EFSA Journal

SCIENTIFIC OPINION

ADOPTED: 28 September 2016

doi: 10.2903/j.efsa.2016.4602

Risk to plant health of *Ditylenchus destructor* 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, Olaf Mosbach-Schulz and Gregor Urek

Abstract

The EFSA Panel on Plant Health performed a pest risk assessment on *Ditylenchus destructor*, the potato rot nematode, for the EU. It focused the assessment of entry, establishment, spread and impact on two crops: potato (*Solanum tuberosum*) and tulip (*Tulipa* spp.). The main pathways for entry of *D. destructor* into the EU and for spread of this nematode within the EU are plants for planting, including seed potatoes and flower bulbs. These commodities are also the main targets for the assessment of the impact. A modelling approach was used to quantitatively estimate entry, spread and impact. Literature and expert judgement were used to estimate model parameters, taking into account uncertainty. A baseline scenario with current pest-specific phytosanitary regulations was compared with alternative scenarios without those specific regulations or with additional risk reduction options. Further information is provided on the host range of *D. destructor* and on survival of the nematode in soil in the absence of hosts. The Panel concludes that the entry of *D. destructor* with planting material from third countries is small compared to the yearly intra-EU spread of this nematode with planting material. Changes in pest-specific regulations have little influence on entry of the pest as other non-specific regulation already lead to a good level of protection against the introduction of the nematode into the pest risk assessment (PRA) area. It is also concluded that the whole PRA area is suitable for establishment of *D. destructor*, but there is insufficient information to make a statement on the persistence of newly introduced populations in the entire PRA area. Impacts of this nematode on the quantity and quality of potato are considered negligible. The impact on flower bulb production in the EU is considered as very low.

Keywords: *Ditylenchus destructor*, potato rot nematode, potato, tulip, European Union, quantitative pest risk assessment, risk reduction options

Requestor: European Commission

Question number: EFSA-Q-2015-00268

Correspondence: alpha@efsa.europa.eu

Acknowledgements: The Panel wishes to thank the hearing experts: Prisca Kleijn and Peter Knippels and EFSA staff member: Svetla Kozelska for the support provided to this scientific opinion.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Grégoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Van Bruggen A, Van Der Werf W, West J, Winter S, Mosbach-Schulz O and Urek G, 2016. Scientific opinion on the risk to plant health of *Ditylenchus destructor* for the EU territory. EFSA Journal 2016;14(12):4602, 124 pp. doi:10.2903/j.efsa.2016.4602

ISSN: 1831-4732

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1. Introduction

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

The European Food Safety Authority (EFSA) is requested, pursuant to Article 22(5.b) and Article 29 (1) of Regulation (EC) No 178/20002[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 and to provide an assessment of the effectiveness of the 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 the Member States (MSs) 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[2] – Section II – Listing of Harmful Organisms as regards the future listing of *Ditylenchus destructor* Thorne

On the basis of the pest categorisation prepared by EFSA PLH Panel (2014), the Working Group on the Annexes of the Council Directive 2000/29/EC suggests listing this pest as a Regulated Non-Quarantine Pest.

D. destructor is sporadically present in the majority of the EU MSs; it has been reported in more than two-thirds of the EU MSs (including Iceland and Norway). Bulbs, rhizomes and tubers are the main pathways for spreading of the pest and should be regulated during the production process.

However, the host range needs to be further defined, together with proper risk reduction options which may be considered for soil control as part of the pest management measures. Further information is also needed as regards the survival period of the pest in the soil without the presence of host organisms.

1.2. Interpretation of the Terms of Reference

The Panel on Plant Health (hereinafter referred to as Panel) interprets the Terms of Reference as a request to conduct a full PRA, to identify risk reduction options and to provide an assessment of the effectiveness of the current EU phytosanitary requirements together with further definition of the host range and proper risk reduction options which may be considered for soil control as part of the pest management measures and information as regards the survival period of the pest in the soil without the presence of host organisms.

The scope of the opinion is to assess the risk of *D. destructor* to potato tubers (*Solanum tuberosum*) and bulbs and corms of ornamental host plants (*Crocus* L., miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort., *Gladiolus tubergenii* hort., *Hyacinthus* L., *Iris* L., *Trigridia* Juss, *Tulipa* L.), intended for planting that are present in the risk assessment area. In Annex IIAII of Council Directive 2000/29, the genus *Tigridia* is misspelled as *Trigridia.* In this document, the term *Tigridia* is used.

In this opinion, the Panel further defined the host range of *D. destructor* and considered defining risk reduction options related to agricultural or horticultural field soils. Further information is also provided as regards to the survival period of the pest in the soil without the presence of host organisms. Information already provided in the pest categorisation of *D. destructor* (EFSA PLH Panel, 2014) is not repeated here unless necessary.

The pest risk assessment area is the territory of the EU with 28 MSs (hereinafter referred to as EU 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.

[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.

In this assessment, a new quantitative approach to develop a PRA is applied. This quantitative approach is developed by the Panel to increase the transparency and objectivity of the assessment. At the time of the finalisation of this opinion, the framework for quantitative assessment is still under development, and this PRA constitutes a test case for the new approach. The new approach allows the comparison of scenarios involving different risk reduction options.

1.3. Specification of the assessment

1.3.1. Pathways

The Panel identified seven pathways for entry and spread of *D. destructor* from infested areas:

1) potato plants for planting (seed potato tubers);
2) plants of other host species for planting (bulbs, tubers, corms, roots and rhizomes of host plants);
3) host plants and plant parts not intended for planting with soil attached originating from areas where the pest occurs;
4) soil or growing media attached to host or non-host plants for planting with roots from areas where the pest occurs;
5) soil adhering to machinery or packaging material from countries where the pest occurs;
6) soil and growing media from countries where the pests occur;
7) water-related pathways.

Selection of relevant pathways for assessment

The selection of the most important of the seven 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'.

Above-mentioned pathways are further described in Appendix A. They can be grouped into plant- or soil-related pathways. Pathway 1 (potato plants for planting: seed potato tubers) and pathway 2 (plants of other host species for planting: bulbs, tubers, corms, roots and rhizomes of host plants) are considered the major pathways for entry of *D. destructor* into the risk assessment area from third countries and for intra-EU spread. Due to the biology of this endoparasitic pest and the lack of specific survival stages (such as cysts in, e.g. potato cyst nematodes), soil-related pathways are less important. Therefore, only plant-related pathways are chosen for further assessment. Within the category of flower bulbs, the panel has focused the assessment on tulip bulbs because of the large production volume in the EU, the large trade volumes (both external and internal) and the unambiguous status of tulip as a host plant of *D. destructor*. Only tulips will be considered for this assessment.

1.3.2. Specification of assessment scenarios including RRO scenarios

The pest risk analysis considers seven scenarios for risk reduction including a baseline scenario A0 representing a situation with all current regulations and phytosanitary measures in place (Table 1). Scenario A1 represents a hypothetical situation in which existing phytosanitary measures (as specified in Annex IIAII of Council Directive 2000/29/EC) specific to *D. destructor* only are withdrawn. These two options for regulation are combined with the two main pathways: seed potato tubers (PW1) and tulip bulbs for planting (PW2). There five additional scenarios A2–A6 that consider single risk reducing options that are superimposed upon the baseline scenario A0. The scenario A2 considers a requirement for seed potatoes to be cultivated in pest-free places of production. This scenario affects entry with seed potatoes. Scenario A3 considers a requirement for flower bulbs to be cultivated in pest-free places of production in third countries. This scenario affects entry with flower bulbs. Scenario A4 considers a requirement for flower bulbs to be cultivated within the EU in pest-free areas. This scenario affects spread of the nematode with flower bulbs. Scenario A5 imposes a hot water treatment before flower bulbs are planted, and affects spread. Scenario A6 considers the use of chemical soil disinfection before planting of seed potatoes. No scenarios were carried out to study the cumulative effects of multiple risk reduction options (RROs). Moreover, the effectiveness of scenarios is evaluated taking each pathway separately and an overall evaluation across pathways is not conducted. These limitations do not seriously hamper the interpretation of the effectiveness of measures because potato and flower bulbs cultivation are mostly spatially separated (although not entirely) and the effectiveness of multiple risk reducing options at different stage (entry, establishment, spread and impact) can be inferred from the importance of entry and spread (see results). The seven scenarios for RROs are summarised in Table 1, and further

Table 1: Overview of the scenarios

Scenarios		PW1 potato	PW2 tulips	Considered in section
Baseline scenario				
A0	Baseline scenario: current regulations	x[(a)]	x	All sections
Deregulation scenario				
A1	All current regulations specific for *D. destructor* are withdrawn	x	x	All sections
Scenarios with additional regulation				
A2	Current regulations plus a regulation that **seed potatoes** for import into the EU are originating from **pest-free places of production**	x	–[(b)]	Entry
A3	Current regulations plus a regulation that **flower bulbs** imported into the EU are originating from **pest-free places of production**	–	x	Entry
A4	Current regulations for *D. destructor* plus a regulation that European **flower bulbs** originate from **pest-free areas**	–	x	Spread
A5	Current regulations for *D. destructor* plus a regulation that European **flower bulbs** should be subjected to **hot water treatment** before planting	–	x	Spread
A6	Current regulations plus use of **chemical treatments (including chemical soil fumigation before planting)** of **potatoes**	x	–	Impact

(a): Scenario is applicable to the pathway.
(b): Scenario is not applicable to the pathway.

details are given in Appendix A. Overall, nine assessments were carried out.

The risk reduction options relevant for the scenarios are specified in detail in Appendix H.

1.3.3. 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:

- The temporal horizon of the assessment is 5 years. Over this time frame, we do not expect significant changes in pattern of trade or levels of infestation of *D. destructor* in source areas according to stable trade flow in last 10 years.
- The temporal resolution is 1 year.
- The spatial extent of this PRA is the EU.
- As to spatial resolution: This opinion considers differences between the EU MSs in the prevalence of *D. destructor*, as reported by the National plant health authorities. Three classes of countries are distinguished according to the reported prevalence: higher prevalence, lower prevalence and absent (vague wording used to reflect lack of quantitative data). Calculations are made for each category. The spatial resolution is thus at the levels of the country class. Further details are given in Section 3.3.1 and in Appendix F.

2. Data and methodologies

2.1. Data

EFSA conducted an extensive literature search for the pest categorisation of *D. destructor* (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). Relevant host genera (only agricultural/horticultural plants that are vegetatively propagated) were selected from the list provided by Esser (1985). A specific literature search was then conducted on these genera in Thomson Reuters Web of Knowledge to collect information on host plants of *D. destructor*. For further information, see Appendix I.

Information on the trade data and distribution of main host plants was obtained from the EUROSTAT (online) and FAOSTAT (online) databases. The EUROPHYT (online) database, which collects notifications of interceptions of plants or plant products that do not comply with the EU legislation, was consulted searching for pest-specific notifications on interceptions.

Information provided by the literature and online databases on pest distribution, damage and management was complemented with information obtained from a short questionnaire (hereinafter referred to as the MS Questionnaire) that was sent by the PLH Panel to the National Plant Protection Organization (NPPO) of all the EU MSs in 2014 (EFSA PLH Panel, 2014). This questionnaire aimed to clarify the current distribution of *D. destructor* at the country level and update information available in the European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval (EPPO PQR, online). A summary table on the pest status, based on EPPO PQR (online) and MS replies, is presented in Section 3.3.1 (Table 4).

2.2. Methodologies

The Panel performed the pest risk assessment for *D. destructor* 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).

A specific quantitative assessment model was used to perform the pest risk assessment. The specification of the model is described in Appendix B. This model was used to carry out scenario studies (Section A.4).

When conducting this pest risk assessment, the Panel took into consideration also 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 Statistical Reporting (EFSA, 2014a),
- Guidance on the structure and content of EFSA's scientific opinions and statements (EFSA, 2014b).

The assessment follows a quantitative approach, in which the steps of entry, establishment, spread and impact are elaborated quantitatively for two pathways, seed potatoes and tulip bulbs, under seven RRO scenarios, identified as A0–A6, according to the Terms of Reference. Within each step, substeps are distinguished to quantitatively assess the underlying component processes. The substeps are detailed in appendices: Appendix D for entry, Appendix E for establishment, Appendix F for spread and Appendix G for impact. An overall summary description of the four steps is provided in Appendix B, which describes the overall risk assessment model without mathematical equations. The model calculation performed for this opinion is shown in Annexes A, B, C and D.

In short, the entry step (Section 3.1; Appendix D) estimates the total amount of infested planting material that enters the EU from third countries each year. The establishment step (Section 3.2; Appendix E) estimates how many infested plants will grow each year across the EU from this infested planting material. The spread step (Section 3.3; Appendix F) estimates the total amount of infested planting material that is traded within the EU each year, and results in infested plants. The impact step (Section 3.4; Appendix G) estimates the impacts in agriculture (potato cultivation) and horticulture (tulip cultivation) that arise from both entry and spread.

Uncertainty involved in estimating entry, establishment, spread and impact, is represented using a probability distribution which expresses the best 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.

In the model calculation, the uncertainty of each component is passed through the model equation, in a way that its contribution to the uncertainty of the final result can be shown. The **decomposition of uncertainty** calculates the relative contribution (as a proportion) of each individual input to the overall uncertainty of the result (sum to 1).

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 under-estimating the actual value. In the opinion the median is also referred as 'best estimate'.

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 '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 **credibility range**. The credibility 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 above the range, and it is extremely unlikely that it is below the range.

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

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**.

Nevertheless, the distributions of one variable under different scenarios can be compared via the corresponding median values, e.g. consider a variable with a median value of 13 within scenario 1 and the same variable with a median value of 6 within scenario 2. This can be interpreted as the variable in scenario 2 being about half of scenario 1 in terms of its central value. The same principle is also valid for other characteristics of the distribution of a variable under different scenarios, such as comparisons of quartiles or percentiles.

3. Assessment

3.1. Entry

The aim of this section is to estimate quantitatively the number of infested seed potatoes or tulip bulbs that enter each year the risk assessment area from third countries (i.e. outside the EU). The assessment of entry is made separately for seed potatoes (PW1) and tulip bulbs (PW2) and the assessments are made under different scenarios whereby scenario A0 represents the current situation and scenario A1 represent removal of current pest-specific legislation.

3.1.1. Introduction to entry

Seed potatoes are the first pathway that is estimated, and cultivated host plants are grown from the possibly infected seed. The pest is present within the host plant and therefore will be planted together with the host. A successful transfer to the host can be assumed in most cases. Seed potato infested by *D. destructor* is crucial for establishment of new field infestations. If this is considered part of transfer, then this subsequent infestation process is very likely. These subsequent infestations may lead to *D. destructor* being reproduced and surviving for a specific time in soil on alternative hosts including fungi, providing a source for future infestations of host plants.

Entry is assessed in successive steps as follows:

- total trade flow from third countries; this flow is calculated as the product of the trade flow in tonnes/year and the number of potatoes per tonne;
- proportion of the trade flow that originates from fields infested with *D. destructor*;
- proportion of the harvested potatoes in infested fields that is infested with *D. destructor*;
- effectiveness of culling and cleaning operations in the country of origin that aims at reducing the proportion of infested tubers in the trade;
- survival of infested tubers during transport from third countries to the EU;
- proportion of the infested tubers that pass import inspection;
- survival of infested tubers during transport within the EU.

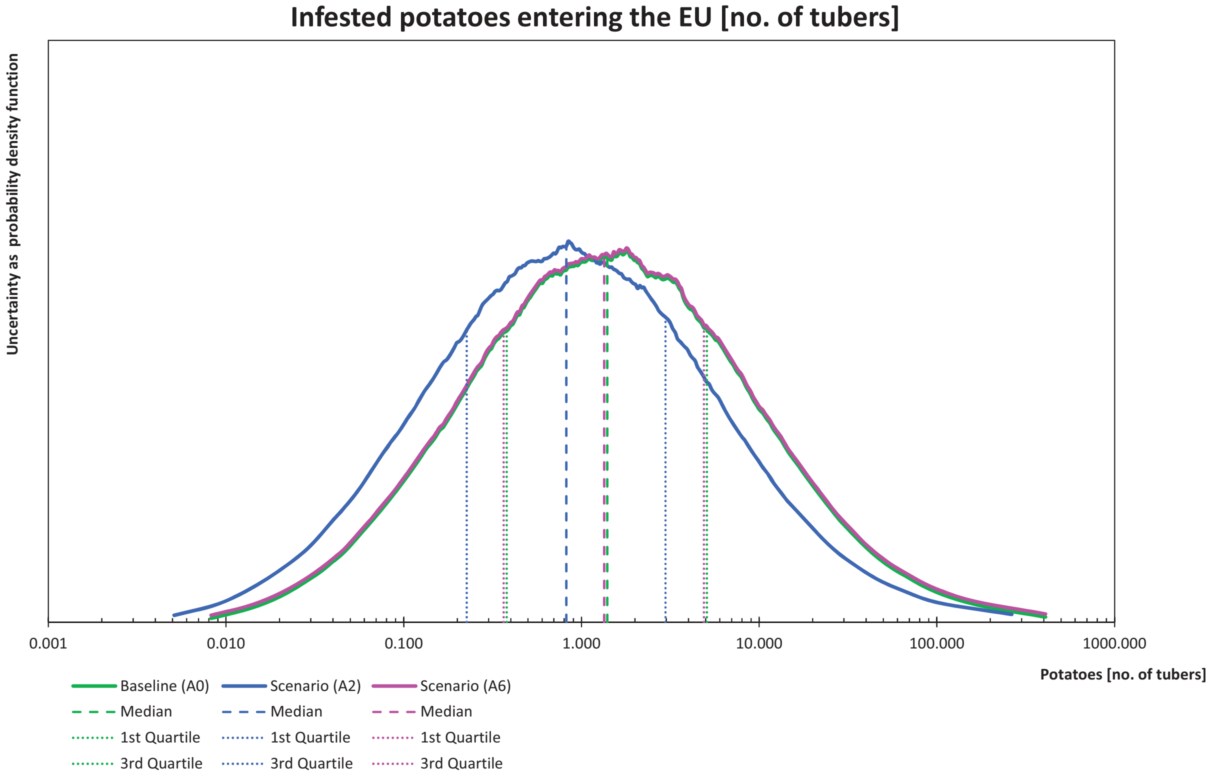
These steps are combined in a calculation formula for the total number of infested tubers that are planted in Europe per year. For further information, see Appendix B.

The Panel carried out literature search and expert elicitation to quantify the subsequent stages in the entry process. The estimations take into account data and expert knowledge, and where necessary, uncertainty about parameter values is expressed by estimating probability distributions for parameter values. The estimation of the probability distribution proceeds in two steps. First, the experts express their knowledge and beliefs by giving five quantiles of the distribution. Second, a probability model is fitted on the basis of the expert estimates. During calculations with the model, values are drawn from each parameter distribution. The random draws are combined by simple multiplication (Appendix B), and this process is repeated 20,000 times, to obtain a frequency distribution of outcomes. The outcome distributions are generated separately for each scenario. Further details on the estimation process for entry are given in the Appendix D.

3.1.2. Results on entry via the seed potato pathway

The median number of infested potatoes planted in EU countries from Switzerland or Canada, representing the only third countries from which seed potatoes are imported in the EU, predicted by the entry model with estimated parameters, and resulting in introduction of *D. destructor,* is 1.3 infested potatoes per year, with a 50% uncertainty interval from 0.4 to 5 infested tubers per year. The low number of introductions is mainly due to the small trade volume (mean value of 352 tonnes/year) but also due to low proportion of infested tubers. A probability distribution of the yearly number of infested potatoes planted is given in Figure 1. Overall, these numbers indicate that the import of infested tubers with trade from third countries is small. The numbers are not changed under the deregulation scenario A1. As explained in Section 1.3.2 and detailed in Appendices D–G, the lack of difference between scenario A0 and A1 is due to the Panel's reasoning that general quality requirements and inspections for other quarantine pests in potato will remain in place, even if the pest-specific regulations for *D. destructor* are withdrawn. This reasoning was implemented by using the exact same parameter values for making model calculations in the two scenarios (see Appendices D–G for details on the parameter values used).

The number of infested potato tubers planted is reduced under scenario A2, which requires the production of seed potatoes in pest-free places of production in the country of origin. The Panel assumed that requiring production in pest-free places of production would result in a modest reduction in the proportion of infested potatoes in the trade flow from third countries, due to an increased effectiveness of phytosanitary measures (Appendix D; Table D.7). In this case, the median number of infested tubers in the simulations is 0.8 with a 50% uncertainty interval ranging from 0.2 to 3 tubers per year. While these values are lower than in the baseline scenario, the predicted ranges overlap substantially due to uncertainty in the predictions. Therefore, this risk reducing option is not considered to result in significant (Figure 1) reduction in entry. Furthermore, the entry is negligible when compared to the spread of the nematode with planting material within the EU, as presented in Section 3.3.



The figure depicts the frequency distribution of the number of infested potatoes planted in the EU following import from Switzerland and Canada, under the baseline scenario A0 and a scenario with an import regulation for *D. destructor* requiring production in third countries in pest-free places of production (scenario A2). Results for the scenario without regulations for *D. destructor* (scenario A1; not shown in figure) are identical to those of the baseline (scenario A0).

Figure 1: Simulation results on the entry of *D. destructor* with import of seed potatoes from third countries

3.1.3. Uncertainty on entry via the seed potato pathway

The simulations do not give a single value as an answer, but a distribution of values, based on stochastic simulations with a model that takes into account uncertainty in model components.

The result of the entry model is the mathematical product of its parameter inputs (Appendix B). Therefore, a 1% change in any of the parameters (whatever process it represents) has a 1% effect on the calculated number of infested potatoes planted in PRA area. In other words, the parameters are equally sensitive. Uncertainty in the final number of infested potatoes planted can be traced back to different sources of uncertainty. The more uncertain a parameter is, the greater its contribution is to the overall uncertainty in predicted entry. The model components with the largest uncertainty contribute the most to the uncertainty in the final outcome.

