A I (2.3.1): Plants of Palmae, intended for planting, having a diameter of the stem at the base of over 5 cm and belonging to the following genera: *Brahea* Mart., *Butia* Becc., *Chamaerops* L., *Jubaea* Kunth, *Livistona* R. Br., *Phoenix* L., *Sabal* Adans., *Syagrus* Mart., *Trachycarpus* H. Wendl., *Trithrinax* Mart., *Washingtonia* Raf., produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer	A *plant passport* is required, for which the plants must have been grown at a *registered place of production* And must have been *inspected* for contamination by organisms listed in Annex I A which is generally based on a *sample*	2.01 and 2.03 and 2.04 and 2.05

B.4.1.3. Host plant group 4

Table B.22: Phytosanitary measures for host plant group 4 in scenario A2

Phytosanitary measure 2000/29/EC	Corresponding combination of RROs	Reference to RROs
Annex III A (16): The introduction of plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds, from Third countries, shall be prohibited in all Member States	*Prohibition* of import	1.17
Annex III A (17): The introduction of plants of *Phoenix* spp. other than fruit and seeds, from Algeria and Morocco, shall be prohibited in all Member States	*Prohibition* of import	1.17

In scenario A2, the special requirements of Annex IV A I (18) and Annex IV A II (11) of the Council Directive 2000/29/EC for specified host plants of *R. similis* are removed. However, a new special requirement is included in the legislation, recognising that plants may become infested with *R. similis* if they are grown in infested growing medium, or if the plants are grown from infested planting material (e.g. cuttings taken from infested plants) regardless of the presence of *R. similis* in the growing medium. The measure applies to products of all origins (outside and within the EU).

Table B.23: New phytosanitary measure in scenario A2

New phytosanitary measure in scenario A2:	Corresponding combination of RROs	Reference to RROs
For plants with roots, planted or intended for planting: Official statement: that the plants have been grown in nurseries, And that the plants have been grown from certified planting material, which was produced in accordance with a certified production scheme and which was tested and found free from *R. similis*, And that the plants originate in an area, established in the country of export by the national plant protection service in that country, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures, Or that the plants originate in a place of production, established in the country of export by the national plant protection service in that country, as being free from *R. similis* in accordance with relevant International Standards for Phytosanitary Measures, Or That the plants have been grown in sterile growing medium in pots on shelves at least 50 cm above the ground and the growing medium has been maintained free from harmful organisms		2.05 2.02 and 2.03 2.08 2.08 1.01 and 1.05 and 1.06 and 1.07

B.4.2. Stage 2: Summary tables of the active RROs in each RA sub-step

Risk reduction scenario A1, expressed in terms of RROs, is structured along the RA sub-steps in the risk assessment model (Table B.24 for entry and Table B.25 for spread). The reference to the relevant section of the Council Directive 2000/29/EC, or to NEW formulated legislation, is specified in each cell.

Table B.24: Scenario A2 – RROs implemented for each pathway per sub-step of entry

	RA sub-steps for ENTRY							
	E1				E2	E3	E4	E5
RRO	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Pest-free consignment	Transport	Entry	Transfer
PATHWAY: PW1 (small rooted host plants, all plant species are regulated for *R. similis*)								
Control measures								
1.01				NEW				
1.05				IV I A (34) b, NEW				
1.06			IV I A (34) a	NEW				
1.07				IV I A (34) b, NEW				
1.08					IV I A (34) b			

RRO	RA sub-steps for ENTRY							
	E1				E2	E3	E4	E5
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Pest-free consignment	Transport	Entry	Transfer
Supporting measures								
2.01	NEW		IV I A (34)a		V B I (1), V B I (7b)		Article 13 (1)	
2.02	NEW	NEW	IV I A (34)a	NEW			NEW	
2.03	NEW	NEW	IV I A (34)a	NEW	V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34)		Article 13 (1)	
2.05				NEW				
2.08	NEW	NEW						
PATHWAY: PW3 (large rooted host plants, all plant species are regulated for *R. similis*)								
Control measures								
1.01				NEW				
1.05				IV I A (34) b, NEW				
1.06			IV I A (34) a	NEW				
1.07				IV I A (34) b, NEW				
1.08					IV I A (34) b, IV A I (39)			
1.14					IV A I (39)			
Supporting measures								
2.01	NEW		IV I A (34)a	IV A I (39)	V B I (1), V B I (7b), IV A I (39)		Article 13 (1)	
2.02	NEW	NEW	IV I A (34)a	NEW			NEW	
2.03	NEW	NEW	IV I A (34)a	NEW	V B I (1), V B I (7b)		Article 13 (1)	
2.04					V B I (1), V B I (7b), IV A I (34), IV A I (39)		Article 13 (1)	
2.05				IV A I (39), NEW				
2.08	NEW	NEW						

Table B.25: Scenario A2 – RROs implemented for each host group per sub-step of SPREAD

RRO	RA sub-steps for SPREAD							
	Targeted at production (analogous to E1)				S1	S2	S3	S4
	Pest-free area (FAO, 1995 – ISPM No. 4)	Pest-free place of prod (FAO, 1999 – ISPM No. 10)	Pest-free prod. site (FAO, 1999 – ISPM No. 10)	Pest-free crop	Human assisted	Vector spread	Natural spread	Eradication
PATHWAY: PW1 (small rooted host plants, all plant species are regulated for *R. similis*)								
Control measures								
1.01				NEW				
1.05				NEW				
1.06				NEW				
1.07				NEW				
Supporting measures								
2.01	NEW				V A I (2.1)			
2.02	NEW	NEW		NEW				
2.03	NEW	NEW		NEW	V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			
2.08	NEW	NEW						
PATHWAY: PW3 (large rooted host plants, all plant species are regulated for *R. similis*)								
Control measures								
1.01				NEW				
1.05				NEW				
1.06				NEW				
1.07				NEW				
Supporting measures								
2.01	NEW				V A I (2.1), V A I (2.3.1)			
2.02	NEW	NEW		NEW				
2.03	NEW	NEW		NEW	V A I (2.1)			
2.04					V A I (2.1)			
2.05					V A I (2.1)			
2.08	NEW	NEW						

B.4.3. Stage 3. Descriptive assessment of effectiveness of RROs operating at each sub-step

At each RA sub-step, the effectiveness of the implemented RRO (presented in Tables B.24 and B.25) on reduction of the pest abundance is assessed.

B.4.3.1. ENTRY Sub-step E1 (Table B.24), pest abundance in the harvested product, before preparation of consignment

For all host plants (all host plants are regulated in scenario A2):

Pest-free area

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free area for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the surveillance activities to confirm the pest absence in the area.

Pest-free production place

The alternative implementation of RROs 2.02, 2.03 and 2.08 to establish a pest-free place of production for *R. similis* is very effective in preventing the association of *R. similis* with the pathway. The effectiveness may be limited by the strength of the phytosanitary procedures in the country of origin and the accuracy of the activities to confirm the pest absence in the production place.

Pest-free production site combined with pest-free crop

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting contributes to prevention of association of *R. similis* with the pathway. The combination with RRO 1.01 to establish that the plants are grown in isolation, and with RROs 2.02 and 2.03, requiring that the plants are grown from certified plants for planting that have been produced according to a certification scheme and tested for the absence of *R. similis*, results in a very effective prevention of association of *R. similis* with the pathway.
The requirement that trees and shrubs need to be free from signs or symptoms of harmful nematodes implies a visual inspection, which is insufficient to detect infestation of growing plants by *R. similis* and to ensure pest freedom of the production site.
The option of replanting of plants in pest-free growing medium (RRO 1.08) is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.

For all host plants (trees and shrubs):

The additional implementation of RROs 2.01 and 2.05 requiring that trees and shrubs must be produced in nurseries, and a visual inspection of trees and shrubs for signs or symptoms of harmful nematodes, does not provide additional prevention to the level already obtained by the requirement for a pest-free country, pest-free place of production or pest-free production site combined with pest-free crop.

B.4.3.2. ENTRY Sub-step E2 (Table B.24), (pest abundance in consignment, before transport)

For all host plants (all host plants are regulated in scenario A2):

Pest-free consignment

The implementation of RRO 1.08, replanting of plants in pest-free growing medium prior to dispatch, is not effective; *R. similis* may be present in roots of infested plants and are therefore moving together with the plants.
The implementation of RROs 2.01, 2.03 and 2.04 issuing a plant health certificate based on a general plant health inspection prior to export, is not effective because the general inspection is unlikely to detect *R. similis* in the sample.

B.4.3.3. ENTRY Sub-step E3 (pest abundance during transport, before entry in area of destination)

For all host plants:

No RROs implemented in scenario A2.

B.4.3.4. ENTRY Sub-step E4 (Table B.24)

For all host plants (all host plants are regulated in scenario A2):

Import inspection and testing:

The implementation of RROs 2.01, 2.02, 2.03 and 2.04 to establish that all consignments of plants with roots need to be sampled and tested for the presence of *R. similis* at import, rather than visually inspected, is effective for intercepting infested consignments and a great improvement over visual inspection. The effectiveness may be reduced if sampling and testing protocols are insufficiently accurate for *R. similis* detection.

In this scenario A2, R*. similis* is listed in Annex I A II, therefore any consignment where *R. similis* is detected will be rejected. This is in contrast with the baseline scenario A0, where only consignments of the host plants that are listed as subject of contamination for *R. similis* in Annex II A I/II A II are rejected. (Article 13 of the Council Directive 2000/29/EC).

B.4.3.5. ENTRY Sub-step E5 (pest abundance after transfer to host plants)

For all host plants:

No RROs implemented in scenario A1.

B.4.3.6. SPREAD Sub-step S1 (Table B.25)

Pest-free production area

The implementation of RROs 2.01, 2.02, 2.03 and 2.08 to establish a pest-free area for *R. similis*, for plants with roots produced within the EU, is very effective in preventing spread within the EU. The effectiveness may be limited by the accuracy of the surveillance activities to confirm the pest absence in the area.

Pest-free production place

The alternative implementation of RROs 2.02, 2.03 and 2.08 to establish a pest-free place of production for *R. similis*, for plants with roots produced within the EU, is very effective in preventing spread of *R. similis* within the EU. The effectiveness may be limited by the accuracy of the activities to confirm the pest absence in the production place.

Pest-free production site

The implementation of RROs 1.06, 2.01, 2.02 and 2.03 to establish a pest-free growing medium at the time of planting, and of RROs 1.05 and 1.07 to maintain the pest freedom of the growing medium since planting, for plants with roots produced within the EU, is effective to prevent spread of *R. similis*. The combination with RRO 1.01 to establish that the plants are grown in isolation, and with RROs 2.02 and 2.03, requiring that the plants are grown from certified plants for planting that have been produced according to a certification scheme and tested for the absence of *R. similis*, results in a very effective prevention of spread of *R. similis*.

Human assisted spread

The implementation of RROs 2.01, 2.03, 2.04 and 2.05 to establish the absence of *R. similis* in the consignment before the plants are moved has a low effectivity and has little added value to the other measures to prevent spread, because the probability to detect *R. similis* by a general plant health inspection is low.

B.4.4. Stage 4. Quantification of RA parameters

Based on the assessment in stage 3, the parameters for the RA model are estimated in Sections A.2.1.2, A.2.1.4, A.3.1, A.3.2.1 and A.4.1.2 of this opinion.

Appendix C – Risk reduction options for application in the EFSA quantitative risk assessment framework for plant health

Table C.1: Risk reduction options for application in the EFSA quantitative risk assessment framework for plant health

RRO no.	Risk reduction option title
Control Measures: Control (of a pest) is defined in FAO, 2016 - ISPM No. 5 as 'Suppression, containment or eradication of a pest population [FAO, 1995]'. Control Measures are measures that have a direct effect on pest abundance	
1.01	Growing plants in isolation
1.02	Timing of planting and harvesting
1.03	Chemical treatments on crops including reproductive material
1.04	Chemical treatments on consignments or during processing
1.05	Cleaning and disinfection of facilities, tools and machinery
1.06	Soil treatment
1.07	Use of non-contaminated water
1.08	Physical treatments on consignments or during processing
1.09	Controlled atmosphere
1.10	Waste management
1.11	Use of resistant and tolerant plant species/varieties
1.12	Roguing and Pruning
1.13	Crop rotation, associations and density, weed/volunteer control
1.14	Heat and cold treatments
1.15	Conditions of transport
1.16	Biological control and behavioural manipulation
1.17	Post-entry quarantine and other restrictions of movement
Supporting measures: Supporting measures are organisational measures or procedures that do not directly affect pest abundance, but support the choice of appropriate Control Measures	
2.01	Inspection and trapping
2.02	Laboratory testing
2.03	Sampling
2.04	Phytosanitary certificates and plant passport
2.05	Certified and approved premises
2.06	Certification of reproductive material (voluntary/official)
2.07	Delimitation of buffer zones
2.08	Surveillance

Appendix D – Data on pest risk assessment model of *Radopholus similis* for the EU territory

D.1. Classification schemes

D.1.1. Country classes of infestations

Countries are classified as subtropical/tropical when parts of their area are between 40° North latitude and 40° South latitude. Countries are assumed to be infested, when interceptions were detected or pest reports on *R. similis* were given.

Table D.1: Country classes of infestations

Class	I	II	III	IV
Interceptions known/pest reports	Yes	Yes	No	No
Tropical/subtropical	Yes	No	Yes	No

Table D.2: Countries with known interceptions or pest reports in tropical/subtropical regions (Class I)

AS	American Samoa
AU	Australia
BB	Barbados
BF	Burkina Faso
BI	Burundi
BJ	Benin
BN	Brunei Darussalam (Brunei)
BO	Bolivia
BR	Brazil
BZ	Belize
CD	Congo, Democratic Republic of
CF	Central African Republic
CG	Congo
CI	Cote D'ivoire
CK	Cook Islands
CM	Cameroon
CO	Colombia
CR	Costa Rica

CU	Cuba
DM	Dominica
DO	Dominican Republic
EC	Ecuador
EG	Egypt
ET	Ethiopia
FJ	Fiji
FM	Micronesia, Federated States of
GA	Gabon
GD	Grenada
GF	French Guiana
GH	Ghana
GM	Gambia
GN	Guinea
GP	Guadeloupe
GT	Guatemala
GU	Guam
GW	Guinea-Bissau
GY	Guyana
HN	Honduras
ID	Indonesia
IL	Israel
IN	India
JM	Jamaica
KE	Kenya
KN	St Kitts and Nevis
LB	Lebanon
LC	St lucia
LK	Sri lanka
MA	Morocco
MG	Madagascar
MQ	Martinique
MU	Mauritius

MW	Malawi
MX	Mexico
MY	Malaysia
MZ	Mozambique
NC	New Caledonia
NF	Norfolk Island
NG	Nigeria
NI	Nicaragua
NU	Niue
OM	Oman
PA	Panama
PE	Peru
PF	French polynesia
PG	Papua New Guinea
PH	Philippines
PK	Pakistan
PW	Palau
QT	West Indies
RE	Reunion
RW	Rwanda
SB	Solomon Islands
SC	Seychelles
SD	Sudan
SG	Singapore
SN	Senegal
SO	Somalia
SR	Suriname
SV	El Salvador
TH	Thailand
TO	Tonga
TT	Trinidad and Tobago
TZ	Tanzania, United Republic of
UG	Uganda

US	United States
VC	St Vincent and the Grenadines
VE	Venezuela
VI	Virgin Islands (US)
WS	Samoa
XB	Canary Islands
YD	South Yemen
YE	Yemen
ZA	South Africa
ZM	Zambia
ZW	Zimbabwe

Table D.3: Countries with known interceptions or pest reports not in tropical/subtropical regions (Class II)

CA	Canada

Table D.4: Countries without known interceptions or pest reports in tropical/subtropical regions (Class III)

AE	United Arab Emirates
AF	Afghanistan
AG	Antigua and Barbuda
AI	Anguilla
AL	Albania
AM	Armenia
AN	Netherlands Antilles
AO	Angola
AR	Argentina
AW	Aruba
AZ	Azerbaijan
BD	Bangladesh
BH	Bahrain
BL	Saint Barthelemy
BM	Bermuda
BQ	Bonaire, Sint Eustatius and Saba

BS	Bahamas
BT	Bhutan
BW	Botswana
CC	Cocos (Keeling), Islands
CL	Chile
CN	China (People's Republic of)
CV	Cape Verde
CW	Curacao
CX	Christmas Island
DJ	Djibouti
DZ	Algeria
EH	Western Sahara
ER	Eritrea
GI	Gibraltar
GQ	Equatorial Guinea
HK	Hong Kong
HM	Heard Island and Mcdonald Islands
HT	Haiti
IO	British Indian Ocean Territory
IQ	Iraq
IR	Iran, Islamic Republic of
JO	Jordan
JP	Japan
KG	Kyrgyz, Republic
KH	Cambodia
KI	Kiribati
KM	Comoros
KP	Korea, Democratic People's Republic of (North Korea)
KR	Korea, Republic of (South Korea)
KW	Kuwait
KY	Cayman Islands
LA	Lao People's Democratic Republic (Laos)
LR	Liberia
LS	Lesotho

LY	Libyan arab Jamahiriya (Libya)
MH	Marshall Islands
ML	Mali
MM	Myanmar (Burma)
MN	Mongolia
MO	Macao
MP	Northern Mariana Islands
MR	Mauritania
MS	Montserrat
MV	Maldives
NA	Namibia
NE	Niger
NP	Nepal
NR	Nauru
NZ	New Zealand
PM	Saint Pierre and Miquelon
PN	Pitcairn
PS	Occupied Palestinian Territory (West Bank -Including East Jerusalem and Gaza Strip)
PY	Paraguay
PZ	Panama Canal
QA	Qatar
SA	Saudi Arabia
SH	Saint Helena
SL	Sierra Leone
SS	South Sudan
ST	Sao Tome and Principe
SX	Sint Maarten (Dutch Part)
SY	Syrian arab republic (syria)
SZ	Swaziland (Ngwane)
TC	Turks and Caicos Islands
TD	Chad
TG	Togo
TJ	Tajikistan
TK	Tokelau

TL	Timor-leste
TM	Turkmenistan
TN	Tunisia
TP	East Timor
TR	Turkey
TV	Tuvalu
TW	Taiwan
UM	United States Minor Outlying Islands
UY	Uruguay
UZ	Uzbekistan
VD	North Vietnam
VG	Virgin Islands, British
VN	Vietnam
VU	Vanuatu
WF	Wallis and Futuna
XA	American Oceania
XC	Ceuta
XL	Melilla
XP	West Bank and Gaza Strip
YT	Mayotte

Table D.5: Countries without known interceptions or pest reports not in tropical/subtropical regions (Class IV)

AD	Andorra
AQ	Antarctica
BA	Bosnia and Herzegovina
BV	Bouvet Island
BY	Belarus (Belorussia)
CH	Switzerland
CS	Serbia and Montenegro
FK	Falkland Islands
FO	Faroe Islands

GE	Georgia
GL	Greenland
GS	South Georgia and South Sandwich Islands
IS	Iceland
KZ	Kazakhstan
LI	Liechtenstein
MD	Moldova, Republic of
ME	Montenegro
MK	Former Yugoslav Republic of Macedonia
NO	Norway (incl.sj excl.1995,1996)
QP	High Seas
RU	Russian Federation (Russia)
SJ	Svalbard
SM	San Marino
UA	Ukraine
VA	Holy See
XK	Kosovo
XM	Montenegro
XR	Polar Regions
XS	Serbia
YU	Yugoslavia

D.1.2. Host classification

Plants are recognised as hosts, if their genus was identified as host in the pest categorisation or interceptions with *R. similis* were detected.

Table D.6: List of host plants (genus)

Pest reports as in the pest categorisation	Interceptions	Regulated Family	Genus
1	0		*Abelmoschus*
0	1		*Acorus*
1	0		*Aeschynanthus*
1	0		*Allium*
0	1	Araceae	*Alocasia*
1	0		*Ananas*

Pest reports as in the pest categorisation	Interceptions	Regulated Family	Genus
1	1	Araceae	*Anthurium*
0	1		*Anubias*
0	1		*Anubias*
1	0		*Arachis*
1	1		*Areca*
1	0		*Bambusa*
1	0		*Beta*
1	0		*Brassica*
1	1	Marantaceae	*Calathea*
1	0		*Camellia*
1	0		*Capsicum*
0	1		*Caryota*
1	0		*Chamaedorea*
1	0		*Chrysalidocarpus*
1	0		*Citrullus*
1	0	Citrus	*Citrus*
1	0		*Cocos*
1	0		*Coffea*
1	1	Araceae	*Colocasia*
0	1	Araceae	*Cryptocoryne*
1	0		*Cucumis*
1	0		*Cucurbita*
1	0		*Curcuma*
1	0		*Daucus*
1	1	Araceae	*Dieffenbachia*
1	0		*Dioscorea*
0	1	Araceae	*Epipremnum*
1	0		*Fragaria*
1	0		*Glycine*
1	0		*Hedychium*
0	1		*Heliconia*
1	0		*Hibiscus*

Pest reports as in the pest categorisation	Interceptions	Regulated Family	Genus
0	1		*Howea*
1	0		*Illicium*
1	0		*Indigofera*
1	0		*Ipomea*
1	0		*Lactuca*
0	1		*Licuala*
1	0		*Litchi*
0	1		*Livistona*
1	0		*Mangifera*
1	1	Marantaceae	*Maranta*
1	0		*Medicago*
1	0	Araceae	*Monstera*
1	1	Musaceae	*Musa*
1	0		*Oryza*
1	0		*Peperomia*
1	0	Persea	*Persea*
1	0		*Phaseolus*
1	1	Araceae	*Philodendron*
1	0		*Pinus*
1	0		*Piper*
1	0	Poncirus	*Poncirus*
0	1	Araceae	*Pothos*
1	0		*Psidium*
1	0		*Pyrus*
1	0		*Raphanus*
0	1	Streliziaceae	*Ravenala*
1	0		*Ricinus*
1	0		*Saccharum*
0	1		*Schefflera*
1	1	Araceae	*Scindapsus*
1	0		*Secale*
1	0		*Solanum*
1	0		*Sorghum*

Pest reports as in the pest categorisation	Interceptions	Regulated Family	Genus
1	0	Araceae	*Spathiphyllum*
1	0	Streliziaceae	*Strelitzia*
1	1	Araceae	*Syngonium*
1	0		*Trifolium*
0	1		*Vallisneria*
1	0		Water-Aquarium-Plants
1	0		*Zea*
1	0		*Zingiber*

Legend: 1 = pest reports/interceptions known/0 = not known.

D.1.3. Trade classification: plants for planting

Table D.7: Trade classes as defined in EUROSTAT (CN8 codes)

CN code	Description
06021010	Unrooted vine cuttings and slips
06021090	Unrooted cuttings and slips (excl. vines)
06022010	Vine slips, grafted or rooted
06022090	Trees, shrubs and bushes, grafted or not, of kinds which bear edible fruit or nuts (excl. vine slips)
06023000	Rhododendrons and azaleas, grafted or not
06024000	Roses, whether or not grafted
06029010	Mushroom Spawn
06029020	Pineapple plants
06029030	Vegetable and strawberry plants
06029041	Live Forest Trees
06029045	Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. fruit, nut and forest trees)
06029049	Outdoor trees, shrubs and bushes, incl. Their roots (excl. cuttings, slips and young plants, and fruit, nut and forest trees)
06029050	Live outdoor plants, incl. Their roots (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants and roots, unrooted cuttings, slips, rhododendrons, azaleas, roses, mushroom spawn, pineapple plants, vegetable and strawberry plants, trees, shrubs and bushes)
06029070	Indoor rooted cuttings and young plants (excl. cacti)
06029091	Indoor flowering plants with buds or flowers (excl. cacti)
06029099	Live indoor plants and cacti (excl. rooted cuttings, young plants and flowering plants with buds or flowers)

D.2. Pathways and stratification

D.2.1. Pathway classification

Table D.8: Pathways as reported in the risk assessment

Plant type	Pathway number	
	Family regulated: yes	**Family regulated: no**
Indoor	**1**	**2**
Outdoor	**3**	**4**

D.2.2. Pathway stratification within the assessment model

Table D.9: Pathways as used in the risk assessment model

Pathway name	CN code: 0602…	Description	Indoor/outdoor	Regulated	Pathway no
A	1090	Unrooted cuttings and slips (excl. vines), non-regulated families	In	No	2
B	1090	Unrooted cuttings and slips (excl. vines), regulated families	In	Yes	1
C	9020	Pineapple plants (non-regulated family)	In	No	2
D[(a)]	9030	Vegetable and strawberry plants (non-regulated families)	Out	No	#
E	9045	Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. . . .), non-regulated families	In	No	2
F	9050	Live outdoor plants, incl. their roots (excl. . . .), non-regulated families	Out	No	4
G	9050	Live outdoor plants, incl. their roots (excl. . . .), regulated families	Out	Yes	3
H	9070	Indoor rooted cuttings and young plants (excl. cacti), non- regulated families	In	No	2
I	9070	Indoor rooted cuttings and young plants (excl. cacti), regulated families	In	Yes	1
J	9099	Live indoor plants and cacti, smaller than 1 m, non-regulated families	In	No	2
K	9099	Live indoor plants and cacti, smaller than 1 m, regulated families	In	Yes	1
L	9099	Live indoor plants and cacti, larger than 1 m, non-regulated families	Out	No	4
M	9099	Live indoor plants and cacti, larger than 1 m, regulated families	Out	Yes	3

(a) = CN code 0602 9030 is not used in the assessment; # CN code 0602 9030 is not used in the assessment in any pathway.

D.3. Entry model

Table D.10: Parameter of the entry model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model	
N0	Imp_Path	Total yearly import from countries class I [100 kg] by pathway	EUROSTAT by CN8
e1	Conv_Pcs2kg_Path	Conversion from weight [in kg] to number of plants [–] by pathway	CN Manual
e2	Prop_Host_Path	Proportion of host plants [%] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [–] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
e4	Prop_Inf_Path	Proportion of infested packs exported to Europe [%] by pathway	Expert Knowledge Elicitation
e5	Surv_Insp_Path	Proportion of infested packs passing the EU border inspection [%] by pathway	Expert Knowledge Elicitation
N1	Packs_Inf_p, Packs_Inf_Path	Infested packages entering EU [–] by pathway no/pathway	Calculated by Monte Carlo simulation

D.3.1. Equation

The Entry model calculates the number of infested packs entering the EU from third countries of class I for different pathways N = 1, 2, 3, 4.

$$\text{Packs}_{\text{Inf},p} = \sum\nolimits_{\text{Path\_p}} \text{Packs}_{\text{Inf, Path}} = \sum\nolimits_{\text{Path\_p}} \left[\text{Imp}_{\text{Path}} \times 100/\text{Conv}_{\text{Pcs2kg, Path}} \times \text{Prop}_{\text{Host;Path}}/\text{Conv}_{\text{Packs2pcs, Path}} \times \text{Prop}_{\text{Inf, Path}} \times \text{Surv}_{\text{Insp, Path}}\right]$$

(1st step) Starting point of the Entry Model are the annual imports of different kinds of plants for planting into the EU (Imp) from tropical/subtropical countries with known pest reports or interceptions of *R. similis*. Annual trade volumes (in 100 kg) of the recent years 2010–2015 are used and converted to total numbers of imported plants (2nd step) by dividing through the average unit weights as defined in the CN manual (Conv_Pcs2kg).

To estimate the number of infested packages with *R. similis* entering the EU (Packs_inf) several multiplication factors are applied.

To correct for the possible host plants the number of plants for planting is multiplied by the proportion of host plants in the different categories of planting material (3rd step). Proportions of the years 2010, 2012–2014 are used from the Dutch trade inspection database (NL-NPPO, 2017). Infestations are recognised on the level of packages. Therefore, the number of plants is converted to number of packs (4th step) by dividing by the average numbers of plants per package, which is also reported in the Dutch database.

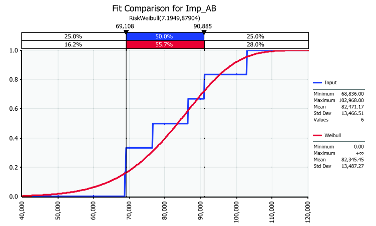
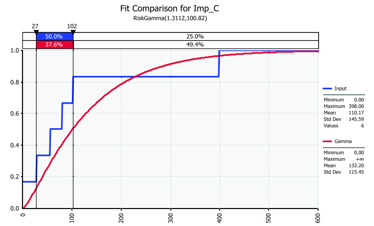
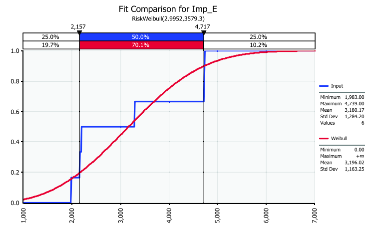
Further multiplication factors take into account the infestation rate (Prop_Inf) of planting material (5th step), and the part, which will (6th step) not be detected at the import control (Surv_Insp).

D.3.2. Total yearly import from countries class I (Imp) by pathway (N0)

The total import of plants for planting from countries with known interceptions or pest reports in tropical or subtropical regions were taken EUROSTATs database on international trade (EU trade since 1988 by CN8, DS-016890). Data were available for different CN8 categories.

Table D.11: The total import of plants for planting from countries with known interceptions or pest reports in tropical or subtropical regions

Pathway name	**A**	**B**	**C**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Pathway no	**2**	**1**	**2**	**2**	**4**	**3**	**2**	**1**	**2**	**1**	**4**	**3**
Total yearly import from countries class I (Imp) [100 kg] (Eurostat)												
All scenarios												
2010	90,885		102	4,717	22,657		342,011		155,013			
2011	102,968		79	4,739	18,022		307,841		146,660			
2012	86,490		55	1,983	12,970		261,239		181,829			
2013	76,540		27	2,157	12,798		248,294		163,578			
2014	69,108		398	2,199	15,465		221,708		177,267			
2015	68,836		0	3,286	18,538		212,140		154,613			
Fitted distributions (Imp)												
1st percentile	46,379		3	770	7,540		176,415		136,031			
25th percentile	73,928		48	2,361	14,319		233,426		154,457			
50th percentile	83,539		101	3,167	16,941		261,694		162,676			
75th percentile	91,987		182	3,992	19,342		293,388		171,333			
99th percentile	108,690		533	5,960	24,331		388,138		194,528			
Distribution type	Weibull		Gamma	Weibull	Weibull		LogNormal		LogNormal			
1st parameter	7.1949		1.3112	2.9952	5.2301		265,481.0		163,157.4			
2nd parameter	87,904		100.82	3,579.3	18,171		45,320.3		12,560.2			

A	B	C	E
	as A		
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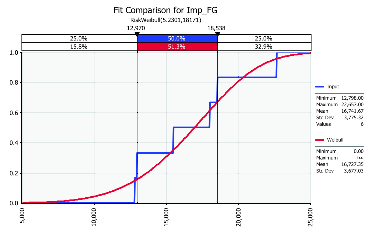
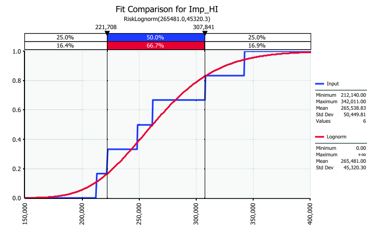
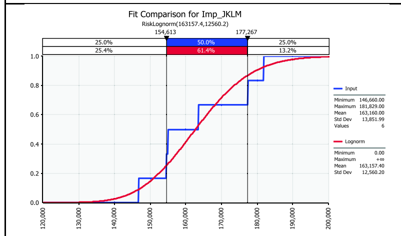
	as F		as H
J	**K**	**L**	**M**
	as J	as J	as J

Figure D.1: The total import of plants for planting from countries with known interceptions or pest reports in tropical or subtropical regions

D.3.3. Conversion from weight [in kg] to number of plants [in pcs] (Conv_Pcs2kg) by pathway (e1)

The conversion factors from pieces to weight were taken from the CN coding system. Data were available for different CN8 categories.