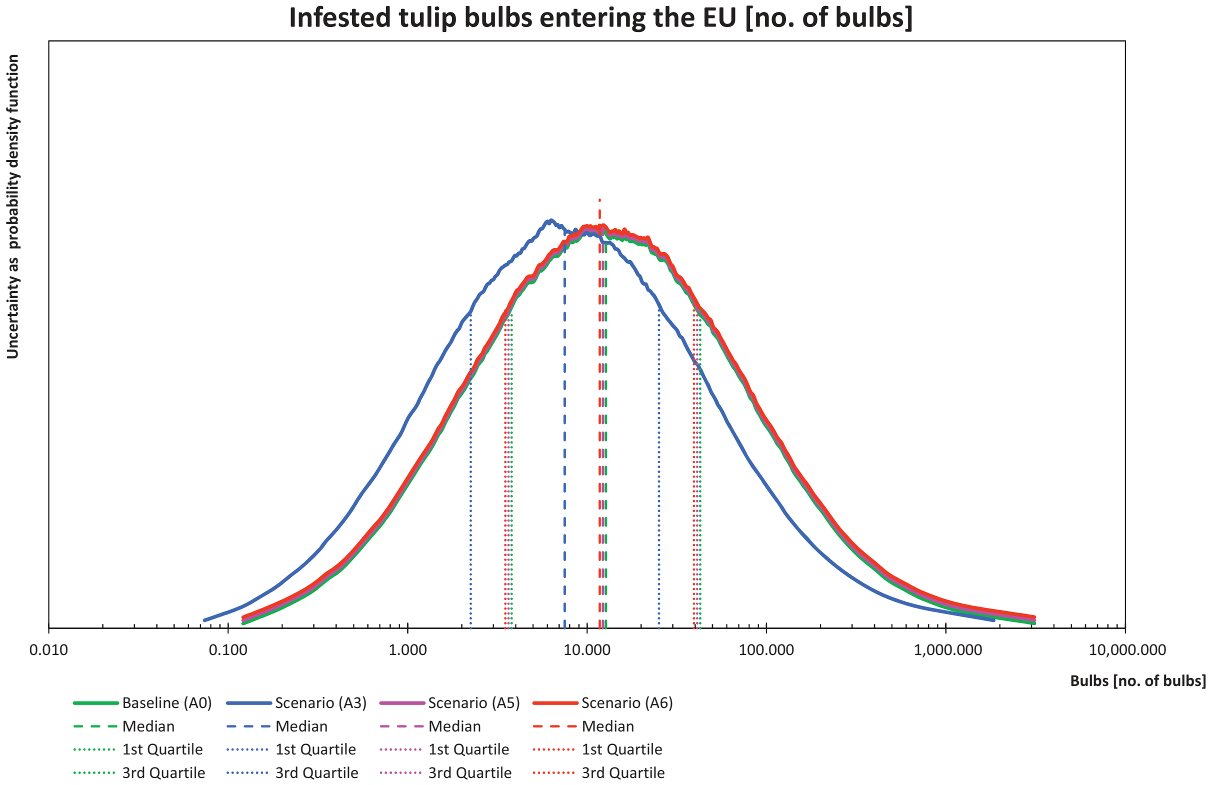
More than 90% uncertainty in calculated entry is due to uncertainty about the proportion of infested potatoes harvested in infested fields. Other factors are of minor influence on uncertainty (Details in Appendix D: Table D.15 and Figure D.9).

3.1.4. Results on entry via the flower bulb pathway

The tulip bulbs are the pathway and the cultivated host plants are grown from the possibly infected bulbs. It is therefore assumed that there will be a successful transfer to the host in most cases.

Tulip bulbs infested by *D. destructor* are crucial for establishment of new field infestations. If this is considered part of transfer, then this subsequent infestation process is very likely. These subsequent infestations may lead to *D. destructor* being reproduced and surviving for a specific time in soil on alternative hosts including fungi, providing a source for future infestations of host plants.

The predicted yearly number of infested tulips planted in EU countries from third countries as specified in the Appendix D, and resulting in the introduction of *D. destructor* is in the order of 10 bulbs per year (with a median value of 12 in the baseline scenario, and a 50% uncertainty interval ranging from 4 to 41 (Figure 2). This number of introductions is the consequence of a relatively small import volume (mean value of 1,052 tonnes/year), a proportion of infested fields in the country of origin of approximately 0.02 (i.e. 2%) and a very low proportion of infested bulbs from those fields (median value of 1 in 10,000 bulbs being infested). Cleaning, survival during transport and import inspection contribute to lowering the flow of infested bulbs, but the import of infested bulbs is not negligible. The 50% uncertainty interval of the number of infested tulip bulbs planted in the EU from third countries is 4–41 infested bulbs per year, while the 90% uncertainty interval is 0.6–229 infested bulbs, i.e. a factor 382 between the lower and upper 5% prediction limits, projecting substantial uncertainty.



Frequency distribution of the number of infested tulip bulbs planted in Europe following import from third countries. Two scenarios are compared: a baseline scenario with current regulations (A0) and a scenario with an additional requirement for production of flower bulbs in pest-free places of production in third countries (A3). Results for the scenario without regulations for *D. destructor* (scenario A1; not shown in figure) are identical to those of the baseline (scenario A0).

Figure 2: Simulation results on the entry of *D. destructor* with import of tulip bulbs from third countries

The median number is 10 bulbs in the baseline scenario A0, and only slightly lowered in the A3 scenario requiring flower bulbs in third countries to be produced in pest-free places of production (Figure 2). The 50% probable range of predicted entry is from 4 to 41 infested bulbs in the baseline scenario and from 2 to 25 bulbs in the A3 scenario, indicating limited effectiveness of the measure considered in A3, when considering the uncertainty in the assessment. The results of the scenarios A1 (removal of regulations) are identical to those of the baseline, indicating that these measures have no effect on the entry (they are aimed at reducing spread) as described in Appendix D, Section D.2.4. The horizontal axis is logarithmic to represent widely different possible outcomes for entry in a single figure. The distributions of predicted entry span approximately four orders of magnitude from lowest entry numbers that are considered possible in rare cases (lower 1% point around 0.1 infested tuber per year) to the highest numbers that are also considered possible in rare cases (upper 1% point around 1,000 infested tubers per year).

3.1.5. Uncertainty on entry via the flower bulb pathway

Uncertainty in the proportion of bulbs from infested fields that are infested with *D. destructor* is responsible for 96% of the uncertainty in calculated entry.

3.1.6. Overall conclusion on the assessment of entry for the different assessments

The results indicate that the entry of *D. destructor* with planting material from third countries is quite small. Scenarios for reducing this entry did not elucidate options that result in relevant reductions in entry. Uncertainties in the calculated entry are substantial and mostly due to a lack of data on the proportion of infested tubers harvested from infested fields. Based on biological principles, it may be inferred that some fields must be infested because total eradication of the nematode is not practically feasible. However, the number of infested tubers or flower bulbs harvested from fields with low population densities of this nematode is not known because the proportion of infested material (believed to be in the order of 1–10,000) is too low to be measured empirically. Therefore, these parameters were estimated on the basis of expert judgement, with wide margins of uncertainty (see Appendix D). Despite the uncertainties, the Panel states confidence in the estimation of these very low rates of entry.

3.2. Establishment

3.2.1. Introduction to establishment

The aim of this section is to estimate the number of pest populations that will establish after entering the PRA area. According to ISPM No 5 (FAO, 2016), establishment is defined as 'Perpetuation, for the foreseeable future, of a pest within an area after entry'. For the purpose of this assessment, the foreseeable future is the vegetation period following planting of an infested potato tuber or tulip bulb. The definition of establishment for this opinion does therefore not include survival over multiple years. Establishment of the nematode is quantitatively assessed, but survival is not quantitatively assessed.

As specified in Section 3.1 and quantified in Appendix D, the import of seed potato from third countries is marginal compared to all seed potatoes planted in the EU. This is similar for the flower bulb pathway. Although the total volume of imported seed potatoes or tulip bulbs is negligible (see Section 3.1), establishment of *D. destructor* was assessed for nematode-infested potato tubers from Switzerland and Canada (the only third countries exporting seed potatoes to the EU) and flower bulbs from Norway, Turkey, Canada, USA, Chile and New Zealand, which constitute the only countries where *D. destructor* is present that export tulip bulbs to the EU).

Once *D. destructor* is introduced into a field within the PRA area with infested plants for planting, it will most certainly establish because of its association with the host plant and in general suitable environmental conditions throughout the PRA area. Suitable conditions for establishment are supported by the fact that *D. destructor* has already been reported from the 21 EU MSs. Although the nematode has a restricted distribution in the majority of them, successful establishment in the PRA area is therefore possible. Despite the fact that *D. destructor* was described as a new species from the USA in 1945 (Thorne, 1945), the nematode may be endemic to Europe considering the extent and timing of reported occurrences of a potato rot nematode belonging to the genus *Ditylenchus* (Quanjer, 1927). However, given the wide distribution of the pest in the PRA area, it is not relevant for this assessment whether the pest is endemic or whether it was introduced in the past. The nematode can persist over years by feeding on a wide range of host plants (including weeds and volunteer root crops) decaying plant material and soil-borne fungi.

As stated in the EFSA pest categorisation on *D. destructor* (EFSA PLH Panel, 2014), the temperature range for the completion of the life cycle of *D. destructor* is very wide ranging from 5 to 34°C with optimal temperatures between 20 and 27°C (Sturhan and Brzeski, 1991). Throughout the PRA area, these conditions will be found during the vegetation period. Moisture conditions in the soil will also be suitable for nematode development wherever host crops, in particular potato, are grown. Moisture requirements of the crop will be satisfied by, e.g. irrigation if natural precipitation is not sufficient.

Apart from suitable environmental conditions, the presence of host plants is critical for the establishment of this nematode. Specifically the lack of an effective survival stage requires constant availability of nutritional sources. *D. destructor* is a polyphagous nematode with a wide host range comprising more than 100 cultivated plants and weeds belonging to a wide variety of families (Decker, 1969; Esser, 1985; Sturhan and Brzeski, 1991). For more detailed data on host plants see Table 9 and Table 10 of the pest categorisation (EFSA PLH Panel, 2014). Suitable cultivated and weed host plants are present throughout the risk assessment area. The nematode can also feed on several fungal genera (see also Section 3.2.3). Potato is by far the most important crop attacked by *D. destructor*. It was described as the type host of *D. destructor* and is widely grown in the EU (see pest categorisation – EFSA PLH Panel, 2014). Only a fraction of the host plants of *D. destructor* is listed in Council Directive 2000/29/EC (Annex IIAII). As requested by the European Commission, the host range is further defined in Section 3.2.2.

Soil moisture is important for movement of nematodes in soil. It can therefore affect host finding and invasion by namatodes originating from soil, but once the nematode has entered a susceptible host plant, soil conditions are not likely to affect establishment unless these will result in failure of crop establishment. It is not likely that soil conditions will affect establishment of *D. destructor* after planting infested tubers or bulbs.

Following establishment, survival in plant tissue or in soil will be important to determine the feasibility and effectiveness of control interventions. Nematode survival might extend beyond the foreseeable future, i.e. the vegetation period following the planting of an infested tuber or bulb. After harvest of an infested host crop, part of the nematode population might be removed with the host plant (Moore, 1971) or left in the field with decaying plant material. In the absence of alternative hosts in the field, several factors will influence survival in soil and these are specified in Section 3.2.3 (Survival in soil).

3.2.2. Further specification on the host range

In order to further specify the cultivated host range, crops that have been listed as host plants in the pest categorisation and which have an underground propagative part were further evaluated as regards their host status. The specification of the host range is based on the host range list of cultivated host provided in the pest categorisation (Table 9 in Pest Categorisation – EFSA PLH Panel, 2014). Some of these crops are included in Annex IIAII of Council Directive 2000/29/EC (gladioli, hyacinths, iris, tulips). Other crops, such as garlic, dahlia and hop, that are reported to be host plants are not listed in Council Directive 2000/29/EC (see also Appendix I, Table 4).

Although any host crop may contribute to the survival of endemic or introduced populations, nematode will only spread on vegetative underground propagative material that is infested and transferred to a new location. The nematode mainly attacks underground parts of plants such as the tubers, bulbs, corms, stolons and roots (Decker, 1969; Sturhan and Brzeski, 1991) and will only occasionally be found on aboveground parts of some plant species (Decker, 1969; MacGuidwin et al., 1992). Unlike the related species *Ditylenchus dipsaci*, *D. destructor* has not been reported from seeds (Decker, 1969). Crops that are seed propagated (such as sugar beet) or cuttings of aboveground plant parts (such as sweet potato) are therefore not further considered for entry or spread. Those crops will most likely not act as a pathway as the pest is not likely to be present in seeds or cuttings. Similarly, wild host plant species (including weeds) specified in Table 10 of the Pest Categorisation (EFSA PLH Panel, 2014) will not be a pathway and therefore will not be considered for this specification.

There are indications that host plants differ in their sensitivity (to suffer damage) and susceptibility (to allow multiplication of the nematodes) to *D. destructor*. For instance, differences in resistance of potato varieties against *D. destructor* have been reported (e.g. Mwaura et al., 2014). The existence of biological races differing in their host range has been suggested but so far no races of *D. destructor* have been described (Sturhan and Brzeski, 1991). Molecular studies have distinguished several haplotypes within *D. destructor* based on ITS-rRNA gene sequences but those groupings did not correlate with pathogenicity groupings (Subbotin et al., 2011). An earlier report such as the one of an exceptional population of *D. destructor* from groundnut which does not affect potato occurring in South Africa has proven not to be a biological race. The nematode was initially identified as *D. destructor* (DeWaele et al., 1991) but later described as a separate new species, *Ditylenchus africanus* (Wendt et al., 1995). Further intraspecific distinctions (such as races or pathotypes) are therefore not justified at present and will not be considered for this specification.

The host status of all plants listed in Annex IIAII of Council Directive 2000/29/EC was further assessed based on a literature search (specification of search terms is provided in Appendix I). Species of the genera *Crocus* L. and *Tigridia* L. (misspelled *Trigridia* L. in Council Directive 2000/29/EC) are reported to be wild hosts of *D. destructor* according to the Pest Categorisation (EFSA PLH Panel, 2014). Both genera are commercially produced ornamentals and are listed in Annex IIAII of the Council Directive 2000/29/EC.

A summary of the literature search is given in Appendix I. A summary of results is presented in Table 2. Most reports considered were produced in the 1950s until the 1970s. Only few reports have been published on the host status in the last two decades. It is also not always clear from the reports whether the crops affected are host plants or only suffered damage as incidental hosts. For instance, *Gladiolus* may be damaged but based on observations made by Goodey (1952) may not allow multiplication of the nematode. Based on these observations and in the absence of other reports stating host status, *Gladiolus* may not be considered a host plant.

The host status could not be resolved in all cases. This is mainly due to the fact that many reports state that the nematode was associated with a plant without giving further details on the type of relationship. For the purpose of this assessment, it was considered evidence for the host status for that particular crop when damage was reported. It should be noted that according to number of records or attention received in, e.g. annual reports, differences in damage caused by *D. destructor* on crops may be observed. From this, it may be deducted that iris and tulips are severely affected host plants whereas other such as *Tigridia* spp. or *Gladiolus* spp. are either minor host plants, (or are less sensitive) or may not be economically important (present or past).

Table 2: Summary of assessment on the status of plants as hosts for *D. destructor* listed in Annex IIAII of the Council Directive 2000/29/EC

Host plant	Status	Comment
Crocus	Host plant	Reports until 1980, mostly Dutch reports in yearbooks
Gladiolus	Unclear status	Few reports in literature until 1959, inconclusive evidence as the pest has been associated with damaged tubers but speculated that feeding took place on fungi and not plant tissue
Hyacinthus	Host plant	Few reports until 1982
Iris	Host plant	Relatively large number of reports until 1983, iris appears to be a sensitive host plant
Tigridia (*Trigridia*)	Host plant	One report (1959) stating that *Tigridia pavonia* is a host
Tulipa	Host plant	Relatively large number of reports until 1984
Potato	Host plant	Type host (not evaluated as status undoubtful)

Table 3 gives a summary of plants species that were listed in the Pest Categorisation (EFSA PLH Panel, 2014) as host plants for *D. destructor* based on references compiled by several authors (Esser, 1985; Sturhan and Brzeski, 1991; CABI, online; NEMAPLEX, online). The host status of onion could not be resolved due to ambiguous data. Contradictory statements are also available for strawberry which can be affected by *D. destructor*. However, there are also reports stating that strawberry will not be affected. It is not clear if this is due to physiological differences of nematode populations or varietal differences in strawberry or experimental conditions. Begonias are probably wrongly reported as host plants as Goodey (1952) could not find nematodes associated with tubers. There are also no other reports substantiating the host status of begonias.

Table 3: Summary of assessment on the status of plants as hosts for *D. destructor* not listed in Annex IIAII of the Council Directive 2000/29/EC

Host plant	Status	Comment
Begonias	Non-host	Only one report found saying that begonias are not affected
Strawberry	Unclear status	Contradictory reports with inconclusive evidence
Onion	Unclear status	Contradictory reports with inconclusive evidence
Garlic	Host plant	Recent reports (years 1986–2012)
Dahlias	Host plant	Reports 1958–1960
Hop	Host plant	Reports 1952–2013, Czech Republic reported recently impact
Rhubarb	Host plant	Reports 1966–1970

In conclusion, the plants listed in Annex IIAII of the Council Directive 2000/29/EC do not fully cover the range of host plants that are vegetatively propagated. The following plants which are not listed in Annex IIAII of Council Directive 2000/29/EC are hosts for *D. destructor*, are vegetatively propagated and may therefore be a pathway for *D. destructor*: dahlias, garlic, hop and rhubarb. The nematode was also found damaging the latter three host plants more recently. Gladioli on the other hand are listed in Annex IIAII of the Council Directive 2000/29/EC but are probably a less suitable host plant than before mentioned crops.

Due to the wide host range of the nematode, many major crops grown in rotations with potato will be host plants. Volunteer potatoes will also sustain nematode populations as well as weeds. It will therefore be extremely difficult – if possible at all – to design crop rotations that will eradicate nematode populations. Most likely this will only be possible if extended periods of black fallow were maintained (see Section 3.2.3).

3.2.3. Survival of *Ditylenchus destructor* in soil

Populations of *D. destructor* will undoubtedly decline to low levels when no host plant tissue is present. Strong fluctuations of population levels are common for nematodes and have also been observed in the related species *D. dipsaci* which declines significantly overwinter (Schnabelrauch et al., 1980). The survival period of *D. destructor* cannot be exactly determined and may depend on several other factors (soil conditions, antagonistic organisms, climatic conditions). Because of the availability of nutritional sources, it is therefore likely that the nematode will survive for long periods in agricultural soils although probably at low population densities. The difficulty in detecting certain stages of the nematode, in particular eggs, complicates soil population studies or determination of intervention thresholds. Nematode populations in soil are likely to be underestimated. However, because of the difficulties of detecting the pest in soil such information is not available. Nevertheless, even a low density infestation with nematodes can build up to damaging levels when host plants are present and conditions are suitable. In most cases, low population densities may not lead to detectable damage on crop plants.

After harvest of the crop (e.g. infested potato tubers), the pest will be removed to some extent from the field but a proportion of the nematodes will remain in the soil either free in the soil or within plant tissue, e.g. in tubers not harvested or discarded on the field (Moore, 1971). The nematode may feed on plant parts left in the field, but when potato tubers in which nematodes feed are ploughed in, survival is greatly reduced (Thorne, 1961). Andersson (1967) reported that continuous cultivation of potato lead to a decline of *D. destructor* populations. Rotting or drying of tubers will reduce nematode numbers and nematodes may leave decaying plant tissue and move into the soil. However, the nematode will move only short distances in soil (as specified in Section 3.3) and initial active movement of the nematode will not exceed distances larger than 1 m. Therefore, establishment will be restricted to the site of introduction. There may be some passive dispersal predominantly as a result of tillage or soil movement operations, e.g. during harvest. The spread pattern within a field will be similar to that described for potato cyst nematodes (Been and Schomaker, 2000) or agricultural weeds (Heijting et al., 2009). Establishment of such transferred nematodes will depend on nutritional sources.

Environmental conditions, mainly temperature and moisture, will influence population development. In the soil, survival of *D. destructor* in the absence of cultivated host plants greatly depends on soil moisture. Outside host tissue the nematode does not survive when humidity is below 40%. There are contradictory reports on the ability of *D. destructor* to withstand desiccation and low temperatures (Sturhan and Brzeski, 1991) but unlike *D. dipsaci*, *D. destructor* does most likely not go into an anhydrobiotic stage. Juveniles of *D. dipsaci* are capable of aggregating under adverse conditions and to form so-called 'nematode wool which can withstand desiccation for many years at temperatures of 15–20°C'. According to most authors, such stage will not be formed by *D. destructor*. However, eggs can withstand cold temperatures and most likely eggs overwinter (Thorne, 1961). According to Ustinov and Tereshenko (1959, cited in Decker, 1969), freezing does not affect egg vitality.

A protective stage may not be critical for survival if the nematode has other strategies for maintaining persisting populations. According to Esser and Smart (1977), the nematode persisted in the soil where only non-host crops were grown for 3 years. Similarly, Gubina (1988) reported that *D. destructor* may survive for many years in the soil. However, reports also indicate that *D. destructor* does not survive for extended periods. Shorter survival periods have been reported by MacGuidwin and Slack (1991); they state that all stages can survive for at least 6 weeks without host plants.

Long-term survival of the pest will depend most likely on the availability of nutritional sources, either host plant tissue (see Section 3.2.2) or fungi. Eggs of *D. destructor* may be able to overwinter but free stages of the nematode require a host plant (or fungus) during the next season in order to multiply or maintain populations. In warm winters, the nematode may multiply by feeding on host plant residues, (weed) hosts or fungal mycelia (Esser and Smart, 1977; Brodie, 1984; Esser, 1985; Sturhan and Brzeski, 1991; Švilponis et al., 2011).