Table D.12: Conversion from weight [in kg] to number of plants [in pcs] (Conv_Pcs2kg) by pathway (e1)

Pathway name	**A**	**B**	**C**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Pathway no	**2**	**1**	**2**	**2**	**4**	**3**	**2**	**1**	**2**	**1**	**4**	**3**
Conversion from weight [in kg] to number of plants [in pcs] (Conv_Pcs2kg) [kg] (CN system)												
All scenarios												
1st percentile					10							
25th percentile					19							
50th percentile	0.0180		0.1000	0.0290	27		0.0350		1		2	
75th percentile					47							
99th percentile					100							
Fitted distributions (Conv_Pcs2kg)												
1st percentile					6.6156							
25th percentile					18.7398							
50th percentile	0.0180		0.1000	0.0290	28.6666		0.0350		1		2	
75th percentile					43.8517							
99th percentile					124.1614							
Distribution type	Constant		Constant	Constant	LogNormal		Constant		Constant		Constant	
1st parameter	0.0180		0.1000	0.0290	34.965		0.0350		1		2	
2nd parameter					24.416							

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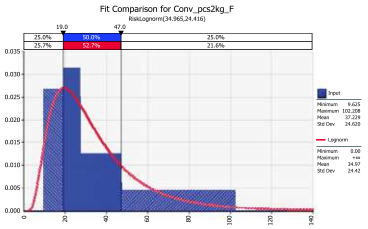
<tr><td>
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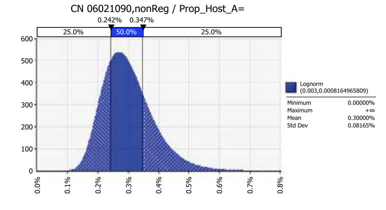
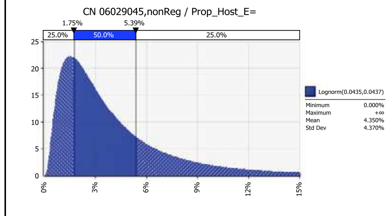
Figure D.2: Conversion from weight [in kg] to number of plants [in pcs] (Conv_Pcs2kg) by pathway (e1)

D.3.4. Proportion of host plants (Prop_Host) by pathway (e2)

Proportion of host plants were calculated from the information provided in the Dutch trade inspection data (NL-NPPO, 2017) using the CN10 classification and the list of host plants. Pathway K has no host plants (closed pathway).

Table D.13: Proportion of host plants (Prop_Host) by pathway (e2)

Pathway Name	**A**	**B**	**C**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Pathway No	**2**	**1**	**2**	**2**	**4**	**3**	**2**	**1**	**2**	**1**	**4**	**3**
Proportion of host plants (Prop_Host) [%] (Dutch Import Control Database)												
All scenarios												
2010	0.40%	0.20%	100.00%	7.60%	0.00%		3.70%	7.30%	1.20%	0.00%	8.70%	0.00%
2012	0.30%	0.20%	100.00%	8.60%	0.00%		2.50%	4.10%	0.70%	0.00%	10.80%	0.10%
2013	0.20%	0.20%	100.00%	1.10%	14.50%	0.90%	2.40%	4.60%	0.70%		8.90%	0.10%
2014	0.30%	0.20%	28.40%	0.10%	4.50%	0.60%	1.60%	2.20%	0.00%		8.50%	0.40%
Fitted distributions (Prop_Host)												
1st percentile	0.155%			0.440%	0.23%	0.251%	1.119%	1.48%	0.108%		7.016%	0.012%
25th percentile	0.242%			1.748%	1.33%	0.599%	1.932%	3.07%	0.329%		8.481%	0.053%
50th percentile	0.289%	0.200%	100.000%	3.069%	2.71%	0.751%	2.415%	4.13%	0.518%	0.000%	9.164%	0.098%
75th percentile	0.347%			5.391%	5.54%	0.899%	3.017%	5.56%	0.816%		9.902%	0.183%
99th percentile	0.539%			21.407%	31.86%	1.226%	5.207%	11.50%	2.485%		11.970%	0.836%
Distribution type	LogNormal	Constant	Constant	LogNormal	LogNormal	Weibull	LogNormal	LogNormal	LogNormal	Constant	LogNormal	LogNormal
1st parameter	0.30%	0.2%	100%	4.35%	4.75%	3.8665,	2.55%	4.55%	0.65%	0%	9.23%	9.23%
2nd parameter	0.08%			4.37%	6.84%	0.0082621	0.87%	2.10%	0.49%		1.06%	1.06%

A	B	C	E
	Constant	Constant	
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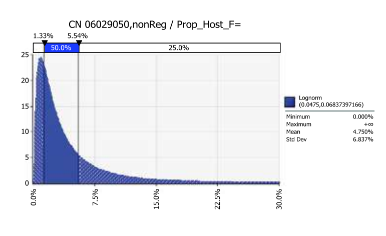	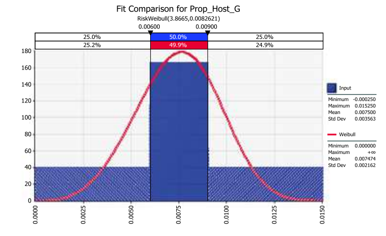	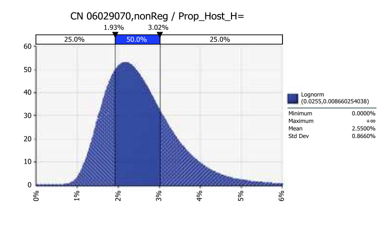	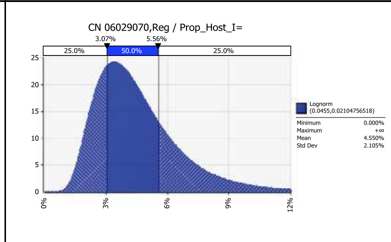
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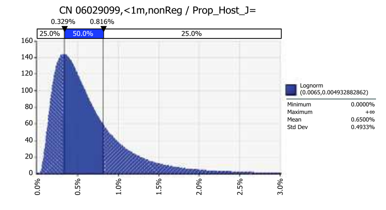
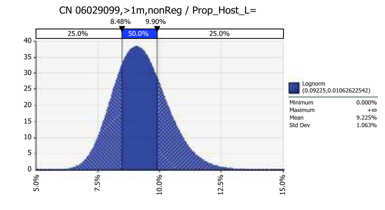
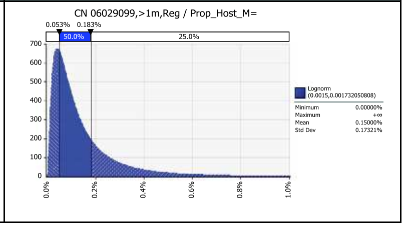
	Constant		

Figure D.3: Proportion of host plants (Prop_Host) by pathway (e2)

D.3.5. Conversion from number of plants to number of packs (Conv_Packs2pcs) by pathway (e3)

The average pack size of host plants were calculated from the information provided in the Dutch trade inspection data (NL-NPPO, 2017) using the CN10 classification and the list of host plants.

Table D.14: Conversion from number of plants to number of packs (Conv_Packs2pcs) by pathway (e3)

Pathway name	**A**	**B**	**C**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Pathway no	**2**	**1**	**2**	**2**	**4**	**3**	**2**	**1**	**2**	**1**	**4**	**3**
Plants per pack (Conv_Packs2pcs) by pathway [–] (Dutch Import Control Data)												
All scenarios												
2010	1,376	2,075	82	1,220			233	4,077	32	1	118	1
2012	1,715	1,792	46	1,339			763	4,821	25	1	211	926
2013	1,654	2,036	35	265		1	476	4,445	67		211	168
2014	1,764	2,289	80	416		1	751	4,483	1		253	27
Fitted distributions (Conv_Packs2pcs)												
1st percentile	1,224	1,574	5	161			184	3,749	4		99	11
25th percentile	1,510	1,911	45	444			378	4,251	14		158	72
50th percentile	1,627	2,048	61	671	1	1	506	4,456	24	1	191	152
75th percentile	1,744	2,185	77	1,015			678	4,662	39		230	320
99th percentile	2,031	2,522	116	2,796			1,387	5,164	136		367	2,001
Distribution type	Normal	Normal	Normal	LogNormal	Constant	Constant	LogNormal	Normal	LogNormal	Constant	LogNormal	LogNormal
1st parameter	1,627	2,048	61	810	1	1	556	4,457	31	1	198	281
2nd parameter	173	204	24	548			253	304	27		57	437

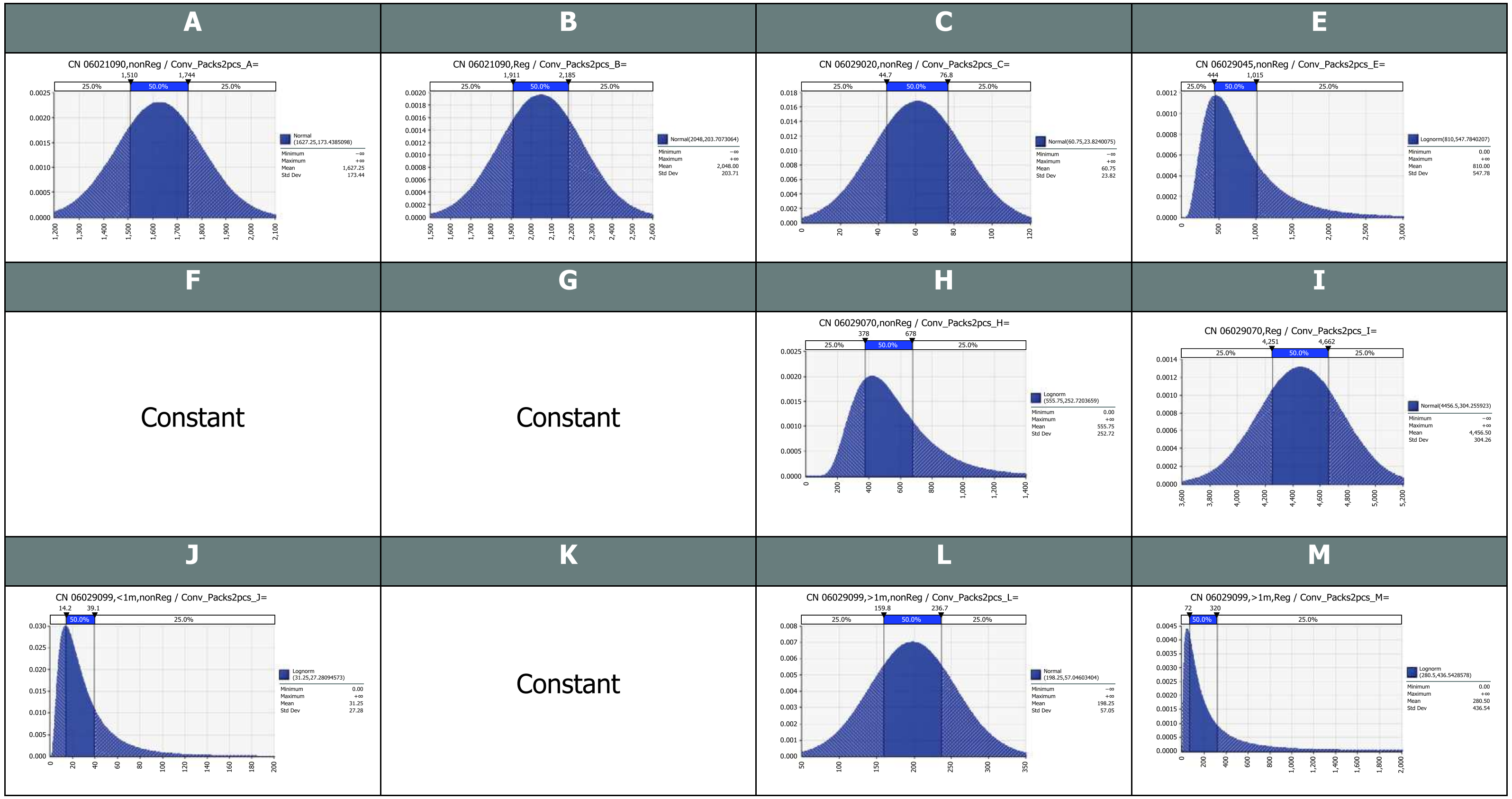


Figure D.4: Conversion from number of plants to number of packs (Conv_Packs2pcs) by pathway (e3)

D.3.6. Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4)

The proportion of infested packs exported to Europe was elicited for each pathway class.

D.3.6.1. Scenario A0

Table D.15: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A0

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Proportion of infested packs exported to Europe (Prop_Inf) [%] (by expert elicitation)				
Scenario A0				
1st percentile	0.0001%	0.0001%	0.0001%	0.0001%
25th percentile	0.1000%	0.1000%	0.1000%	0.1000%
50th percentile	1.0000%	0.5000%	2.0000%	2.0000%
75th percentile	2.0000%	1.0000%	5.0000%	5.0000%
99th percentile	80.0000%	60.0000%	90.0000%	80.0000%
Fitted distributions (Prop_Inf)				
1st percentile	0.0001%	0.0005%	0.000%	0.00001%
25th percentile	0.130%	0.115%	0.150%	0.150%
50th percentile	0.738%	0.427%	1.418%	1.418%
75th percentile	2.455%	1.111%	6.107%	6.108%
99th percentile	13.999%	4.891%	36.891%	36.901%
Distribution type	Gamma	BetaGeneral	BetaGeneral	BetaGeneral
1st parameter	0.42107	0.58806	0.31588	0.31588
2nd parameter	0.045607	71.455	6.1873	6.1867

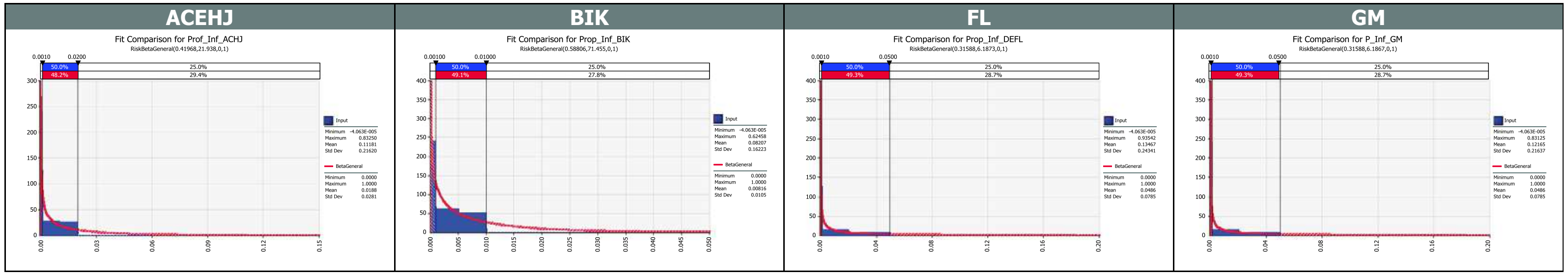


Figure D.5: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A0

D.3.6.1. Scenario A1

Table D.16: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A1

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Proportion of infested packs exported to Europe (Prop_Inf) [%] (by expert elicitation)				
Scenario A1				
1st percentile	0.0001%	0.0001%	0.0001%	0.0001%
25th percentile	0.1000%	0.1000%	0.1000%	0.1000%
50th percentile	1.0000%	1.0000%	2.0000%	2.0000%
75th percentile	2.0000%	2.0000%	5.0000%	5.0000%
99th percentile	80.0000%	80.0000%	90.0000%	90.0000%
Fitted distributions (Prop_Inf)				
1st percentile	0.0001%	0.0001%	0.000%	0.00001%
25th percentile	0.130%	0.130%	0.150%	0.150%
50th percentile	0.738%	0.739%	1.418%	1.418%
75th percentile	2.455%	2.446%	6.107%	6.107%
99th percentile	13.999%	13.198%	36.891%	36.896%
Distribution type	Gamma	BetaGeneral	BetaGeneral	BetaGeneral
1st parameter	0.42107	0.41968	0.31588	0.31588
2nd parameter	0.045607	21.938	6.1873	6.1873

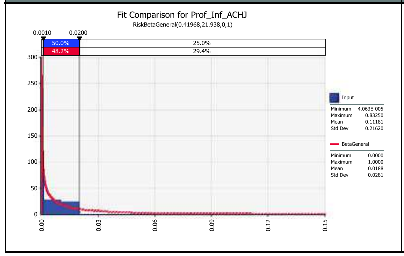
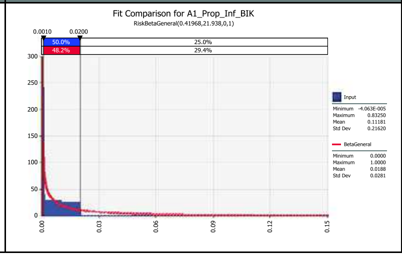
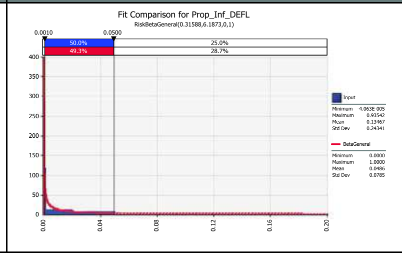
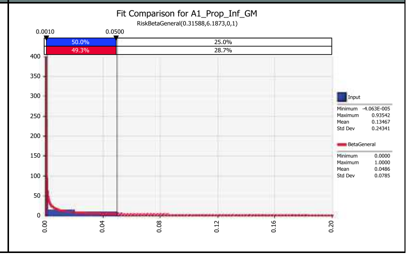
ACEHJ	BIK	FL	GM
			

Figure D.6: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A1

D.3.6.3. Scenario A2

Table D.17: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A2

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Proportion of infested packs exported to Europe (Prop_Inf) [%] (by expert elicitation)				
Scenario A2				
1st percentile	0.0000%	0.0001%	0.0001%	0.0001%
25th percentile	0.1000%	0.1000%	0.1000%	0.1000%
50th percentile	0.5000%	0.5000%	2.0000%	2.0000%
75th percentile	1.0000%	1.0000%	5.0000%	5.0000%
99th percentile	60.0000%	60.0000%	80.0000%	80.0000%
Fitted distributions (Prop_Inf)				
1st percentile	0.0005%	0.0005%	0.000%	0.00001%
25th percentile	0.115%	0.115%	0.150%	0.150%
50th percentile	0.427%	0.427%	1.418%	1.418%
75th percentile	1.110%	1.111%	6.108%	6.108%
99th percentile	4.879%	4.891%	36.905%	36.901%
Distribution type	BetaGeneral	BetaGeneral	BetaGeneral	BetaGeneral
1st parameter	0.58937	0.58806	0.31588	0.31588
2nd parameter	71.685	71.455	6.1867	6.1867

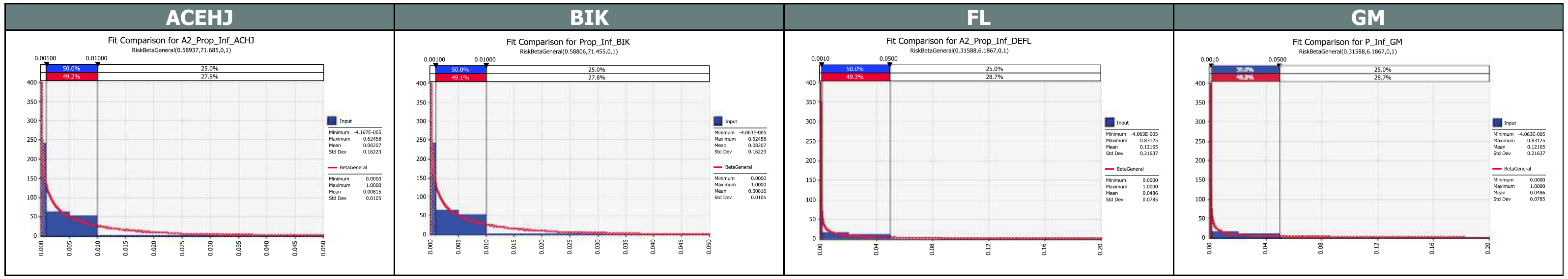


Figure D.7: Proportion of infested packs exported to Europe (Prop_Inf) by pathway (e4) for scenario A2

D.3.7. Proportion of infested packs passing the EU border inspection (Surv_Insp) by pathway (e5)

The proportion of infested packs exported to Europe was elicited for each pathway class.

D.3.7.1. Scenarios A0, A1

Table D.18: Proportion of infested packs passing the EU border inspection (Surv_Insp) by pathway (e5) for scenarios A0 and A1

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Proportion of infested packs passing the EU border inspection (Surv_Insp) [%] (by expert elicitation)				
Scenarios A0, A1				
1st percentile	100%	50%	100%	50%
25th percentile	100%	75%	100%	75%
50th percentile	100%	80%	100%	82%
75th percentile	100%	85%	100%	85%
99th percentile	100%	98%	100%	98%
Fitted distributions (Surv_Insp)				
1st percentile		59.751%		60.077%
25th percentile		74.830%		75.598%
50th percentile	100%	80.181%	100%	81.045%
75th percentile		84.886%		85.787%
99th percentile		93.361%		94.118%
Distribution type	Constant	BetaGeneral	Constant	BetaGeneral
1st parameter		22.89		21.768
2nd parameter		5.9053		5.3424

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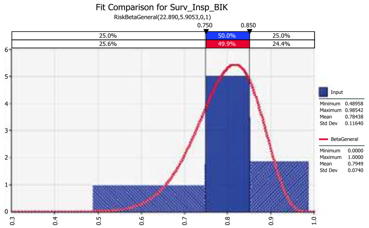
<td>
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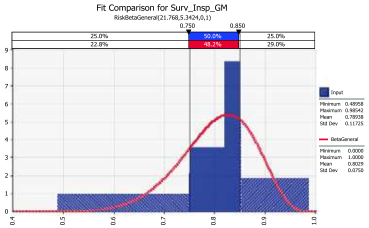
<td>
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Figure D.8: Proportion of infested packs passing the EU border inspection (Surv_Insp) by pathway (e5) for scenarios A0 and A1

D.3.7.2. Scenario A2

Table D.19: Proportion of infested packs passing the EU border inspection (Surv_Insp) by pathway (e5) for scenarios A2

Pathway name	**ABCEHIJK**	**FGLM**
Pathway no	**1,2**	**3,4**
Proportion of infested packs passing the EU border inspection (Surv_Insp) [%] (by expert elicitation)		
Scenarios A0, A1		
1st percentile	25%	30%
25th percentile	30%	35%
50th percentile	40%	50%
75th percentile	50%	60%
99th percentile	80%	80%
Fitted distributions (Surv_Insp)		
1st percentile	15.565%	17.641%
25th percentile	32.186%	39.093%
50th percentile	40.437%	49.499%
75th percentile	49.072%	59.935%
99th percentile	69.430%	81.651%
Distribution type	BetaGeneral	BetaGeneral
1st parameter	6.3827	5.314
2nd parameter	9.2466	5.415

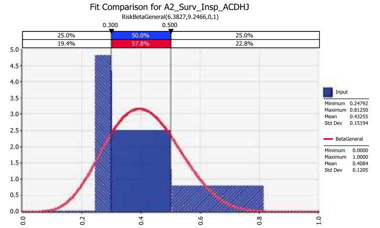
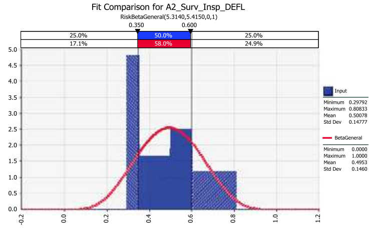
ABCEHIJK	FGLM
	

Figure D.9: Proportion of infested packs passing the EU border inspection (Surv_Insp) by pathway (e5) for scenarios A2

D.3.8. Infested packages entering EU (Packs_Inf) by pathway (N1)

D.3.8.1. Scenario A0

Table D.20: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A0

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Infested packages entering EU (Packs_Inf) [–] (calculated)				
Scenario A0				
1st percentile	0	0	0	0
5th percentile	1	0	0	0
10th percentile	7	1	1	0
16.7th percentile	22	3	3	0
25th percentile	58	6	9	1
33rd percentile	117	11	23	1
50th percentile	333	24	87	6
67th percentile	783	47	242	16
75th percentile	1,163	67	389	26
83.3rd percentile	1,813	97	648	44
90th percentile	2,724	139	994	72
95th percentile	4,245	202	1,553	120
99th percentile	8,783	380	3,407	275
Mean	1,017	53	364	27
Standard deviation	1,914	81	884	62

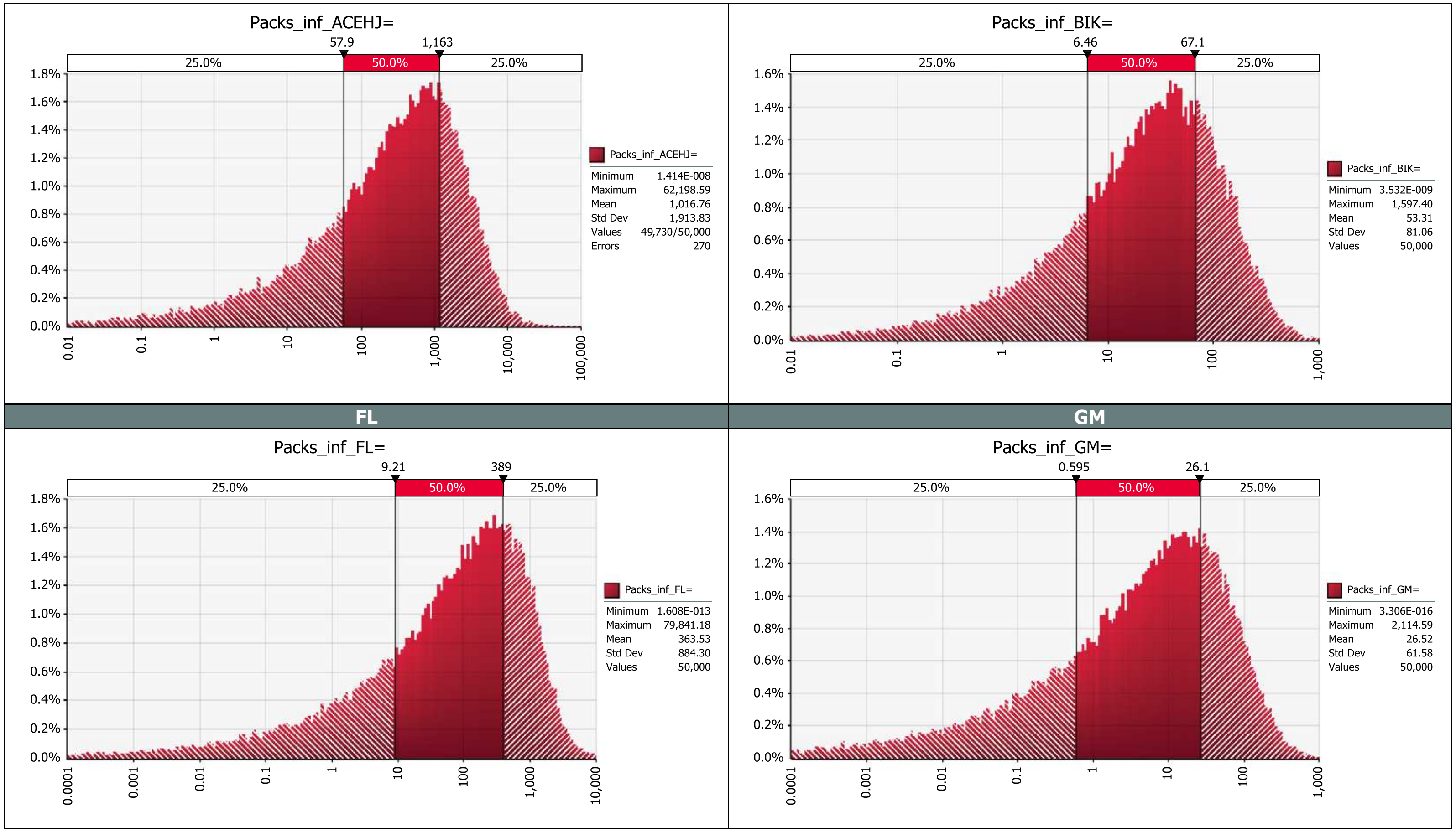


Figure D.10: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A0

D.3.8.2. Sensitivity Analysis (Scenario A0)

Table D.21: Sensitivity Analysis (Scenario A0) for PW2

ACEHJ			
Parameter	**Std.Regr.**		**Partition**
R^2		**0.73**	**100%**
Prof_Inf_ACHJ	0.82	0.68	93%
Conv_Packs2pcs_H	−0.16	0.02	3%
Prop_Host_H	0.14	0.02	3%
Imp_H	0.07	0.00	1%
Prop_Host_J	0.04	0.00	0%
Conv_Packs2pcs_J	−0.03	0.00	0%
Conv_Packs2pcs_C	−0.03	0.00	0%
Imp_C	0.03	0.00	0%
Prop_Host_E	0.01	0.00	0%
Imp_J	0.01	0.00	0%
Imp_A	–	–	0%
Conv_Packs2pcs_E	–	–	0%
Conv_Packs2pcs_A	–	–	0%
Prop_Host_A	–	–	0%
Imp_E	–	–	0%

Table D.22: Sensitivity Analysis (Scenario A0) for PW1

BIK			
Parameter	**Std.Regr.**		**Partition**
R^2		0.82	100%
Prop_Inf_BIK	0.85	0.72	88%
Prop_Host_I	0.29	0.09	10%
Imp_H	0.11	0.01	1%
Surv_Insp_BIK	0.06	0.00	0%
Conv_Packs2pcs_I	−0.05	0.00	0%

	BIK		
Parameter	**Std.Regr.**		**Partition**
Imp_A	0.01	0.00	0%
Conv_Packs2pcs_B	–	–	0%
Imp_J	–	–	0%

Table D.23: Sensitivity analysis (Scenario A0) for PW4

	FL		
Parameter	**Std.Regr.**		**Partition**
R^2		0.54	100%
Prop_Inf_DEFL	0.67	0.44	83%
Prop_Host_F	0.28	0.08	14%
Conv_pcs2kg_F	−0.09	0.01	1%
Conv_Packs2pcs_L	−0.06	0.00	1%
Imp_F	0.04	0.00	0%
Prop_Host_L	0.03	0.00	0%
Imp_J	0.02	0.00	0%

Table D.24: Sensitivity analysis (Scenario A0) for PW3

	GM		
Parameter	**Std.Regr.**		**Partition**
R^2		0.55	100%
P_Inf_GM	0.70	0.50	90%
Conv_pcs2kg_F	−0.16	0.02	4%
Prop_Host_M	0.11	0.01	2%
Prop_Host_G	0.09	0.01	2%
Imp_F	0.08	0.01	1%
Conv_Packs2pcs_M	−0.05	0.00	0%
Surv_Insp_GM	0.04	0.00	0%
Imp_J	–	–	0%

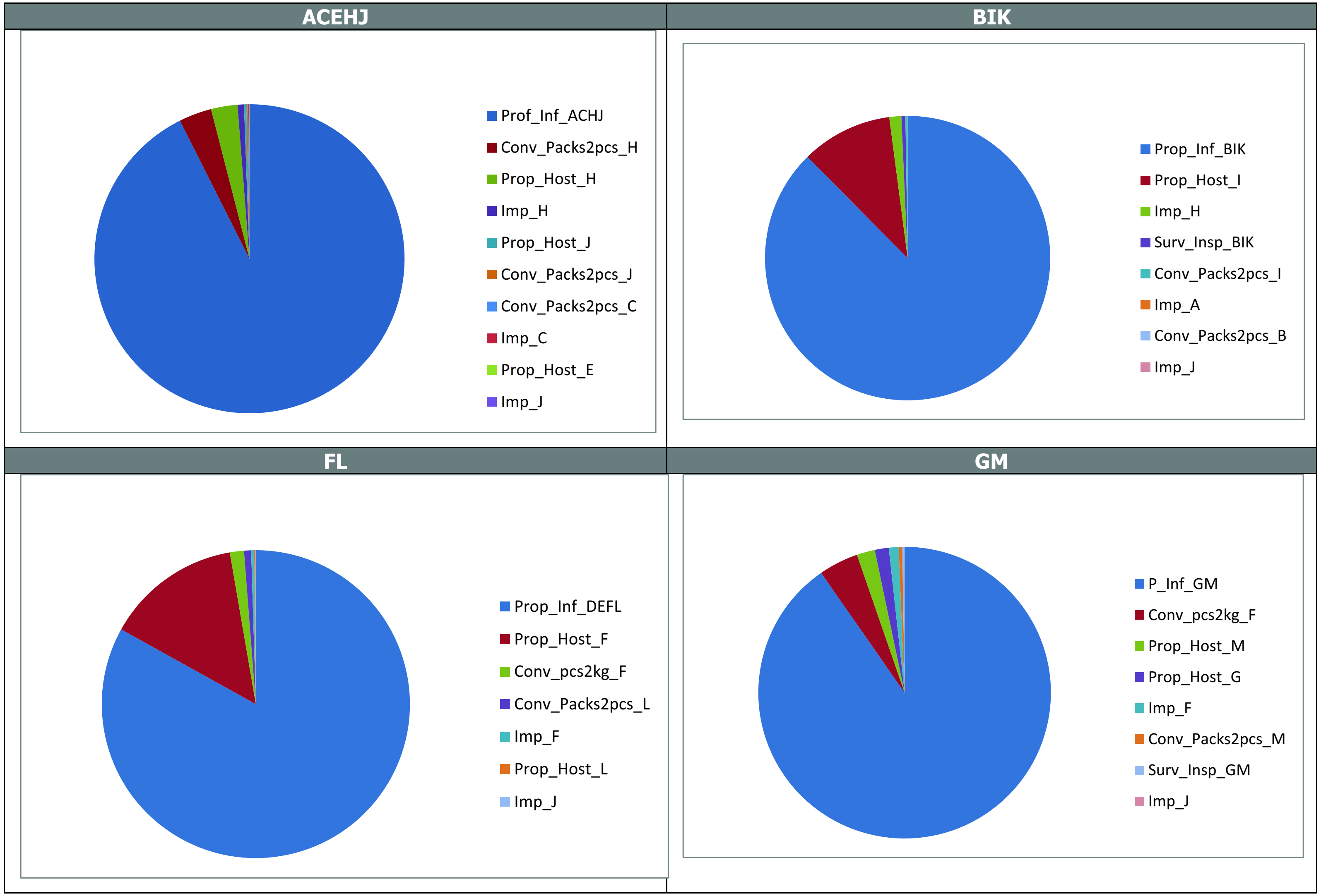


Figure D.11: Sensitivity analysis (Scenario A0) for PW1, PW2, PW3 and PW4

D.3.8.3. Scenario A1

Table D.25: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A1

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Infested packages entering EU (Packs_Inf) [–] (calculated)				
Scenario A1				
1st percentile	0	0	0	0
5th percentile	1	0	0	0
10th percentile	7	1	1	0
16.7th percentile	22	4	3	0
25th percentile	58	9	9	1
33rd percentile	117	19	23	2
50th percentile	333	54	87	7
67th percentile	783	124	242	20
75th percentile	1,163	184	389	33
83.3rd percentile	1,813	284	648	57
90th percentile	2,724	419	994	91
95th percentile	4,245	643	1,553	150
99th percentile	8,783	1,270	3,407	336
Mean	1,017	154	364	33
Standard deviation	1,914	270	884	81

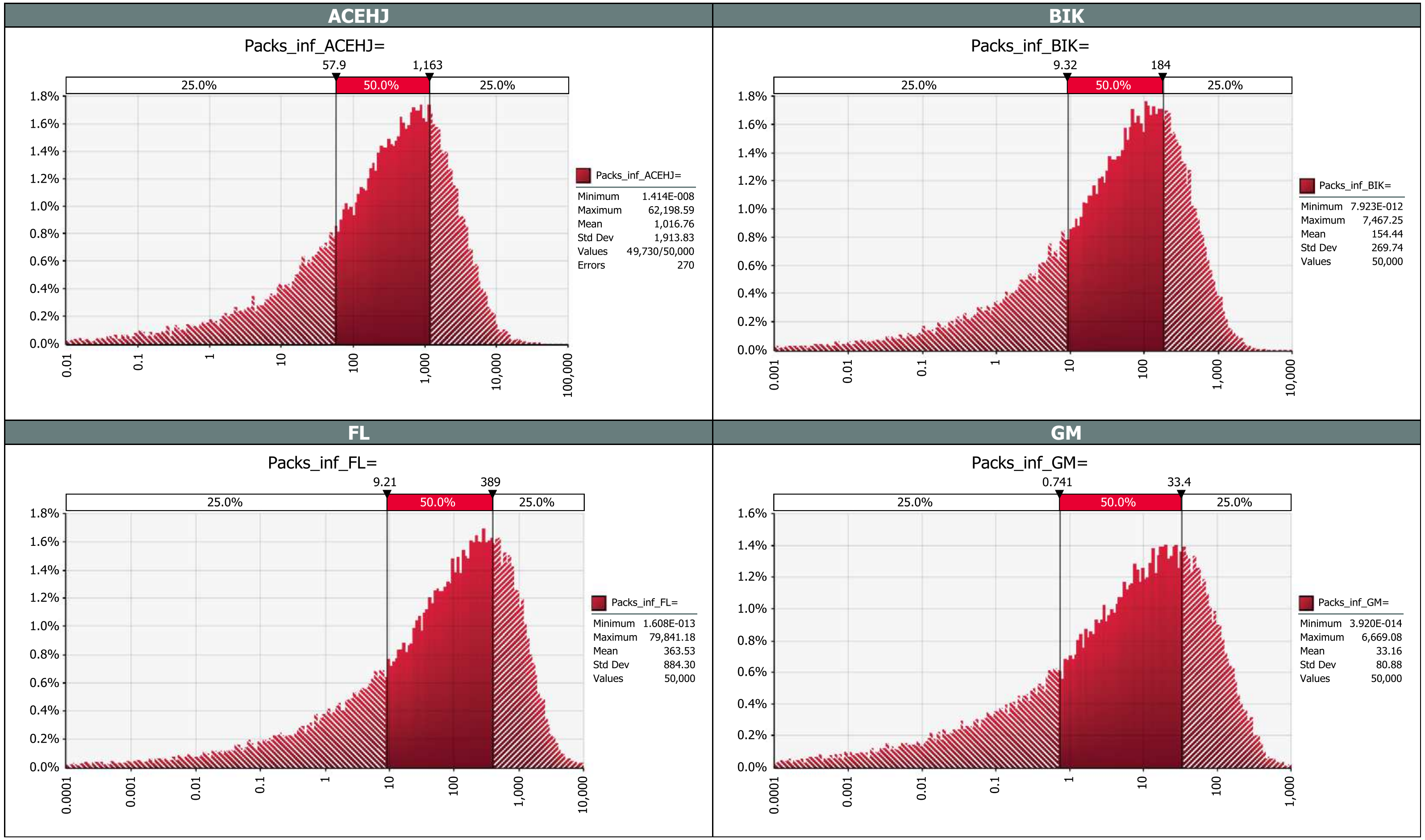


Figure D.12: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A1

D.3.8.4. Scenario A2

Table D.26: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A2

Pathway name	ACEHJ	BIK	FL	GM
Pathway no	**2**	**1**	**4**	**3**
Infested packages entering EU (Packs_Inf) [–] (calculated)				
Scenario A2				
1st percentile	0	0	0	0
5th percentile	1	0	0	0
10th percentile	4	1	0	0
16.7th percentile	10	2	1	0
25th percentile	19	3	4	0
33rd percentile	33	5	11	1
50th percentile	74	12	40	3
67th percentile	149	24	115	9
75th percentile	210	33	186	15
83.3rd percentile	314	49	309	27
90th percentile	457	71	482	43
95th percentile	676	105	779	74
99th percentile	1,343	208	1,784	175
Mean	176	27	181	16
Standard deviation	305	44	447	40

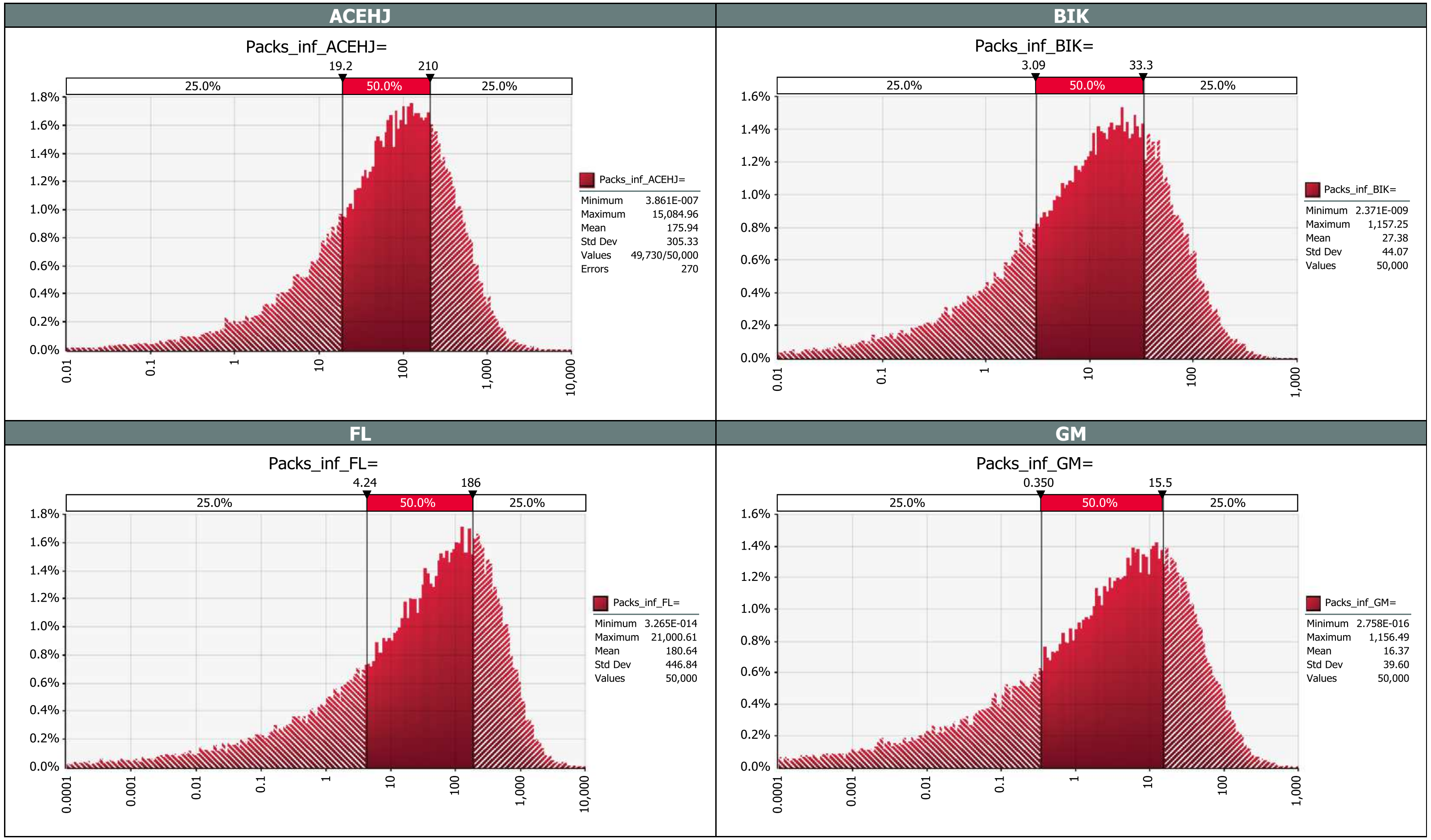


Figure D.13: Infested packages entering EU (Packs_Inf) by pathway (N1) for scenario A2

D.3.8.5. Comparison figures: Cumulative Distribution Functions (CDF)

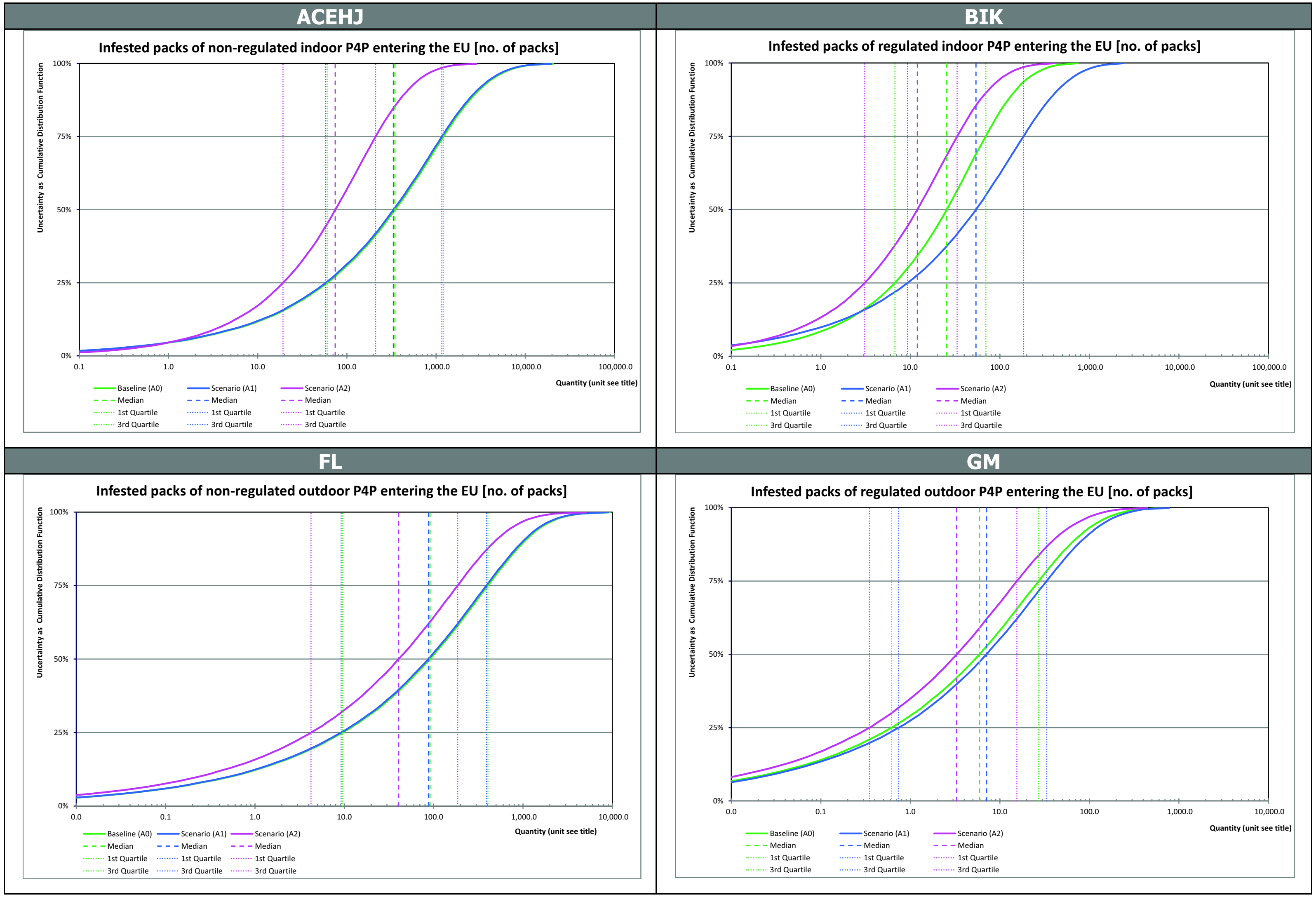


Figure D.14: Comparison figures: Cumulative Distribution Functions (CDF)

D.3.8.6. Comparison figures: Probability Density Function (PDF)

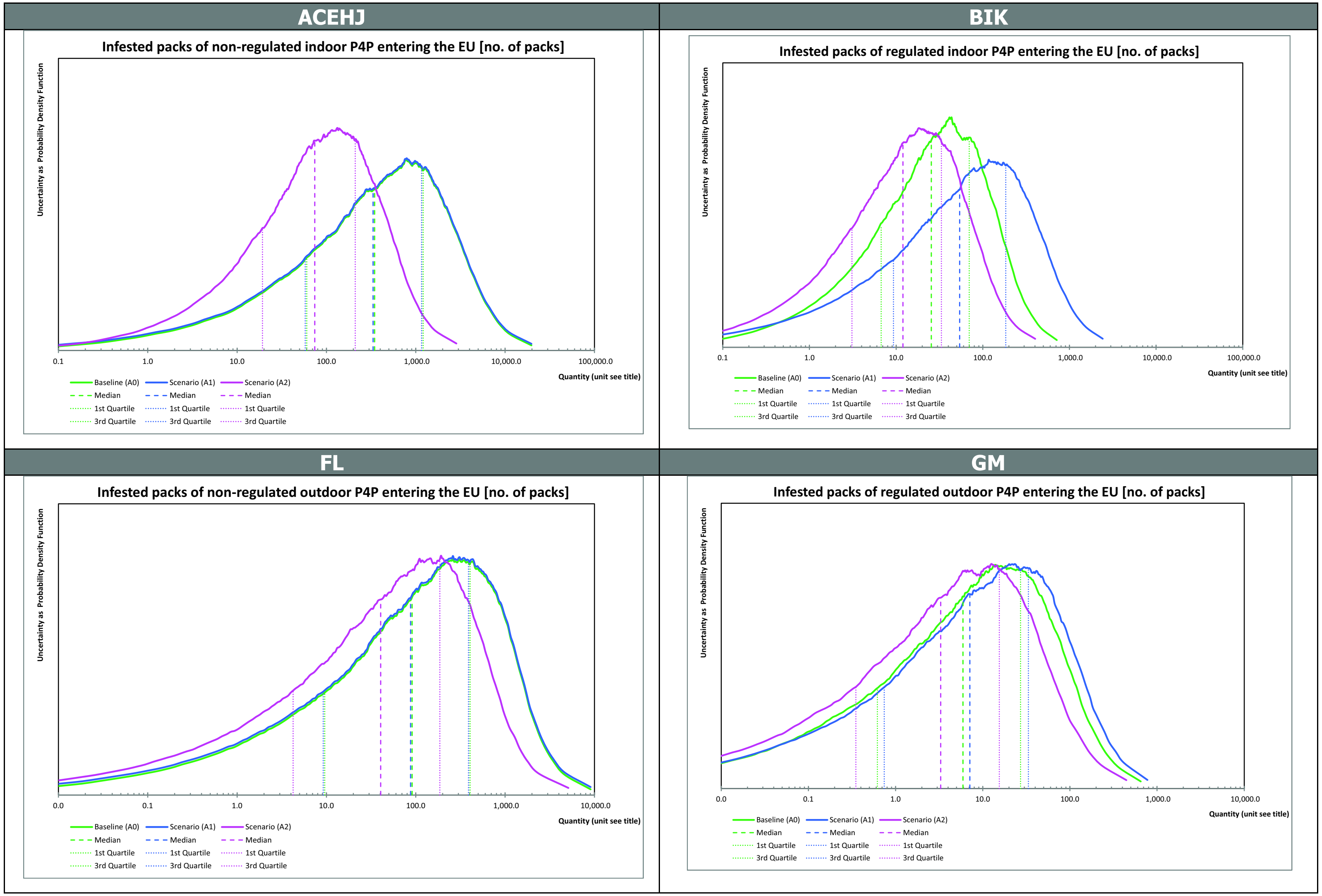


Figure D.15: Comparison figures: Probability Density Function (PDF)

D.3.8.7. Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

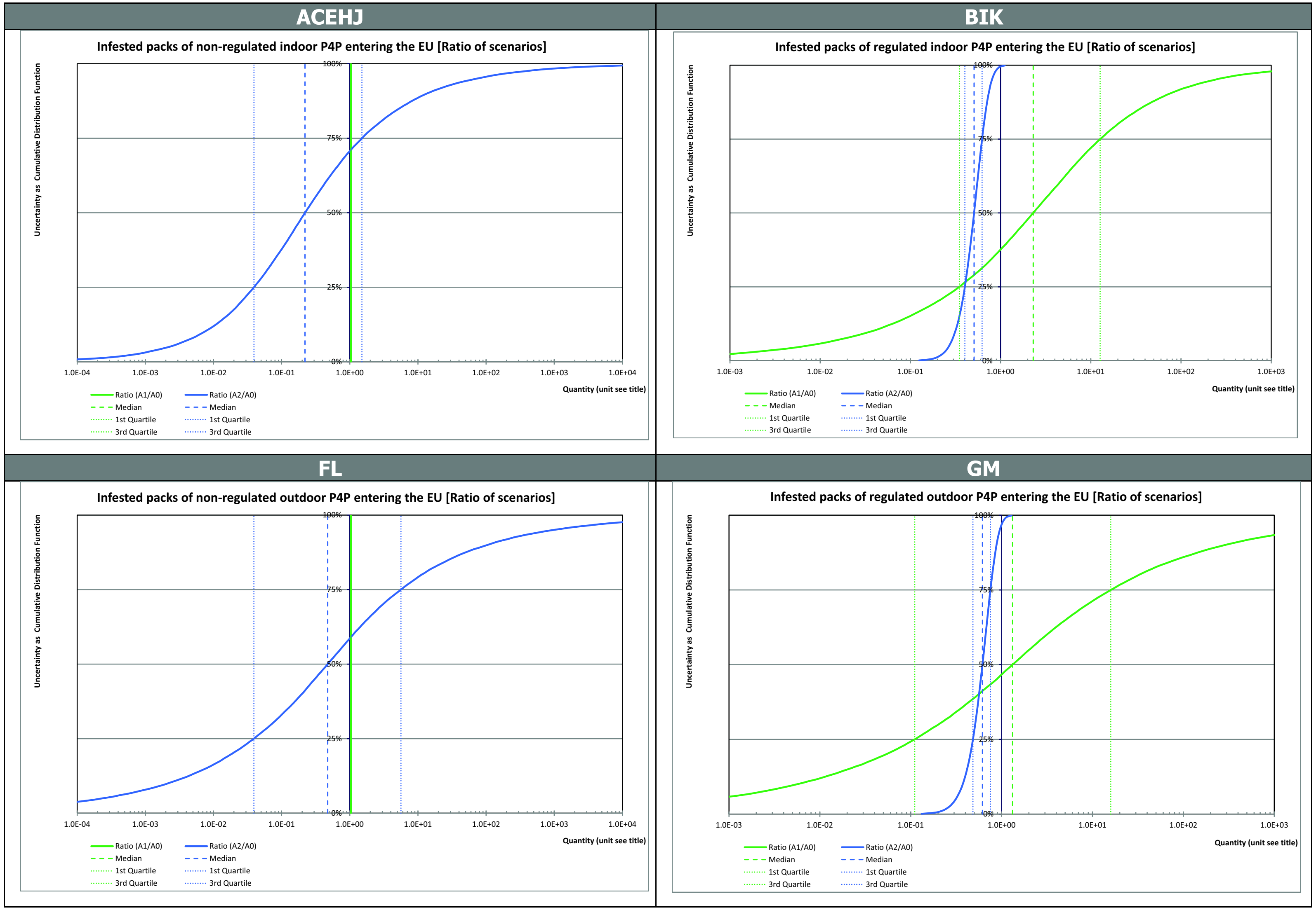


Figure D.16: Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

D.3.8.8. Comparison figures: Probability Density Functions of the Ratio (PDF-R)

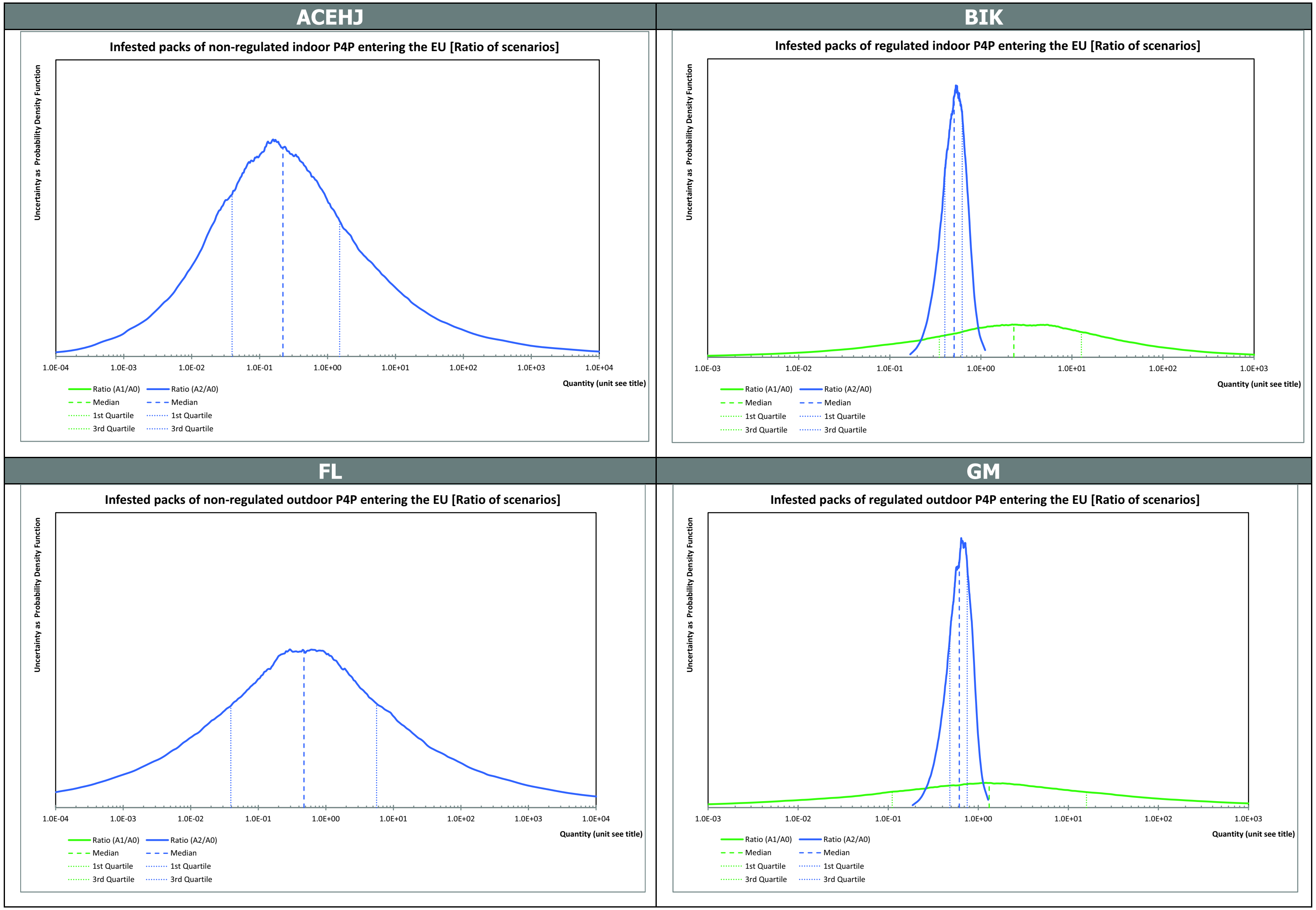


Figure D.17: Comparison figures: Probability Density Functions of the Ratio (PDF-R)

D.4. Establishment model

Table D.27: Parameter of the establishment model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path = A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model	
N1	Packs_Inf_Path	Infested packages entering EU [–] by pathway	Calculated by Monte Carlo simulation
b1	Prop_P4P_Path	Proportion of packs used as plants for planting [%]	Dutch trade inspection data (NL-NPPO, 2017)
b2	Prop_Est_Path	Proportion of individual plants establishing a founder population ()	Expert Knowledge Elicitation
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [–] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
N2_GH	Est_GH_p, Est_GH_Path	Established greenhouses [–] by pathway	Calculated by Monte Carlo simulation
N2_Plants	Est_Plants_p, Est_Plants_Path	Established populations at consumer level (incl. plants finally produced) [–] by pathway	Calculated by Monte Carlo simulation
	Plants_Cons_Path	Established populations at consumer level from finally produced plants (see impact)	Calculated by Monte Carlo simulation

D.4.1. Equation

The Establishment model calculates the number of greenhouses with established founder populations in the EU, and the number of individual plants with established founder populations at consumer level (including plants finally produced) for different pathways N = 1, 2, 3, 4.

$$\mathrm{Est}_{\mathrm{GH,\ p}} = \sum\nolimits_{\mathrm{Path\_p}} \mathrm{Est}_{\mathrm{GH,\ Path}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Packs}_{\mathrm{Inf,\ Path}} \times \mathrm{Prop}_{\mathrm{P4P,\ Path}} \times \mathrm{Prop}_{\mathrm{Est,\ Path}}\right]$$

$$\mathrm{Est}_{\mathrm{Plants,\ p}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Est}_{\mathrm{Plants,\ Path}} + \mathrm{Plants}_{\mathrm{Cons,\ Path}}\right] = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{Packs}_{\mathrm{Inf,\ Path}} \times \left(1 - \mathrm{Prop}_{\mathrm{P4P,\ Path}}\right) \times \mathrm{Prop}_{\mathrm{Est,\ Path}} \times \mathrm{Conv}_{\mathrm{Packs2pcs,\ Path}} + \mathrm{Plants}_{\mathrm{Cons,\ Path}}\right]$$

The Establishment model distinguishes the use of the infested packs (Packs_inf) for further propagation or direct transfer to the consumer.

The number of infested packs (Packs_inf) is multiplied by the proportion for use for further propagation (1st step), and the proportion of infested packs (2nd step). It is assumed that infestation is seldom, and a single infested pack has the potential to infest a greenhouse. Therefore, each infested pack, which will establish a founder population and is used for further propagation, will cause the infestation of a total greenhouse. (Est_GH).

The remaining part of the planting material will be distributed to the consumer. The number of packs is multiplied by the number of plants per pack, because at consumer level each plant has the potential to establish a founder population.

Finally, the total number of established plants (Est_plant) is calculated by summing the direct transfer to the consumer and the indirect via infested plants after propagation (see impact for Plants_Cons).

D.4.2. Proportion of packs used as plants for planting (Prop_P4P) (b1)

The average proportion of host plants for further propagation in greenhouses were calculated from the information provided in the Dutch trade inspection Database (NL-NPPO, 2017) using the CN10 classification and the list of host plants. Outdoor pathways (3,4) are set to zero.