Feeding of *D. destructor* on several fungi has been reported (Faulkner and Darling, 1961) but has not been demonstrated to happen in soil (Thorne, 1961). Nematodes reared previously on fungal plates were able to infect plants afterwards (Gubina, 1988). This indicates that feeding on fungi may play a role under natural conditions and may explain some of variable reports on soil survival (Esser and Smart, 1977; MacGuidwin and Slack, 1991). The extent is not known and cannot be quantified.

For survival of *D. destructor*, the presence of host plants is very important. Because of the wide host range including cultivated and weed hosts, it is also likely that host plants will be present in agricultural fields. Many crops grown that may be grown in rotations with potato are host plants such as wheat, barley, rye, sugar beet as main crops and fodder radish and white mustard as intercrops. Those crops may either be grown after the potato harvest or at the beginning of the next vegetation period. It is not possible to define standard or typical potato rotations as this largely depends on the respective production systems in the MSs. The effect of crop rotation on pest abundance cannot be quantified but is considered minor to improved general farm hygiene measures, particularly improved health status of planting material (seed potato and bulbs), and better weed control.

Many weed species are listed as host plants (EFSA PLH Panel, 2014 – Pest categorisation) and may be considered important for the persistence of *D. destructor*. If weeds are not effectively controlled, they could serve as alternative host plants during the cropping period or between cropping periods. The important role of weeds has been stressed by several authors (e.g. Goodey, 1952; Andersson, 1967). More efficient weed control to reduce alternative host plants and improved seed potato health are thought to have contributed to reduced pest reports (Sturhan and Brzeski, 1991). Although the reasons why damage was reported on potato during the period 1945–1975 and much less after the 1970s are not known, weed control over the past decades has considerably improved and weeds as alternative host plants may not be present as abundantly under current cropping systems as they were in the past.

It should also be noted that agricultural production is undergoing changes regarding specialisation and cultivation practices, changes in landownership/cropping of rented land as well as due to the EU policies on direct payments to farmers for intercropping (greening). Increased use of mixed cropping may result in an increased availability of suitable host plants which in turn may contribute to sustain nematode populations. Whether nematode populations on intercrops will be maintained at higher levels than in the past remains to be seen in the future. In any case, attention should be paid to the fact that positive effects of improved weed control on nematode populations are not counterbalanced by growing suitable host plants as intercrops during periods which helped to reduce nematode populations.

3.2.4. Overall conclusion on establishment

Ditylenchus destructor is present in the majority of MSs, even though the exact distribution is not known. Climatic conditions are favourable for the development and reproduction of this nematode across the PRA area and host species, both economically important crops (e.g. potato, bulb flowers) as well as weeds, are present throughout the EU. Conditions for the establishment of *D. destructor* in the PRA area are considered suitable but there is not sufficient information to make a statement on the persistence of population of *D. destructor* after being introduced into a field with infested planting material.

The Panel therefore assesses the probability of establishment as 1 (or so close to 1 that the Panel did not consider it justified to use other parameter values in the model calculations) for scenarios A0 and A1 (see Table E.1 in Appendix E) because:

- the pest when introduced to the field will be already associated with its host plants and hosts are widely grown or naturally present;
- environmental conditions (temperature and moisture) for host plants and pest development are suitable;
- successful establishment has been proven by the fact that the pest is already established in the majority of MSs;

- the RROs considered in the scenarios A0 and A1 aim to reduce the pest abundance for entry and will therefore not influence establishment;
- additional RROs aiming at preventing establishment are not available at present. Although the application of nematicides or biological control agents is theoretically possible, effective control has not been demonstrated. It is also not likely that the current key control element, removal of infested plants, is replaced by a seed treatment.

3.3. Spread

3.3.1. Introduction to spread

Ditylenchus destructor is present in the majority of MSs (20 MS) and is absent from eight MSs (MS Questionnaire; EPPO PQR, online) (Table 4). Most MSs reported a restricted distribution. The only MS that has reported the presence of this nematode "in all parts of the area where crops are grown" is the Netherlands, the major EU producer of plants for planting (including seed potato and flower bulbs) (EUROSTAT, online).

Information on the pest presence is only available at national level. There is no EU requirement for surveys to detect *D. destructor* and no systematic surveys are reported to be carried out at MS level. The reporting in Table 4 should therefore be interpreted with caution.

Table 4: Current distribution of *D. destructor* in the risk assessment area, based on answers received from the EU 28 MSs, Iceland and Norway

Current situation	Member States
Present, restricted distribution	Austria, Belgium, Bulgaria, Estonia, France, Germany, Greece[(a)], Hungary, Latvia[(a)], Lithuania[(a)], Luxembourg[(a)], Poland, Romania[(a)], Slovak Republic
Present, few occurrences	Czech Republic, Ireland[(a)], Sweden, United Kingdom, Norway[(a)]
Present, in all parts of the area where host crops are grown	Netherlands
Present, no details	Malta
Absent	Croatia, Cyprus[(a)], Denmark, Finland, Italy, Portugal, Slovenia, Spain, Iceland[(a)]

(a): When no information was made available to EFSA, the pest status in the EPPO PQR (online) was used. EPPO PQR, European and Mediterranean Plant Protection Organization Plant Quarantine Data Retrieval System.

According to ISPM No. 5 (FAO, 2016), spread is defined as the "Expansion of the geographical distribution of a pest within an area". As described in Section 3.2, host plants of *D. destructor* are widespread in the EU and environmental conditions are suitable for pest establishment and development in PRA area where host plants are grown.

Although *D. destructor* has a restricted distribution in those MSs where it is present, the spatial distribution of the nematode cannot be resolved at a fine spatial resolution (e.g. NUTS 1) due to lack of data. Generally, it is not known in which areas within a MS the pest is present or absent.[3] In the current assessment, the Panel focuses on the spread of the nematode from field to field based on movement of planting material. Because of the similarity of this spread process to the entry from third countries, a similar modelling approach is used.

a) Relevant pathways for spread

The main pathways for spread that are considered for this PRA are seed potatoes and host plants for planting that are vegetatively propagated (flower bulbs). Host plants grown from seeds do not contribute to spread as *D. destructor* is mainly associated with underground plant parts (Decker, 1969). Seed transmission of this nematode has not been reported in contrast to the closely related species *D. dipsaci* which may be associated with seeds of various crops such as onion, garlic or alfalfa (Palti, 1981).

[3] The only MS that reported that the pest is present »in all parts of the area where crops are grown« is the Netherlands. It should be noted that this MS is also the most important MS for the production of plants for planting (including seed potato) (EUROSTAT, online); the main pathways for *D. destructor*.

b) Farm-saved seed

Although any potato tuber planted to grow a potato crop may be considered a seed potato, seed potatoes for the purposes of this document are defined as seed potatoes which are produced under a certification scheme as required by Commission Implementing Directive 2014/20/EU.[4] Farm-saved seed potato is an important source of potato planting material. It is estimated that almost 70% of the whole EU potato production area is planted with farm-saved seed potatoes (ESA, online). According to Council Directive 2007/33/EC,[5] farm-saved seed potatoes may only be moved locally and will therefore only be relevant for short-distance spread, e.g. within farms. Farm saved seed provides a plausible pathway for spread of pests and pathogens within farms because of the absence of specific phytosanitary regulations to ensure seed health. The Panel has not assessed spread via farm-saved seed, but recognises its potential importance in local spread of *D. destructor* once it is introduced via other pathways.

c) Short-distance spread

Active movement of the nematodes is generally less than 1 m/year and therefore natural active spread will not be considered. Passive transport over short distance will most likely occur with agricultural activities within a field or between adjacent or nearby fields. Run-off water, flooding events and wind erosion may also contribute to spread but will be of minor importance.

Short-distance spread will occur with plants for planting (including seed potatoes). Since this is the same pathway as for long-distance spread, no distinction relating to the distance will be made between those pathways. This also includes farm-saved seed potato which shall not be traded or moved over long distances.

d) Long-distance spread

Plants for planting will contribute to long distance as well as short-distance spread. Only certified planting material may be moved over long distances. Therefore the Panel focuses its assessment on the role of certified planting material in the long distance. To make an assessment of the extent of intra-European spread of *D. destructor* with potato seed, the production volumes of potato seed and infestation levels with *D. destructor* were taken into account. Three classes of infestation level were distinguished to differentiate countries with high reported abundance of the pest from those with low reported abundance or absence (Table 5). Class 1 include only one country (the Netherlands), reporting that the nematode is present in all parts of the area where host crops are grown. Class 2 includes those countries that report the presence of the nematode, but restricted distribution, few occurrences, or gave no details. Class 3 includes countries that reported the absence spread EU countries are grouped into three classes according to their pest notifications (see Table 5).

Table 5: Classification of EU28 according to pest status of *D. destructor*

Classification	Pest status	List of countries
Class 1:	**Present, in all parts** of the area where host crops are grown	Netherlands (NL)
Class 2:	**Present, restricted distribution**	Austria (AT), Belgium (BE), Bulgaria (BG), Germany (DE), Estonia (EE), Greece (EL), France (FR), Hungary (HU), Lithuania (LT), Luxembourg (LU), Latvia (LV), Poland (PL), Romania (RO), Slovakia (SK)
	Present, few occurrences	Czech Republic (CZ), Ireland (IE), Sweden (SE), United Kingdom (UK)
	Present, no details	Malta (MT)
Class 3:	**Absent**	Cyprus (CY), Denmark (DK), Spain (ES), Finland (FI), Croatia (HR), Italy (IT), Portugal (PT), Slovenia (SI)

[4] Commission Implementing Directive 2014/20/EU of 6 February 2014 determining Union grades of basic and certified seed potatoes, and the conditions and designations applicable to such grades. OJ L 38, 7.2.2014, p. 32–38.

[5] Council Directive 2007/33/EC of 11 June 2007 on the control of potato cyst nematodes and repealing Directive 69/465/EEC. OJ L 156, 16.6.2007, p. 12–22.

3.3.1.1. Introduction to the seed potatoes pathway for spread

The pathway model that was developed to quantify spread of infested potato seed is similar to the model for entry, but with modifications where appropriate. The model does – for instance – not consider survival of the nematode during transport from a third country to the EU (as such transport does not occur) and it does not consider the effects of import inspection. For details, see the Appendix F.

The importance of assessing movement of the nematode with intra-European trade in comparison to its movement with international trade can be illustrated by just comparing the size of the two trade flows. They differ by four orders of magnitude (a factor 10^4) being 2,053,321 tonnes/year estimated seed potatoes originating in the EU for intra-EU use (see Table C.7 in Appendix C) and 352 tonnes/year estimated volume of seed potatoes imported into the EU from Canada and Switzerland (see Table D.2 in Appendix D).

Two scenarios for the assessment are considered:

1) (A0) scenario which considers the current situation in which existing phytosanitary measures are carried out, and
2) (A1) scenario in which existing phytosanitary measures specific to *D. destructor* are withdrawn.

Phytosanitary measures against *D. destructor* are specified in Council Directive 2000/29/EC (mainly Annex IIAII). There are also EU Directives on *Ralstonia solanacearum* (Council Directive 98/57/EC[6] of 20 July 1998 on the control of *R. solanacearum* (Smith) Yabuuchi et al.[7]) and *Clavibacter michiganensis* subsp. *sepedonicus* (Council Directive 93/85/EEC[8] of 4 October 1993 on the control of potato ring rot[9]). Both Directives with amendments require sampling and testing of potato lots for the detection of the causal agents of brown and ring rot, respectively. During the examination of tubers of a lot (standard sample size is 200 tubers) tubers will be washed and cut. This will likely detect any infestation by *D. destructor* if rotting has already occurred.

Other harmful organisms which are regulated in the EU also require the application of phytosanitary measures. These will also contribute to the detection of *D. destructor*, e.g. such as for *Epitrix* spp. Commission Implementing Decision 2012/270/EU[10] of 16 May 2012 as regards emergency measures to prevent the introduction into and the spread within the Union of *Epitrix cucumeris* (Harris), *Epitrix similaris* (Gentner), *Epitrix subcrinita* (Lec.) and *Epitrix tuberis* (Gentner) (Commission Implementing Decision 2012/270/EU) requires washing or brushing before movement[11] of potato. Such treatments followed by inspection will facilitate detection of potato tuber rot. There are also requirements for *Meloidogyne chitwoodi* and *Meloidogyne fallax* and there is Directive 69/464/EEC[12] of 8 December 1969 on control of potato wart disease.

EU regulations on seed potato (Commission Implementing Directive 2014/20/EU of 6 February 2014 determining Union grades of basic and certified seed potatoes, and the conditions and designations applicable to such grades) also specify tolerances for tubers as regards (among other) blemishes or diseases. Basic (grades S and SE) and certified (Union grade A and B) seed potato lots shall not exceed 0.5% tubers affected by rots. During inspection, rots – including those caused by *D. destructor* – are therefore likely to be detected during inspection which will lead to rejection of the lot.

3.3.1.2. Introduction to the flower bulbs (tulips) pathway for spread

Introduced populations

Worldwide the majority of tulip bulbs are produced in the Netherlands. According to personal communication by P. Kleijn (2016, see Appendix J), the imported tulip bulbs are distributed to

[6] Council Directive 98/57/EC of 20 July 1998 on the control of *Ralstonia solanacearum* (Smith) Yabuuchi et al. OJ L 235, 21.8.1998, p. 1–39.
[7] Amended by Commission Directive 2006/63/CE of 14 July 2006 amending Annexes II to VII to Council Directive 98/57/EC on the control of *Ralstonia solanacearum* (Smith) Yabuuchi et al.
[8] Council Directive 93/85/EEC of 4 October 1993 on the control of potato ring rot. OJ L 259, 18.10.1993, p. 1–25.
[9] Amended by Commission Directive 2006/56/EC of 12 June 2006 amending the Annexes to Council Directive 93/85/EEC on the control of potato ring rot.
[10] 2012/270/EU: Commission Implementing Decision of 16 May 2012 as regards emergency measures to prevent the introduction into and the spread within the Union of *Epitrix cucumeris* (Harris), *Epitrix similaris* (Gentner), *Epitrix subcrinita* (Lec.) and *Epitrix tuberis* (Gentner) (notified under document C(2012) 3137). OJ L 132, 23.5.2012, p. 18–21.
[11] Those measures are similar for the introduction (relevant for Entry).
[12] Council Directive 69/464/EEC of 8 December 1969 on control of Potato Wart Disease. OJ L 323, 24.12.1969, p. 1–2.

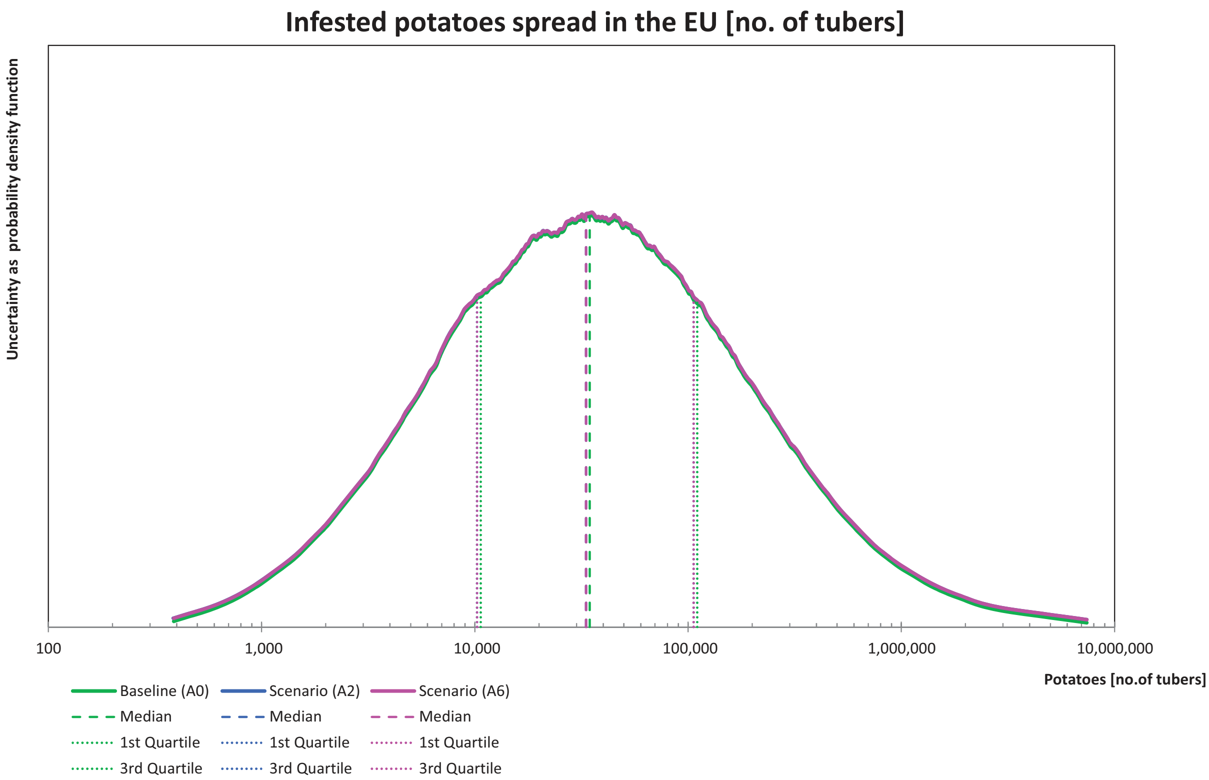
professional flower growers only. Most of the imported bulbs are used for the commercial production of cut flowers.

The importance of assessing movement of the nematode with intra-European tulip bulbs trade in comparison to its movement with international trade can be illustrated by just comparing the size of the two trade flows: 55,168 tonnes/year estimated tulip bulbs originating in the EU for Intra-EU use (see Table C.18 in Appendix C) compared with 1,630 tonnes/year estimated volume of tulip bulbs imported (total import) into the Netherlands from third countries (see Table C.15 in Appendix C). The percentage of imported tulip bulbs (to EU-originating seed) is less than 3%.

Besides EU regulations, there are also certification schemes as laid out by the Dutch flower bulb industry which specify the conditions under which tulip bulbs can be produced (BKD, 2016).

3.3.2. Results on spread for the potato pathway

The median number of infested potatoes planted in EU countries from EU sources is estimated by the model at 33,000 per year, with a 50% uncertainty interval from 10,000 to 106,000 infested tubers (Figure 3). The yearly intra-EU flow of infested planting material is thus vastly more important than the flow resulting from import of seed potatoes from third countries. The main reasons for this greater importance are (1) the much greater volume of the internal trade compared to the trade with third countries, and (2) the comparatively higher estimated abundance of *D. destructor* in European producer countries of seed potatoes (notably the Class 1 countries; see Appendix C, Table C.5) as compared to the Switzerland and Canada. Among the seed potato producing countries, the largest contribution to within-European spread is attributed by the model to Class 1 MS, which has the biggest share (estimated at 24%) in the intra-European seed potato trade, and smaller contributions to the other producers (19 EU MSs) within Class 2 (together 68%) and Class 3, eight EU MSs (together 8%), respectively. Due to the large share in the seed trade, and the higher abundance of *D. destructor* estimated for the Netherlands on the basis of the survey results, the Class 1 MS is contributing in the model 33% to the within EU spread of *D. destructor*, MSs within Class 2 are together estimated to contribute 67%. Contribution of other seed producers (Class 3) to the within EU spread of *D. destructor* is negligible. These estimates are uncertain due to high uncertainty in the abundance of *D. destructor* in different countries, as a result of the absence of rigorous monitoring. There is low uncertainty about the relative importance of intra-EU spread and entry of the nematode from third countries, the latter being much smaller due to the much smaller trade flow and the requirement of pest freedom.



Frequency distribution of the number of infested potatoes planted in Europe following trade from other European countries (predominantly the Netherlands, but also from Germany, France, the UK and other seed-producing MSs) under the baseline scenario A0 and a scenario with an import regulation for *D. destructor* requiring production in third countries in pest-free places of production (scenario A2). Under the A0 scenario, the median number is 33,000 infested tubers per year, with a 50% uncertainty interval ranging from 10,000 to 106,000 infested tubers. The difference between the scenarios A0 and A2 is negligible. Results for the scenario without regulations for *D. destructor* (scenario A1; not shown in figure) are identical to those of the baseline (scenario A0). The number of infested potatoes planted each year is also equal to the baseline scenario in scenario A2 (seed potatoes from third countries must be produced in pest-free places of production) and A6 (chemical treatment of the soil before planting). A2 has negligible impact because the tradeflow from third countries is comparatively small, while A6 has no impact because this RRO affects the impact.