Table D.28: Proportion of packs used as plants for planting

Pathway name	**A**	**B**	**C**	**E**	**F**	**G**	**H**	**I**	**J**	**L**	**M**
Pathway no	**2**	**1**	**2**	**2**	**4**	**3**	**2**	**1**	**2**	**4**	**3**
Proportion of packs used as plants for planting (Prop_P4P) [%] (Dutch Import Control Database)											
All scenarios											
2010	100%	100%	97%	99%			89%	99%	36%		
2012	93%	100%	100%	78%			94%	100%	82%		
2013	97%	100%	100%	0%			97%	100%	96%		
1014	96%	100%	71%	34%			97%	100%	100%		
Fitted distributions (Prop_P4P)											
1st percentile	85.772%	99.279%	92.000%	0.007%			80.697%	97.611%	6.656%		
25th percentile	95.771%	99.849%	98.857%	14.476%			92.833%	99.633%	66.915%		
50th percentile	97.423%	99.920%	99.483%	57.082%	0.00%	0.00%	95.217%	99.829%	90.951%	0.00%	0.00%
75th percentile	98.429%	99.958%	99.766%	92.145%			96.809%	99.920%	98.941%		
99th percentile	99.533%	99.991%	99.967%	99.999%			98.815%	99.988%	100.000%		
Distribution type	1-LogNormal	1-LogNormal	1-LogNormal	Beta General	Constant	Constant	1-LogNormal	1-LogNormal	Beta General	Constant	Constant
1st parameter	3.38%	0.13%	1.03%		0%	0%	5.73%		0.33%	0%	0%
2nd parameter	2.85%	0.15%	1.79%				3.77%		0.53%		

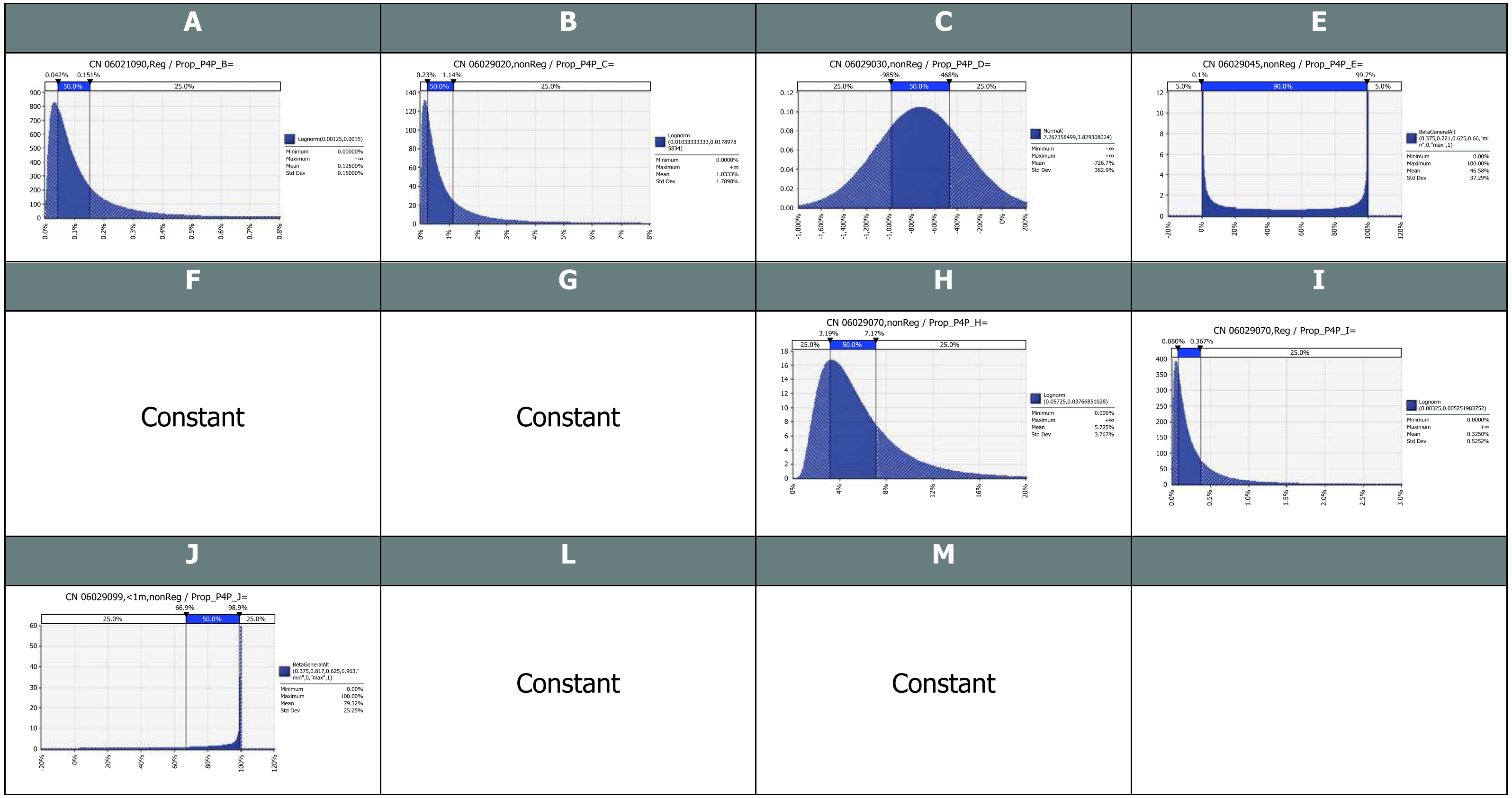


Figure D.18: Proportion of packs used as plants for planting

D.4.3. Proportion of individual plants establishing a founder population (Prop_Est) (b2)

The proportion of infested plants, which will establish a founder population, was elicited for indoor and outdoor conditions.

Table D.29: Proportion of individual plants establishing a founder population

Pathway name	**ABCEHIJ**	**FGLM**
Pathway no	**1,2**	**3,4**
Proportion of individual plants establishing a founder population (Prop_Est) [%] (by expert elicitation)		
All scenarios		
1st percentile		10%
25th percentile		40%
50th percentile	100%	60%
75th percentile		70%
99th percentile		100%
Fitted distributions (Prop_Est)		
1st percentile		11.697%
25th percentile		41.476%
50th percentile	100%	57.329%
75th percentile		72.191%
99th percentile		94.560%
Distribution type	Constant	BetaGeneral
1st parameter	100%	2.7935
2nd parameter		2.1592

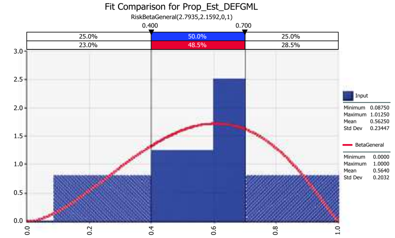
ABCEHIJ	FGLM
Constant	

Figure D.19: Proportion of individual plants establishing a founder population

D.4.4. Established greenhouses (GH_est) by pathway (N2_GH)

D.4.4.1. Scenario A0

Table D.30: Established greenhouses (GH_est) by pathway for scenario A0

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Established greenhouses (GH_est) by pathway [–] (calculated)				
Scenario A0				
1st percentile	0.03	0.03	0.00	0.00
5th percentile	1.14	0.40	0.00	0.00
10th percentile	5.98	1.29	0.00	0.00
16.7th percentile	20.16	3.14	0.00	0.00
25th percentile	53.20	6.44	0.00	0.00
33rd percentile	107.37	10.86	0.00	0.00
50th percentile	305.22	24.42	0.00	0.00
67th percentile	718.66	47.34	0.00	0.00
75th percentile	1,070.37	66.89	0.00	0.00
83.3rd percentile	1,664.20	96.86	0.00	0.00
90th percentile	2,509.40	138.12	0.00	0.00
95th percentile	3,907.45	201.35	0.00	0.00
99th percentile	8,137.29	380.05	0.00	0.00
Mean	937.79	53.15	0.00	0.00
Standard deviation	1,775.83	80.83	0.00	0.00

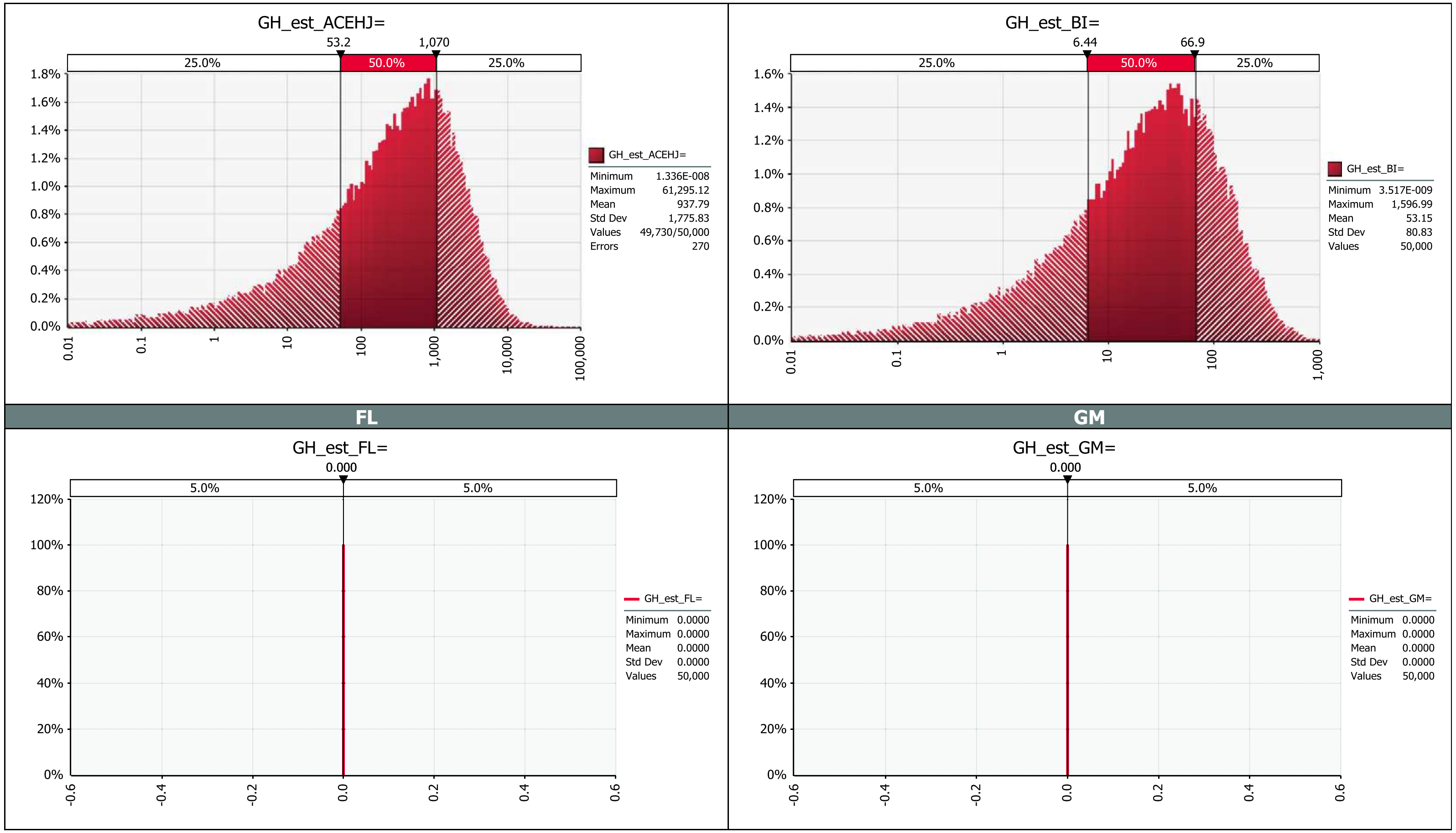


Figure D.20: Established greenhouses (GH_est) by pathway for scenario A0

D.4.4.2. Sensitivity Analysis (Scenario A0)

Table D.31: Sensitivity Analysis (Scenario A0) for PW2

ACEHJ			
Parameter	**Std.Regr.**		**Partition**
R^2		0.72	100%
Prof_Inf_ACHJ	0.82	0.67	92%
Conv_Packs2pcs_H	–0.16	0.03	4%
Prop_Host_H	0.15	0.02	3%
Imp_H	0.07	0.01	1%
Prop_Host_J	0.04	0.00	0%
Conv_Packs2pcs_C	–0.03	0.00	0%
Imp_C	0.03	0.00	0%
Conv_Packs2pcs_J	–0.02	0.00	0%
Prop_P4P_J	–0.02	0.00	0%
Prop_P4P_H	–0.01	0.00	0%
Prop_Host_E	0.01	0.00	0%
Imp_J	0.01	0.00	0%
Imp_A	–	–	0%
Prop_P4P_E	–	–	0%
Prop_P4P_C	–	–	0%
Prop_P4P_A	–	–	0%
Conv_Packs2pcs_E	–	–	0%
Conv_Packs2pcs_A	–	–	0%
Prop_Host_A	–	–	0%
Imp_E	–	–	0%

Table D.32: Sensitivity Analysis (Scenario A0) for PW1

	BIK		
Parameter	**Std.Regr.**		**Partition**
R^2		0.82	100%
Prop_Inf_BIK	0.85	0.72	88%
Prop_Host_I	0.29	0.09	10%
Imp_H	0.11	0.01	1%
Surv_Insp_BIK	0.06	0.00	0%
Conv_Packs2pcs_I	−0.05	0.00	0%
Imp_A	0.01	0.00	0%
Conv_Packs2pcs_B	–	–	0%
Prop_P4P_I	–	–	0%
Prop_P4P_B	–	–	0%

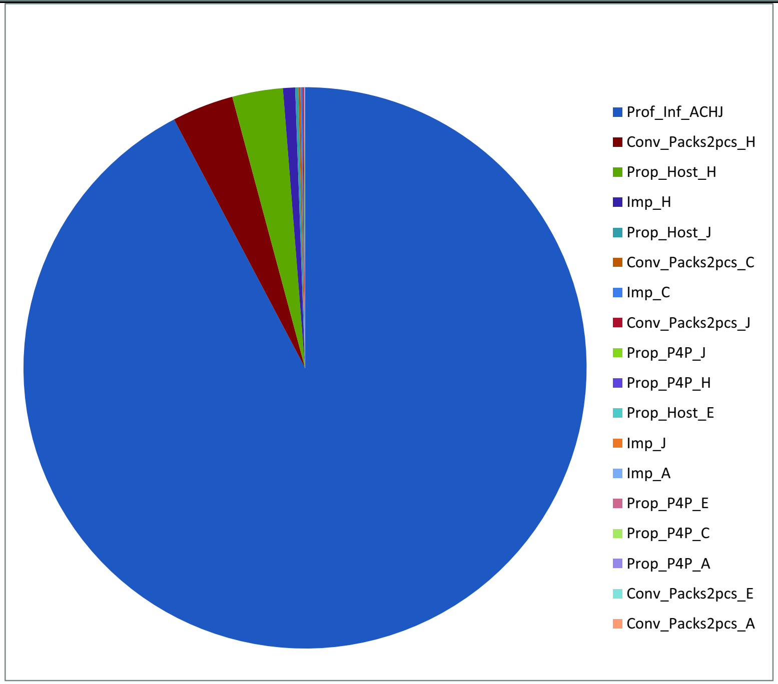
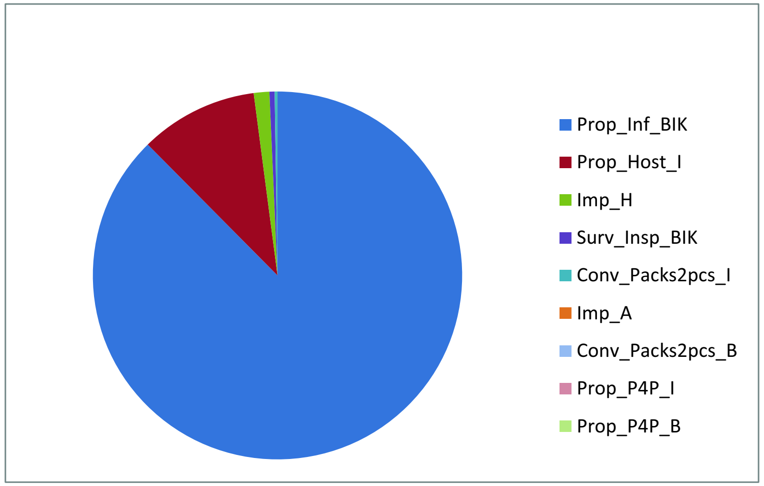
ACEHJ	BIK
	

Figure D.21: Sensitivity Analysis (Scenario A0) for PW1 and PW2

D.4.4.3. Scenario A1

Table D.33: Established greenhouses (GH_est) by pathway for scenario A1

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Established greenhouses (GH_est) by pathway [–] (calculated)				
Scenario A0				
1st percentile	0.03	0.00	0.00	0.00
5th percentile	1.14	0.20	0.00	0.00
10th percentile	5.98	1.03	0.00	0.00
16.7th percentile	20.16	3.50	0.00	0.00
25th percentile	53.20	9.29	0.00	0.00
33rd percentile	107.37	18.82	0.00	0.00
50th percentile	305.22	53.93	0.00	0.00
67th percentile	718.66	123.76	0.00	0.00
75th percentile	1,070.37	183.50	0.00	0.00
83.3rd percentile	1,664.20	282.79	0.00	0.00
90th percentile	2,509.40	417.67	0.00	0.00
95th percentile	3,907.45	640.89	0.00	0.00
99th percentile	8,137.29	1,264.84	0.00	0.00
Mean	937.79	153.96	0.00	0.00
Standard deviation	1,775.83	268.90	0.00	0.00

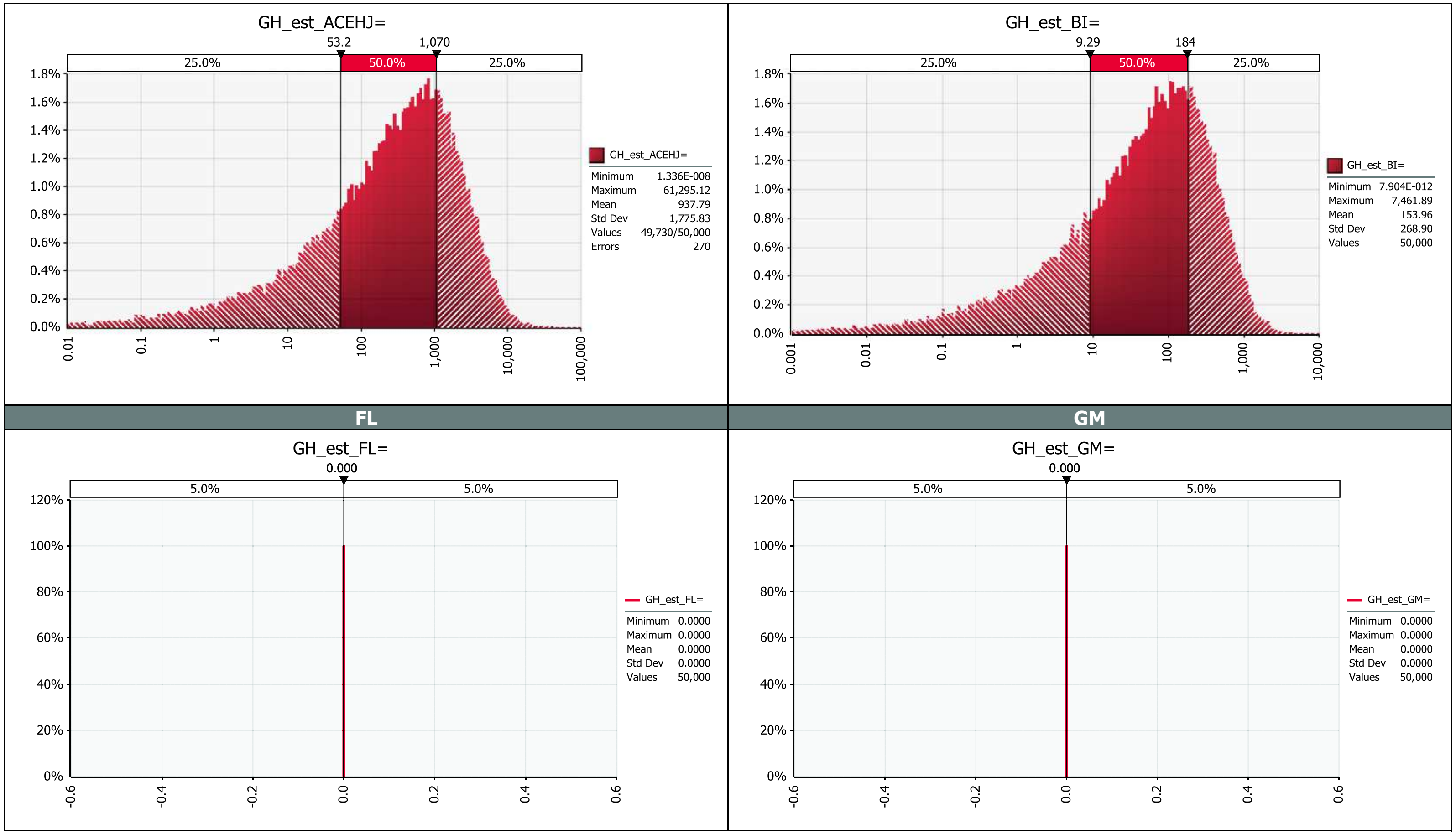


Figure D.22: Established greenhouses (GH_est) by pathway for scenario A1

D.4.4.4. Scenario A2

Table D.34: Established greenhouses (GH_est) by pathway for scenario A2

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no:	**2**	**1**	**4**	**3**
Established greenhouses (GH_est) by pathway [–] (calculated)				
Scenario A2				
1st percentile	0.07	0.01	0.00	0.00
5th percentile	1.07	0.19	0.00	0.00
10th percentile	3.55	0.61	0.00	0.00
16.7th percentile	8.75	1.51	0.00	0.00
25th percentile	17.59	3.09	0.00	0.00
33rd percentile	30.27	5.24	0.00	0.00
50th percentile	67.94	11.96	0.00	0.00
67th percentile	136.75	23.62	0.00	0.00
75th percentile	193.13	33.20	0.00	0.00
83.3rd percentile	288.95	48.80	0.00	0.00
90th percentile	419.77	70.62	0.00	0.00
95th percentile	624.20	104.50	0.00	0.00
99th percentile	1,251.73	207.63	0.00	0.00
Mean	162.25	27.30	0.00	0.00
Standard deviation	285.23	43.94	0.00	0.00

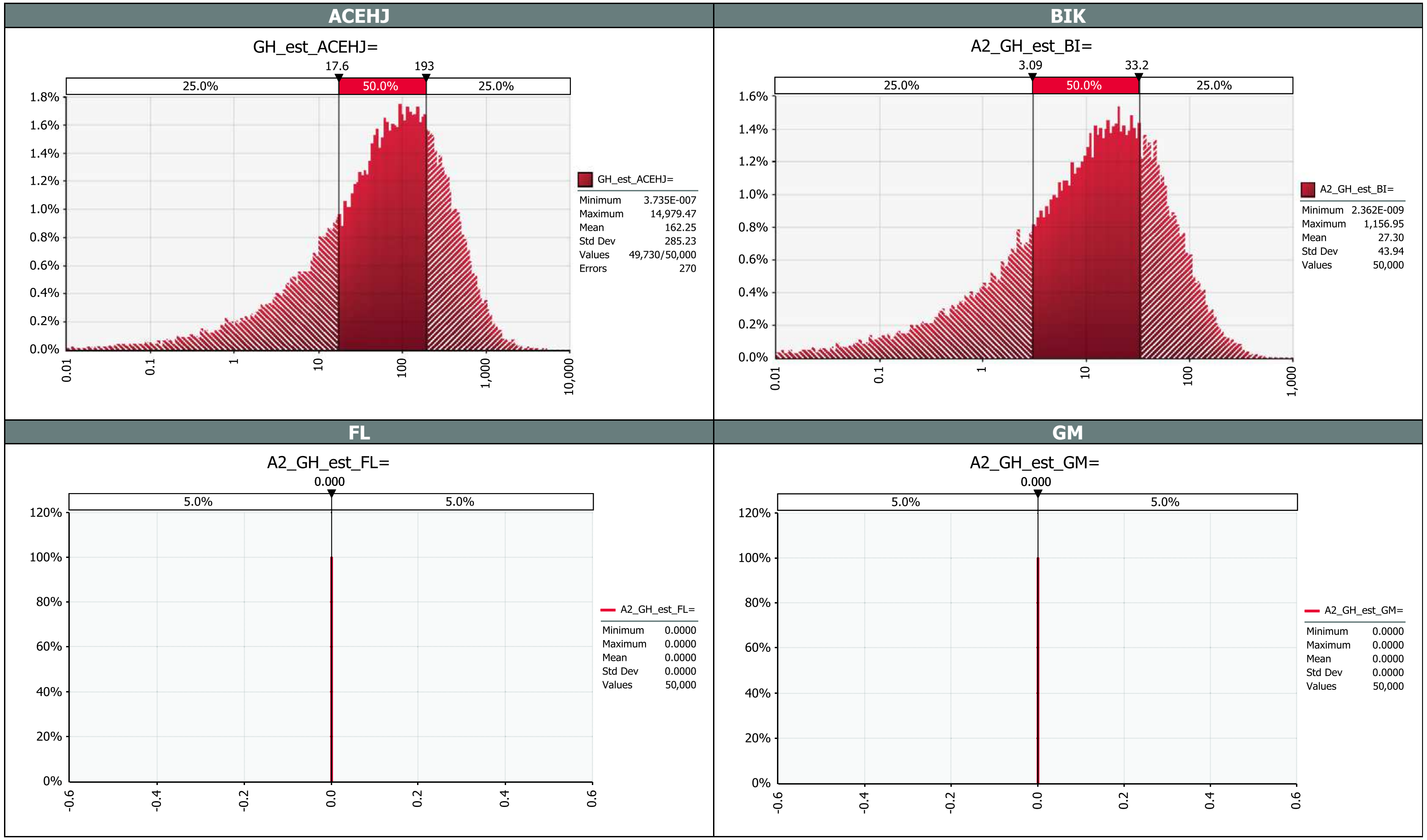


Figure D.23: Established greenhouses (GH_est) by pathway for scenario A2

D.4.4.5. Comparison figures: Cumulative Distribution Functions (CDF)

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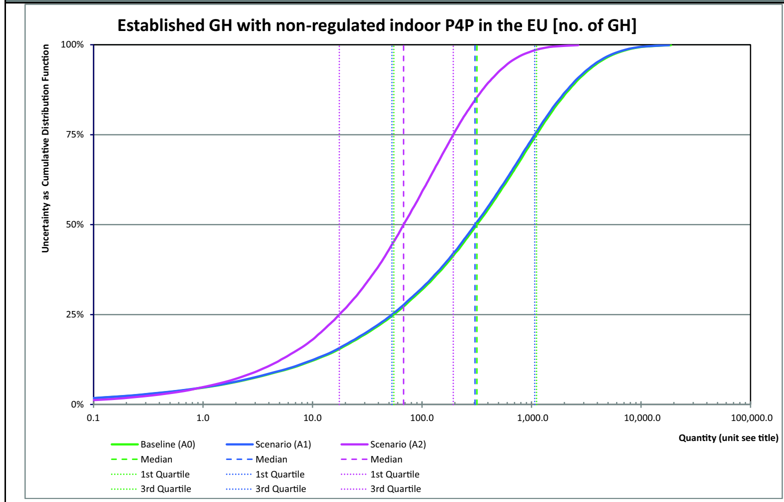
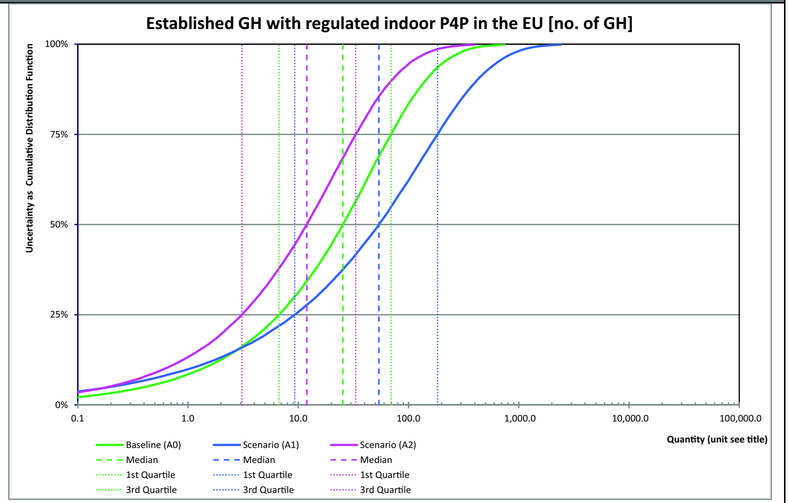
<tr><td>
</td><td>
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Figure D.24: Comparison figures: Cumulative Distribution Functions (CDF)

D.4.4.6. Comparison figures: Probability Density Function (PDF)

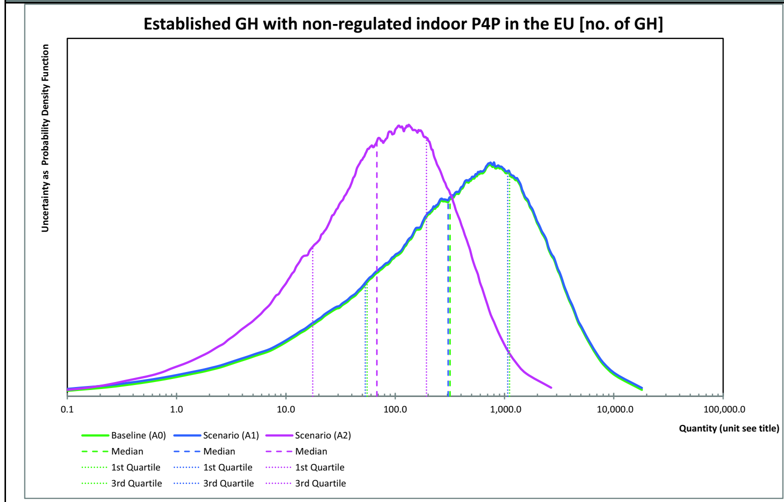
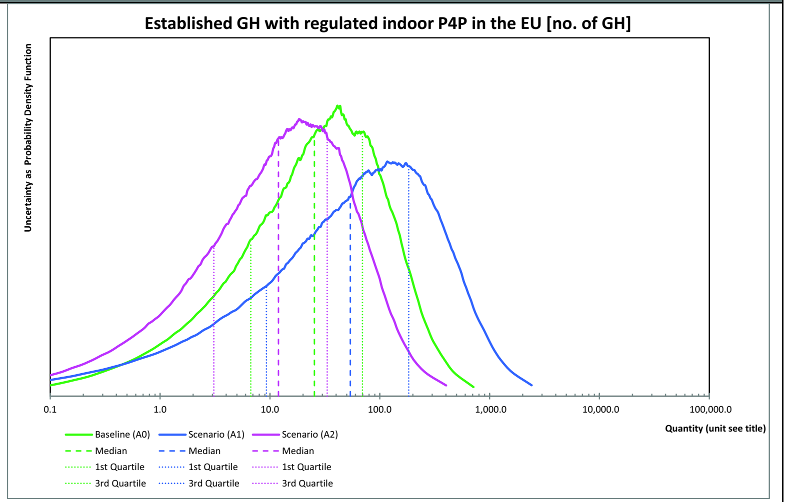
ACEHJ	BIK
	
FL	**GM**

Figure D.25: Comparison figures: Probability Density Function (PDF)

D.4.4.7. Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

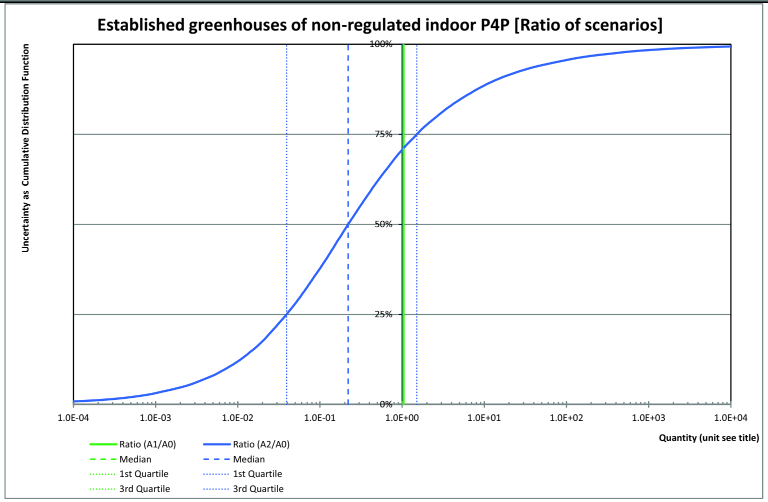
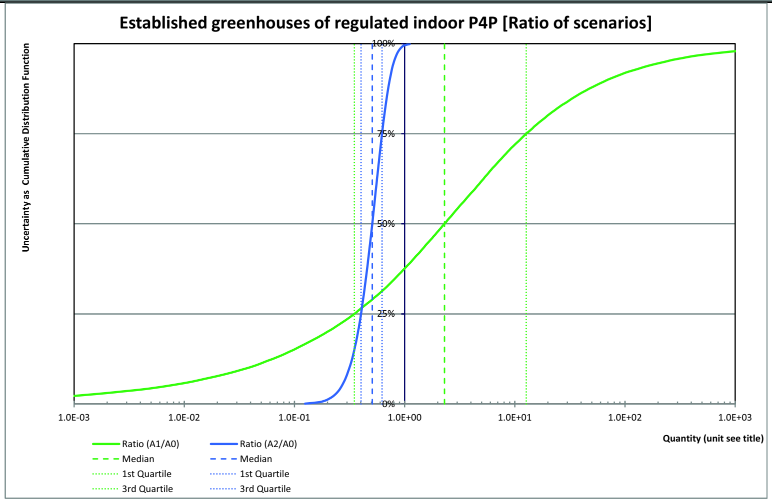
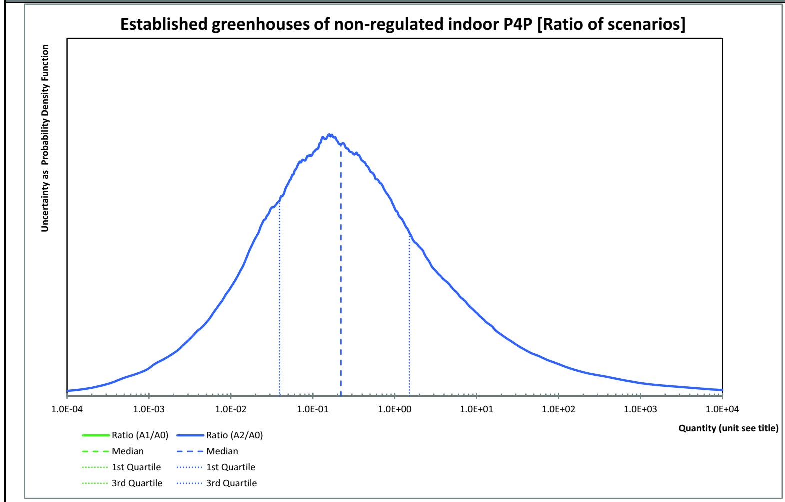
ACEHJ	BIK
	
FL	**GM**

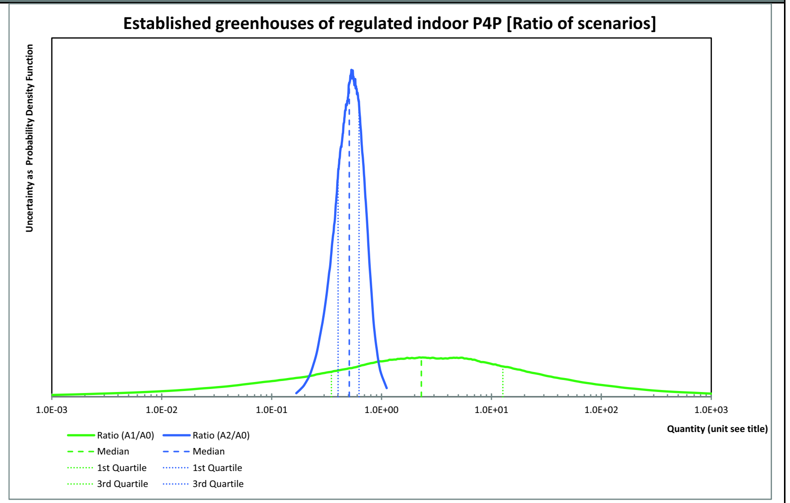
Figure D.26: Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

D.4.4.8. Comparison figures: Probability Density Functions of the Ratio (PDF-R)

ACEHJ



BIK



FL

GM

Figure D.27: Comparison figures: Probability Density Functions of the Ratio (PDF-R)

D.4.5. Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway (N2_Plants)

D.4.5.1. Scenario A0

Table D.35: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A0

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway [–] (calculated)				
Scenario A0				
1st percentile	11	58	8	0
5th percentile	467	834	100	0
10th percentile	2,428	2,727	311	0
16.7th percentile	8,322	6,706	781	1
25th percentile	21,755	13,941	1,715	5
33rd percentile	44,029	24,024	3,148	12
50th percentile	128,821	56,758	8,286	46
67th percentile	304,625	119,810	19,091	137
75th percentile	466,889	176,684	28,906	233
83.3rd percentile	762,104	282,194	45,508	417
90th percentile	1,225,710	440,230	67,943	713
95th percentile	2,098,789	754,039	103,516	1,270
99th percentile	5,912,902	2,152,167	194,548	3,339
Mean	525,001	196,712	24,451	277
Standard deviation	1,600,373	618,207	44,967	748

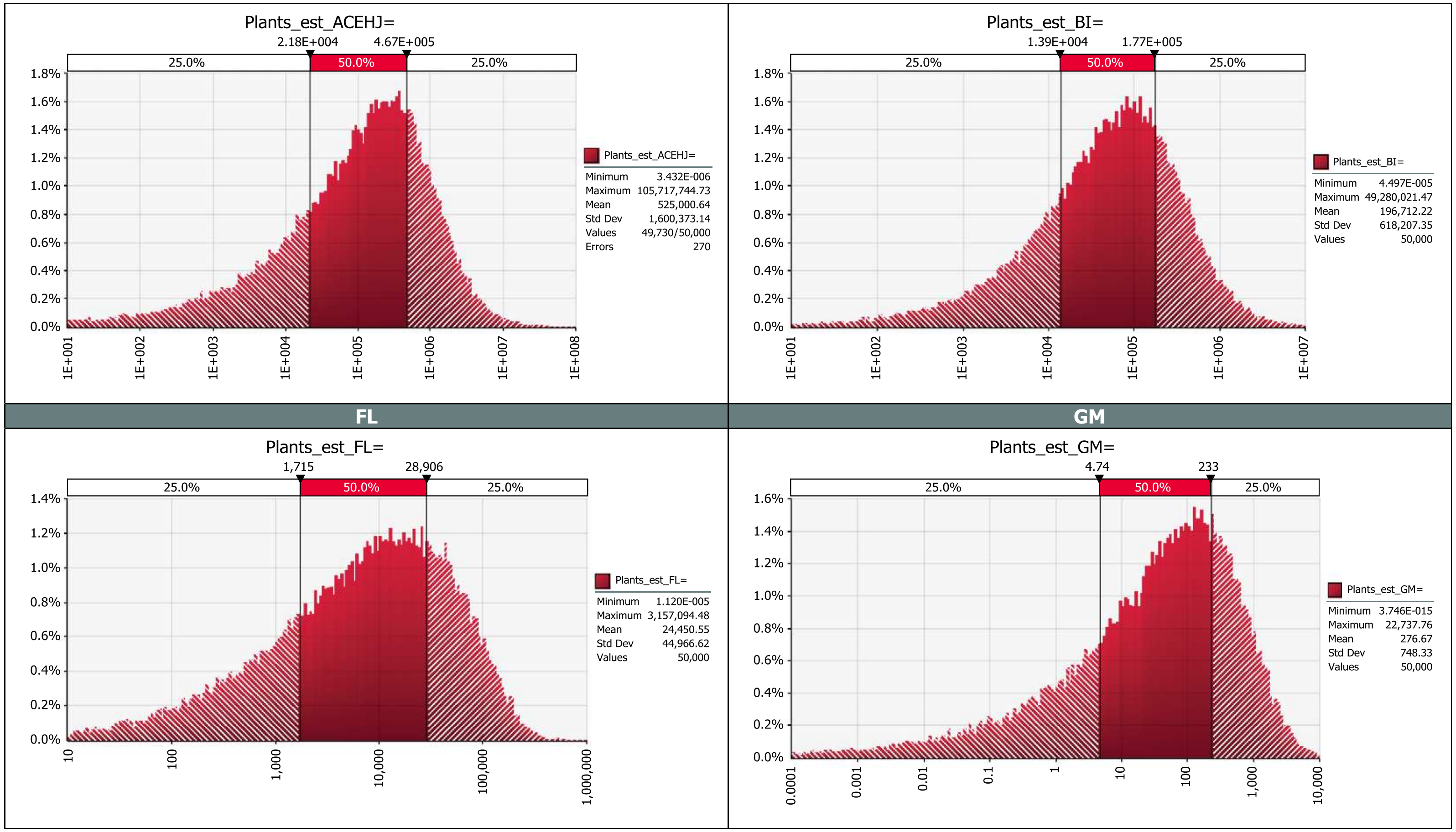


Figure D.28: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A0

D.4.5.2. Sensitivity Analysis (Scenario A0)

Table D.36: Sensitivity Analysis (Scenario A0) for PW2

	ACEHJ		
Parameter	**Std.Regr.**		**Partition**
R^2		0.38	100%
Prof_Inf_ACHJ	0.50	0.25	65%
Fakt_GHP4P_ABCHIJ	0.31	0.09	24%
Prop_GHP4P_ABCHIJK	0.14	0.02	5%
Prop_Host_H	0.10	0.01	2%
Red_all	–0.09	0.01	2%
Imp_H	0.06	0.00	1%
Prop_Host_A	0.01	0.00	0%
Imp_A	–	–	0%
Imp_J	–	–	0%
Prop_P4P_J	–	–	0%
Prop_P4P_H	–	–	0%
Prop_P4P_E	–	–	0%
Prop_P4P_C	–	–	0%
Prop_P4P_A	–	–	0%
Conv_Packs2pcs_E	–	–	0%
Conv_Packs2pcs_A	–	–	0%
Imp_E	–	–	0%
Prop_Host_E	–	–	0%
Imp_C	–	–	0%
Conv_Packs2pcs_C	–	–	0%
Conv_Packs2pcs_J	–	–	0%
Prop_Host_J	–	–	0%
Conv_Packs2pcs_H	–	–	0%

Table D.37: Sensitivity Analysis (Scenario A0) for PW1

BIK			
Parameter	**Std.Regr.**	**Partition**	
R^2		0.31	100%
Prop_Inf_BIK	0.41	0.16	52%
Fakt_GHP4P_ABCHIJ	0.30	0.09	29%
Prop_Host_I	0.15	0.02	7%
Prop_GHP4P_ABCHIJK	0.14	0.02	6%
Red_all	−0.09	0.01	2%
Surv_RRO_BGIM	0.06	0.00	1%
Imp_H	0.05	0.00	1%
Surv_Insp_BIK	0.04	0.00	0%
Surv_Cert_BGI	0.02	0.00	0%
Conv_Packs2pcs_I	–	–	0%
Conv_Packs2pcs_B	–	–	0%
Prop_P4P_I	–	–	0%
Prop_P4P_B	–	–	0%
Imp_A	–	–	0%

Table D.38: Sensitivity analysis (Scenario A0) for PW4

FL			
Parameter	**Std.Regr.**		**Partition**
R^2		0.65	100%
Prop_Inf_DEFL	0.75	0.56	87%
Prop_Est_DEFGML	0.20	0.04	6%
Prof_Inf_ACHJ	0.13	0.02	2%
Prop_Host_E	0.11	0.01	2%
Fakt_GHP4P_ABCHIJ	0.08	0.01	1%
Prop_P4P_E	−0.06	0.00	1%
Prop_Host_L	0.05	0.00	0%
Prop_GHP4P_ABCHIJK	0.04	0.00	0%

FL			
Parameter	**Std.Regr.**		**Partition**
Imp_J	0.04	0.00	0%
Red_all	–0.03	0.00	0%
Imp_E	0.03	0.00	0%
Conv_Packs2pcs_E	–0.01	0.00	0%
Conv_Packs2pcs_L	–	–	0%
Prop_Host_F	–	–	0%
Conv_pcs2kg_F	–	–	0%
Imp_F	–	–	0%

Table D.39: Sensitivity Analysis (Scenario A0) for PW3

GM			
Parameter	**Std.Regr.**		**Partition**
R^2		0.51	100%
P_Inf_GM	0.59	0.35	69%
Prop_Host_M	0.37	0.14	28%
Prop_Est_DEFGML	0.13	0.02	3%
Surv_Insp_GM	0.03	0.00	0%
Imp_J	0.02	0.00	0%
Imp_F	0.01	0.00	0%
Conv_Packs2pcs_M	–	–	0%
Prop_Host_G	–	–	0%
Conv_pcs2kg_F	–	–	0%

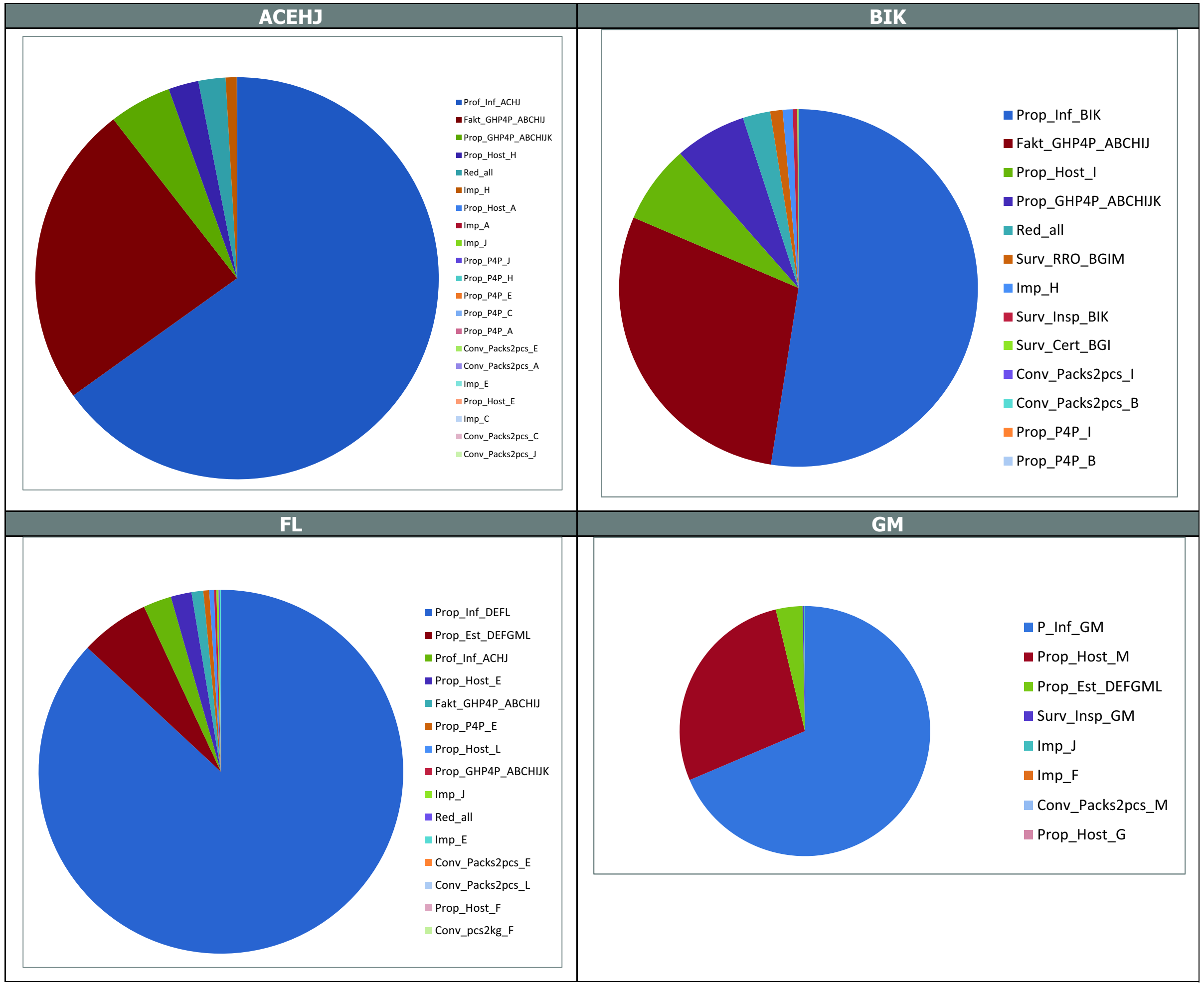


Figure D.29: Sensitivity Analysis (Scenario A0) for PW1, PW2, PW3 and PW4

D.4.5.3. Scenario A1

Table D.40: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A1

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway [–] (calculated)				
Scenario A1				
1st percentile	11	15	8	0
5th percentile	467	702	100	0
10th percentile	2,428	3,574	311	0
16.7th percentile	8,322	12,162	781	2
25th percentile	21,755	32,859	1,715	6
33rd percentile	44,029	67,226	3,148	15
50th percentile	128,821	197,034	8,286	58
67th percentile	304,625	478,257	19,091	170
75th percentile	466,889	744,243	28,906	287
83.3rd percentile	762,104	1,247,111	45,508	515
90th percentile	1,225,710	1,979,334	67,943	881
95th percentile	2,098,789	3,518,539	103,516	1,588
99th percentile	5,912,902	10,614,174	194,548	4,279
Mean	525,001	880,158	24,451	348
Standard deviation	1,600,373	2,842,342	44,967	975

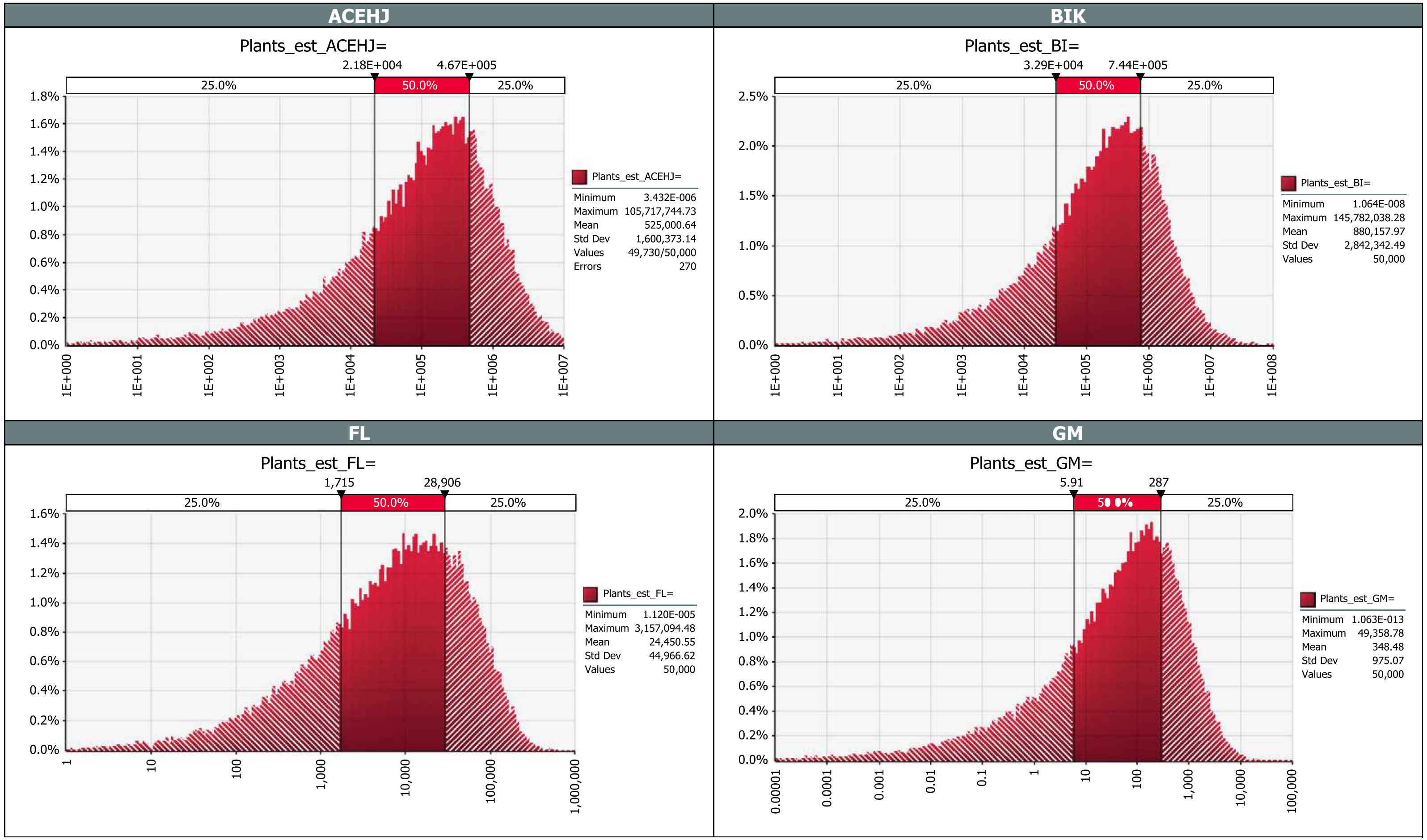


Figure D.30: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A1

D.4.5.4. Scenario A2

Table D.41: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A2

Pathway name	**ACEHJ**	**BIK**	**FL**	**GM**
Pathway no	**2**	**1**	**4**	**3**
Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway [–] (calculated)				
Scenario A2				
1st percentile	6	7	1	0
5th percentile	96	93	15	0
10th percentile	320	309	48	0
16.7th percentile	769	766	137	1
25th percentile	1,600	1,576	349	3
33rd percentile	2,753	2,752	762	7
50th percentile	6,363	6,707	2,645	27
67th percentile	13,208	14,890	7,262	81
75th percentile	18,954	22,141	11,495	138
83.3rd percentile	29,666	36,185	19,214	252
90th percentile	45,178	58,149	30,060	432
95th percentile	73,900	101,035	46,456	784
99th percentile	192,703	293,863	93,167	2,058
Mean	19,506	26,578	10,359	170
Standard deviation	57,539	99,016	19,360	469

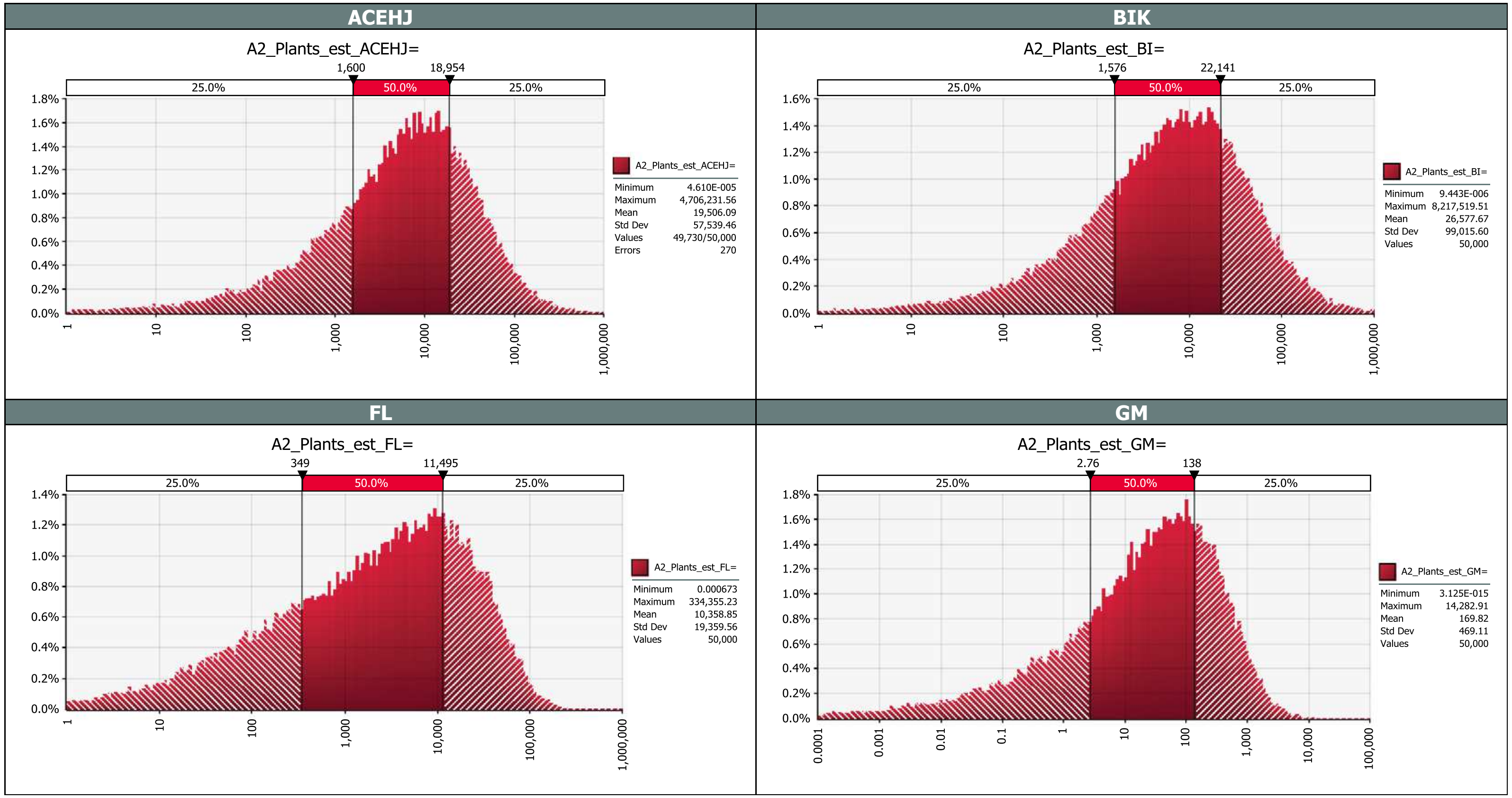


Figure D.31: Established populations at consumer level (incl. plants finally produced) (Plants_est) by pathway for scenario A2

D.4.5.5. Comparison figures: Cumulative Distribution Functions (CDF)

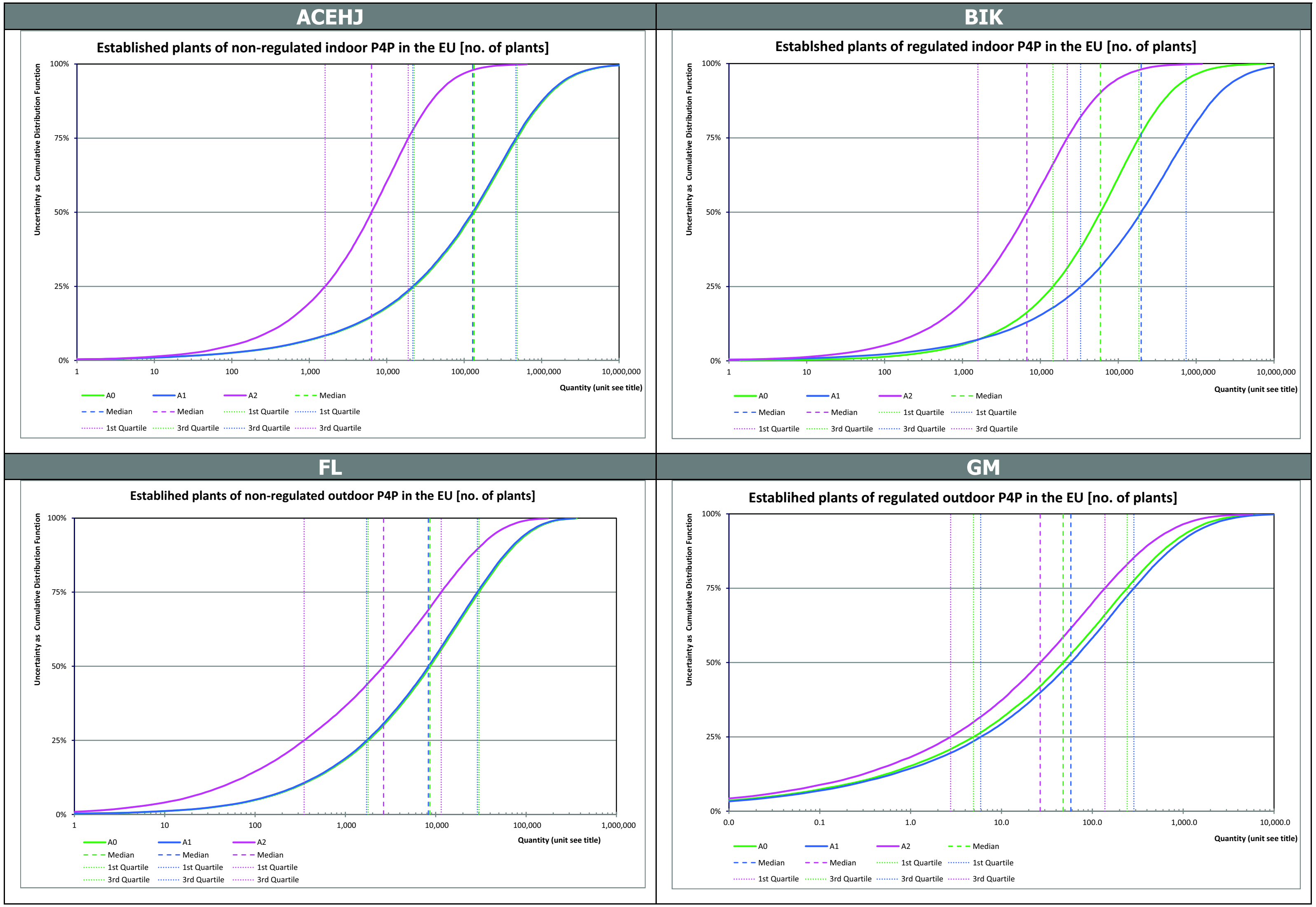


Figure D.32: Comparison figures: Cumulative Distribution Functions (CDF)

D.4.5.6. Comparison figures: Probability Density Function (PDF)

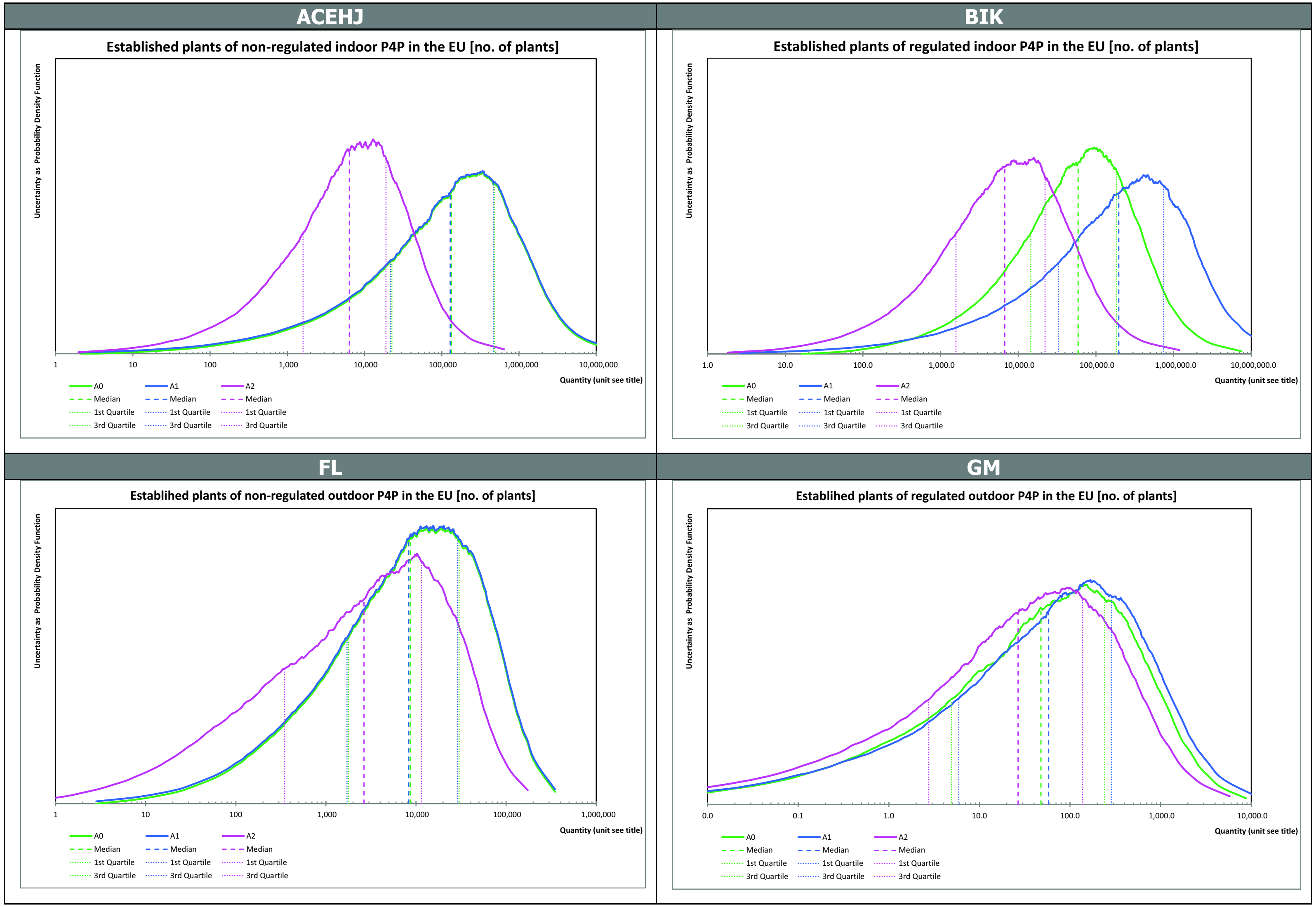


Figure D.33: Comparison figures: Probability Density Function (PDF)