Figure 3: Simulation results on the spread of *D. destructor* with the intra-European trade in seed potatoes

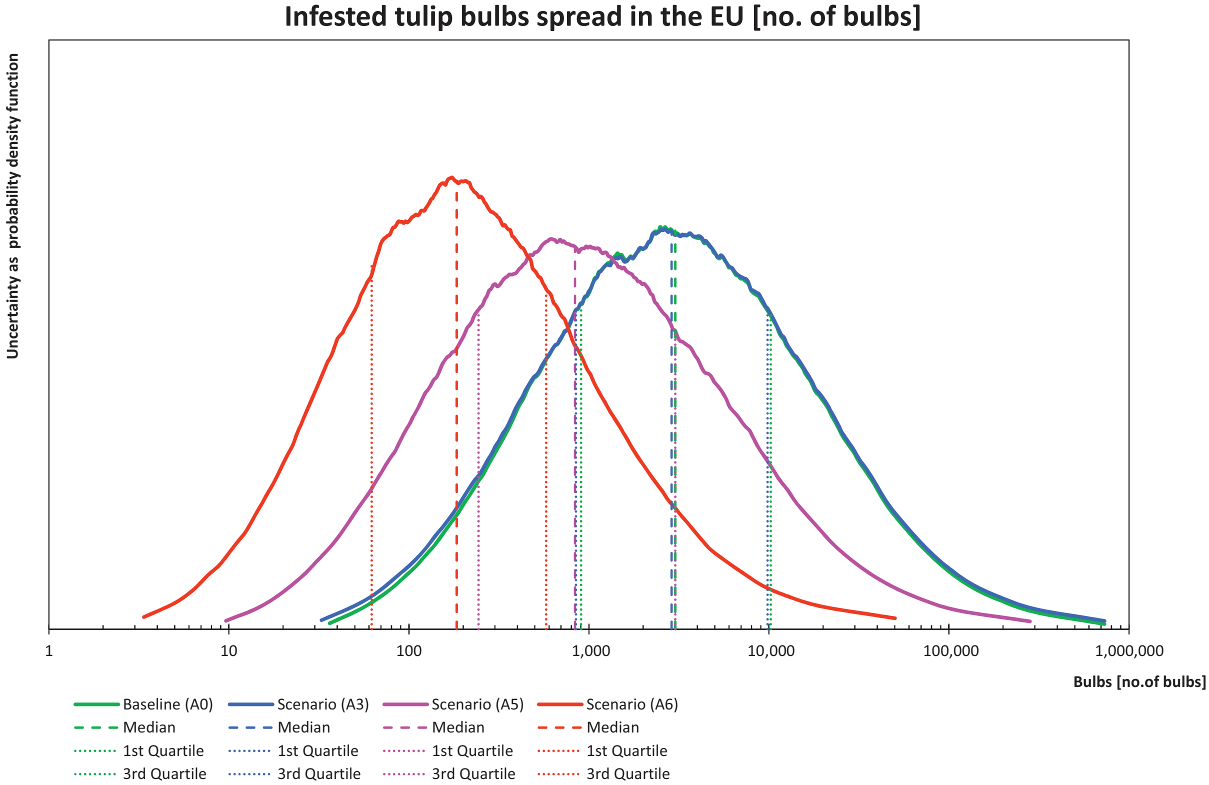
3.3.3. Uncertainty on spread for the potato pathway

In the case of the intra-European trade in seed potato, 98% of the uncertainty in the scenario calculations is due to uncertainty in the proportion of infested seed tubers that are harvested from production fields that are infested with *D. destructor.*

3.3.4. Results on spread for the flower bulb pathway

The predicted yearly median number of infested tulips planted in EU countries from the Netherlands is 2,900 with a 50% uncertainty interval from 870 to 9,843 infested bulbs planted in the EU each year. This number is more than a factor 240 greater than the median number of infested tulips planted in the EU each year following import from third countries (this number was 12 bulbs per year; Section 3.1). The most important reason for the much greater importance of within-EU spread compared to entry from third countries is the comparative large size of the intra-European trade in flower bulbs: 55,000 tonnes/year (see Appendix C, Table C.18).

Reductions in the spread of infested bulbs between the MSs are attained in the scenarios A4 and A5, respectively, requiring production of the flower bulbs in pest-free areas (scenario A4; pink line) or hot water treatment before planting (scenario A5; orange line). Scenario A4 has a median of 837 and a 50% uncertainty interval of (244; 3,017) while scenario A5 has a median of 192 and a 50% uncertainty interval of (65; 603).



Frequency distribution of the number of infested tulip bulbs planted in the risk assessment area and originating from another Member State. The median number of infested bulbs planted each year is around 2,900 with a 50% uncertainty interval from 870 to 9,800 infested bulbs. Reductions in the spread of infested bulbs between the Member States are attained in the scenarios A4 and A5, respectively, requiring production of the flower bulbs in pest-free areas (scenario A4; pink line) or hot water treatment before planting (scenario A5; orange line). Results of scenario A3 (requirement of production of flower bulbs in pest-free places of production in third countries) are similar to the baseline (A0). Results for the scenario without regulations for *D. destructor* (scenario A1; not shown in figure) are identical to those of the baseline (scenario A0).

Figure 4: Simulation results on the intra-European spread of *D. destructor* with tulip planting material

3.3.5. Uncertainty on spread for the flower bulb pathway

Uncertainty in the predictions is for 92% due to uncertainty in the proportion of infested tulip bulbs that are harvested from infested fields.

3.3.6. Overall conclusion on spread

Ditylenchus destructor is present in the majority of MSs (MS Questionnaire; EPPO PQR, online). The nematode is not able to move actively over large distances. Passive transport over short distance most likely occur with agricultural activities within a field or between adjacent or nearby fields. Run-off water, flooding events and wind erosion may also contribute to spread but will be of minor importance. Short-distance spread also occurs with plants for planting.

The main pathways for spread of *D. destructor* within the EU that contribute to long distance as well as short distance spread are plants for planting including seed potatoes and flower bulbs.

The Netherlands is the largest seed potato producer in the EU followed by France, Germany and UK. These four countries represent almost 80% of the whole EU production areas of seed potatoes. The intra-EU trade of seed potatoes represents 80% of the total EU production.

The flow of infested planting material within EU is estimated to be much more important than the flow resulting from import of seed potatoes from third countries. Among the seed potato producing countries, the largest contribution to within-European spread of *D. destructor* is according to the model calculation attributed to the Class 1 MS. The Netherlands has the biggest individual share in the intra-European seed potato trade. A lower contribution is calculated for the nineteen countries classified in the Class 2 that reported restricted distribution of the pest. The Netherlands is also the world's largest producer of tulip bulbs that are grown on more than 10,000 ha, which represents 88% of world production (Buschman, 2005). Much greater estimated trade of tulip bulbs is again the most important reason for the much greater importance of within-EU spread of *D. destructor* compared to entry from third countries. Other factors contributing to the dominance of calculated spread compared to entry are the higher estimate of the proportion of infested tulip bulbs harvested from infested fields and the absence of two factors reducing pest abundance in the spread pathway as compared to the entry pathway. These factors contributing to a reduction in entry but not to a reduction in spread are mortality of the pest during international transport and import inspection.

3.4. Impact

3.4.1. Introduction to impact

Because aboveground symptoms caused by *D. destructor* are often not observed (Sturhan and Brzeski, 1991), damage may be overlooked and aboveground plant parts may not be included in sampling. Therefore, there is some uncertainty to the colonisation of aboveground plant parts (MacGuidwin et al., 1992). Environmental conditions may play a role in expression of disease symptom and host plants frequently remain unattacked in infested areas (Sturhan and Brzeski, 1991). Although potentially several cultivated crop plants may be damaged, damage is only rarely reported from some crops such as celery, sugar beet, carrot, parsnip and radish (Sturhan and Brzeski, 1991). However, no MSs reported impact on these aforementioned crops and it is justified to assume that damage is limited. All plants from which damage was reported in recent years in the EU (potato, iris, and hop) were propagated vegetatively (MS Questionnaire).

D. destructor affects the production of host crops, both in terms of yield and quality of the product. Here, we estimate the impacts on potato and flower bulb production in the PRA area. Tulips are used as a focal crop to represent the impact on flower bulbs.

3.4.1.1. Assessment of impact on potatoes

Potato is one of the most important crops intended for human consumption. World's major potato producing areas are Europe and Asia representing more than 80% of the whole world production (FAOSTAT, online). The total EU potato production area was 1,641.650 ha in 2014 with a total potato tuber yield of almost 46 million tonnes (EUROSTAT, online, table: apro_acs_a). The production area of seed potatoes in the EU in 2014 was 109.790 ha, 7% of the whole potato production area (ESCAA, online: http://www.escaa.org/index/action/page/id/8/title/field-production-area-for-seeds) with estimated yield of 25 tonnes/ha. Potatoes are grown in all MSs; the largest potato producers in the EU are Germany, Poland, the Netherlands, France and the UK.

Ditylenchus destructor has been reported to be an important pest of potato in temperate regions of Europe and the USA (Sturhan and Brzeski, 1991). It may cause rotting of potato tubers thereby reducing yield and quality and tuber rotting may also continue during storage if conditions for nematode development are favourable. However, losses in potato caused by *D. destructor* were mainly observed between 1950 and 1970. In recent years, there were few reports on damage caused by this nematode species, indicating that the importance of this nematode as a pest of potato has declined.

There are two different kinds of possible impacts of *D. destructor* on potato production:

a) **Reduction in the quantity of potatoes** produced due to the effect of nematodes on the growth of the plant. This is mainly relevant for ware potatoes and these represent more than 90% of all potatoes produced in the EU.
b) **Reduction in the market value (quality) of potatoes** produced in an infested field due to the presence of nematodes in the product. This is particularly important for seed potatoes.

These two impacts were assessed separately.

Yield reduction depends on several factors such as climate and soil condition, nematode population density and potato variety. According to Mwaura et al. (2014, 2015), the number of tubers formed will not be reduced by *D. destructor* but the weight of tubers is affected. The weight reduction depends on the level of tolerance of the potato variety (Mwaura et al., 2014) and nematode population density

(Mwaura et al., 2015). At low densities (1–10 nematodes/100 g soil), measurable/quantifiable yield loss due to tuber weight reduction is not likely to occur; however, external and internal damage on the tubers may be observed (Mwaura et al., 2015).

The yield loss is likely to differ between plants that grow from infested tubers, and plants that grow from healthy tubers and are only infected at a later stage by nematodes originating from the soil. These two types of yield loss were assessed separately:

'Yield loss due to infection of the soil': Yield loss occurring when planting healthy seed potato tubers in infested fields such that the plants become eventually infested by *D. destructor*. The initial nematode population density will be low and several factors (such as soil conditions) may affect the plant–nematode interaction; the overall impact will be low in comparison to yield loss caused by planting nematode-infested potato tubers.

'Yield loss due to infection of the seed': Yield loss occurring from planting infested seed potato tubers whereby the pest status of the field is considered irrelevant. The initial nematode population density will be high as the nematode is initially present in the plant.

Total yield loss in the PRA area is the sum of these two types of losses.

The total yield loss across the EU due to the planting of infected seed is calculated by multiplying the total number of infested tubers planted each year across the EU by the expected yield per plant and a factor expressing the proportion yield loss. This calculation is made separately for three classes of countries, accounting for differences between these classes in potato area and average yield. The results are summed to obtain the EU total yield loss due to seed infection.

The total yield loss across the EU due to infection of potato plants from soil is calculated by assessing the total number of plants getting infested in this way across the EU. Three classes of countries are distinguished in the calculations according to their reporting on the prevalence of *D. destructor*. For each class, the potato production is multiplied by the proportion of fields with *D. destructor* in the class and the proportion of infested potatoes harvested from infested fields. This production volume of nematode-afflicted potatoes suffers a proportion yield loss which is estimated on the basis of literature and expert judgement. The proportions of infested fields and the proportions of infested potatoes harvested from infested fields are the same as the respective proportions used in the assessment of spread, where the panel estimated the proportion of infested seed potato fields and the proportion of infested seed potatoes harvested from infested fields for each of three classes of countries (Section 3.3). For details see the Appendix A.

3.4.2. Specification on soil treatments for managing *Ditylenchus destructor*

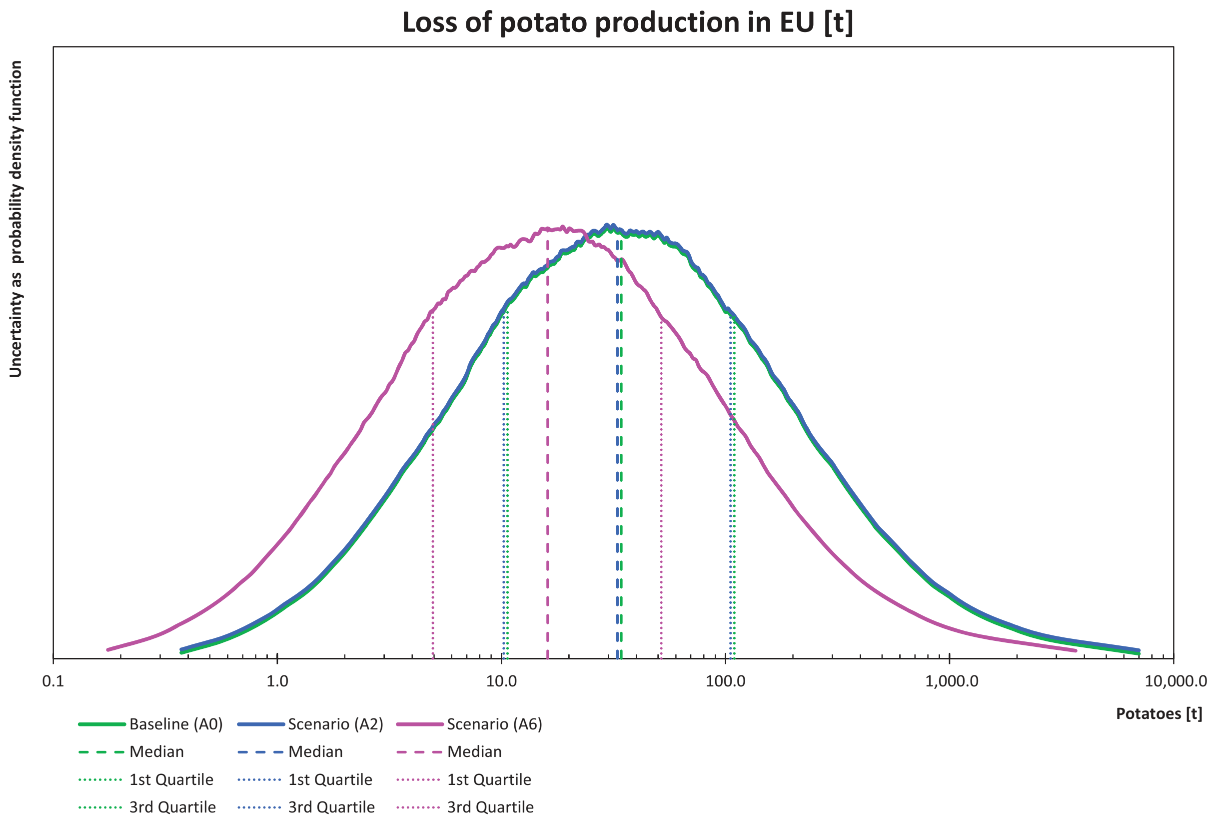
Several RROs, such as chemical control, steaming of soil, inundation and biofumigation (see Appendix G), which are more or less effective are available to suppress populations of *D. destructor* within soil, but only chemical soil fumigation before planting has been considered within this assessment.

Certain fumigants that are currently available can effectively decrease nematode populations in the soil. They are most effective in adequately moist soils that are well drained and containing little clay or organic matter (Whitehead, 1998). Some fumigants (dazomet and metam sodium) could be used in some MSs to control *D. destructor* in fields used for the production of planting material. In 1966, Safjanov (cited in Decker, 1969) reported on the effectiveness of carbathion (= metam sodium) and dazomet against *D. destructor*. The infection was reduced from 16% to 1.1–1.8% with carbathion (1.5–2.2 tonnes/ha) and from 37.4% to 4.4–5.3% and 11.5% to 0.9–2.2% with dazomet (0.75–1 tonnes/ha). The Panel considers the effectiveness of soil fumigants against *D. destructor* between 60% and 95%. Today, the practical usage of soil fumigants is highly restricted due to environmental and human health reasons (Directive 2009/128/EC[13]).

[13] Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. OJ L 309, 24.11.2009, p. 71–86.

3.4.3. Results on impact for the potato pathway

3.4.3.1. Impact on potato production



Frequency distribution of potato yield loss over the whole EU (tonnes) due to *D. destructor* expressed under the baseline scenario A0, under a scenario with regulations for *D. destructor* lifted (scenario A1), a scenario with an import regulation for *D. destructor* requiring production in third countries in pest-free places of production (scenario A2) and a scenario which assumes that all fields for the production of potatoes will receive a soil treatment (chemical fumigation) effective against *D. destructor* (scenario A6).

Figure 5: Simulation results on the impact of *D. destructor* on ware potato production in Europe as a result of entry and spread of this nematode via the potato pathway

The impact of *D. destructor* on ware potato production in the EU is estimated at a median value of 33 tonnes across the whole of the EU, i.e. in the order of magnitude of the production of a single potato field of 1 ha (32 tonnes/ha as an EU average). With a total potato growing area in the EU of 1.7 million ha, this is a negligible impact. The 50% uncertainty interval (from the 25 to 75 percentile) is 10–105 tonnes, and the 99 percentile 1,780 tonnes, indicating the Panel has very low uncertainty on the negligible impact of this nematode under current regulations. The impact under the worst case (99 percentile) is still only 0.003% of total EU production, a number which could never be measured under practical conditions.

Scenario A2 (production in pest-free places of production in third countries importing seed potatoes into the EU) does not change this impact. Scenario A6 (soil treatment in the field receiving potato seed) results in a 48% reduction in median impact. However, this is not a relevant reduction given the minimal impact under the baseline scenario.

3.4.3.2. Reduction in the market value of potatoes produced in an infested field due to the presence of nematodes in the product

Damage to seed potato may be caused by the presence of this nematode (zero tolerance) and may result in downgrading; it is unknown how often this occurs. Actual downgrading of product will depend on detection of the nematode in the plant product. Because no sampling and testing procedures for *D. destructor* are specified in the EU legislation, detection of the nematode will most likely be during inspection and finding of rotten tubers (latent infestation will not be detected).

The impact of degrading of seed potatoes due to an infestation by *D. destructor* is assessed on the basis of information provided in EPPO Reporting Service (EPPO, online). As mentioned above, downgrading of seed potatoes during certification is not known as such non-compliance is not reported. The only report of an intercepted seed potato commodity in recent years is from 2011 (RO, with origin HU). The impact of *D. destructor* as regards downgrading of seed potato lots is thus of minimal importance under current conditions. Under the A1 scenario (lifting of the *D. destructor*-specific regulation of the IIAII Annex of the Council Directive 2000/29/EC), this will not change because of current EU legislation on the certification of seed potatoes (Commission Implementing Directive 2014/20/EU) will be in place which does only allow a small tolerance for rots. Other control measures will also continue for other potato pathogens such as *R. solanacearum* and *Clavibacter michiganensis* subsp. *sepedonicus*. Current tests are not expected to be more efficient than those inspections because they are likely to detect rots but latent *D. destructor* infestations will not be detected by any method.

Under a hypothetical scenario of intensified measures against *D. destructor*, a reduction in the impact in the seed potato production is conceivable; however, with the current impact being minimal, this reduction in impact will be of minimal importance. This scenario is therefore not further considered for model calculations.

3.4.4. Sources of uncertainty in the estimation of impacts in potato

Eighty-seven per cent of the uncertainty in the quantitative yield loss of potatoes is due to uncertainty in the proportion of infested potatoes harvested in infested fields. The uncertainty analysis indicates that the impact pathway via the soil is substantially more important than the impact pathway via the seed.

Impact due to quality losses was estimated to be negligible, based on interception data. There is some uncertainty on the scale of this type of impact because there is no reporting requirement when infestations are intercepted before the product receives a phytosanitary certificate. Thus, the impact could be higher than suggested by the interceptions. No quantitative analysis was made of the uncertainty in this assessment.

3.4.5. Results on impact for the flower bulb pathway

Only quality loss has been assessed in case of tulip bulbs. In the Netherlands, which is the most important grower of tulip bulbs in the world, flower bulbs must be grown under specific quality schemes enforced by the Flower Bulb Inspection Service (*Bloembollenkeuringsdienst;* BKD), which performs both visual inspections and laboratory analyses. The inspection methods, registration, sampling of infected plants and measures are based on the EU and national legislation, and specific directives of the Dutch Food and Ware Authority (*Nederlandse Voedsel en Waren Autoriteit*; NVWA). In the case of EU-quarantine pests, the NVWA transferred powers to the BKD, Flower Bulb Inspection Service, to perform quality control and to detect plant pests and diseases (Personal communication by P. Knippels, 2016, see Appendix J).

The number of detections of *D. destructor* in the flower bulbs has decreased over the last decades and the nematode has mostly been detected during field inspections. A limited number of detections have been made during the dry bulb inspections as a part of the export inspections. *D. destructor* was detected in lots of *Crocus* and *Tulipa* (Personal communication by P. Knippels, 2016 see Appendix J).

The number of detections during the field inspections was very low in 2015; 2 out of 617 inspected lots of *Crocus* spp. and 0 out of 16.060 inspected lots of *Tulipa* spp. were found positive. The number of detections during the inspection of bulbs after harvesting was 11 out of 617 inspected lots of *Crocus* (Personal communication by P. Knippels, 2016 see Appendix J).

With respect to very few reports indicating *D. destructor* infestation on flower bulb production and very limited number of interceptions of bulb flowers contaminated with this nematode (EUROPHYT, online), the Panel considers the impact of this nematode on flower bulb production in the EU as very low.

Few data are available on the impact of *D. destructor* in the production of planting material of flower bulbs. The available data suggest there is low impact, but bulb producers must remain vigilant for this organism.

3.4.6. Overall conclusion on impact

Ditylenchus destructor has been reported as a serious pest of potato and other crops in the past but more recently, only few MSs reported impact caused by this nematode. One of the main reasons for the apparent decline in impact caused by *D. destructor* may be seed certification and the use of healthy seed potato tubers (Sturhan and Brzeski, 1991). Cooling during storage may also have contributed to the reduction in impact of the nematode as the nematode does not multiply between 4 and 8°C. Better weed control has likely also contributed to lower impact as this lowers availability of hosts. Furthermore, general seed potato certification requirements, more recently specified in the Commission Implementing Directive 2014/20/EU, and inspection requirements for other regulated pests (e.g. *C. michiganensis* subsp. *sepedonicus*) which require sampling and testing of potato tubers, are likely to contribute to low impact caused by the nematode.

The distribution of the pest is not known in detail but the majority of MSs reported that *D. destructor* is present in their territory. The main damage to ware potatoes is rotting of tubers, but this occurs rarely. Damage to seed potato may be caused by the presence of this nematode (zero tolerance) and may result in downgrading; it is unknown how often this occurs. Because no sampling and testing procedures for *D. destructor* are specified in the EU legislation, detection of the nematode will most likely be during inspection and finding of rotten tubers (latent infestation will not be detected).