D.4.5.7. Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

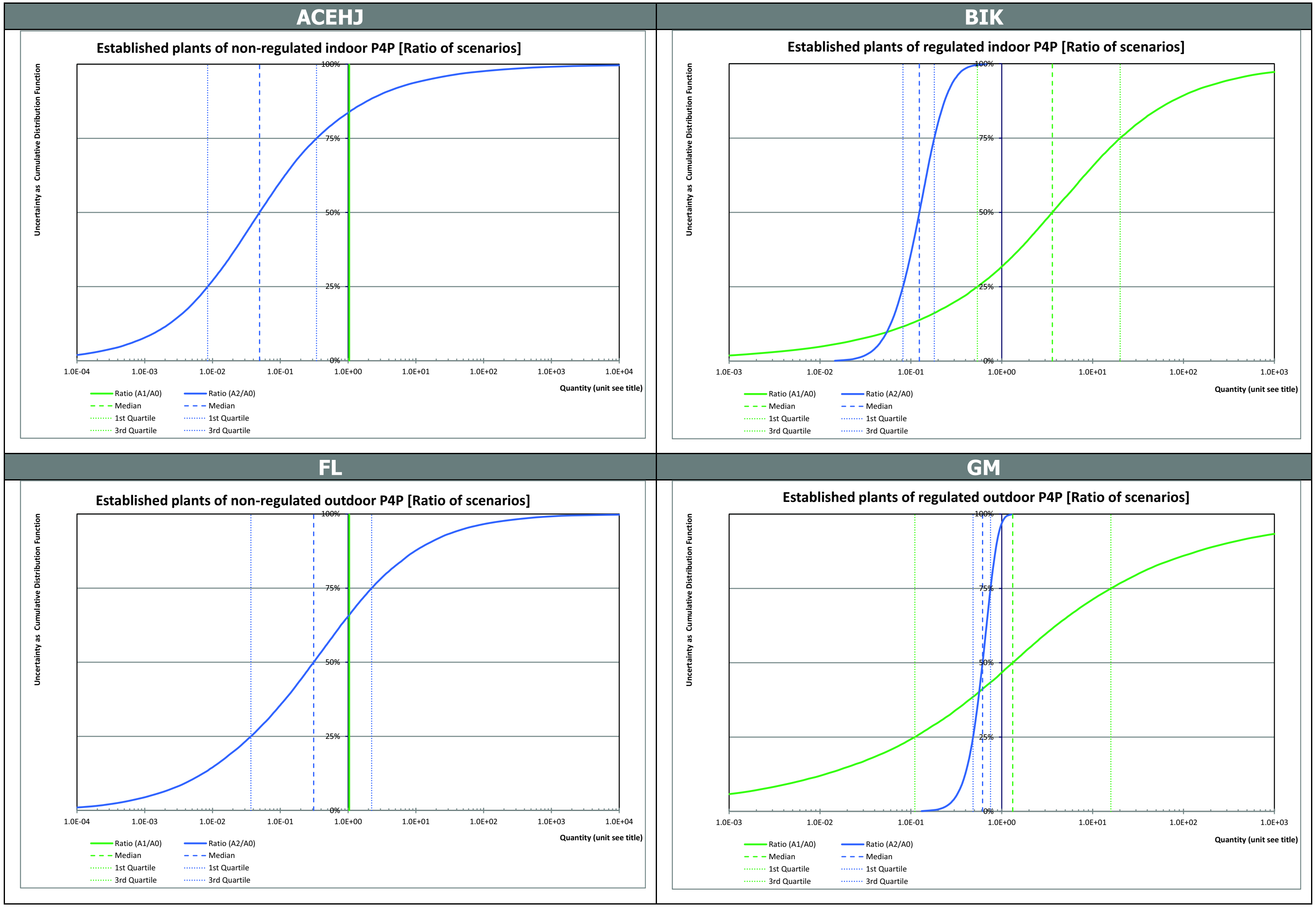


Figure D.34: Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

D.4.5.8. Comparison figures: Probability Density Functions of the Ratio (PDF-R)

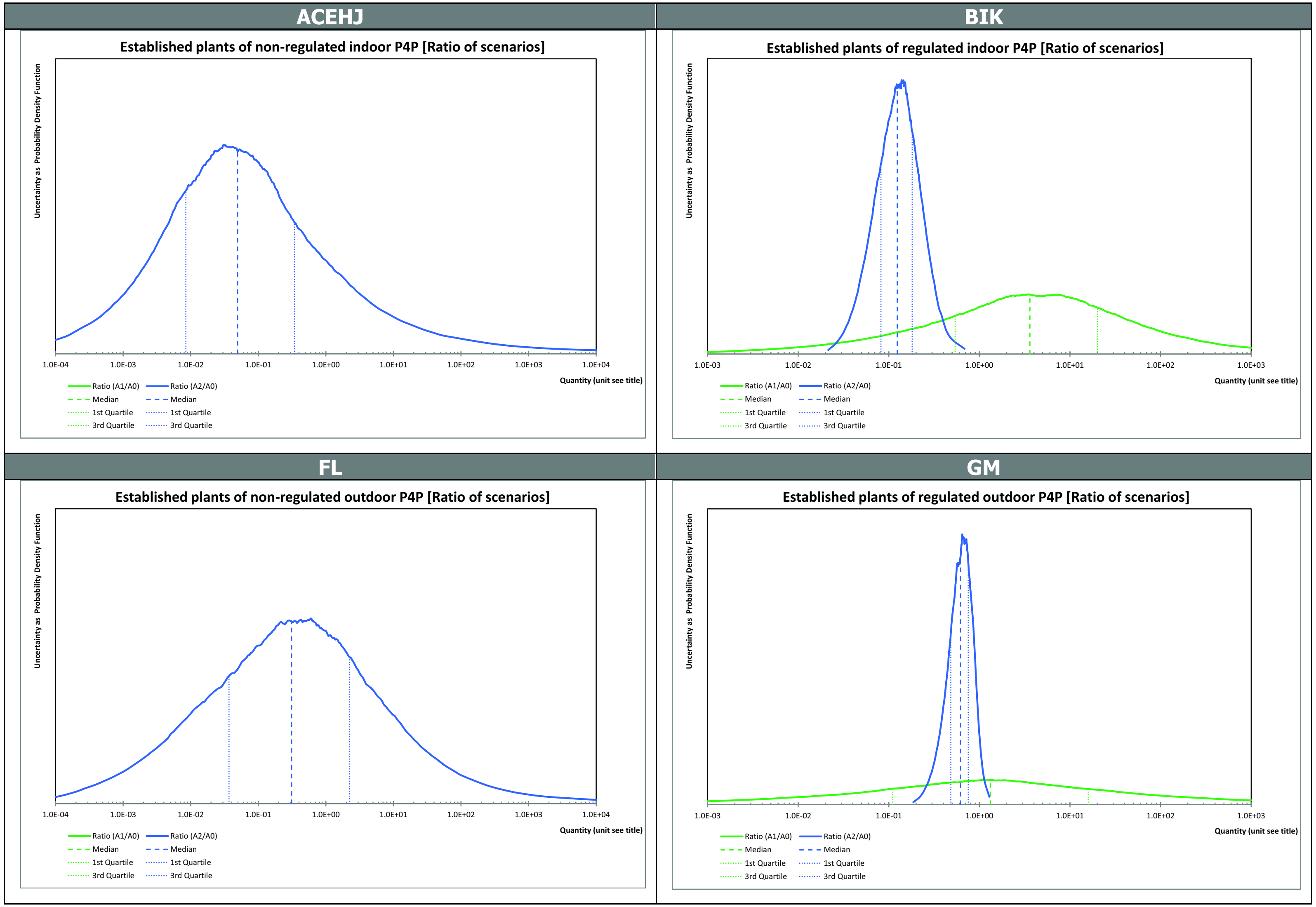


Figure D.35: Comparison figures: Probability Density Functions of the Ratio (PDF-R)

D.5. Spread model

Table D.42: Parameter of the spread model

Abbreviation	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path=A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model	
N2_GH	Est_GH_Path	Established greenhouses [–] by pathway	Calculated by Monte Carlo simulation
s1	Surv_RRO_Path	Proportion of infested greenhouses after application of usual mitigation measures [%]	Expert Knowledge Elicitation
s2	Prop_GHP4P	Proportion of greenhouses producing further plants for planting [%]	Expert Knowledge Elicitation
s3	Fact_GHP4P	Multiplication factor for spread via production of plants for planting [–]	Dutch trade inspection data (NL-NPPO, 2017)
N3_GH	GH_spread	Infested greenhouses after spread [–] by pathway	Calculated by Monte Carlo simulation

D.5.1. Equation

The spread model calculates the number of greenhouses with established founder populations after spread via planting material for different pathways N = 1, 2, 3, 4.

$$GH_{Spread,\ p} = \sum\nolimits_{Path\_p} GH_{Spread,\ Path} = \sum\nolimits_{Path\_p} \left[Est_{GH,\ Path} \times Surv_{RRO,\ Path} \times \left(Prop_{GHP4P,\ Path} \times Fact_{GHP4P,\ Path} + \left(1 - Prop_{GHP4P,\ Path}\right)\right)\right]$$

The spread model calculates the number of infested greenhouses after spread via propagation material. The number of greenhouses before spread is corrected by the proportion of greenhouses, which will be detected by regular RRO (Surv_RRO).

Two cases are distinguished for spread: (1) The greenhouse produces intermediate products and sends these to additional greenhouses (Fact_GHp4p); (2) the greenhouse produces already for the final consumer. In the first case, additional greenhouses are infested; in the latter, only the original greenhouse will be infested.

The estimator (GH_Spread) is the sum of both cases weighted by the proportion of greenhouses for further propagation.

D.5.2. Proportion of infested greenhouses after application of usual mitigation measures (Surv_RRO) (s1)

The proportion of infested greenhouses after application of usual mitigation measures was elicited non-regulated and regulated families (indoor only).

D.5.2.1. Scenarios A0, A1

Table D.43: Proportion of infested greenhouses after application of usual mitigation measures for scenarios A0 and A1

Pathway name	**ACEHJ**	**BI**
Pathway no	**2**	**1**
Proportion of infested greenhouses after application of usual mitigation measures (Surv_RRO) [%] (by expert elicitation)		
Scenarios A0, A1		
1st percentile		30%
25th percentile		60%
50th percentile	100%	70%
75th percentile		80%
99th percentile		90%
Fitted distributions (Surv_RRO)		
1st percentile		34.185%
25th percentile		60.027%
50th percentile	100%	70.256%
75th percentile		79.264%
99th percentile		93.864%
Distribution type	Constant	BetaGeneral
1st parameter	100%	7.2501
2nd parameter		3.2554

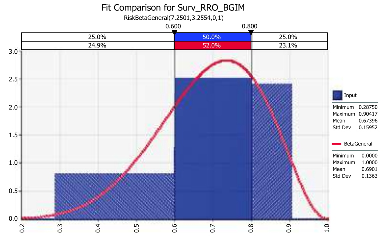
ABCEHIJ	FGLM
Constant	

Figure D.36: Proportion of infested greenhouses after application of usual mitigation measures for scenarios A0 and A1

D.5.2.2. Scenario A2

Table D.44: Proportion of infested greenhouses after application of usual mitigation measures for scenario A2

Pathway name	**ABCEGHIJ**
Pathway no	
Proportion of infested greenhouses after application of usual mitigation measures (Surv_RRO) [%] (by expert elicitation)	
Scenario A2	
1st percentile	25%
25th percentile	30%
50th percentile	40%
75th percentile	50%
99th percentile	80%
Fitted distributions (Surv_RRO)	
1st percentile	15.565%
25th percentile	32.186%
50th percentile	40.437%
75th percentile	49.072%
99th percentile	69.429%
Distribution type	BetaGeneral
1st parameter	6.3827
2nd parameter	9.2466

ABCEGHIJ

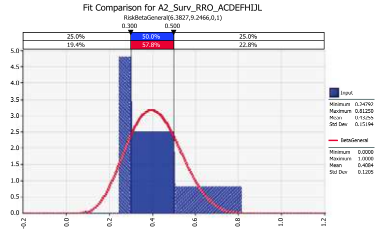


Figure D.37: Proportion of infested greenhouses after application of usual mitigation measures for scenario A2

D.5.3. Proportion of greenhouses producing further plants for planting (Prop_GHP4P) (s2)

The proportion of greenhouses producing further plants for planting was elicited for indoor pathways.

Table D.45: The proportion of greenhouses producing further plants for planting

Pathway name	**ABCEHIJ**
Pathway no	**1,2**
Proportion of greenhouses producing further plants for planting (Prop_GHP4P) [%] (by expert elicitation)	
All scenarios	
1st percentile	0%
25th percentile	5%
50th percentile	10%
75th percentile	20%
99th percentile	50%
Fitted distributions (Prop_GHP4P)	
1st percentile	0.209%
25th percentile	4.717%
50th percentile	10.542%
75th percentile	19.466%
99th percentile	50.035%
Distribution type	BetaGeneral
1st parameter	1.0764
2nd parameter	6.8505

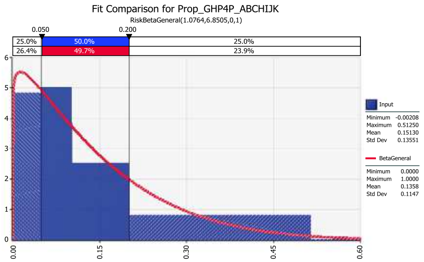


Figure D.38: The proportion of greenhouses producing further plants for planting

D.5.4. Multiplication factor for spread via production of plants for planting (Fakt_GHP4P) (s3)

Multiplication factor for spread via production of plants for planting was elicited for indoor pathways.

Table D.46: Multiplication factor for spread via production of plants for planting

Pathway name	**ABCEHIJ**
Pathway no:	**1,2**
Multiplication factor for spread via production of plants for planting (Fakt_GHP4P) [–] (by expert elicitation)	
All scenarios	
1st percentile	1
25th percentile	8
50th percentile	10
75th percentile	15
99th percentile	50
Fitted distributions (Fakt_GHP4P)	
1st percentile	0
25th percentile	0
50th percentile	3
75th percentile	11
99th percentile	67
Distribution type	Gamma
1st parameter	0.37823
2nd parameter	22.87

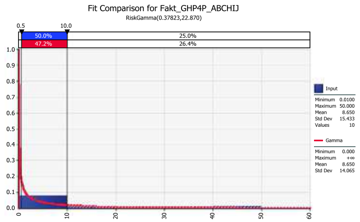


Figure D.39: Multiplication factor for spread via production of plants for planting

D.5.1. Infested greenhouses after spread (GH_spread) by pathway (N3)

D.5.1.1. Scenario A0

Table D.47: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A0

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Infested greenhouses after spread (GH_spread) by pathway [–] (calculated)		
Scenario A0		
1st percentile	0.04	0.02
5th percentile	1.57	0.35
10th percentile	8.22	1.14
16.7th percentile	28.17	2.81
25th percentile	73.09	5.78
33rd percentile	149.29	9.97
50th percentile	437.04	22.94
67th percentile	1,036.18	48.17
75th percentile	1,618.51	70.19
83.3rd percentile	2,691.25	109.34
90th percentile	4,317.78	168.76
95th percentile	7,495.34	285.61
99th percentile	23,386.75	795.35
Mean	1,894.37	75.04
Standard deviation	5,949.12	219.88

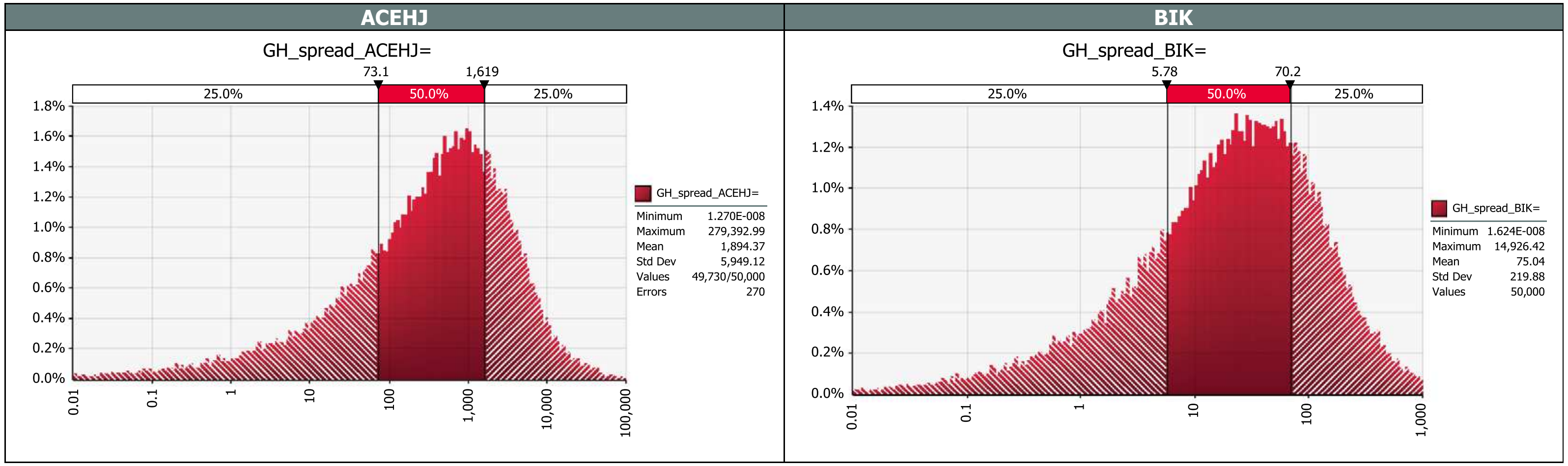


Figure D.40: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A0

D.5.1.2. Sensitivity Analysis (Scenario A0)

Table D.48: Sensitivity Analysis (Scenario A0) for PW2 after spread (GH_spread) by pathway

	ACEHJ		
Parameter	**Std.Regr.**		**Partition**
R^2		0.36	100%
Prof_Inf_ACHJ	0.49	0.24	65%
Fakt_GHP4P_ABCHIJ	0.30	0.09	24%
Prop_GHP4P_ABCHIJK	0.14	0.02	5%
Conv_Packs2pcs_H	−0.09	0.01	2%
Prop_Host_H	0.08	0.01	2%
Imp_H	0.05	0.00	1%
Conv_Packs2pcs_C	−0.02	0.00	0%
Conv_Packs2pcs_J	−0.02	0.00	0%
Prop_Host_J	0.02	0.00	0%
Imp_C	0.02	0.00	0%
Prop_P4P_J	−0.01	0.00	0%
Prop_P4P_H	−0.01	0.00	0%
Imp_A	–	–	0%
Imp_J	–	–	0%
Prop_P4P_E	–	–	0%
Prop_P4P_C	–	–	0%
Prop_P4P_A	–	–	0%
Conv_Packs2pcs_E	–	–	0%
Conv_Packs2pcs_A	–	–	0%
Prop_Host_A	–	–	0%
Imp_E	–	–	0%
Prop_Host_E	–	–	0%

Table D.49: Sensitivity analysis (Scenario A0) for PW1

	BIK		
Parameter	**Std.Regr.**		**Partition**
R^2		0.35	100%
Prop_Inf_BIK	0.44	0.19	55%
Fakt_GHP4P_ABCHIJ	0.32	0.10	29%
Prop_Host_I	0.15	0.02	7%
Prop_GHP4P_ABCHIJK	0.15	0.02	7%
Surv_RRO_BGIM	0.06	0.00	1%
Imp_H	0.06	0.00	1%
Surv_Insp_BIK	0.04	0.00	0%
Conv_Packs2pcs_I	−0.03	0.00	0%
Conv_Packs2pcs_B	–	–	0%
Prop_P4P_I	–	–	0%
Prop_P4P_B	–	–	0%
Imp_A	–	–	0%

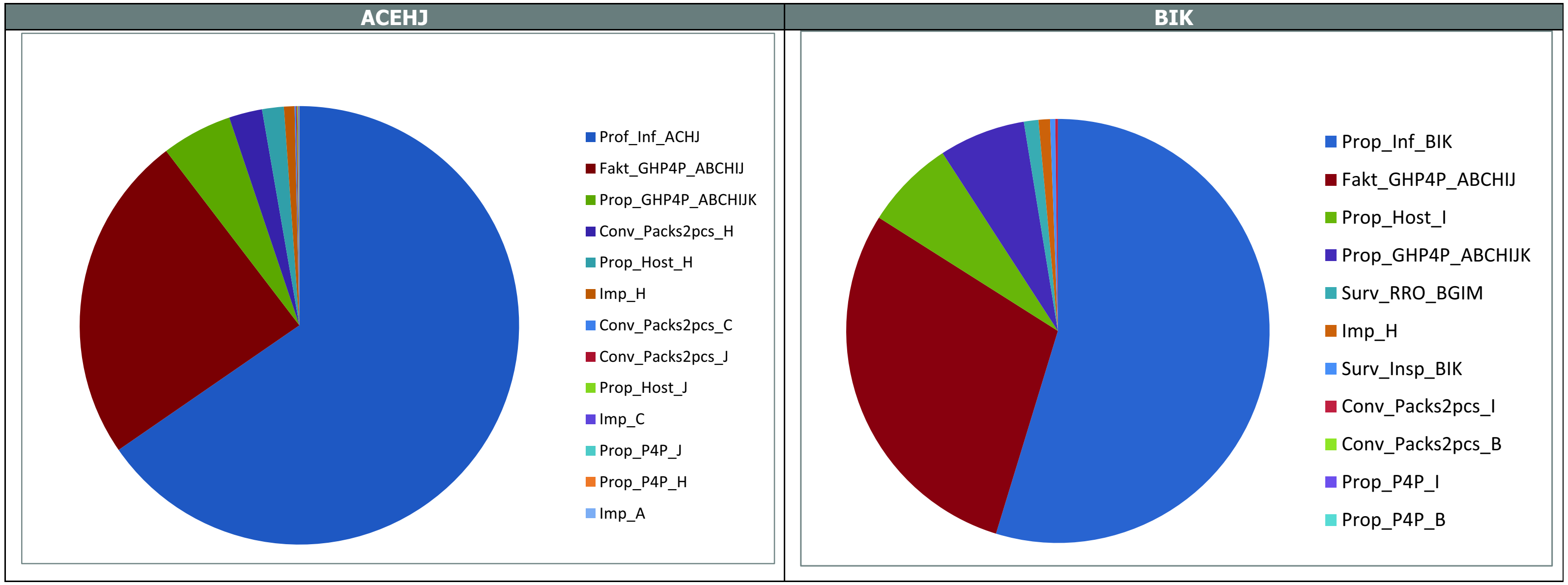


Figure D.41: Sensitivity Analysis (Scenario A0) for PW1 and PW2

D.5.1.3. Scenario A1

Table D.50: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A1

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Infested greenhouses after spread (GH_spread) by pathway [–] (calculated)		
Scenario A1		
1st percentile	0.04	0.01
5th percentile	1.57	0.27
10th percentile	8.22	1.39
16.7th percentile	28.17	4.78
25th percentile	73.09	12.87
33rd percentile	149.29	26.14
50th percentile	437.04	76.25
67th percentile	1,036.18	180.74
75th percentile	1,618.51	276.55
83.3rd percentile	2,691.25	451.57
90th percentile	4,317.78	725.84
95th percentile	7,495.34	1,259.72
99th percentile	23,386.75	3,684.41
Mean	1,894.37	316.11
Standard deviation	5,949.12	979.45

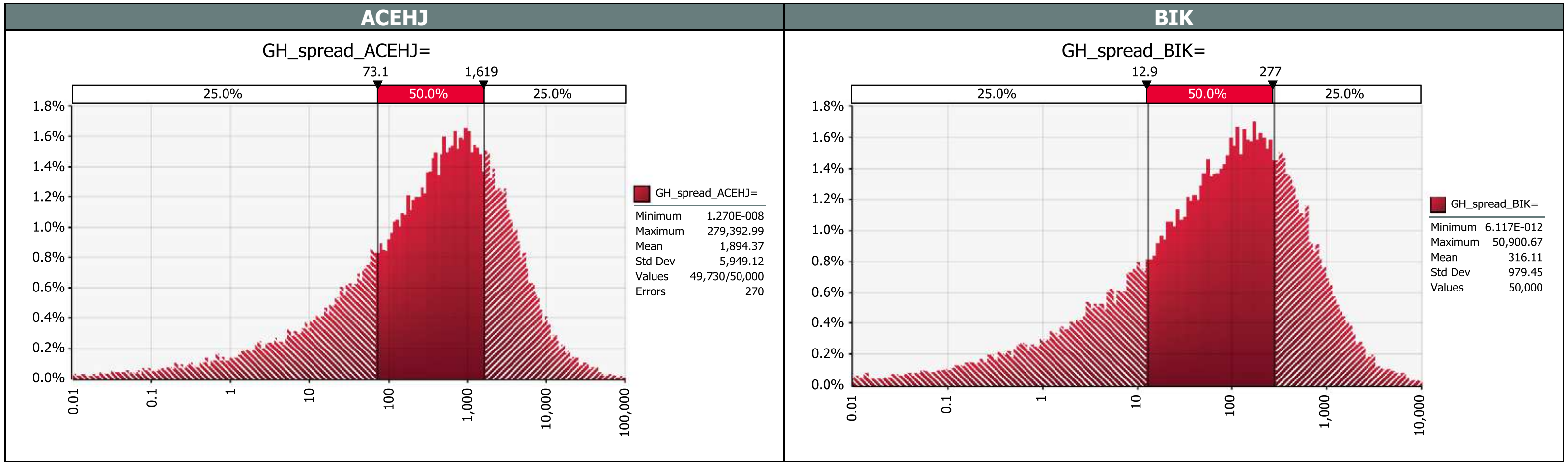


Figure D.42: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A1

D.5.1.4. Scenario A2

Table D.51: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A2

Pathway name **Pathway no**	**ACEHJ** **2**	**BIK** **1**
Infested greenhouses after spread (GH_spread) by pathway [–] (calculated)		
Scenario A2		
1st percentile	0.04	0.01
5th percentile	0.53	0.10
10th percentile	1.79	0.31
16.7th percentile	4.38	0.76
25th percentile	9.10	1.57
33rd percentile	15.72	2.71
50th percentile	37.51	6.43
67th percentile	78.85	13.76
75th percentile	117.24	20.40
83.3rd percentile	189.73	32.81
90th percentile	303.07	50.87
95th percentile	530.47	89.05
99th percentile	1,566.29	249.20
Mean	137.80	23.11
Standard deviation	503.35	75.71

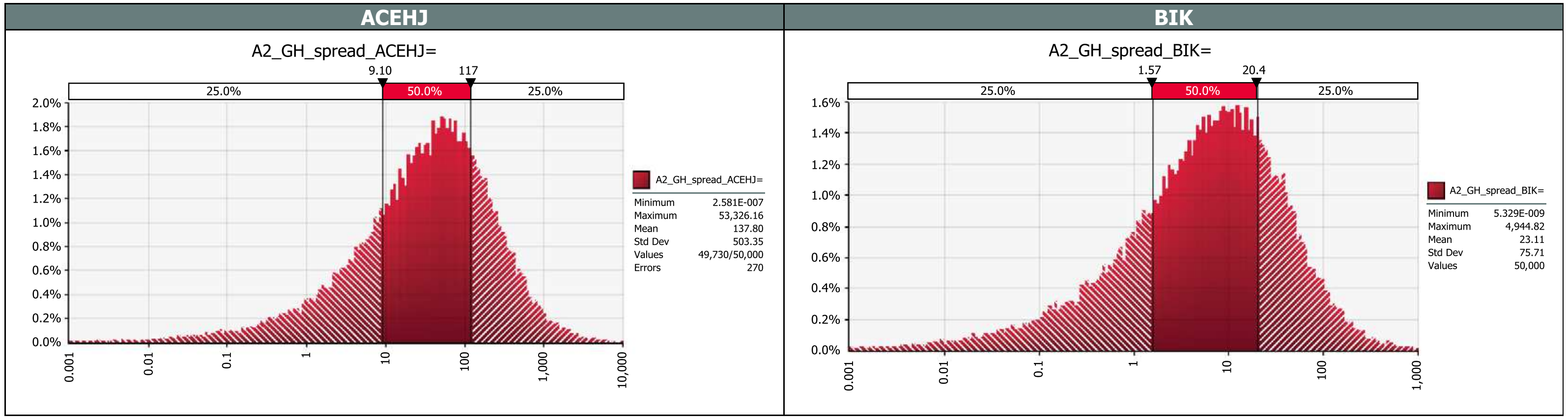


Figure D.43: Infested greenhouses after spread (GH_spread) by pathway PW1 and PW2 for scenario A2

D.5.1.5. Comparison figures: Cumulative Distribution Functions (CDF)

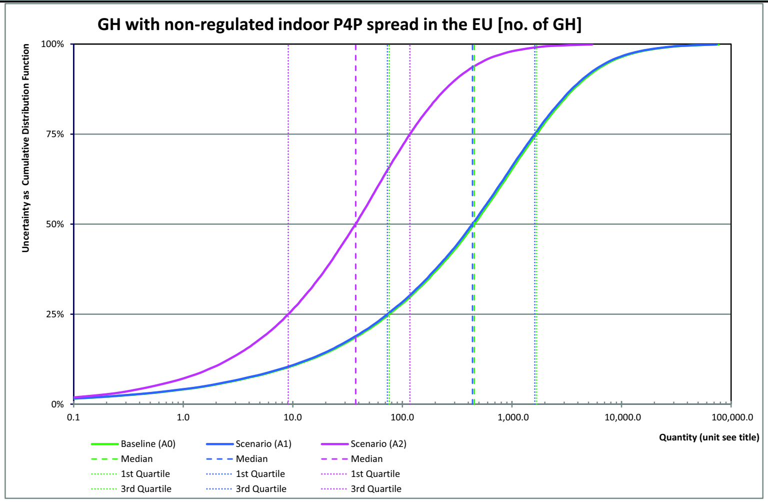
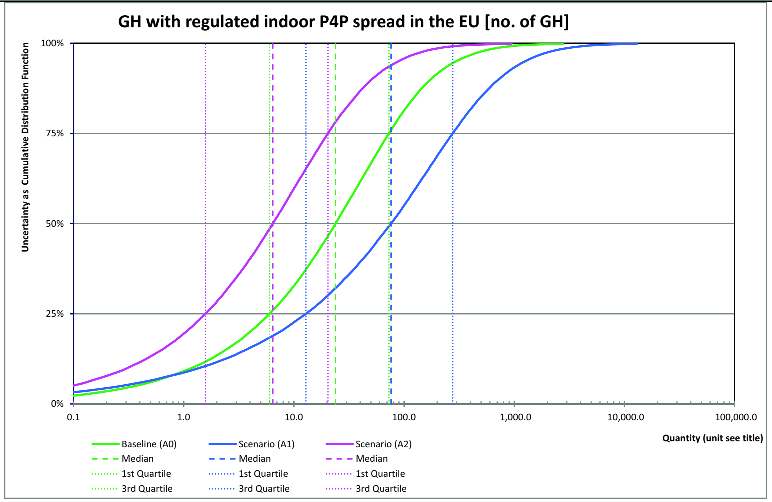
ACEHJ	BIK
	

Figure D.44: Comparison figures: Cumulative Distribution Functions (CDF)

D.5.1.6. Comparison figures: Probability Density Function (PDF)