The impact of the nematode on the quantity and quality of the yield is considered negligible in case of ware potato and highly restricted in case of seed potato (e.g. Lithuania case, where potato tubers originated from infested fields were consequently destroyed or used for human or animal consumption, see EPPO, online), respectively.

The pest is not known to cause impact on ecosystem services, biodiversity or the environment. It is a pest of agricultural and horticultural crops which is able to cause only in rare cases quality and quantity losses. Because of the above reasons, impact caused by this nematode under the current situation (scenario A0) is considered low. It is not likely that under scenario A1 (removal of current pest-specific regulations in Annex IIAII of Council Directive 2000/29/EC) impact will increase because several other measures as mentioned above will prevent further spread and agricultural practices (e.g. weed control) are not likely change.

4. Conclusions

Ditylenchus destructor is present in all MSs except in Croatia, Cyprus, Denmark, Finland, Italy, Portugal, Slovenia and Spain. It feeds on potato, several flower bulb species and many other host plants, including weeds. After evaluating the evidence for entry, establishment, spread and impact, the Panel came to the following conclusions:

Entry

The Panel considers the entry of *D. destructor* with planting material from third countries to be very low. Scenarios for reducing this entry did not elucidate options that result in relevant reductions in entry.

Establishment

D. destructor is present in the majority of MSs (20). Climatic conditions are favourable for the development and reproduction of this nematode throughout the pest risk area. Cultivated host species, (e.g. potato, bulb flowers) as well as weeds, are present throughout the EU. There is insufficient information to make a statement on the persistence of population of *D. destructor* after its introduction into a field with infested planting material.

Spread

This nematode is not able to move actively over large distances. Passive transport over short distance most likely occurs with agricultural activities within a field or between adjacent or nearby fields. Run-off water, flooding events and wind erosion may also contribute to spread but will be of minor importance. The main pathway for spread of *D. destructor* is the movement of planting material, including seed potatoes and flower bulbs. The movement of planting material contributes to spread over short as well as long distances.

The flow of infested planting material within EU is estimated to be much more important in causing new infestations across the EU than the flow resulting from import of seed potatoes from third countries. Among the seed potato producing countries, the largest contribution to within-European spread is according to the model calculation attributed to the Class 1 MS. The Netherlands, which has the biggest share in the intra-European seed potato trade, and has reported the presence of this nematode in all parts of the area where host crops are grown. Smaller contributions are according to the model calculation attributed to the 19 countries that reported a restricted distribution of the pest.

Impact

The pest is not known to cause impact on ecosystem services, biodiversity or the environment. It is a pest of agricultural and horticultural crops but rarely causes quality or quantity losses in agriculture under modern agricultural practices (e.g. weed control and high quality planting material). Therefore, impact caused by this nematode is considered low under the current regulation in Annex IIAII of the Council Directive 2000/29/EC (scenario A0). It is not likely that lifting these pest-specific regulations (scenario A1) will increase because other regulations for pests and diseases in planting material will also be effective against *D. destructor.*

Uncertainty

Assessment of entry and spread of the nematode is affected by substantial uncertainty regarding the proportion of infested fields and the proportion of infested tubers and bulbs harvested from infested fields in third countries as well as EU countries (PRA area). These uncertainties are due to a lack of survey data on pest abundance. Such data if based on pest-specific surveillance would allow for better estimates for the proportion of infested fields than those currently used in the calculations. Similarly, the within field distribution of nematodes is never known and can only be estimated by sampling in field. Nematode distribution will influence the proportion of infested tubers. However, several factors such as patchy distribution with varying nematode densities, crop and variety grown, soil moisture, and soil temperature influence the proportion of tubers that will become affected. Effects of variation of these factor and their interactions are very difficult to estimate. It is unreasonable to suggest that increased knowledge on one or several of these parameters will reduce uncertainty. Nevertheless, there is very low uncertainty that intra-EU spread of this nematode is several orders of magnitude more important than entry. Likewise, there is also low uncertainty on the ineffectiveness of the current risk reducing options, even if the pest-specific measures were lifted. Impact of this nematode is very low in potatoes and flower bulbs under current conditions, with low uncertainty. Given the low impact of the nematode under current regulations, there is low uncertainty on the lack of need on intensifying measures specifically targeted against this nematode.

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Abbreviations

BKD	Dutch Flower Bulb Inspection Service (Bloembollenkeuringsdienst)
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
ISPM	International Standard for Phytosanitary Measures
ITS	Internal transcribed spacer
MS	Member State
NPPO	National Plant Protection Organization
NVWA	Dutch Food and Ware Authority (Nederlandse Voedsel en Waren Autoriteit)
PLH	Plant Health
PRA	pest risk assessment
PQR	Plant Quarantine Retrieval
PW	pathway
RNQP	regulated non-quarantine pest
RRO	risk reduction option
rRNA	ribosomal RNA
WG	Working Group

Appendix A – Definitions specific for the assessment

A.1. Description of pathways

A.1.1. Plant-related pathways

Pathway 1. Potato plants for planting

Potato is the main host of *Ditylenchus destructor.* The nematode attacks mainly potato tubers and stolons. The probability of *D. destructor* being associated with seed potato is high if the production site is infested with this nematode. Seed potato originating from infested production sites is recognised by the Panel as a principal means by which this nematode enters new areas.

The importation of seed potatoes into the PRA area is highly restricted (Plant Health Council Directive 2000/29/EC, Annex III). Only seed potatoes from Switzerland may be imported into the EU (Plant Health Council Directive 2000/29/EC, Annex III). Derogations for the importation of seed potatoes from Canada exist under special conditions (Commission Implementing Decisions 2014/368/EU[14] and 2011/778/EU[15]; Commission Decision 2003/61/EC[16] and extensions). Since 1981, Canadian seed potatoes may be imported from Prince Edward Island and New Brunswick; those potatoes shall only be planted in southern EU Member States (now Cyprus, Greece, Italy, Malta, Portugal and Spain). *D. destructor* is known to occur in localised areas of Prince Edward Island only (CABI, online; EPPO PQR, online). Although it can be concluded that this nematode is well established in most MSs, it does not occur in Cyprus (EPPO PQR, online); Italy, Portugal and Spain (MS questionnaire) and has only a limited distribution in Greece (EPPO PQR, online) and Malta (MS questionnaire). No MS to which seed potatoes from Canada may be imported reported wide distribution of *D. destructor.*

Pathway 2. Plants of other host species for planting

D. destructor has a broad host range and is able to parasitise mainly underground parts of plants such as bulbs, corms, rhizomes, stolons and roots (Decker, 1969). If host species are grown in the infested production fields, the probability of *D. destructor* being associated with them is considered as high. For further details on host range, see Section 3.2.2 (further specification on the host range).

Pathway 3. Host plants and plant parts not intended for planting with soil attached, originating from areas where the pest occurs

Plants not intended for planting are considered to pose a much lower risk than plants for planting. Although this is not a closed pathway, the likelihood of introducing the pest with potato is very low as this is a highly restricted pathway. Annex IIIA of Council Directive 2000/29/EC prohibits the importation of ware potatoes from all third countries apart from Algeria, Egypt, Israel, Libya, Morocco, Switzerland, Syria, Tunisia and Turkey.

Under derogation, Cuban ware potatoes (Commission Decision 2005/649/EC[17]; Commission Decision 2003/63/EC[18]; Commission Decision 2000/246/EC[19] and extensions) may be imported. Prior to export, the potatoes must have been cleaned so that they are free from soil, leaves and other plant debris and must be inspected for the presence of all harmful organisms. Potatoes must be grown in Cuba directly from the seed potato certified in one of the MSs or in any other country which is allowed

[14] 2014/368/EU: Commission Implementing Decision of 16 June 2014 amending Implementing Decision 2011/778/EU authorising certain Member States to provide for temporary derogations from certain provisions of Council Directive 2000/29/EC in respect of seed potatoes originating in certain provinces of Canada (notified under document C(2014) 3878). OJ L 178, 18.6.2014, p. 27–28.

[15] 2011/778/EU: Commission Implementing Decision of 28 November 2011 authorising certain Member States to provide for temporary derogations from certain provisions of Council Directive 2000/29/EC in respect of seed potatoes originating in certain provinces of Canada (notified under document C(2011) 8633). OJ L 317, 30.11.2011, p. 37–41.

[16] 2003/61/EC: Commission Decision of 27 January 2003 authorising certain Member States to provide for temporary derogations from certain provisions of Council Directive 2000/29/EC in respect of seed potatoes originating in certain provinces of Canada (notified under document number C(2003) 334). OJ L 23, 28.1.2003, p. 31–34.

[17] 2005/649/EC: Commission Decision of 13 September 2005 amending Decision 2003/63/EC authorising Member States to provide for temporary derogations from Council Directive 2000/29/EC in respect of potatoes, other than potatoes intended for planting, originating in certain provinces of Cuba OJ L 238, 15.9.2005, p. 18.

[18] 2003/63/EC: Commission Decision of 28 January 2003 authorising Member States to provide for temporary derogations from Council Directive 2000/29/EC in respect of potatoes, other than potatoes intended for planting, originating in certain provinces of Cuba (notified under document number C(2003) 338). OJ L 24, 29.1.2003, p. 11–14.

[19] 2000/246/EC: Commission Decision of 15 March 2000 authorising Member States temporarily to provide for derogations from certain provisions of Council Directive 77/93/EEC in respect of potatoes, other than potatoes intended for planting, originating in Cuba (notified under document number C(2000) 692). OJ L 77, 28.3.2000, p. 20–22.

to export potatoes to the EU. Given that *D. destructor* does not occur in Cuba this trade does not pose a risk for entry into the EU.

New Zealand ware potatoes (Commission Decision 2001/199/EC[20]) are imported under strict conditions that include the requirement that they shall be accompanied by a phytosanitary certificate issued in New Zealand in accordance with Articles 7 and 13 of Directive 2000/29/EC and have been found to be free from harmful organisms, particularly *Graphognathus leucoloma* (Boheman), *Globodera pallida* (Stone) Behrens, *Globodera rostochiensis* (Wollenweber) Behrens, *Ralstonia solanacearum* (Smith) Yabuuchi et al. and *Synchytrium endobioticum* (Schilbersky) Percival (but not: *Ditylenchus destructor*). in growing season inspections and tests on soil or crop samples. Although *D. destructor* is known to occur in New Zealand it has only been reported from hop (EPPO PQR, online).

D. destructor is known to occur in New Zealand, Switzerland and Turkey but the other third countries from where potatoes can be imported do not report the pest. Ware potatoes from New Zealand, Switzerland or Turkey may therefore pose a higher risk of introducing the pest than potatoes from countries which have not reported the pest.

Although the nematode may be present inside ware potato tubers, the risk is considered low as the potatoes will be processed for consumption. Regardless at which level (household or processing plant), tubers will undergo a heat treatment. Plant residues like peels or culled tubers may still pose a risk. Generally awareness on the need of appropriate waste disposal facilities has increased or is addressed in legislation (e.g. Council Directive 2007/33/EC). It is also assumed that organic waste is either composted or processed (e.g. biogas production) before disposal on agricultural fields. Composting or biogas fermentation will reduce the viability of nematodes considerably. Waste soil derived from the processing process is covered under soil-related pathways.

Flower bulbs will only be planted and are therefore considered in pathway 2. Other host plants as specified in Section 3.2.2 (Table 3), such as garlic, could be imported for consumption. The same considerations as for ware potato apply.

A.1.2. Soil-related pathways

Although *D. destructor* is mainly present inside host plant tissue, it may be present in soil (Foot and Wood, 1982). 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 field is infested with *D. destructor*, the nematode may be present and transported with plants, soil or growing media originating from such sites.

The following pathways (4–7) are soil-related pathways (presented in the EFSA PLH Panel (2015) opinion on soil and growing media.

Pathway 4. Soil or growing media attached to host or non-host plants for planting with roots from areas where the pest occurs

Pathway 5. Soil adhering to machinery or packaging material from countries where the pest occurs

Pathway 6. Soil and growing media from countries where the pest occurs

The EC Plant Health Council Directive 2000/29 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*

[20] 2001/199/EC: Commission Decision of 9 March 2001 authorising the Member States to provide for derogations from certain provisions of Council Directive 2000/29/EC in respect of potatoes, other than potatoes intended for planting, originating in New Zealand (notified under document number C(2001) 685). OJ L 071, 13/03/2001 p. 28–30.

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)*."

These measures reduce the chance that *D. destructor* is introduced with soil transported with hosts/non-hosts from third countries (pathway 4 and 5).

Besides the fact that soil may be attached to planting material, soil may also be associated with plants for processing. Soil associated with root and tuber crops may be delivered in considerable quantities together with the crop to a processing facility. However, this pathway is far more relevant for spread than it is for entry because of trade volumes. Soil from potato, sugar beet or root vegetable processors should be handled or treated in such a way that there is no identifiable risk of spreading soil-borne pests. Such requirements exist for potato processing facilities handling potatoes from fields on which potato cyst nematodes have been detected. According to EU Council Directive 2007/33/EC, those facilities need to have appropriate and officially approved waste disposal procedures. Those procedures will also have an effect on *D. destructor.* Since *D. destructor* does not have a protective survival stage, current storing and handling procedures of soil will most likely negatively affect survival of *D. destructor* in soil. The availability of host plants (or fungi) is crucial for nematode survival. In the absence of nutritional sources, soil moisture will most likely have the greatest effect on nematode survival (Sturhan and Brzeski, 1991). See also Section 3.2.3 on survival in soil).

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 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 such as potato tubers.

A.1.3. Water-related pathways

Pathway 7. Movement of surface water (run-off rain) in fields and through ditches, streams and rivers

Ditylenchus destructor can be transported by runoff water to ditches alongside infested fields and into irrigation systems. The probability of *D. destructor* being dispersed with this pathway is limited to fields in the vicinity of the contaminated field and therefore to the local growing area of infested host plants of this nematode. However, for *D. destructor* to enter into the EU by such a pathway would require very specific circumstances such as river catchments common to the EU and non-EU countries. The probability of the nematode being associated with this pathway is considered as very low.

A.2. Definitions regarding the quantification of entry and spread pathways

Trade volumes are expressed in metric tonnes of seed potato tubers. The level of infestation of the product with *D. destructor* is expressed in terms of the number of infested tubers per metric tonne of seed potato tubers. The density of the nematode in individual potatoes is not considered. There are 10,000–50,000 seed potatoes tubers per metric tonne, depending, e.g. on the variety, shape of tuber, size/grade, etc. (Landwirtschaftkammer Nordrhein-Westfalen, 2015). Within this opinion, a value of 20,000 tubers per metric tonne is used in all calculations.

In the case of flower bulbs, the trade volume is measured in units of metric tonnes of bulbs. The number of bulbs per one metric tonne varies by species, grade, etc. Within this opinion, the assessment is focused to tulip bulbs (it is estimated that average weight of a tulip bulb is 20 g, Personal communication Kleijn, 2016), a value of 50,000 tulip bulbs per metric tonne is used in all calculations.

A.3. Definitions relevant to entry and spread

Countries report the pest status in their territory according to ISPM No. 8 'Determination of pest status in an area' (FAO, 1998) and this standard describes the main categories for reporting the pest status: present, absent or transient. However, the pest status may be verbally expressed, the level of distribution of a pest cannot be adequately described by the guidance given in ISPM No. 8 (FAO, 1998). It does not allow quantification and is therefore only of limited use for the purpose of a quantitative risk assessment. However, ISPM No. 8 (FAO, 1998) provides some examples how the pest status may be expressed but it does not give guidance when these terms should be applied.

For the purpose of this PRA, a distinction will be made for the statements 'present, wherever host crops are grown' and 'present, few occurrences' or 'present, restricted distribution'. In the former case, a wider distribution will be assumed, particularly when all or most parts of a country are suitable for host plant production. No distinction will be made within the categories 'present, few occurrences' or 'present, restricted distribution'. Since no country reported that *D. destructor* is transient, this category is not considered in this opinion.

The absence, if verified by pest-specific surveillance, should be reflected by a distribution close to 0% infested fields; the same should apply to pest-free areas. In this assessment, the distribution of values is considered slightly higher as in most cases such specification on surveillance is not provided. Moreover, many countries are neighbouring countries that reported the pest presence or have a climate which is in principal suitable for the pest. For these reasons, the Panel considers that there may be a low chance of the pest presence which is reflected in the distribution of values.

According to the reported presence of the pest, three classes will be distinguished and defined by their distribution of values (percentage of infested fields); those distributions will be used throughout this document. It should be noted that these distributions are not based on data but are fixed by expert judgement in order to make verbal statements accessible to quantification and to allow comparison of countries with different pest status reports.

In order to quantify entry and spread pathways, the Panel grouped countries (third countries and EU) into three classes according to their verbal description on pest notifications (see Table A.1).

The distribution of estimated parameter values is given in the relevant sections/annexes.

Table A.1: Classification of countries according to their pest status report

Classification	Pest status (relevant examples)
Class 1:	**Present, in all parts** of the area where host crops are grown
Class 2:	**Present, restricted distribution**
	Present, few occurrences
	Present, no details
Class 3:	**Absent**

It should also be noted that there are additional limitations that influence the suitability of pest records for use in quantitative PRAs. Some of them are listed in ISPM No. 8 (FAO, 1998) and mainly concern reliability of records. ISPM No. 8 (FAO, 1998) gives some guidance for evaluating the reliability of the pest records but often the information necessary for such evaluation – such as technical information on surveillance- is not reported. ISPM No. 6 'Guidelines for surveillance' (FAO, 1997) describes the elements of information from general surveillance and specific surveys that may be included in a pest record. Determination of pest status in a country may be influenced by the type and extent of surveillance. The level of investigation (including the way sampling and testing is performed) and the extent of expert involvement will greatly influence the outcome of such activities. Apart from conducting general or specific surveillance, pest status may also be reported based on other information such as scientific publications. Due to the lack of before mentioned technical information, statements on pest records are in general not comparable among countries.

A.4. Specification of assessment scenarios

A.4.1. Scenario (A0)

Scenario (A0): This is the baseline scenario in which all phytosanitary measures currently in place are carried out in order to prevent spread of *D. destructor*.

As specified in the pest categorisation, several articles of the EU Plant Health Directive 2000/29/EC are relevant for the prevention of entry or spread of *D. destructor*. Pest-specific regulations for *D. destructor* are found in Annex IIAII (a) 3. of Council Directive 2000/29/EC. Flower bulbs and corms of *Crocus* L., miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort., *Gladiolus* *tubergenii* hort., *Hyacinthus* L., *Iris* L., *Tigridia* Juss, *Tulipa* L., intended for planting, and potato tubers (*Solanum tuberosum* L.), intended for planting shall be free from *D. destructor*. This is the only pest-specific risk reduction option currently in place.

Host plants of *D. destructor* are also regulated in Annex IIIA of Council Directive 2000/29/EC with regard to the import prohibitions or restrictions into the EU for specific commodities (seed and ware potato), as well as in Annex VAI, VAII and VBI as commodities subject to plant health inspections and phytosanitary certificate or plant passport requirements. Derogations exist as specified in the Section A.1 on the description of pathways.

Other directives, such as Commission Implementing Directive 2014/20/EU on the conditions and designations of seed potatoes, or marketing directives are in place and contribute to the prevention of spread(for more information see Pest Characterisation of *D. destructor* in EFSA PLH Panel, 2014).

Limitations of pest-specific measures in scenario A0 for the prevention of spread of *Ditylenchus destructor*

Although the effectiveness of the current pest-specific regulation is not assessed in detail, this risk reduction option may not be fully effective because of technical limitations in detecting *D. destructor* in asymptomatic tubers or detecting low infestation rates in consignments. In general, the absence of a pest in a consignment cannot be verified (see also ISPM No. 31 (FAO, 2008)) but detection may be improved by specification of procedures. Council Directive 2000/29/EC does not specify sampling and testing procedures for the detection and identification of *D. destructor*. In the absence of specified EU sampling and testing procedures, inspections for the detection of rots will be carried out as a standard operation in the MSs, i.e. visual examination of the lots, documentary checks and compliance with phytosanitary requirements. Detection of *D. destructor* will therefore rely on detecting symptoms as a first step rather than detection of the pest. Because no further details on sampling and testing are given for *D. destructor,* it is unclear how current regulation will detect low level infestations or reduce spread of asymptomatic tubers infested by *D. destructor*.

A.4.2. Scenario (A1)

Scenario (A1): Existing phytosanitary measures specifically related to *D. destructor* are withdrawn; all other phytosanitary regulations remain in place.

As mentioned under scenario A0, there is only one pest-specific regulation in place which is listing of the organism in Annex IIAII of Council Directive 2000/29/EC. In scenario A1, it is assumed that this regulation will be lifted but all other regulations, e.g. import restrictions or marketing directives will remain in place. Those are specified above and further information can also be found in the pest characterisation of *D. destructor* (EFSA PLH Panel, 2014).

Difference between scenarios A0 and A1

The only difference between scenarios A0 and A1 is that the pest-specific regulations in Annex IIAII of Council Directive 2000/29/EC are either in place or not. Changes in Annex IIAII (a) 3 of Council Directive 2000/29/EC will not or only marginally directly affect other phytosanitary measures. As mentioned above, the existing pest-specific regulation has some limitation in detecting the pest. On the other hand, other phytosanitary measures are in place that will (or are capable of) detecting rotten plant tissues.

In the case of seed potatoes, there are specified limits for rots on seed tubers under Commission Implementing Directive 2014/20/EU, this requires inspections of seed tubers to detect such rots. Other phytosanitary regulations also require inspection or sampling and testing (as is the case for *Ralstonia solanacearum* and *Clavibacter michiganensis* subsp. *sepedonicus*). The EU Council Directive 98/56/EC[21] specifies that propagation material has to be substantially free from harmful organism or any symptoms of those based at least on visual inspections. Such inspections will detect symptoms of *D. destructor* infestations. Detection of a consignment with rotting symptoms will supposedly lead in all cases to rejection of those lots for planting irrespective of the causal organism. Inspections for other pests and diseases will remain in place and those will also detect rotten plants; it is considered unlikely that inspections or sampling activities such as those for, e.g. bacterial diseases of potato or *Epitrix* spp. will be lifted in the near future.

[21] Council Directive 98/56/EC of 20 July 1998 on the marketing of propagating material of ornamental plants. OJ L 226, 13.8.1998, p. 16–23.

Certification schemes, such as EPPO Standards or that are part of industry standards, also aim at producing pest-free plants for planting. Such schemes are important for the production of high quality flower bulbs. Those schemes are not covered by current legislation. It is not expected that they will be adapted or changed during the next 5 years when pest-specific regulations are withdrawn.

For above-mentioned reasons, scenarios A0 and A1 are assumed to be equally effective and therefore the same parameter values were used in the assessments (see relevant Appendices D, E, F and G).

The fact that the two regulation scenarios (A0 and A1) have identical percentiles also means that the Panel does not consider the pest-specific regulations for *D. destructor* effective and that the additional effect will be marginal or not accessible to a quantified assessment.

A.4.3. Scenarios A2–A6

The scenarios A2–A6 additional RROs are compared to the scenario A0 as follow:

Scenario (A2): Current regulations (A0) plus a regulation that **seed potatoes** for import into the EU are originating from **pest-free places of production.**

Scenario (A3): Current regulations (A0) plus a regulation that **flower bulbs** imported into the EU are originating from **pest-free places of production.**

Scenario (A4): Current regulations for *D. destructor* (A0) plus a regulation that European **flower bulbs** originate from **pest-free areas.**

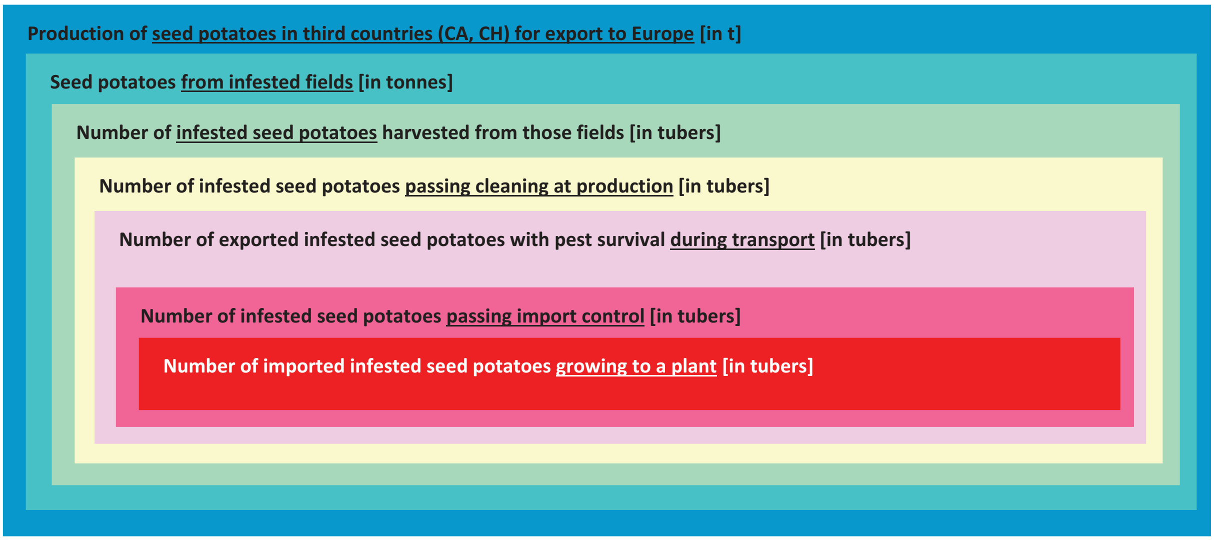
Scenario (A5): Current regulations for *D. destructor* (A0) plus a regulation that European **flower bulbs** should be subjected to **hot water treatment** before planting.

Scenario (A6): Current regulations (A0) plus use of chemical treatments (including soil fumigation before planting) of potatoes.

Appendix B – Description of the model

B.1. Potatoes

B.1.1. Entry



The number of potato plants infested with *D. destructor* each year across the whole of Europe is obtained by multiplying the trade flow (production of seed potatoes in third countries) with a series of multipliers to account for (1) the proportion of seed tubers harvested from infested fields, (2) the proportion of infested tubers harvested from infested fields, (3) the proportion of infested tubers passing cleaning at production, (4) the proportion of infested tubers in which the pest survives during transport, (5) the proportion of infested tubers passing import inspection, and (6) the proportion of infested tubers in which the pest survives during transport and storage in the EU. The coloured nested boxes represent the calculated value after subsequent multipliers have been applied. For example, seed potatoes from infested fields are obtained by multiplying the total trade flow by the proportion of infested fields in the country of origin, the number of infested potatoes harvested from those fields is calculated by multiplying the total number of seed potatoes from infested fields with the proportion of potatoes harvested from those fields that have the nematode, etc.

Figure B.1: Pictorial representation of the pathway model for entry of *D. destructor* with potato seed from third countries

(1st step) Starting point of the Entry Model is the annual import of seed potatoes into the EU (ImportSeedPotatoes) from third countries with the reported presence of *D. destructor*. Annual trade volumes (in tonnes) of the recent years 2010–2014 are used and converted to total numbers of imported tubers by multiplication with the number of potato tubers per tonne (ConversionToTubers).

To estimate the number of potatoes infested with *D. destructor* entering the EU (NumberEntered InfestedTubers), several multiplication factors are applied.

To calculate the number of infested potatoes leaving the place of production, the total export is multiplied by (2nd step) the proportion of infested fields in the country of origin (Proportion-InfestedFields3rdCountries), (3rd step) the proportion of infested potatoes harvested from an infested field (ProportionInfestedTubersWithinFields3rdCountries), and (4th step) the proportion of infested potatoes passing cleaning and inspection at the place of production (ProportionPassingCleaning).

Further multiplication factors take into account that only (5th step) a part of the pest will survive the transport to the EU (SurvivalTransport), and will (6th step) not be detected at the import control (SurvivalControl).

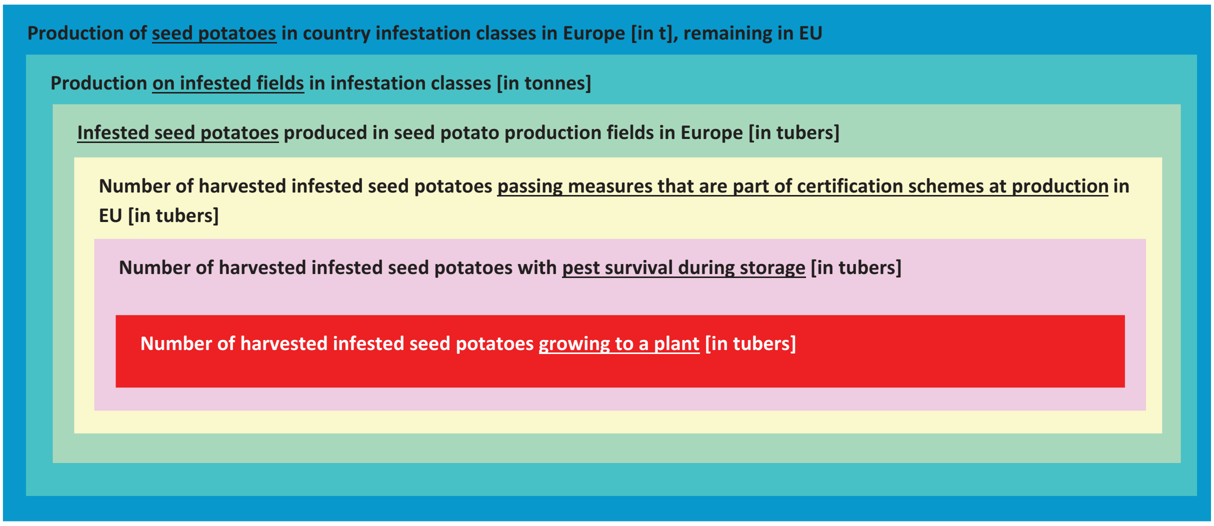
In a final (7th) step, an additional factor accounts for the part of the imported infested seed potatoes in the EU, which finally will result in a new potato plant. (ProportionEstablished). The latter factor is assumed to be one.

NumberEnteredInfestedTubers					
=		ImportSeedPotatoes	*	ConversionToTubers		
	*	ProportionInfested Fields3rdCountries	*	ProportionInfestedTubers WithinFields3rdCountries	*	ProportionPassingCleaning
	*	SurvivalTransport	*	SurvivalControl	*	ProportionEstablished

B.1.2. Establishment

Establishment is given when an infested seed potato results in a new potato plant, which is already considered in the entry model.

B.1.3. Spread



The number of potato plants infested with *D. destructor* each year across the whole of Europe is obtained by multiplying the trade flow (production of seed potatoes in the EU member states) with a series of multipliers to account for (1) the proportion of seed tubers harvested from infested fields, (2) the proportion of infested tubers harvested from infested fields, (3) the proportion of infested tubers passing cleaning for certification at production, (4) the proportion of infested tubers in which the pest survives during transport and storage in the EU, (5) the proportion of the infested tubers growing into infested plants.

Figure B.2: Pictorial representation of the pathway model for spread of *D. destructor* with potato seed within the EU

The Spread Model is similar in the structure to the entry model.

(1st step) Starting point is here the annual production of seed potatoes within the EU, which will be used inside the EU. The countries of the EU are classified into three infestation classes according to their pest status: Class 1 = *D. destructor* widely present; class 2 = partly present/no details; class 3 = absent. The annual production area of seed potatoes per class in the years 2010–2014 (in ha) is converted in the amount of harvested tubers (in tonnes) and corrected downward to account for annual export (in tonnes) to third countries from that class (ProductionSeedPotatoesForEU by class 1–3). Finally the remaining annual amount of seed potatoes (in tonnes) is converted into the total number of produced tubers used within the EU (ConversionToTubers).

Spread is regarded as the flow of infested tubers within the EU (from harvest to planting). To calculate the number of infested tubers produced and planted annually within the EU, some multiplication factors are applied.

The total number of tubers produced and within the EU is multiplied by (2nd step) the proportion of seed potatoes from infested fields in each country infestation class (ProportionInfestedFields by class 1–3), (3rd step) the proportion of infested potatoes harvested from an infested field (ProportionInfested PotatoesWithinFieldsEU), (4th step) the proportion of infested tubers passing control measures that are part of certification (SurvivalCertificationScheme).

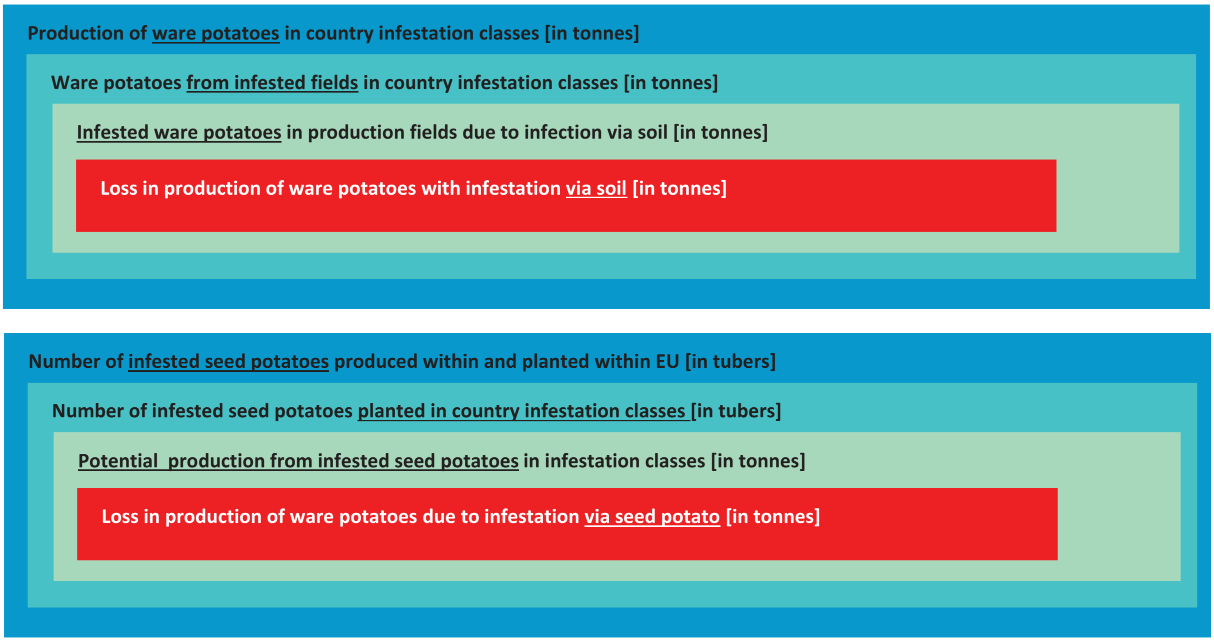
An additional correction factor takes into account that (5th step) only a part of the pest infested tubers will survive during transport and storage before the tubers are planted (SurvivalStorage).

As in the entry model, (6th step) the proportion of seed potatoes that will result in a new potato plant is considered to be 100% (ProportionEstablished).

Finally, to estimate the total number of infested seed potatoes planted within the EU (NumberSpreadInfestedTubers) the number of infested tubers entering the EU each year from third countries (Entry model) is added to the number of infested tubers each year produced and planted within the EU. The intra-EU spread is the sum over the three country infestation classes.

NumberSpreadInfestedTubers						
=	(	ProductionSeedPotatoes ForEUClass1	*	ProportionInfestedFieldsClass1		
	+	ProductionSeedPotatoes ForEUClass2	*	ProportionInfestedFieldsClass2		
	+	ProductionSeedPotatoes ForEUClass3	*	ProportionInfestedFieldsClass3	)	
	*	ConversionToTubers	*	ProportionInfestedTubers WithinFieldsEU		
	*	SurvivalPCertification Scheme	*	SurvivalStorage	*	ProportionEstablished
+		NumberEnteredInfested Tubers				

B.1.4. Impact



Two pathways to impact are considered: (1) potato yield loss due to infection of the plant via the soil, and (2) potato yield loss due to infection of the plant via an infected seed tuber. Infection via the soil considers the total ware potato production across the EU, and considers a proportion of infested fields and infested tubers within infested fields that are the same as in the spread model. Infested tubers represent a yield loss. Infection via the seed tubers is based on the entry and spread, and accounts for differences in yield level between the EU member states.

Figure B.3: Pictorial representation of the pathway model for impact of *D. destructor*

Impact is expressed as loss in the amount of production (in tonnes) of ware potatoes in Europe (LossProductionWarePotatoes).

Two modes of infestation with *D. destructor* are considered to cause impact on ware potatoes: Infestation of the plant via soil in infested fields, and direct infestation of the plant via infested seed.

The first part is structured as follows. (1st step) Starting point is the annual production of ware potatoes (in tonnes) in the different infestation classes within the EU (ProductionWarePotatoes by class 1–3). Annual production figures are used for the years 2010–2014.

The total number of produced tubers is multiplied by (2nd step) the proportion of ware potatoes from infested fields in each class (ProportionInfestedFields by class 1–3), (3rd step) and the proportion of infested potatoes within an infested field (ProportionInfestedPotatoesWithinFieldsEU).

In case of soil treatment (4th/RRO step), the survival of the pest in the soil after treatment is introduced as additional factor (SurvivalSoilTreatment).

The loss is finally calculated by (4th step) the average, relative reduction in production of ware potatoes for infested tubers (RelativeLossPerInfestedTuberViaSoil).

The second part distributes the number of infested seed potatoes spread within the EU (NumberSpreadInfestedTubers/spread model) to the different production areas according to the (5th step) relative production area of ware potatoes per infestation class (RelativeProductionArea WarePotatoes by class 1–3). The proportions were calculated using the average production area of the years 2010–2014 per class.

The number of infested seed potatoes is subsequently multiplied by (6th step) the productivity per plant (i.e. the potato yield per plant) (ProductivityPerPlant by class 1–3) within each class. The latter is estimated from annual yield data (in tonnes/ha) for the different classes in the years 2010–2014, converted to productivity (in tonnes/plant).

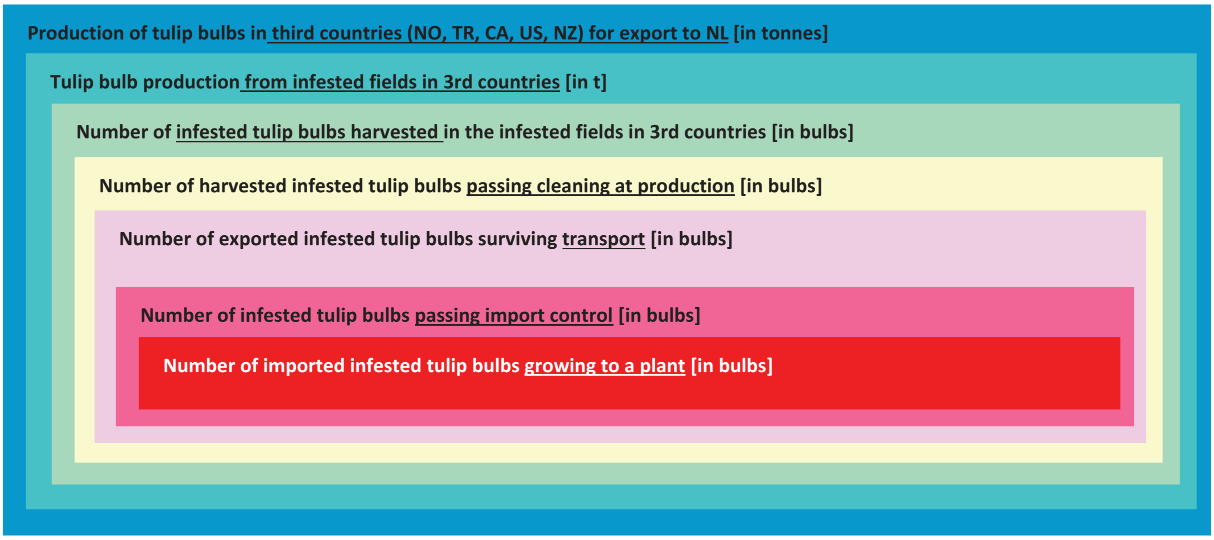
Finally, the loss (in tonnes) is calculated by (7th step) the average, relative reduction in production of ware potatoes from infested seed potatoes (RelativeLossPerInfestedTuberViaSeed).

Both losses are added to the total loss in amount (in tonnes) in ware potato production (LossProductionWarePotatoes).

LossProductionWarePotatoes						
=	(	ProductionWarePotatoesClass1	*	ProportionInfestedFieldsClass1		
	+	ProductionWarePotatoesClass2	*	ProportionInfestedFieldsClass2		
	+	ProductionWarePotatoesClass3	*	ProportionInfestedFieldsClass3	)	
	*	ProportionInfestedTubersWithinFieldsEU	*	SurvivalSoilTreatment		
	*	RelativeLossPerInfestedTuberViaSoil				
+		NumberSpreadInfestedTubers				
	* (	RelativeProductionAreaWarePotatoesClass1	*	ProductivityPerPlantClass1		
	+	RelativeProductionAreaWarePotatoesClass2	*	ProductivityPerPlantClass2		
	+	RelativeProductionAreaWarePotatoesClass3	*	ProductivityPerPlantClass3	)	
+		RelativeLossPerInfestedTuberViaSeed				

B.2. Bulbs

B.2.1. Entry



The number of tulip plants infested with *D. destructor* each year across the whole of Europe is obtained by multiplying the trade flow (production of tulip bulbs in third countries) with a series of multipliers to account for (1) the proportion of bulbs harvested from infested fields, (2) the proportion of infested bulbs harvested from infested fields, (3) the proportion of infested bulbs passing cleaning at production, (4) the proportion of infested bulbs in which the pest survives during transport, (5) the proportion of infested bulbs passing import inspection, and (6) the proportion of infested tubers in which the pest survives during transport and storage in the EU.

Figure B.4: Pictorial representation of the pathway model for entry of *D. destructor* with tulip bulbs from third countries

(1st step) Starting point of the Entry Model is the annual import of tulip bulbs into the Netherlands (ImportTulipBulbs) by third countries with the reported presence of *D. destructor*. Annual trade volumes (in tonnes) of the recent years 2010–2014 are used and converted to total numbers of imported tulip bulbs (ConversionToBulbs).

To estimate the number of bulbs infested with *D. destructor* (NumberEnteredInfestedBulbs) entering the Netherlands some additional multiplication factors are applied.

To calculate the number of infested tulip bulbs leaving the place of production the total export is multiplied by (2nd step) the proportion of bulbs from infested fields in the country of origin (ProportionInfestedFields3rdCountries), (3rd step) the proportion of infested bulbs within an infested field (ProportionInfestedBulbsWithinFields), and (4th step) the proportion of infested bulbs passing cleaning and inspection at the place of production (ProportionPassingCleaning).

Further correction factors take into account that only (5th step) a part of the infested bulbs will retain integrity during transport to the EU (SurvivalTransport), and will (6th step) not be detected at the import control (SurvivalControl).