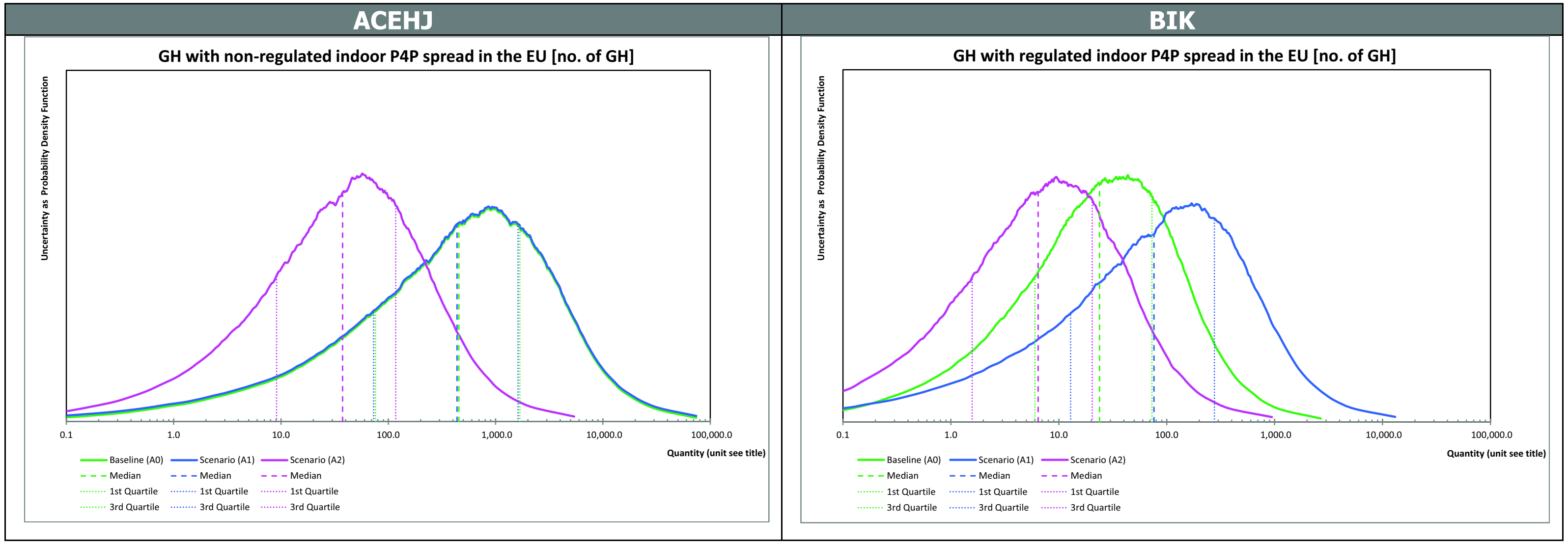


Figure D.45: Comparison figures: Probability Density Function (PDF)

D.5.1.7. Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

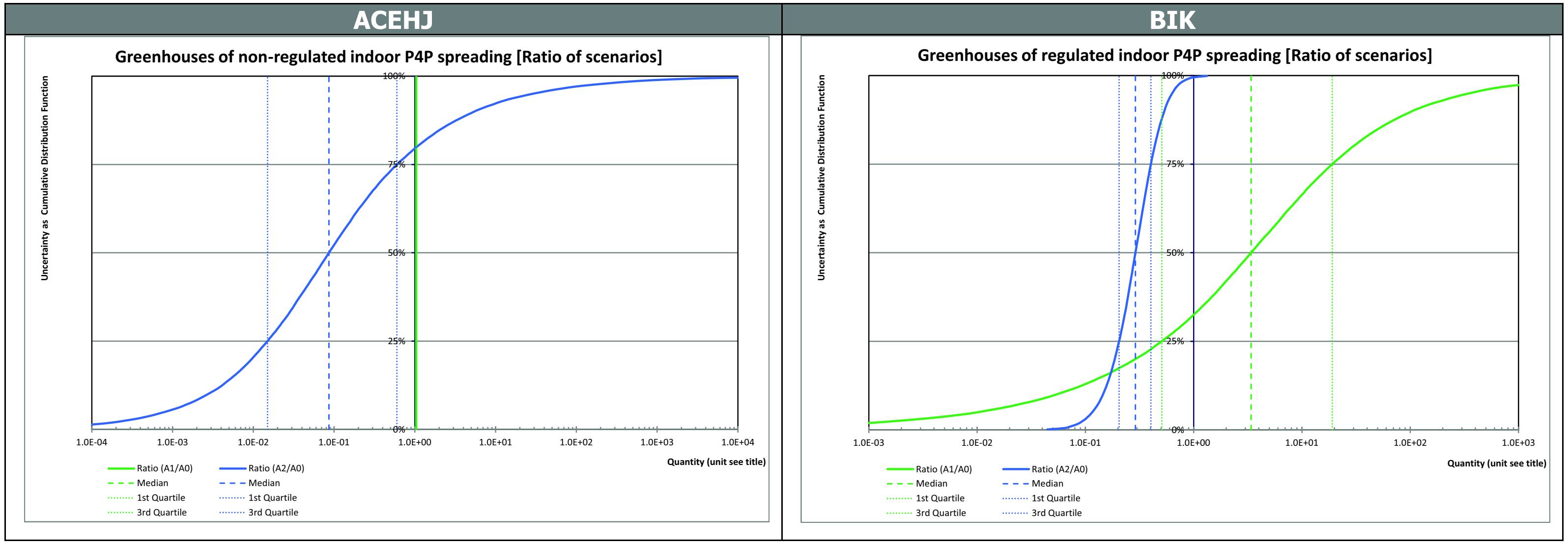


Figure D.46: Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

D.5.1.8. Comparison figures: Probability Density Functions of the Ratio (PDF-R)

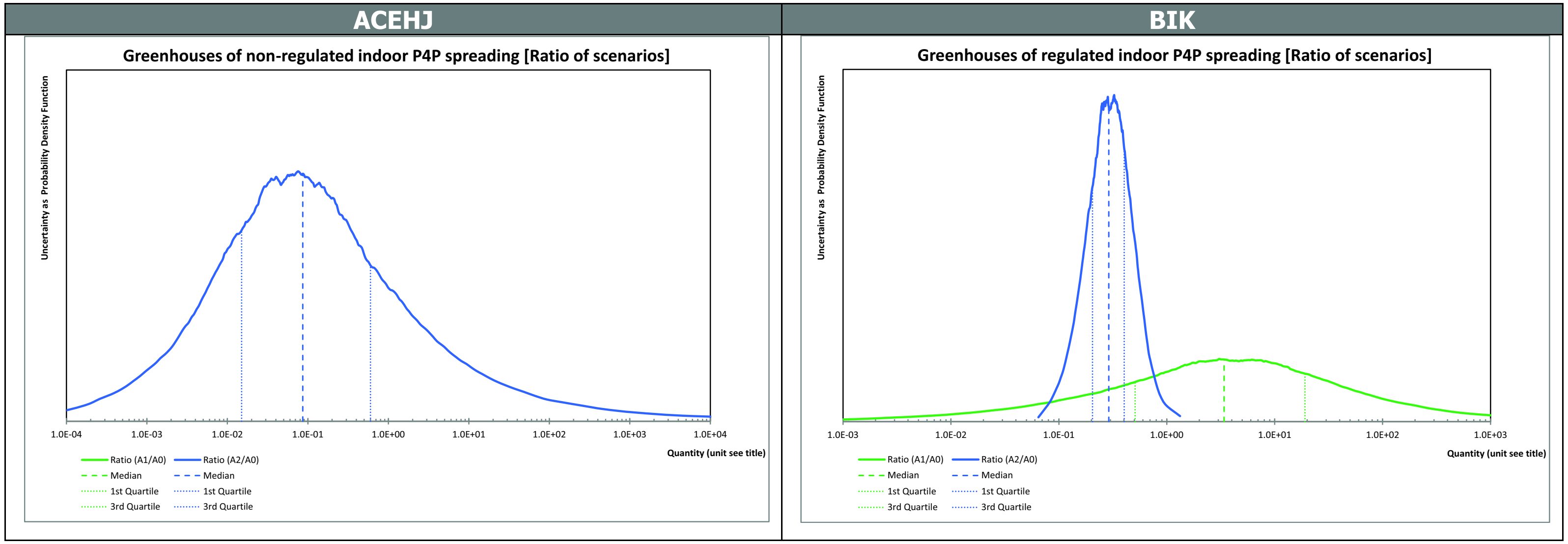


Figure D.47: Comparison figures: Probability Density Functions of the Ratio (PDF-R)

D.6. Impact model

Table D.52: Parameter of the entry model

Abbreviaton	Name	Description	Evidence
	Country_classI	Countries with known interceptions or pest reports in tropical/subtropical regions	
	p = 1, 2, 3, 4	Pathways reported in the risk assessment: Path_1 = ACEHJ, Path_2 = BIK, Path_3 = FL, Path_4 = GM	
	Path=A, B, C, E, F, G, H, I, J, K, L, M	Pathway stratification within the assessment model	
N3_GH	GH_spread_p	Infested greenhouses after spread [–] by pathway	Calculated by Monte Carlo simulation
i1	Surv_Cert_Path	Proportion of greenhouses passing control programs [%]by pathway	Expert Knowledge Elicitation
e3	Conv_Packs2pcs_Path	Conversion from number of plants to number of packs [–] by pathway	Dutch trade inspection data (NL-NPPO, 2017)
i3	Red_all_Path	Reduction in plant material due to the infestation [%]	Expert Knowledge Elicitation
b2	Prop_Est_Path	Proportion of individual plants establishing a founder population [%]	Expert Knowledge Elicitation
N4_GH	GH_det_p, GH_det_Path	Infested greenhouses detected [–] by pathway	Calculated by Monte Carlo simulation
N4_Plants	Plants_imp_p, Plants_imp_Path	Plants impacted [–] by pathway by pathway	Calculated by Monte Carlo simulation
N4_Cons	Plants_Cons_Path	Established populations at consumer level from finally produced plants (see establishment)	Calculated by Monte Carlo simulation

D.6.1. Equation

The impact model calculates the number of greenhouses with detected infestation in the EU, and the loss in plants due to undetected infestation, and finally the number of infested, established plants at the consumer for different pathways N = 1, 2, 3, 4. The latter is reported in the establishment section.

$$\mathrm{GH}_{\mathrm{det,\ p}} = \sum\nolimits_{\mathrm{Path\_p}} \mathrm{GH}_{\mathrm{det,\ Path}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{GH}_{\mathrm{spread,\ Path}} \times (1 - \mathrm{Surv}_{\mathrm{Cert,\ Path}})\right]$$

$$\mathrm{Plants}_{\mathrm{imp,\ p}} = \sum\nolimits_{\mathrm{Path\_p}} \mathrm{Plants}_{\mathrm{imp,\ Path}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{GH}_{\mathrm{spread,\ Path}} \times \mathrm{Surv}_{\mathrm{Cert,\ Path}} \times \mathrm{Conv}_{\mathrm{Packs2pcs,\ Path}} \times \mathrm{Red}_{\mathrm{all,\ Path}}\right]$$

$$\mathrm{Plants}_{\mathrm{cons,\ p}} = \sum\nolimits_{\mathrm{Path\_p}} \mathrm{Plants}_{\mathrm{cons,\ Path}} = \sum\nolimits_{\mathrm{Path\_p}} \left[\mathrm{GH}_{\mathrm{spread,\ Path}} \times \mathrm{Surv}_{\mathrm{Cert,\ Path}} \times \mathrm{Conv}_{\mathrm{Packs2pcs,\ Path}} \times (1 - \mathrm{Red}_{\mathrm{all,\ Path}})\mathrm{Prob}_{\mathrm{Est,\ Path}})\right]$$

The impact model estimates three kinds of impacts separately. First the number of greenhouses after spread is corrected by the proportion of greenhouses, which will not be detected by certification schemes as infested. This results in the number of detected infested greenhouses (GH_det).

If the infestation is not recognised, *R. similis* will reduce the amount of plants (Plants_imp). Here a conversion back to plants (Conv_Packs2pcs) and the reduction of plant material (Red_all) is used in the estimation.

Finally, a number of infested plants will reach the consumer and establish (Plants_cons). The latter is reported in the establishment section.

D.6.2. Proportion of greenhouses passing control programs (Surv_Cert) (i1)

The proportion of infested greenhouses passing control programs was elicited non-regulated and regulated families (indoor only).

D.6.2.1. Scenarios A0, A1

Table D.53: The proportion of infested greenhouses passing control programs for scenarios A0 and A1

Pathway name	**ACEHJ**	**BI**
Pathway no	**2**	**1**
Proportion of greenhouses passing control programs (Surv_Cert) [%] (by expert elicitation)		
Scenarios A0, A1		
1st percentile		80%
25th percentile		92%
50th percentile	100%	95%
75th percentile		98%
99th percentile		100%
Fitted distributions (Surv_Cert)		
1st percentile		77.690%
25th percentile		91.724%
50th percentile	100%	95.339%
75th percentile		97.723%
99th percentile		99.835%
Distribution type	Constant	BetaGen
1st parameter	100%	20.825
2nd parameter		1.3157

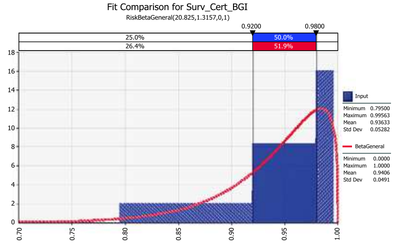
ACEHJ	BI
Constant	

Figure D.48: The proportion of infested greenhouses passing control programs for scenarios A0 and A1

D.6.2.2. Scenario A2

Table D.54: The proportion of infested greenhouses passing control programs for scenario A2

Pathway name	**ABCEHIJ**
Pathway no	**1,2**
Proportion of greenhouses passing control programs (Surv_Cert) [%] (by expert elicitation)	
Scenario A2	
1st percentile	25%
25th percentile	30%
50th percentile	40%
75th percentile	50%
99th percentile	80%
Fitted distributions (Surv_Cert)	
1st percentile	15.561%
25th percentile	32.186%
50th percentile	40.437%
75th percentile	49.072%
99th percentile	69.425%
Distribution type	BetaGeneral
1st parameter	6.3827
2nd parameter	9.2466

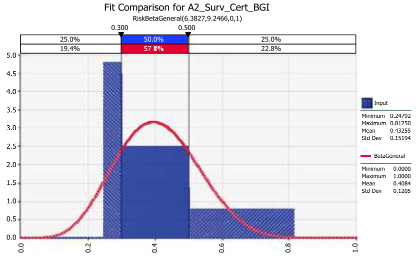
ABCEHIJ


Figure D.49: The proportion of infested greenhouses passing control programs for scenario A2

D.6.3. Reduction in plant material due to the infestation (Red_all) (i2)

The reduction in plant material due to infestation was estimated for indoor production.

Table D.55: The reduction in plant material due to infestation

Pathway name	**ABCEHIJ**
Pathway no	**1,2**
Reduction in plant material due to the infestation (Red_all) [%] (by expert elicitation)	
All scenarios	
1st percentile	2%
25th percentile	25%
50th percentile	30%
75th percentile	50%
99th percentile	75%
Fitted distributions (Red_all)	
1st percentile	4.049%
25th percentile	21.585%
50th percentile	34.004%
75th percentile	48.167%
99th percentile	79.699%
Distribution type	BetaGen
1st parameter	2.1438
2nd parameter	3.8642

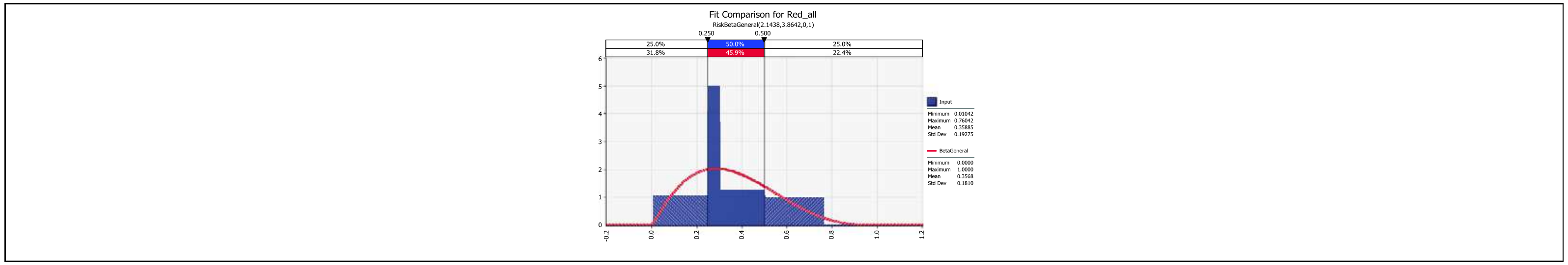


Figure D.50: The reduction in plant material due to infestation

D.6.4. Infested greenhouses detected (GH_det) by pathway (N4_GH)

D.6.4.1. Scenario A0

Table D.56: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A0

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Infested greenhouses detected (GH_det) by pathway [–] (calculated)		
Scenario A0		
1st percentile	0.00	0.00
5th percentile	0.00	0.01
10th percentile	0.00	0.03
16.7th percentile	0.00	0.08
25th percentile	0.00	0.18
33rd percentile	0.00	0.34
50th percentile	0.00	0.90
67th percentile	0.00	2.15
75th percentile	0.00	3.37
83.3rd percentile	0.00	5.82
90th percentile	0.00	9.76
95th percentile	0.00	17.63
99th percentile	0.00	53.63
Mean	0.00	4.42
Standard deviation	0.00	17.79

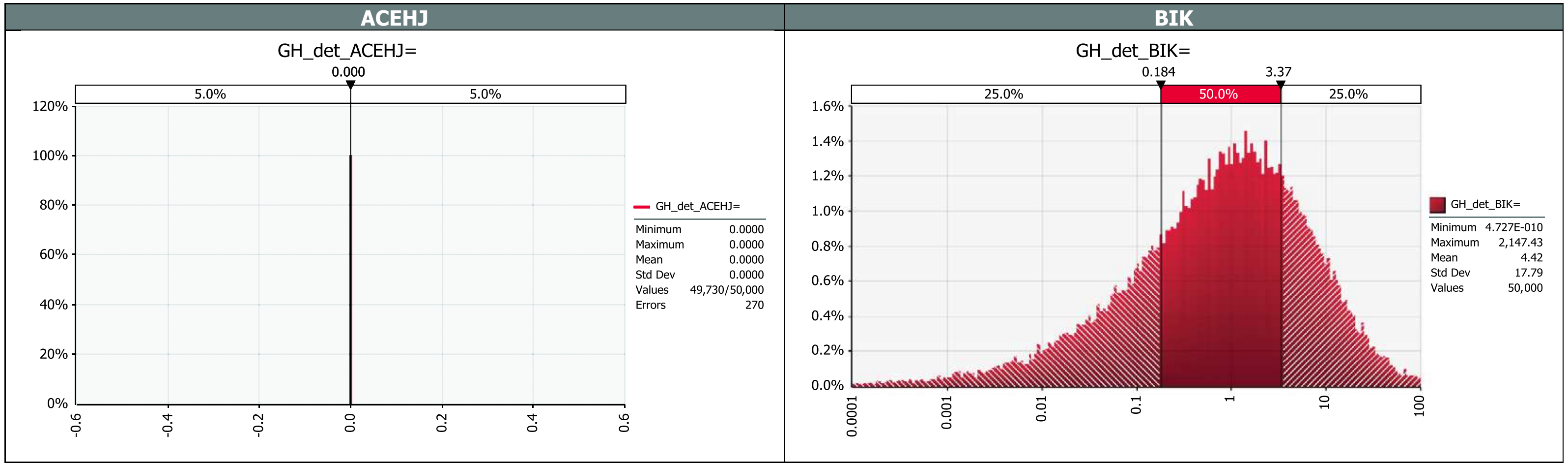


Figure D.51: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A0

D.6.4.2. Sensitivity Analysis (Scenario A0)

Table D.57: Sensitivity Analysis (Scenario A0)

	BIK		
Parameter	**Std.Regr.**		**Partition**
R^2		0.22	100%
Prop_Inf_BIK	0.32	0.10	46%
Fakt_GHP4P_ABCHIJ	0.22	0.05	22%
Surv_Cert_BGI	–0.21	0.04	19%
Prop_Host_I	0.12	0.01	6%
Prop_GHP4P_ABCHIJK	0.11	0.01	5%
Imp_H	0.04	0.00	1%
Surv_RRO_BGIM	0.04	0.00	1%
Surv_Insp_BIK	0.03	0.00	0%
Conv_Packs2pcs_I	–0.02	0.00	0%
Conv_Packs2pcs_B	–	–	0%
Prop_P4P_I	–	–	0%
Prop_P4P_B	–	–	0%
Imp_A	–	–	0%

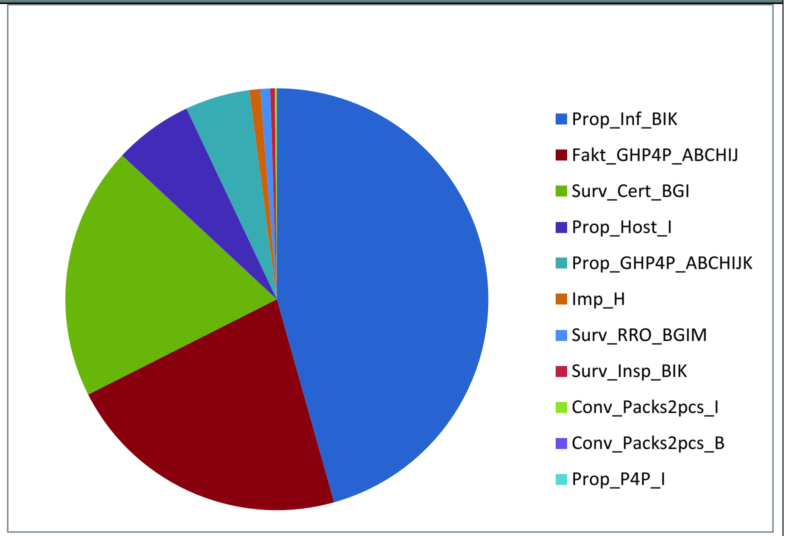
ACEHJ	BIK
	

Figure D.52: Sensitivity Analysis (Scenario A0)

D.6.4.3. Scenario A1

Table D.58: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A1

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Infested greenhouses detected (GH_det) by pathway [–] (calculated)		
Scenario A1		
1st percentile	0.00	0.00
5th percentile	0.00	0.00
10th percentile	0.00	0.00
16.7th percentile	0.00	0.00
25th percentile	0.00	0.00
33rd percentile	0.00	0.00
50th percentile	0.00	0.00
67th percentile	0.00	0.00
75th percentile	0.00	0.00
83.3rd percentile	0.00	0.00
90th percentile	0.00	0.00
95th percentile	0.00	0.00
99th percentile	0.00	0.00
Mean	0.00	0.00
Standard deviation	0.00	0.00

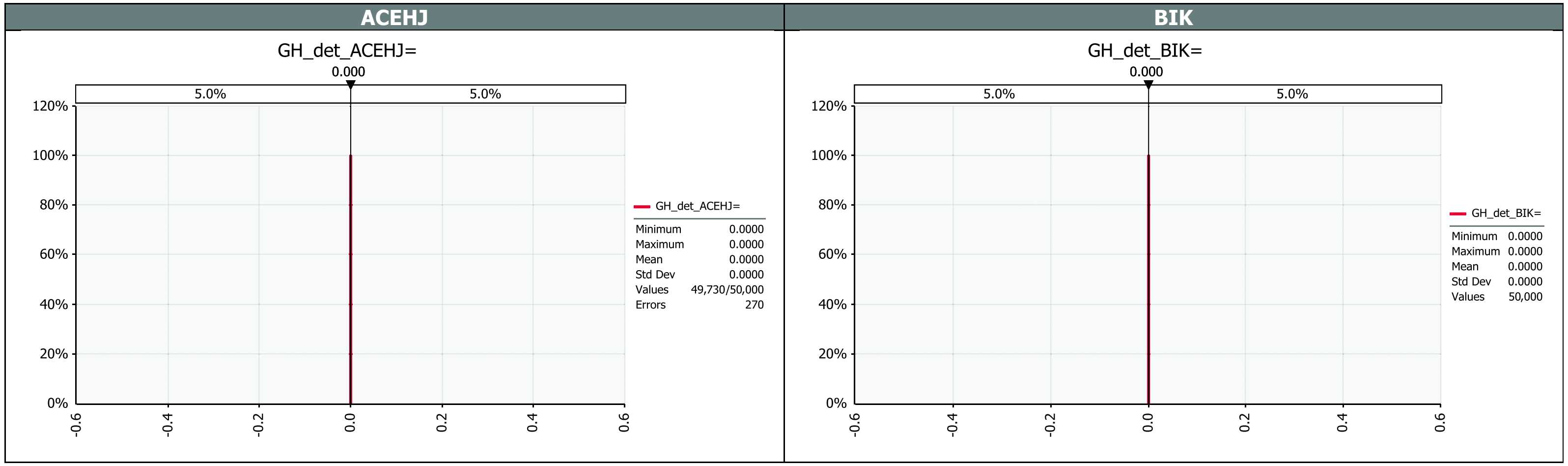


Figure D.53: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A1

D.6.4.4. Scenario A2

Table D.59: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A2

Pathway name **Pathway no**	**ACEHJ** **2**	**BIK** **1**
Infested greenhouses detected (GH_det) by pathway [–] (calculated)		
Scenario A2		
1st percentile	0.02	0.00
5th percentile	0.30	0.05
10th percentile	1.03	0.18
16.7th percentile	2.50	0.44
25th percentile	5.21	0.91
33rd percentile	9.02	1.57
50th percentile	21.48	3.71
67th percentile	45.77	7.97
75th percentile	68.47	11.84
83.3rd percentile	111.14	19.16
90th percentile	179.29	30.43
95th percentile	314.32	53.04
99th percentile	945.80	150.25
Mean	81.43	13.69
Standard deviation	296.97	45.29

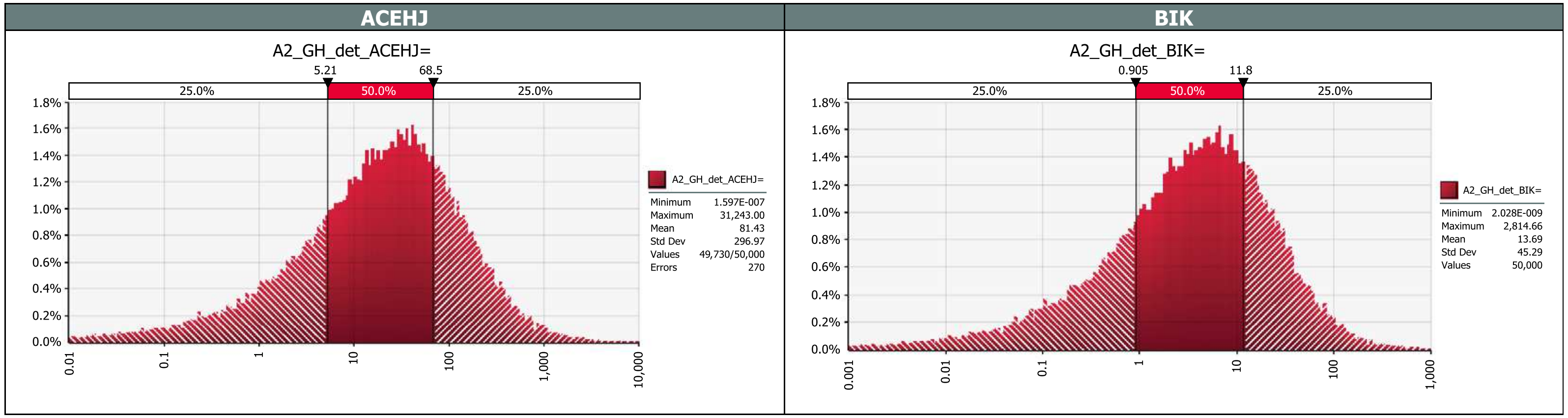


Figure D.54: Infested greenhouses detected (GH_det) by PW1 and PW2 for scenario A2

D.6.4.5. Comparison figures: Cumulative Distribution Functions (CDF)

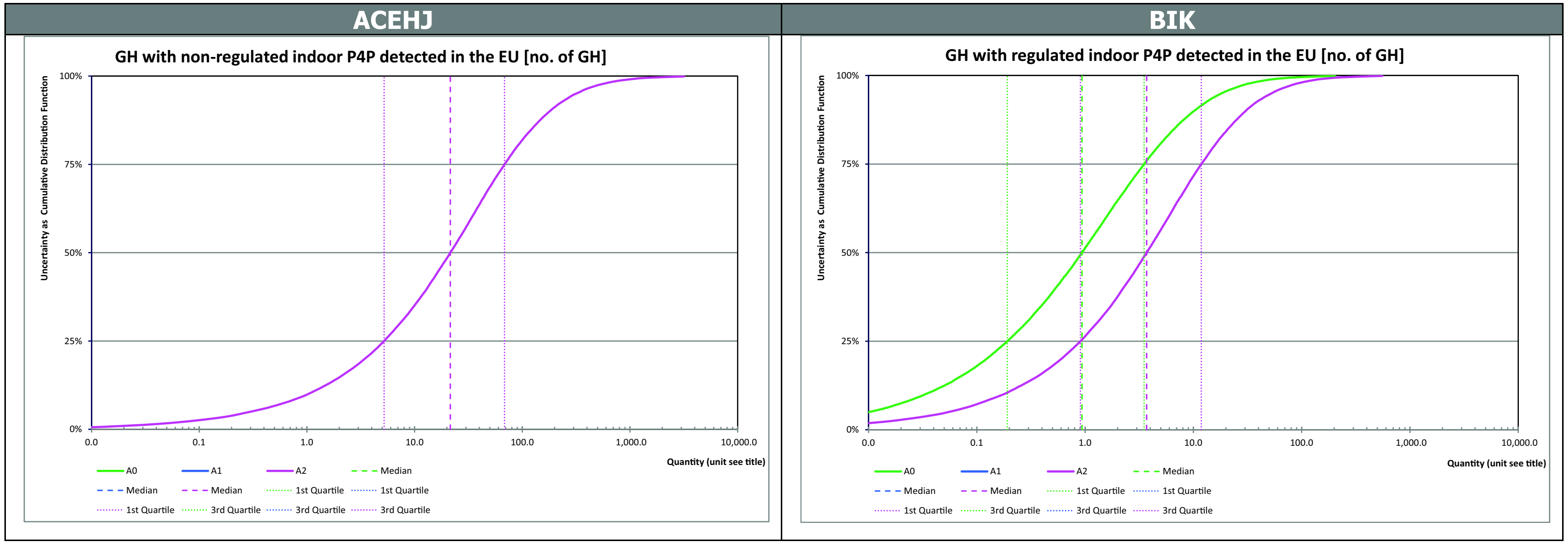


Figure D.55: Comparison figures: Cumulative Distribution Functions (CDF)

D.6.4.6. Comparison figures: Probability Density Function (PDF)

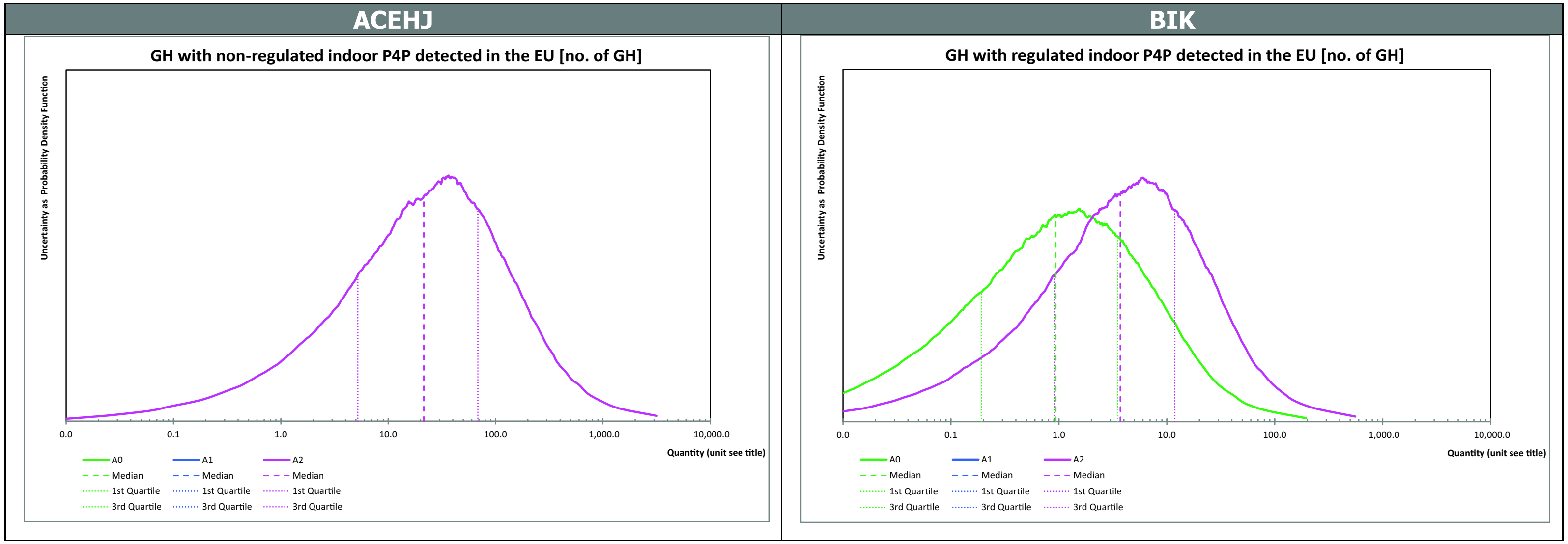


Figure D.56: Comparison figures: Probability Density Function (PDF)