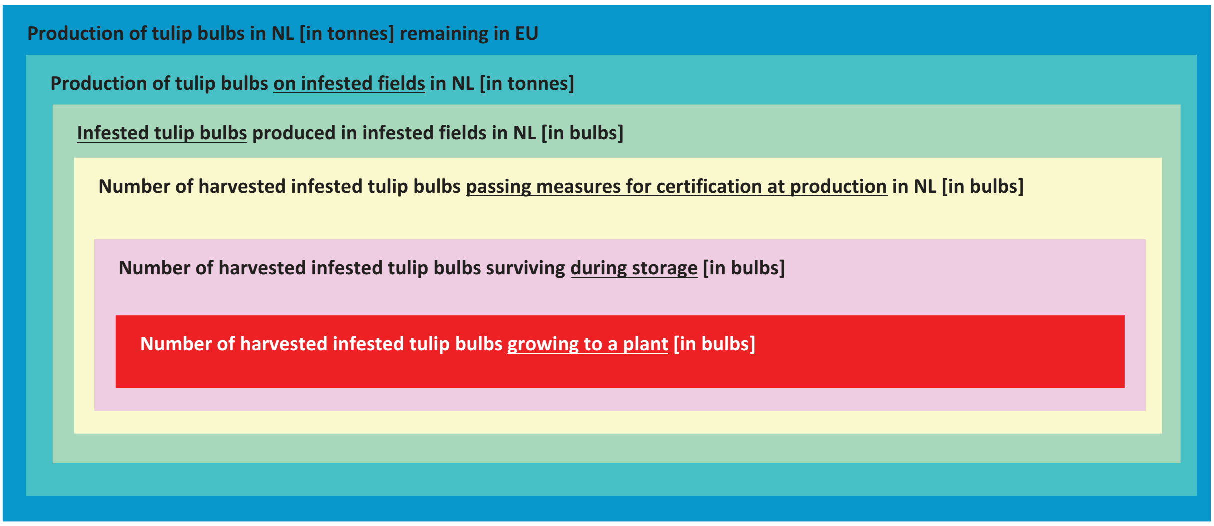
In a final step, an additional factor corrects for the proportion of tulip bulbs imported into the Netherlands that eventually will result in a new tulip plant (ProportionEstablished). The latter step is assumed 100%.

NumberEnteredInfestedBulbs						
=		ImportTulipBulbs	*	ConversionToBulbs		
	*	ProportionInfested Fields3rdCountries	*	ProportionInfestedBulbs WithinFields3rdCountries	*	ProportionPassingCleaning
	*	SurvivalTransport	*	SurvivalControl	*	ProportionEstablished

B.2.2. Establishment

Establishment is given when an infested tulip bulb results in a new tulip, which is already considered in the entry model.

B.2.3. Spread



The number of tulip plants infested with *D. destructor* each year across the whole of Europe is obtained by multiplying the trade flow (production of tulip bulbs in EU member states) with a series of multipliers to account for (1) the proportion of tulip bulbs harvested from infested fields, (2) the proportion of infested tulip bulbs harvested from infested fields, (3) the proportion of infested tulip bulbs passing cleaning for certification at production, (4) the proportion of infested tulip bulbs in which the pest survives during transport and storage in the EU, (5) the proportion of the infested tulip bulbs growing into infested plants.

Figure B.5: Pictorial representation of the pathway model for spread of *D. destructor* with tulip bulbs within the EU

The spread model is similar in structure to the entry model.

(1st step) Starting point is the annual production of tulip bulbs within the Netherlands, which will be planted inside the EU. The annual production area of tulip bulbs in the years 2010–2014 (in ha) is converted to the amount of harvested bulbs (in tonnes) and adjusted downward to account for annual export to third countries (in tonnes) (ProductionSeedBulbsForEUInNL). Finally the remaining annual amount of tulip bulbs (in tonnes) is converted into the total number of produced bulbs used within the EU (ConversionToTubers).

Spread is regarded as the flow of infested bulbs within the EU (from harvest to planting). To calculate the total annual number of infested bulbs used within the EU again some correction factors are applied.

The total number of produced bulbs used within the EU is multiplied by (2nd step) the proportion of tulip bulbs from infested fields in the Netherlands (ProportionInfestedFieldsNL), (3rd step) the proportion of infested bulbs within an infested field (ProportionInfestedBulbsWithinFieldsNL), (4th step) the proportion of infested bulbs passing the control measures in the certification scheme (ProportionPassingCertification).

An additional correction factor takes into account that (5th step) only a part of the pest will survive during transport and storage before the bulbs are planted (SurvivalStorage).

As in the entry model, (6th step) the proportion of tulip bulbs that will result in a new tulip plant is considered to be 100% (ProportionEstablished).

Finally, to estimate the total number of infested tulip bulbs planted each year inside the EU (NumberSpreadInfestedBulbs), the number of annually entering infested bulbs (Entry model) and the annually infested bulbs produced within the EU are summed.

NumberSpreadInfestedBulbs						
=		ProductionTulipBulbsForEUInNL	*	ProportionInfestedFieldsNL		
	*	ConversionToBulbs	*	ProportionInfestedBulbs WithinFieldsNL		
	*	SurvivalCertificationScheme	*	SurvivalStorage	*	ProportionEstablished
+		NumberEnteredInfestedBulbs				

B.2.4. Impact

No quantitative model has been developed for impact in flower bulbs.

Appendix C – Data

C.1. General data

European countries were grouped into three classes according to their pest notifications:

Table C.1: Classification of EU 28 according to the pest status

Classification	Pest status	List of countries
Class 1:	**Present, in all parts** of the area where host crops are grown	Netherlands (NL)
Class 2:	**Present, restricted distribution**	Austria (AT), Belgium (BE), Bulgaria (BG), Germany (DE), Estonia (EE), Greece (EL), France (FR), Hungary (HU), Lithuania (LT), Luxembourg (LU), Latvia (LV), Poland (PL), Romania (RO), Slovakia (SK)
	Present, few occurrences	Czech Republic (CZ), Ireland (IE), Sweden (SE), United Kingdom (UK)
	Present, no details	Malta (MT)
Class 3:	**Absent**	Cyprus (CY), Denmark (DK), Spain (ES), Finland (FI), Croatia (HR), Italy (IT), Portugal (PT), Slovenia (SI)

C.2. Pathway 1: Potatoes/seed potatoes

Table C.2: Production area of potatoes (including seed potatoes) in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area (1,000 ha)					
NL	157.0	159.2	150.0	156.0	156.0	155.6
Class 1	**157.0**	**159.2**	**150.0**	**156.0**	**156.0**	**155.6**
AT	22.0	22.9	21.8	21.1	21.4	21.8
BE	76.3[(a)]	82.3	67.0	75.4	80.4	76.3
BG	13.8	16.2	14.9	12.8	10.2	13.6
CZ	27.1	26.5	23.7	23.2	24.0	24.9
DE	254.4	258.7	238.3	242.8	224.8	243.8
EE	6.1	6.0	5.5	4.6	4.4	5.3
EL	31.4	28.5	24.2	24.7	23.9	26.5
FR	157.1	158.6	154.1	161.0	168.0	159.8
HU	20.8	21.0	25.1	21.0	21.0	21.8
IE	12.2	10.4	9.0	10.7	9.5	10.3
LT	36.2	37.3	31.7	28.3	26.8	32.1
LU	0.6	0.6	0.6	0.6	0.6	0.6
LV	18.3	14.4	12.2	12.4	11.1	13.7
MT	0.7	0.7	0.7	0.7	0.7	0.7
PL	388.3	393.0	373.0	337.0	267.1	351.7
RO	247.2	248.4	229.3	207.6	202.7	227.0
SE	27.2	27.7	24.7	23.9	23.8	25.5
SK	11.0	10.4	8.9	9.0	9.1	9.7
UK	138.0	146.0	149.0	139.0	141.0	142.6
Class 2	**1488.5**	**1509.5**	**1413.6**	**1355.7**	**1270.3**	**1407.5**
CY	4.3	5.1	4.6	4.6	4.9	4.7
DK	38.4	41.6	39.5	39.6	19.6	35.7
ES	77.4	79.9	72.0	72.4	76.0	75.5
FI	25.2	24.4	20.7	22.1	22.0	22.9

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area (1,000 ha)					
HR	11.0	10.9	10.2	10.2	10.3	10.5
IT	62.4	61.6	58.7	50.4	52.4	57.1
PT	25.5	26.5	25.1	26.8	27.2	26.2
SI	4.1	3.6	3.4	3.3	3.6	3.6
Class 3	**248.3**	**253.6**	**234.1**	**229.5**	**215.9**	**236.3**
EU28	**1893.8**	**1922.3**	**1797.7**	**1741.2**	**1642.3**	**1799.4**

(a): Missing value imputed by average of remaining years.
Source: EUROSTAT, online (table apro_acs_a, Areapotatoes; http://ec.europa.eu/eurostat/data/database).

Table C.3: Harvested production of potatoes (including seed potatoes) in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Harvested production (1,000 tonnes)					
NL	6,843.5	7,333.0	6,766.0	6,577.0	7,100.0	6,923.9
Class 1	**6,843.5**	**7,333.0**	**6,766.0**	**6,577.0**	**7,100.0**	**6,923.9**
AT	671.7	816.1	665.4	604.1	750.6	701.6
BE	3,455.8	4,128.7	2,811.5	3,428.0	4,121.5	3,589.1
BG	251.2	232.3	151.3	186.5	132.7	190.8
CZ	665.2	805.3	661.8	536.5	697.5	673.3
DE	10,143.1	11,837.2	10,665.6	9,669.7	11,607.3	10,784.6
EE	110.2	110.6	102.0	92.6	82.3	99.5
EL	791.5	757.8	578.8	666.8	582.4	675.5
FR	6,622.0	7,440.2	6,297.1	6,953.3	8,054.5	7,073.4
HU	488.4	600.1	547.7	487.4	567.4	538.2
IE	419.6	356.1	232.0	410.2	383.0	360.2
LT	471.1	581.0	542.4	420.7	460.9	495.2
LU	19.5	19.7	20.6	17.5	19.0	19.3
LV	293.3	246.8	238.8	236.8	209.9	245.1
MT	15.5	18.9	12.7	12.6	10.8	14.1
PL	8,187.7	9,111.0	9,041.3	7,110.9	7,424.7	8,175.1
RO	3,283.9	4,076.6	2,465.2	3,289.7	3,519.3	3,326.9
SE	816.3	882.0	805.3	806.1	822.1	826.4
SK	125.9	217.3	165.7	164.5	178.8	170.4
UK	6,046.0	6,016.0	4,553.0	5,685.0	5,921.0	5,644.2
Class 2	**42,878.1**	**48,253.7**	**40,558.2**	**40,778.8**	**45,545.8**	**43,602.9**
CY	82.0	126.1	82.2	105.5	117.5	102.7
DK	1,357.8	1,620.2	1,664.2	1,646.3	964.5	1,450.6
ES	2,297.6	2,455.1	2,192.3	2,167.6	2,543.9	2,331.3
FI	659.1	673.3	489.6	621.7	600.3	608.8
HR	178.6	167.5	151.3	162.5	160.9	164.2
IT	1,558.0	1,536.9	1,491.3	1,272.2	1,365.4	1,444.8
PT	383.8	389.8	445.7	487.7	539.9	449.4
SI	101.2	96.2	79.3	62.2	97.2	87.2
Class 3	**6,618.2**	**7,065.0**	**6,595.7**	**6,525.6**	**6,389.6**	**6,638.8**
EU28	**56,339.8**	**62,651.7**	**53,919.9**	**53,881.4**	**59,035.3**	**57,165.6**

Source: EUROSTAT, online (table apro_acs_a, Prodpotatoes; http://ec.europa.eu/eurostat/data/database).

Table C.4: Production area of seed potatoes in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area of seed potatoes (ha)					
NL	35,596.0	37,136.9[(a)]	37,606.7	37,235.1	38,109.8	37,136.9
Class 1	**35,596.0**	**37,136.9**	**37,606.7**	**37,235.1**	**38,109.8**	**37,136.9**
AT	1,585.0[(a)]	1,585.0[(a)]	1,585.0[(a)]	1,585.0[(a)]	1,585.0	1,585.0
BE	2,323.1	2,177.9	2,038.3	2,130.7	2,332.4	2,200.5
BG	308.0	440.0	243.0	189.0	280.0	292.0
CZ	2,609.7	3,194.7	2,441.0	3,172.7	3,012.8	2,886.2
DE	16,142.6	16,296.8	15,512.7	15,769.6	16,056.8	15,955.7
EE	277.1	348.7	250.1	261.7	290.9	285.7
EL	405.9[(a)]	588.5	558.0	240.2	236.9	405.9
FR	16,417.6	16,877.6	16,737.9	17,380.0	18,447.4	17,172.1
HU	255.2	228.2	331.7	193.0	210.0	243.6
IE	700.0	500.0	460.0	329.0	238.0	445.4
LT	205.2	286.6	177.2	129.4	177.2	195.1
LU	401.6	404.0	395.0	465.4	379.3	409.1
LV	286.0	250.0	280.4	252.6	356.6	285.1
MT	0.0	0.0	0.0	0.0	0.0	0.0
PL	5,184.8	5,336.2	5,330.7	4,758.9	5,243.2	5,170.8
RO	482.0	614.0	283.0	318.0	555.7	450.5
SE	1,250.7	1,079.2[(a)]	1,102.4	964.6	999.0	1079.2
SK	559.7	635.2	573.9	499.8	505.0	554.7
UK	14,253.1[(a)]	14,412.6	14,046.0	14,022.9	14,530.8	14,253.1
Class 2	**63,647.3**	**65,255.2**	**62,346.3**	**62,662.5**	**65,437.0**	**63,869.7**
CY	88.0	119.6	98.6	82.5	105.3	101.5
DK	4,040.3[(a)]	4,040.3[(a)]	4,379.0	3,742.0	4,000.0	4,040.3
ES	2,731.2	2,685.2	2,652.0	843.8	2,228.1[(a)]	2,228.1
FI	1,206.0	1,143.0	1,118.0	1,080.0	1,073.0	1,103.5
HR	138.5	61.2	63.5	63.7	73.8	65.6
IT	179.4	186.2	167.9	129.4	140.6	156.0
PT	0.0	0.0	0.0	0.0	0.0	0.0
SI	40.3	48.2	47.0	40.0	30.0	41.3
Class 3	**8,423.7**	**8,283.7**	**8,526.0**	**5,981.4**	**7,650.8**	**7,773.1**
EU28	**107,667.0**	**110,675.8**	**108,479.0**	**105,879.0**	**111,197.6**	**108,779.7**

(a): Missing value imputed by average of remaining years.
Source: ESCAA, online (Areaseedpot; http://www.escaa.org/index/action/page/id/8/title/field-production-area-for-seeds).

Definition of infestation classes is shown in Table C.1.

Table C.5: Production area of seed potatoes by infestation class in Europe

Infestation class	Production area of seed potatoes (ha)	
Class 1	37,137	34%
Class 2	63,870	59%
Class 3	7,773	7%
EU28	108,780	100%

Class 1: 1 country (NL); class 2: 19 countries; class 3: 8 countries.

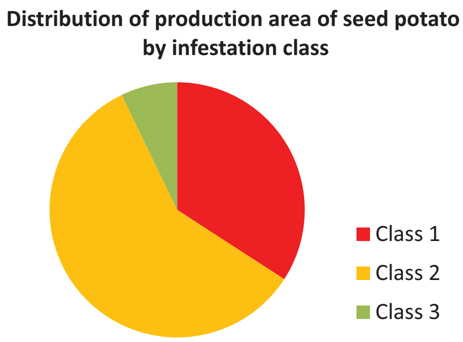


Figure C.1: Distribution of production area of seed potatoes by infestation class in Europe (Class 1: 1 country (NL); class 2: 19 countries; class 3: 8 countries)

Table C.6: Export of seed potatoes from the EU to outside the EU (tonnes)

Country	Year					Average
	2010	2011	2012	2013	2014	
	Export of seed potatoes to countries outside the EU (tonnes)					
NL	417,580.7	467,155.8	413,037.5	421,363.2	497,568.9	443,341.2
Class 1	**417,580.7**	**467,155.8**	**413,037.5**	**421,363.2**	**497,568.9**	**443,341.2**
AT	357.5	468.7	575.3	481.0	916.3	559.8
BE	14,922.6	18,229.5	14,793.9	22,107.8	24,347.0	18,880.2
BG						
CZ	192.0	111.0	154.4	56.5	60.0	114.8
DE	24,432.2	29,922.5	22,720.0	24,680.3	23,556.6	25,062.3
EE	244.3	244.3[(a)]	244.3[(a)]	244.3[(a)]	244.3[(a)]	244.3
FR	61,780.2	64,953.8	72,075.0	69,107.3	76,975.4	68,978.3
GB	53,969.9	73,884.8	79,281.6	75,063.1	75,820.5	71,604.0
GR	27.9	71.8	21.6	40.4[(a)]	40.4[(a)]	40.4
HU	01.6	36.2	61.1	35.7	43.3	55.6
IE	0.0	100.0	50.0[(a)]	50.0[(a)]	50.0[(a)]	50.0
LT	40.0	598.4	480.7	27.0	63.0	241.8
LU	203.5[(a)]	203.5[(a)]	203.5[(a)]	365.0	42.0	203.5
LV	27.5	216.9	32.3	44.0	71.3	78.4
MT	25.0[(a)]	25.0[(a)]	25.0[(a)]	25.0[(a)]	25.0	25.0
PL	725.6	932.0	1110.4	1135.1	2490.0	1278.6
RO	73.2	181.0	140.0	43.0	66.0	100.6
SE	102.2[(a)]	102.2[(a)]	3.8	147.8	155.0	102.2
SK	22.0	22.0	66.2	22.0	20.0	30.4
Class 2	**157,247.2**	**190,303.6**	**192,039.1**	**193,675.3**	**204,986.1**	**187,650.3**
CY						
DK	33,841.9	33,652.2	27,141.3	33,199.7	30,624.7	31,692.0
ES	40.1	535.2	307.7	122.7	305.3	262.2
FI	2,710.7	2,963.3	3,161.1	2,006.6	2,547.3	2,677.8
HR	23.5[(a)]	23.5[(a)]	23.8	23.8	23.0	23.5
IT	181.7	572.6	228.5	228.5	77.0	257.7
PT	33.4	90.4	91.1	48.6	216.9	96.1
SI	39.2	445.5	54.9	266.0	46.5	170.4

Country	Year					Average
	2010	2011	2012	2013	2014	
	Export of seed potatoes to countries outside the EU (tonnes)					
Class 3	**36,870.5**	**38,282.7**	**31,008.4**	**35,895.9**	**33,840.7**	**35,179.7**
EU28	611,344.2	695,143.6	635,562.2	650,599.7	736,061.0	665,742.1

Data for BG and CY are not available.
(a): Missing value imputed by average of remaining years.
Source: EUROSTAT, online (EU trade since 1988 by CN8: 0701 1000 = seed potatoes).

Table C.7: Seed potato production in EU for intra-EU trade by infestation classes

Seed potato production exported or remaining inside the EU					
Year	Seed potato production area	Production of seed potatoes converted from area	Export of seed potatoes to outside of the EU	Remaining seed potatoes inside the EU	Percentage of remaining seed potatoes inside the EU
	(ha)	(tonnes)	(tonnes)	(tonnes)	(%)
Class 1					
2010	35,596.0	889,900.0	417,580.7	472,319.3	53
2011	37,136.9	928,422.5	467,155.8	461,266.7	50
2012	37,606.7	940,167.5	413,037.5	527,130.0	56
2013	37,235.1	930,877.5	421,363.2	509,514.3	55
2014	38,109.8	952,745.0	497,568.9	455,176.1	48
Class 2					
2010	63,647.3	1,591,182.5	157,247.2	1,433,935.3	90
2011	65,255.2	1,631,380.0	190,303.6	1,441,076.4	88
2012	62,346.3	1,558,657.5	192,039.1	1,366,618.4	88
2013	62,662.5	1,566,562.5	193,675.3	1,372,887.2	88
2014	65,437.0	1,635,925.0	204,986.1	1,430,938.9	87
Class 3					
2010	8,423.7	210,592.5	36,870.5	173,722.0	82
2011	8,283.7	207,092.5	38,282.7	168,809.8	82
2012	8,526.0	213,150.0	31,008.4	182,141.6	85
2013	5,981.4	149,535.0	35,895.9	113,639.1	76
2014	7,650.8	191,270.0	33,840.7	157,429.3	82
Europe (Sum of class 1–3)					
2010	107,667.0	2,691,675.0	611,698.4	2,079,976.6	77
2011	110,675.8	2,766,895.0	695,742.1	2,071,152.9	75
2012	108,479.0	2,711,975.0	636,085.0	2,075,890.0	77
2013	105,879.0	2,646,975.0	650,934.4	1,996,040.6	75
2014	111,197.6	2,779,940.0	736,395.7	2,043,544.3	74
Average 2010–14	108,779.7	2,719,492.0	666,171.1	2,053,320.9	76

Calculated from Tables C.4 and C.6.

Table C.8: Production area of ware potatoes in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area of ware potatoes (ha)					
NL	121,374.0	122,093.1	112,393.3	118,764.9	117,890.2	118,503.1
Class 1	**121,374.0**	**122,093.1**	**112,393.3**	**118,764.9**	**117,890.2**	**118,503.1**
AT	20,385.0	21,265.0	20,195.0	19,545.0	19,795.0	20,237.0
BE	73,954.4	80,162.1	64,961.7	73,269.3	78,037.6	74,077.0
BG	13,492.0	15,780.0	14,657.0	12,581.0	9,920.0	13,286.0
CZ	24,470.3	23,255.3	21,209.0	20,037.3	20,977.2	21,989.8
DE	238,227.4	24,2403.2	222,787.3	22,7030.4	208,743.2	227,838.3
EE	5,822.9	5,651.3	5,249.9	4,338.3	4,109.1	5,034.3
EL	30,944.1	27,861.5	23,602.0	24,449.8	23,613.1	26,094.1
FR	140,662.4	141,762.4	137,352.1	143,580.0	149,572.6	142,585.9
HU	20,534.8	20,741.8	24,748.3	20,757.0	20,770.0	21,510.4
IE	11,500.0	9,850.0	8,530.0	10,411.0	9,222.0	9,902.6
LT	35,994.8	37,013.4	31,522.8	28,170.6	26,622.8	31,864.9
LU	218.4	236.0	245.0	124.6	230.7	210.9
LV	18,014.0	14,150.0	11,919.6	12,147.4	10,743.4	13,394.9
MT	710.0	700.0	700.0	690.0	690.0	698.0
PL	383,115.2	387,663.8	367,669.3	332,241.1	261,856.8	346,509.2
RO	246,708.0	247,736.0	228,987.0	207,292.0	202,114.3	226,567.5
SE	25,949.3	26,620.8	23,597.6	22,915.4	22,781.0	24,372.8
SK	10,430.3	9,764.8	8,356.1	8,480.2	8,605.0	9,127.3
UK	123,746.9	131,587.4	134,954.0	124,977.1	126,469.2	128,346.9
Class 2	**1,424,880.2**	**1,444,204.8**	**1,351,243.7**	**1,293,037.5**	**1,204,873.0**	**1,343,647.9**
CY	4,172.0	4,950.4	4,451.4	4,557.5	4,804.7	4,587.2
DK	34,359.7	37,559.7	35,121.0	35,858.0	15,600.0	31,699.7
ES	74,688.8	77,184.8	69,368.0	71,586.2	73,732.0	73,312.0
FI	23,994.0	23,257.0	19,582.0	21,020.0	20,927.0	21,756.0
HR	10,811.5	10,818.8	10,166.5	10,166.3	10,236.2	10,439.9
IT	62,220.6	61,413.8	58,482.1	50,260.6	52,209.4	56,917.3
PT	25,530.0	26,500.0	25,050.0	26,760.0	27,210.0	26,210.0
SI	4,089.7	3,591.8	3,343.0	3,270.0	3,570.0	3,572.9
Class 3	**239,866.3**	**245,276.3**	**225,564.0**	**223,478.6**	**208,289.3**	**228,494.9**
EU28	**1,786,120.5**	**1,811,574.2**	**1,689,201.0**	**1,635,281.0**	**1,531,052.5**	**1,690,645.8**

Calculated from Tables C.2 and C.4: Areawarepot = Areapotatoes — Areaseedpot.