D.6.4.7. Comparison figures: Cumulative Distribution Functions of the Difference (CDF-D)

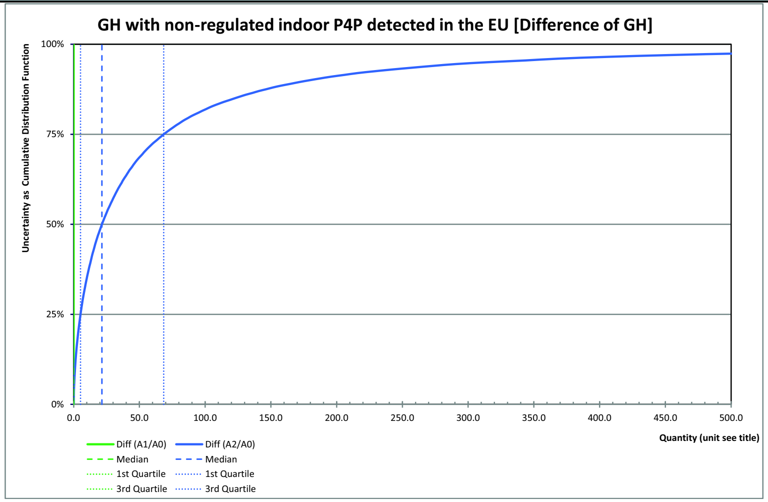
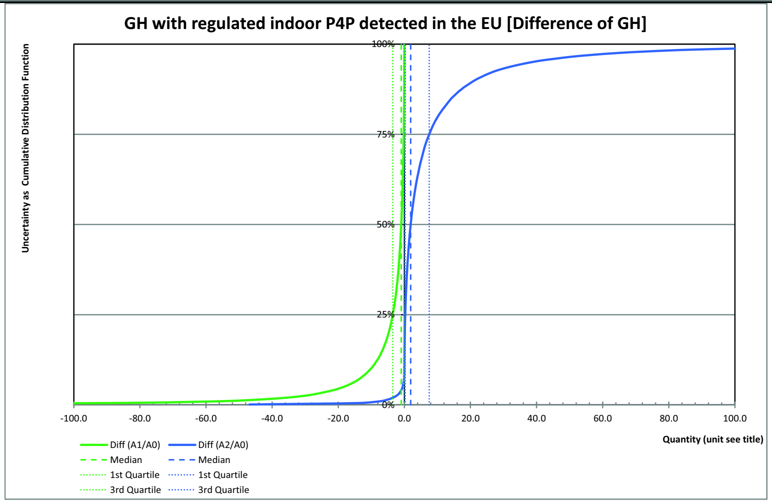
ACEHJ	BIK
	

Figure D.57: Comparison figures: Cumulative Distribution Functions of the Difference (CDF-D)

D.6.4.8. Comparison figures: Probability Density Functions of the Difference (PDF-D)

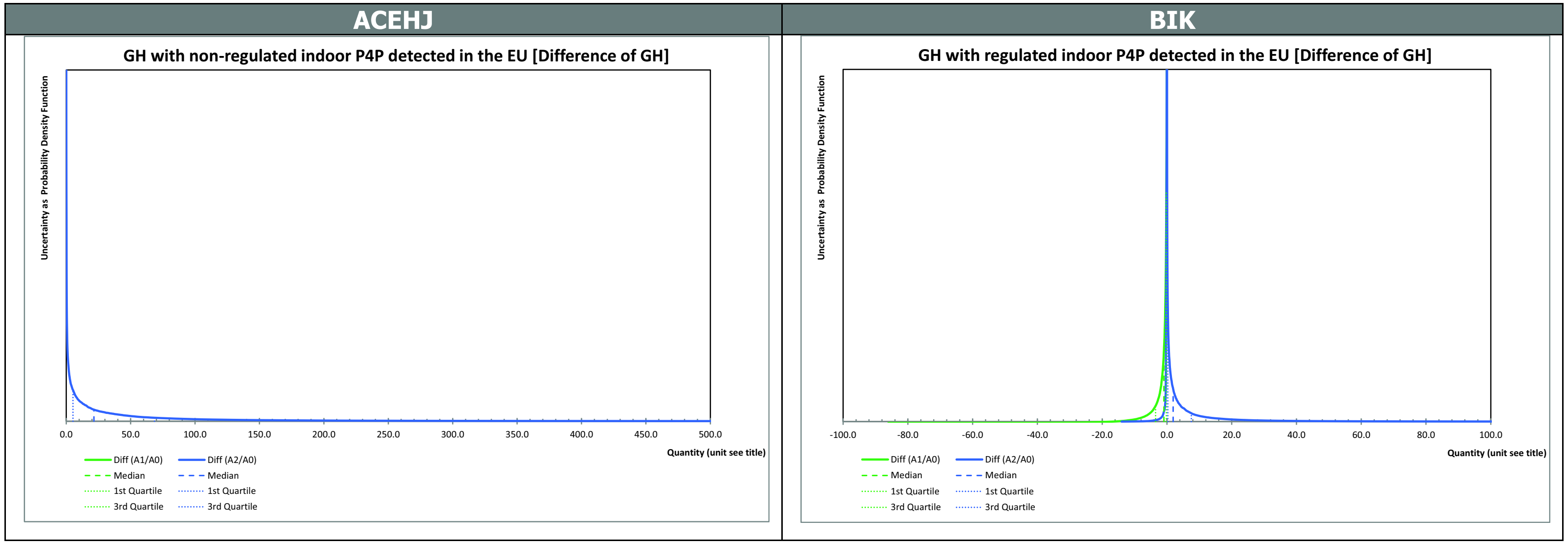


Figure D.58: Comparison figures: Probability Density Functions of the Difference (PDF-D)

D.6.5. Plants impacted (Plants_imp) by pathway (N4_Plants)

D.6.5.1. Scenario A0

Table D.60: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A0

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Plants impacted (Plants_imp) by pathway [–] (calculated)		
Scenario A0		
1st percentile	5	25
5th percentile	197	367
10th percentile	1,006	1,228
16.7th percentile	3,438	3,074
25th percentile	9,270	6,479
33rd percentile	18,832	11,226
50th percentile	56,865	27,537
67th percentile	142,833	60,577
75th percentile	225,821	92,035
83.3rd percentile	385,164	150,310
90th percentile	636,886	242,132
95th percentile	1,130,129	424,525
99th percentile	3,509,160	1,247,136
Mean	278,063	107,717
Standard deviation	880,287	340,006

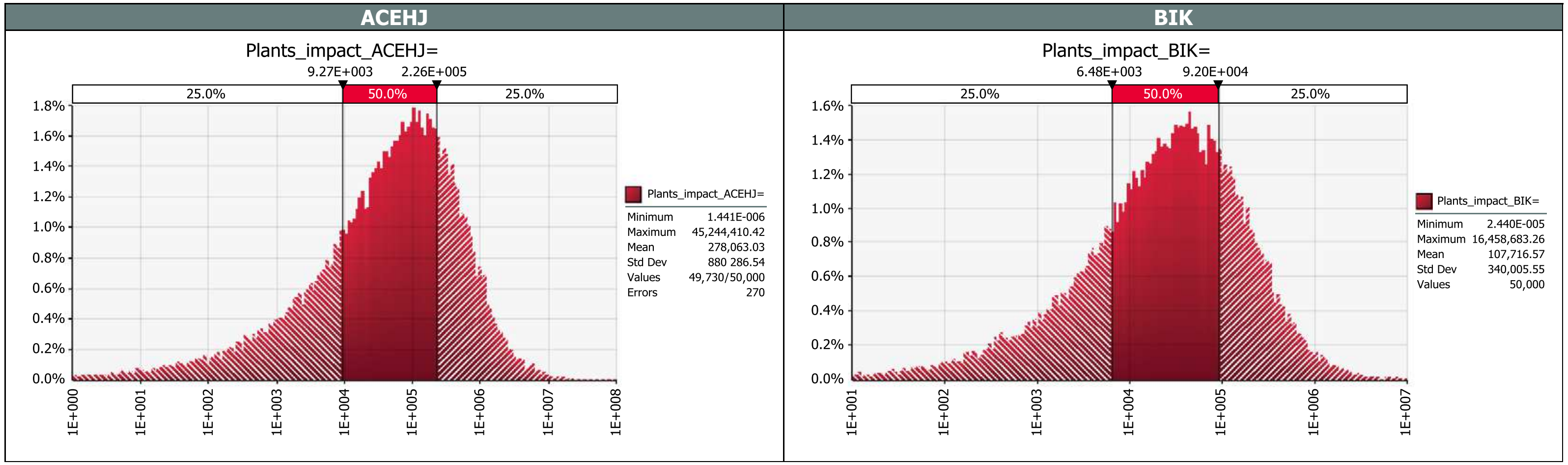


Figure D.59: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A0

D.6.5.2. Sensitivity analysis (Scenario A0)

Table D.61: Sensitivity analysis (Scenario A0) for PW2

	ACEHJ		
Parameter	**Std.Regr.**		**Partition**
R^2		0.37	100%
Prof_Inf_ACHJ	0.48	0.23	63%
Fakt_GHP4P_ABCHIJ	0.29	0.08	23%
Red_all	0.15	0.02	6%
Prop_GHP4P_ABCHIJK	0.14	0.02	5%
Prop_Host_H	0.08	0.01	2%
Imp_H	0.06	0.00	1%
Prop_P4P_H	−0.01	0.00	0%
Imp_A	–	–	0%
Imp_J	–	–	0%
Prop_P4P_J	–	–	0%
Prop_P4P_E	–	–	0%
Prop_P4P_C	–	–	0%
Prop_P4P_A	–	–	0%
Conv_Packs2pcs_E	–	–	0%
Conv_Packs2pcs_A	–	–	0%
Prop_Host_A	–	–	0%
Imp_E	–	–	0%
Prop_Host_E	–	–	0%
Imp_C	–	–	0%
Conv_Packs2pcs_C	–	–	0%
Conv_Packs2pcs_J	–	–	0%
Prop_Host_J	–	–	0%
Conv_Packs2pcs_H	–	–	0%

Table D.62: Sensitivity analysis (Scenario A0) for PW1

	BIK		
Parameter	**Std.Regr.**		**Partition**
R^2		0.32	100%
Prop_Inf_BIK	0.40	0.16	51%
Fakt_GHP4P_ABCHIJ	0.29	0.08	26%
Red_all	0.16	0.03	8%
Prop_Host_I	0.14	0.02	6%
Prop_GHP4P_ABCHIJK	0.14	0.02	6%
Surv_RRO_BGIM	0.06	0.00	1%
Imp_H	0.05	0.00	1%
Surv_Insp_BIK	0.03	0.00	0%
Surv_Cert_BGI	0.02	0.00	0%
Prop_P4P_I	−0.01	0.00	0%
Conv_Packs2pcs_I	–	–	0%
Conv_Packs2pcs_B	–	–	0%
Prop_P4P_B	–	–	0%
Imp_A	–	–	0%

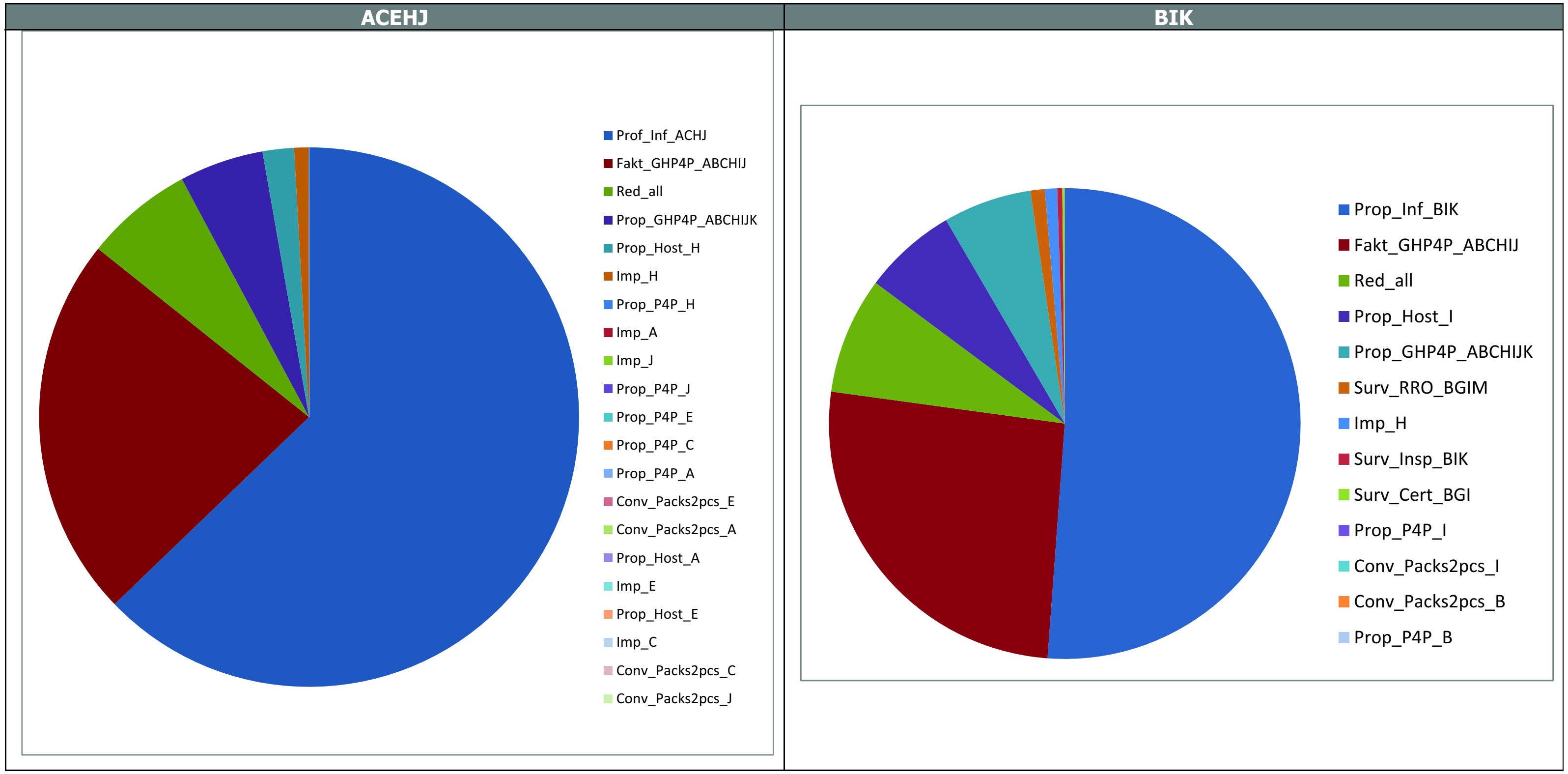


Figure D.60: Sensitivity analysis (Scenario A0) for PW1 and PW2

D.6.5.3. Scenario A1

Table D.63: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A1

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Plants impacted (Plants_imp) by pathway [–] (calculated)		
Scenario A1		
1st percentile	5	6
5th percentile	197	323
10th percentile	1,006	1,650
16.7th percentile	3,438	5,682
25th percentile	9,270	15,590
33rd percentile	18,832	31,838
50th percentile	56,865	96,248
67th percentile	142,833	240,847
75th percentile	225,821	377,850
83.3rd percentile	385,164	649,128
90th percentile	636,886	1,083,457
95th percentile	1,130,129	1,979,300
99th percentile	3,509,160	5,908,241
Mean	278,063	482,096
Standard deviation	880,287	1,688,741

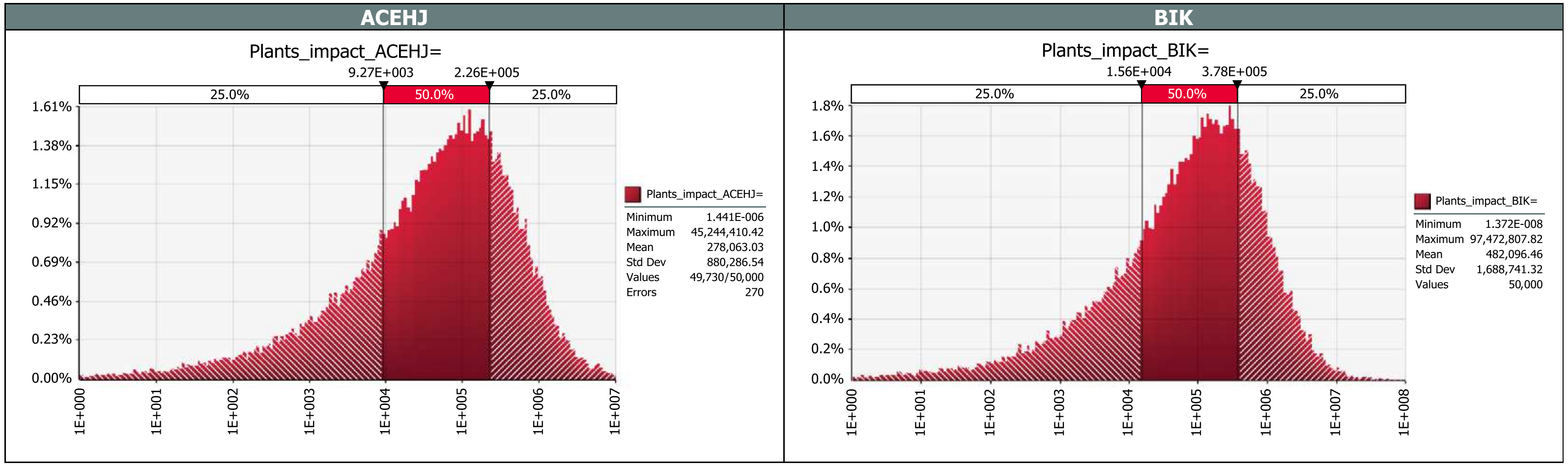


Figure D.61: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A1

D.6.5.4. Scenario A2

Table D.64: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A2

Pathway name	**ACEHJ**	**BIK**
Pathway no	**2**	**1**
Plants impacted (Plants_imp) by pathway [–] (calculated)		
Scenario A2		
1st percentile	2	3
5th percentile	24	40
10th percentile	81	134
16.7th percentile	202	337
25th percentile	433	715
33rd percentile	768	1,264
50th percentile	1,911	3,180
67th percentile	4,304	7,309
75th percentile	6,618	11,229
83.3rd percentile	11,078	18,807
90th percentile	18,031	31,171
95th percentile	32,585	56,856
99th percentile	99,533	171,895
Mean	8,432	14,304
Standard deviation	37,684	50,004

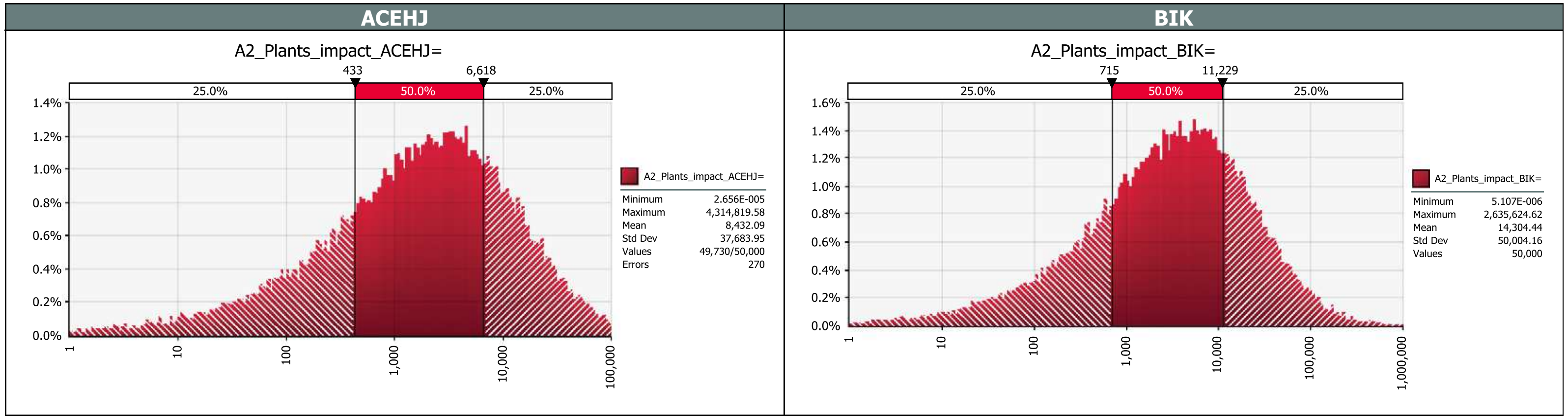


Figure D.62: Plants impacted (Plants_imp) by PW1 and PW2 for scenario A2

D.6.5.5. Comparison figures: Cumulative Distribution Functions (CDF)

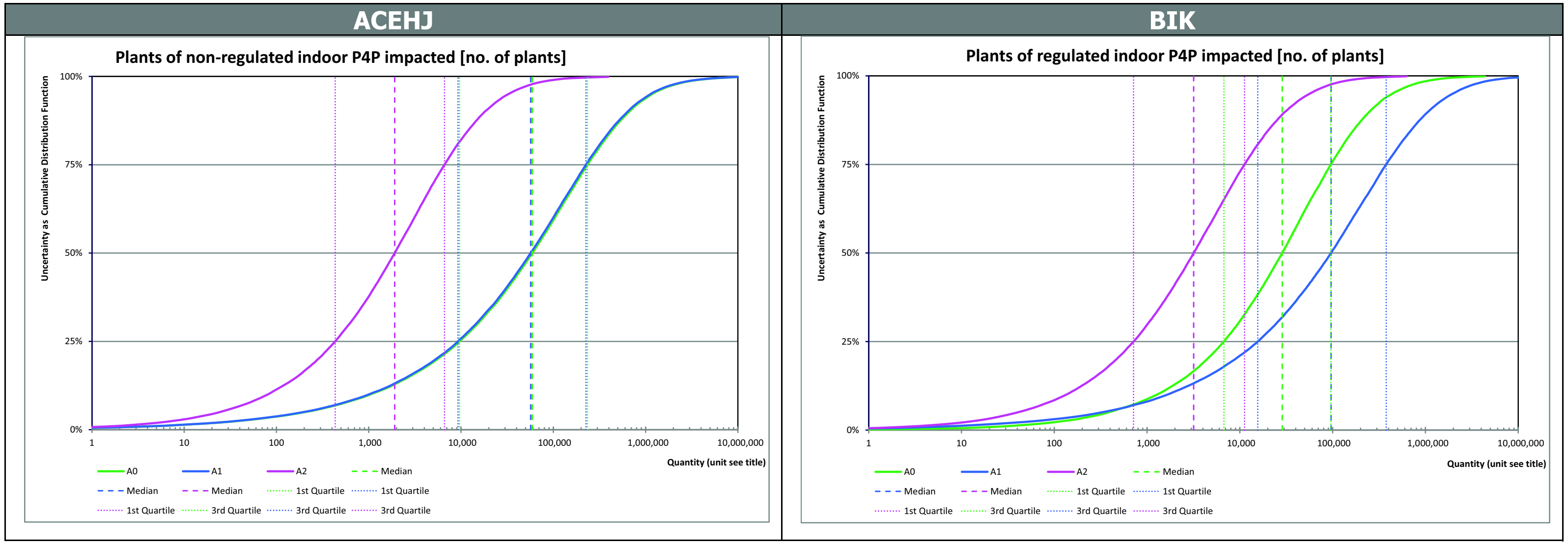


Figure D.63: Comparison figures: Cumulative Distribution Functions (CDF)

D.6.5.6. Comparison figures: Probability Density Function (PDF)

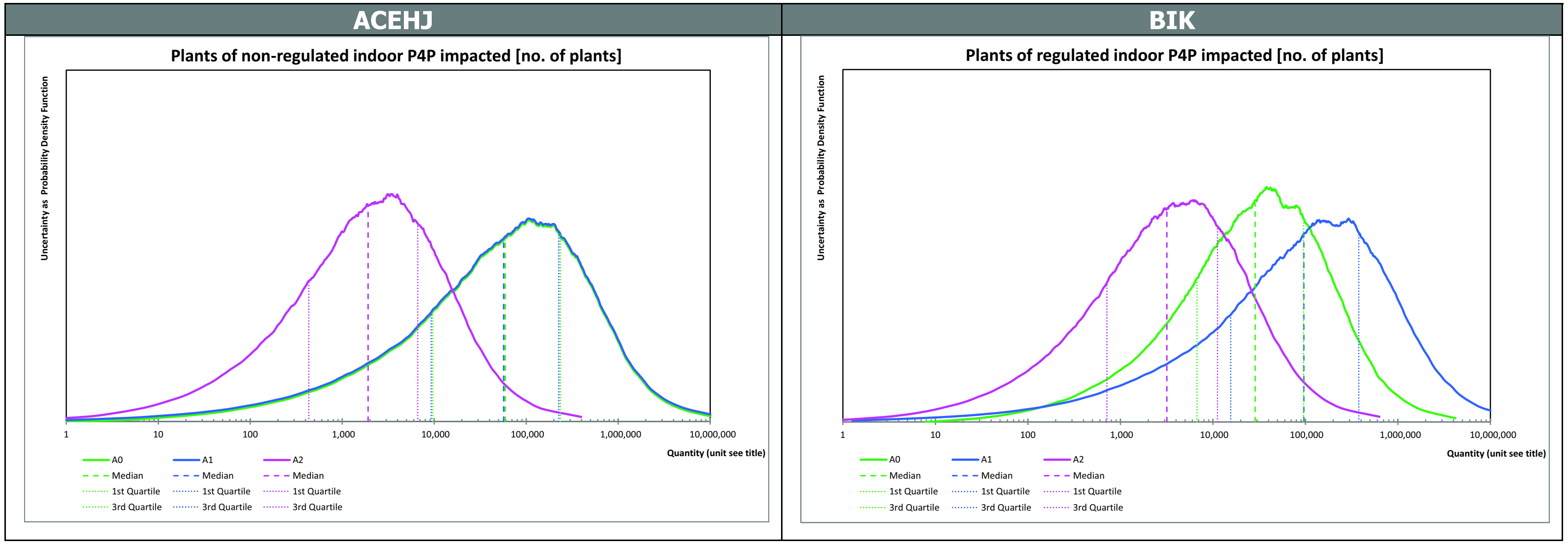
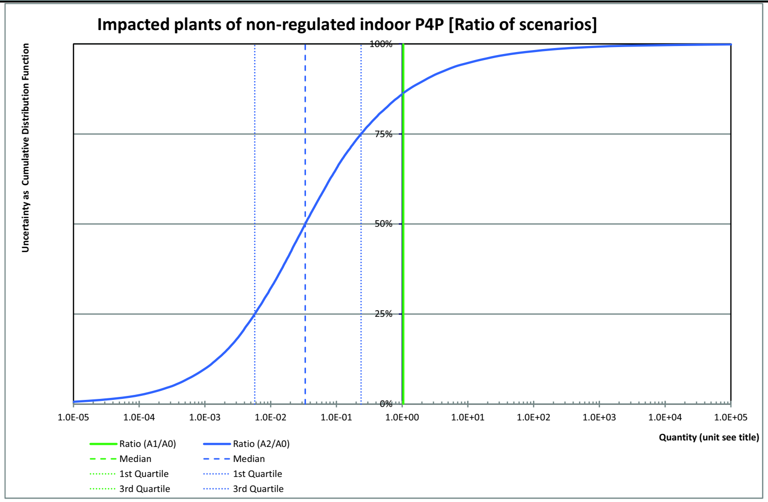


Figure D.64: Comparison figures: Probability Density Function (PDF)

D.6.5.7. Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

ACEHJ



BIK

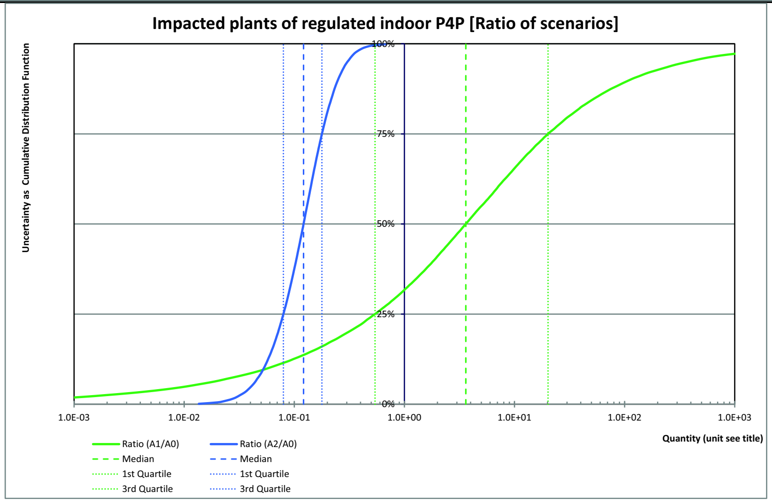


Figure D.65: Comparison figures: Cumulative Distribution Functions of the Ratio (CDF-R)

D.6.5.8. Comparison figures: Probability Density Functions of the Ratio (PDF-R)

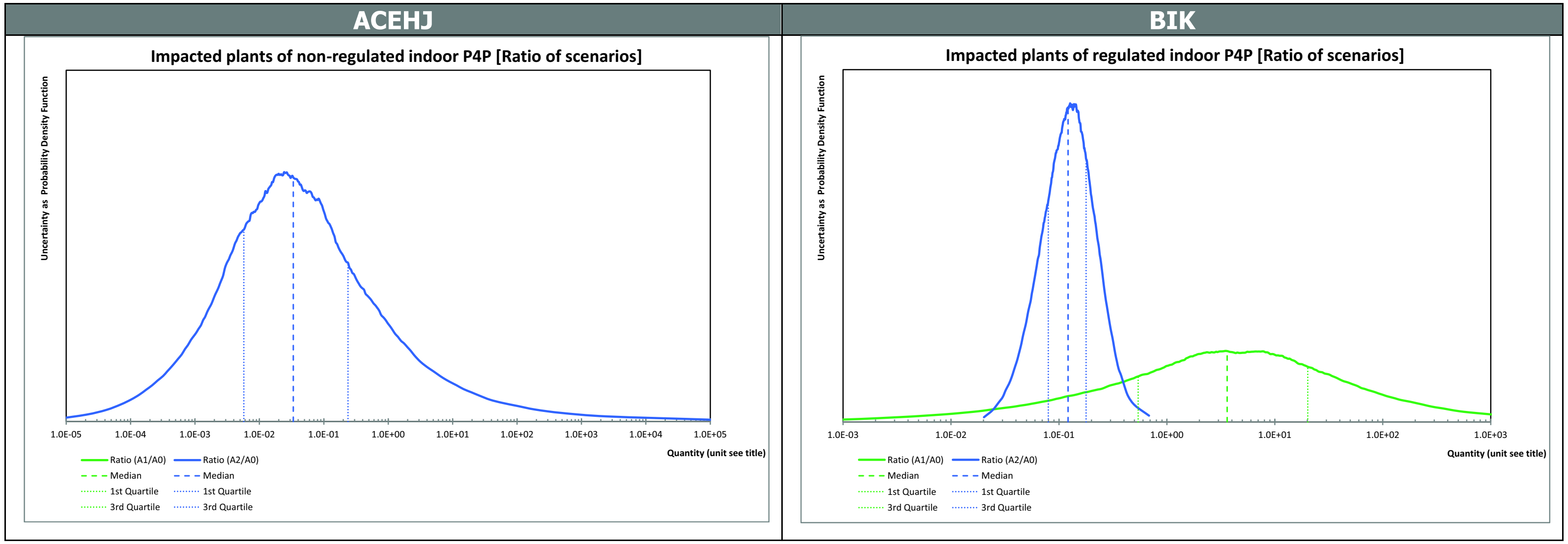


Figure D.66: Comparison figures: Probability Density Functions of the Ratio (PDF-R)

Annex A – *Radopholus similis* @ risk file

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