Definition of infestation classes is shown in Table C.1.

Table C.9: Production area of ware potatoes by infestation class in Europe

Infestation class	Production area of ware potatoes (ha)	
Class 1	118,503	7%
Class 2	1,343,648	79%
Class 3	228,495	14%
EU28	1,690,646	100%

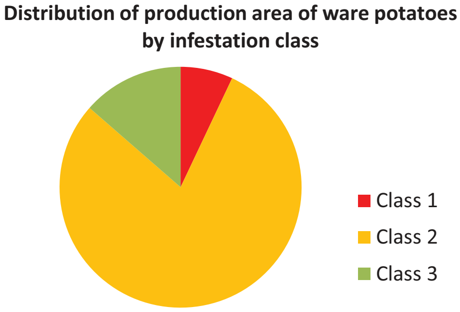


Figure C.2: Distribution of production area of ware potatoes by infestation class in Europe (Class 1: 1 country (NL); class 2: 19 countries; class 3: 8 countries)

Table C.10: Harvested production of ware potatoes in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Harvested production (1,000 tonnes)					
NL	5,953.6	6,404.6	5,825.8	5,646.1	6,147.3	5,995.5
Class 1	**5,953.6**	**6,404.6**	**5,825.8**	**5,646.1**	**6,147.3**	**5,995.5**
AT	632.1	776.4	625.8	564.4	711.0	662.0
BE	3,397.7	4,074.2	2,760.5	3,374.7	4,063.1	3,534.1
BG	243.5	221.3	145.2	181.8	125.7	183.5
CZ	599.9	725.5	600.8	457.1	622.2	601.1
DE	9,739.5	11,429.8	10,277.8	9,275.5	11,205.9	10,385.7
EE	103.3	101.9	95.7	86.1	75.0	92.4
EL	781.4	743.1	564.9	660.8	576.4	665.3
FR	6,211.6	7,018.3	5,878.7	6,518.8	7,593.3	6,644.1
HU	482.0	594.4	539.4	482.5	562.2	532.1
IE	402.1	343.6	220.5	401.9	377.1	349.0
LT	466.0	573.8	538.0	417.5	456.5	490.3
LU	9.5	9.6	10.7	5.9	9.5	9.0
LV	286.2	240.6	231.8	230.5	201.0	238.0
MT	15.5	18.9	12.7	12.6	10.8	14.1
PL	8,058.1	8,977.6	8,908.0	6,991.9	7,293.6	8,045.9
RO	3,271.8	4,061.2	2,458.1	3,281.8	3,505.4	3,315.7
SE	785.0	855.0	777.7	782.0	797.1	799.4
SK	111.9	201.4	151.3	152.0	166.2	156.6
UK	5,689.7	5655.7	4,201.9	5,334.4	5,557.7	5,287.9
Class 2	**41,286.9**	**46,622.3**	**38,999.6**	**39,212.2**	**43,909.8**	**42,006.2**
CY	79.8	123.1	79.7	103.4	114.9	100.2
DK	1,256.8	1,519.2	1,554.7	1,552.8	864.5	1349.6
ES	2,229.3	2,388.0	2,126.0	2,146.5	2,488.2	2,275.6
FI	629.0	644.7	461.7	594.7	573.5	580.7
HR	175.1	166.0	149.7	160.9	159.0	162.1
IT	1,553.5	1,532.2	1,487.1	1,269.0	1,361.9	1,440.7
PT	383.8	389.8	445.7	487.7	539.9	449.4
SI	100.2	95.0	78.1	61.2	96.4	86.2
Class 3	**6,407.6**	**6,857.9**	**6,382.6**	**6,376.1**	**6,198.3**	**6,444.5**
EU28	**53,648.1**	**59,884.8**	**51,208.0**	**51,234.4**	**56,255.4**	**54,446.1**

Calculated from Table C.3 and C.4: Prodwarepot = Prodpotatoes — Areaseedpot * 25 tonnes/ha.

Table C.11: Yield of ware potatoes in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Yield (tonnes/ha)					
NL	49.1	52.5	51.8	47.5	52.1	50.6
Class 1	**49.1**	**52.5**	**51.8**	**47.5**	**52.1**	**50.6**
AT	31.0	36.5	31.0	28.9	35.9	32.7
BE	45.9	50.8	42.5	46.1	52.1	47.5
BG	18.0	14.0	9.9	14.5	12.7	13.8
CZ	24.5	31.2	28.3	22.8	29.7	27.3
DE	40.9	47.2	46.1	40.9	53.7	45.7
EE	17.7	18.0	18.2	19.8	18.3	18.4
EL	25.3	26.7	23.9	27.0	24.4	25.5
FR	44.2	49.5	42.8	45.4	50.8	46.5
HU	23.5	28.7	21.8	23.2	27.1	24.8
IE	35.0	34.9	25.9	38.6	40.9	35.0
LT	12.9	15.5	17.1	14.8	17.1	15.5
LU	43.5	40.6	43.8	47.4	41.2	43.3
LV	15.9	17.0	19.4	19.0	18.7	18.0
MT	21.9	27.0	18.1	18.3	15.7	20.2
PL	21.0	23.2	24.2	21.0	27.9	23.5
RO	13.3	16.4	10.7	15.8	17.3	14.7
SE	30.3	32.1	33.0	34.1	35.0	32.9
SK	10.7	20.6	18.1	17.9	19.3	17.3
UK	46.0	43.0	31.1	42.7	43.9	41.3
Class 2	**29.0**	**32.3**	**28.9**	**30.3**	**36.4**	**31.4**
CY	19.1	24.9	17.9	22.7	23.9	21.7
DK	36.6	40.4	44.3	43.3	55.4	44.0
ES	29.8	30.9	30.6	30.0	33.7	31.0
FI	26.2	27.7	23.6	28.3	27.4	26.6
HR	16.2	15.3	14.7	15.8	15.5	15.5
IT	25.0	24.9	25.4	25.2	26.1	25.3
PT	15.0	14.7	17.8	18.2	19.8	17.1
SI	24.5	26.4	23.4	18.7	27.0	24.0
Class 3	**26.7**	**28.0**	**28.3**	**28.5**	**29.8**	**28.3**
EU28	**30.0**	**33.1**	**30.3**	**31.3**	**36.7**	**32.3**

Calculated from Tables C.8 and C.9: Yieldwarepot = Prodwarepot/Areawarepot.

Table C.12: Productivity of ware potatoes (Yield per seed potato) in Europe

Country	Year					Average
	2010	2011	2012	2013	2014	
	Productivity (kg/seed potato)					
NL	0.981	1.049	1.037	0.951	1.043	1.012
Class 1	**0.981**	**1.049**	**1.037**	**0.951**	**1.043**	**1.012**
AT	0.620	0.730	0.620	0.578	0.718	0.653
BE	0.919	1.016	0.850	0.921	1.041	0.950
BG	0.361	0.280	0.198	0.289	0.253	0.276
CZ	0.490	0.624	0.567	0.456	0.593	0.546
DE	0.818	0.943	0.923	0.817	1.074	0.915

Country	Year					Average
	2010	2011	2012	2013	2014	
	Productivity (kg/seed potato)					
EE	0.355	0.361	0.365	0.397	0.365	0.368
EL	0.505	0.533	0.479	0.541	0.488	0.509
FR	0.883	0.990	0.856	0.908	1.015	0.931
HU	0.469	0.573	0.436	0.465	0.541	0.497
IE	0.699	0.698	0.517	0.772	0.818	0.701
LT	0.259	0.310	0.341	0.296	0.343	0.310
LU	0.869	0.812	0.876	0.948	0.823	0.866
LV	0.318	0.340	0.389	0.379	0.374	0.360
MT	0.438	0.541	0.363	0.366	0.313	0.404
PL	0.421	0.463	0.485	0.421	0.557	0.469
RO	0.265	0.328	0.215	0.317	0.347	0.294
SE	0.605	0.642	0.659	0.682	0.700	0.658
SK	0.215	0.413	0.362	0.358	0.386	0.347
UK	0.920	0.860	0.623	0.854	0.879	0.827
Class 2	**0.580**	**0.646**	**0.577**	**0.607**	**0.729**	**0.628**
CY	0.383	0.497	0.358	0.454	0.478	0.434
DK	0.732	0.809	0.885	0.866	1.108	0.880
ES	0.597	0.619	0.613	0.600	0.675	0.621
FI	0.524	0.554	0.472	0.566	0.548	0.533
HR	0.324	0.307	0.294	0.317	0.311	0.311
IT	0.499	0.499	0.509	0.505	0.522	0.507
PT	0.301	0.294	0.356	0.364	0.397	0.342
SI	0.490	0.529	0.467	0.374	0.540	0.480
Class 3	**0.534**	**0.559**	**0.566**	**0.571**	**0.595**	**0.565**
EU28	**0.601**	**0.661**	**0.606**	**0.627**	**0.735**	**0.646**

Calculated from Table C.8: Productivitywarepot = Yieldwarepot/(50,000 tubers/ha).

Table C.13: Conversion factors

Conversion	Abbreviation	Factor[(a)]
Size of seed potatoes (weight to pieces)	$C_{pieces/tonne}$	20,000 seed potatoes/tonnes
Yield of seed potatoes (area to production)	$Yield_{seedpot} = C_{tonnes/ha}$	25 tonnes/ha
Yield of seed potatoes (area to pieces)	$C_{pieces/ha}$	500,000 seed potatoes/ha
Plantation density (area to plants)	$C_{plants/ha}$	50,000 plants/ha

(a): Under the assumption that 50,000 plants are grown per hectare and each plant produces 10 tubers, 500,000 tubers will be produced per hectare.

C.3. Pathway 2: Tulip bulbs

Table C.14: Pest status according to EPPO PQR (online) (accessed on 17 March 2016)

Country	Pest status according to EPPO PQR (online) (accessed on 17 March 2016)
Norway (NO)	Present, no details
Turkey (TR)	Present, distribution restricted
Canada (CA)	Present, few occurrences
USA (US)	Present, restricted distribution
Chile (CL)	Not present
India (IN)	Not present
Australia (AU)	Not present
New Zealand (NZ)	Present, restricted distribution

Production of tulip bulbs in third countries (NO, TR, CA, US, CL, IN, AU and NZ) for export to Europe/Trade flow of tulip bulbs from third countries

Table C.15: Import of tulip bulbs (tonnes) into NL from different countries

Import of flower bulbs to NL in (tonnes)										
Year	**NZ**	**CL**	**CA**	**AU**	**US**	**NO**	**TR**	**IN**	**Total import**	**Import from NZ, CA, US, NO, TR[(a)]**
2010	1,043.4	643.9	na	58.0	5.0	16.5	na	na	1,767	1,065
2011	762.0	524.0	na	19.9	63.9	na	na	na	1,370	826
2012	891.4	298.9	23.7	12.5	48.5	na	na	na	1,275	964
2013	1,037.9	734.2	102.3	30.2	0.2	na	0.6	na	1,905	1,141
2014	1,232.3	544.1	24.8	26.2	3.2	na	na	0.1	1,831	1,260

na: not available.
(a): Import where the nematode is present is considered for the model.EUROSTAT, online (EU trade since 1988 by CN8: 0601 1030 = dormant tulip bulbs).

Table C.16: Empirical data on flower bulb production in NL

Flower bulb production area in the NL (ha)						
Year	**Gladioli**	**Hyacinths**	**Lilies**	**Daffodils**	**Tulips**	**Other**
2010	1,120	1,380	4,680	1,800	11,400	2,970
2011	1,170	1,450	5,080	1,810	11,860	2,760
2012	1,110	1,450	5,090	1,780	11,250	2,810
2013	1,110	1,430	4,890	1,760	11,350	2,750
2014	1,000	1,480	5,220	1,680	11,440	2,770

Ref: CBS, online.

Table C.17: Export of tulip bulbs (tonnes) from NL to different countries outside the EU

Export of tulip bulbs from NL to outside the EU (tonnes) for most important receiving countries					
Country	**2010**	**2011**	**2012**	**2013**	**2014**
Total export	**35,682.5**	**36,223.5**	**36,383.4**	**37,922.0**	**36,351.1**
United States	13,877.2	13,309.7	13,697.9	15,466.2	13,144.9
Russian Federation	4,902.0	5,717.2	4,840.3	3,819.3	3,860.9
Canada	4,286.8	4,141.8	4,105.4	4,043.4	3,952.5
Japan	3,667.5	3,783.1	3,898	3,773.8	3,490.6
Norway	3,005.6	2,583.8	2,237.4	1,878.1	2,238.3
China	1,076.6	1,545.5	1,774.4	1,744.8	2,526.8
Turkey	669.9	858	1,192.1	2,383.1	2,226
Ukraine	621.9	669.7	979.3	1,190.6	527.1
Switzerland	724.4	724.3	725.4	581.9	598.1
Australia	894.4	697.6	617.7	555.6	588.6
New Zealand	169.1	221.2	223.0	399.8	681.6
South Korea	253.4	302.7	326.0	363.6	376.6
Mexico	296.7	261.2	281.2	250.7	279.5
Chile	62.3	111.7	107.9	262.1	339.5
Brazil	58.1	235.7	181.4	131.7	275.3
Kazakhstan	138.6	158.9	218.7	220.0	141.0
Belarus	102.9	136.1	124.2	181.3	322.5
Israel	190.2	183.2	178.1	148.5	123.2
South Africa	117.5	94.4	106.7	115.1	137.6
Iran	74.4	1.0	194.2	30.2	163.1
Vietnam	69.2	63.9	77.2	60.4	63.1

EUROSTAT, online (EU trade since 1988 by CN8: 0601 1030 = dormant tulip bulbs).

Table C.18: Tulip bulb production in NL for intra-EU trade

Tulip bulb production in NL exported or remaining inside the EU					
Year	Tulip bulb production area in NL	Production of tulips bulbs in NL converted from area	Export of tulip bulbs from NL to outside of the EU	Remaining tulip bulbs inside the EU	Percentage of remaining tulip bulbs inside the EU
	(ha)	(tonnes)	(tonnes)	(tonnes)	(%)
2010	11,400	91,200	35,682.5	55,517.5	61
2011	11,860	94,880	36,223.5	58,656.5	62
2012	11,250	90,000	36,383.4	53,616.6	60
2013	11,350	90,800	37,922.0	52,878.0	58
2014	11,440	91,520	36,351.1	55,168.9	60

Calculated from Tables C.16 and C.17.

Table C.19: Conversion factors

Conversion	Abbreviation	Factor[(a)]
Size of tulip bulbs (weight to pieces)	$C_{bulbs/tonne}$	50,000 bulbs/tonne
Yield of tulip bulbs (area to production)	$Yield_{bulbs} = C_{tonnes/ha}$	8 tonnes/ha
Yield of tulip bulbs (area to pieces)	$C_{bulbs/ha}$	400,000 bulbs/ha

(a): Conversion: An average weight of one tulip bulb is estimated to be 20 g (Personal communication Kleijn, 2016). This means that 1 kg contains 50 tulip bulbs = 50,000 bulbs per tonne. According to Buschman (2005) 4.32 billion tulip bulbs are produced in the Netherlands where production area is estimated to be 10.800 ha. This means that 400,000 tulip bulbs are produced per 1 ha (=4.32 billions/10.800). The estimated production in tonnes per ha is therefore 8 tonnes/ha (400,000 bulbs per ha/50,000 bulbs per tonne).

Appendix D – Additional information and parameter estimation for entry

D.1. The entry model for seed potato pathway

The entry model for seed potato pathway is based on the seven consecutive steps as shown below.

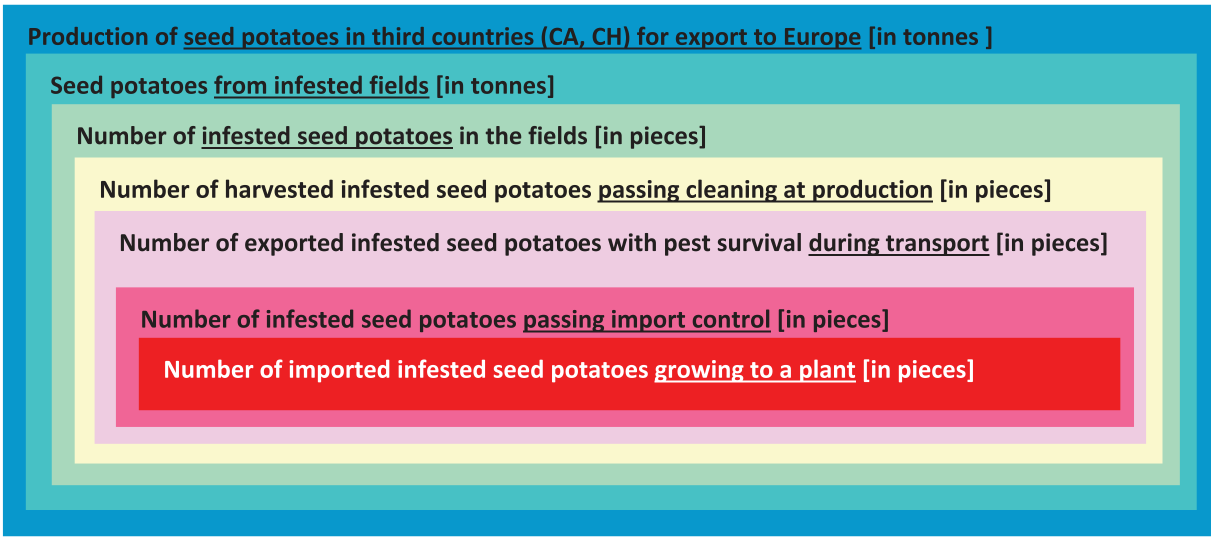


Figure D.1: Pictorial representation of the entry model for the seed potato pathway. See Figure B.1 for detailed explanation

Table D.1: Parameter and model equation of the entry model for seed potato pathway

Abbreviation	Explanation	Evidence
$Prod_{3rdCountry}$	Step 1: Production of seed potatoes in third countries (CH, CA) for export to Europe/Trade flow of seed potatoes from third countries	Production of CH, CA from 2010 to 2014
$Prop_{InfFields}$	Step 2: Proportion of infested fields in the third countries from which seed potatoes are imported	Judgement
$Conv_{Pieces/tonne}$	Conversion: Conversion of production to number of seed potatoes	As in Table C.13
$Prop_{InfTubers}$	Step 3: Proportion of infested seed potatoes within an infested field in third countries	Judgement
$Surv_{Cleaning}$	Step 4: Proportion of infested seed potatoes pathing cleaning, sorting and inspection at production site/(1−) Efficacy of phytosanitary measures or certification schemes on pest abundance in the country of origin	Judgement
$Surv_{Transport}$	Step 5: Proportion of infested seed potatoes with survived pathogen during transport from third countries to Europe/Pest survival during transport and storage in third countries	Judgement
$Surv_{Control}$	Step 6: Proportion of infested seed potatoes pathing import control at the EU border/(1−) Efficacy of import inspection	Judgement
Est_{Plant}	Step 7: Proportion of infested seed potatoes growing to a new potato plant/Pest survival during transport and storage in the EU including planting	

NumberEnteredInfestedTubers						
=		ImportSeedPotatoes	*	ConversionToTubers		
	*	ProportionInfested Fields3rdCountries	*	ProportionInfestedTubers WithinFields3rdCountries	*	ProportionPassing Cleaning
	*	SurvivalTransport	*	SurvivalControl	*	ProportionEstablished

D.1.1. Step 1: Trade flow of seed potatoes from third countries

The volume of the trade flow is one of the key factors affecting the introduction of plant pests. Seed potatoes are the main pathway for *D. destructor* (Sturhan and Brzeski, 1991) but importation of seed potatoes into the EU is highly restricted. Seed potatoes from Switzerland may be imported according to Annex IIIA of Council Directive 2000/29/EC. For Canadian seed potatoes, derogations from Annex IIIA of Council Directive 2000/29/EC exist until 31 March 2024 (Commission Implementing Decision 2011/778/EU and Commission Implementing Decision 2014/368/EU). Therefore only trade with those countries has to be considered. Data on seed potato import from Canada and Switzerland were extracted from EUROSTAT (online) and are summarised in Table D.2. The data from EUROSTAT (online) are used to estimate the potential trade volumes in the next years.

Table D.2: Volume of seed potatoes imported into the EU from 2010 to 2014

Trade of seed potatoes from different countries to Europe (tonnes)			
Year	**Switzerland (CH)**	**Canada (CA)**	**SUM**
2010	186	52	238
2011	417	104	521
2012	215	na	215
2013	687	0.2	687
2014	45	52	97

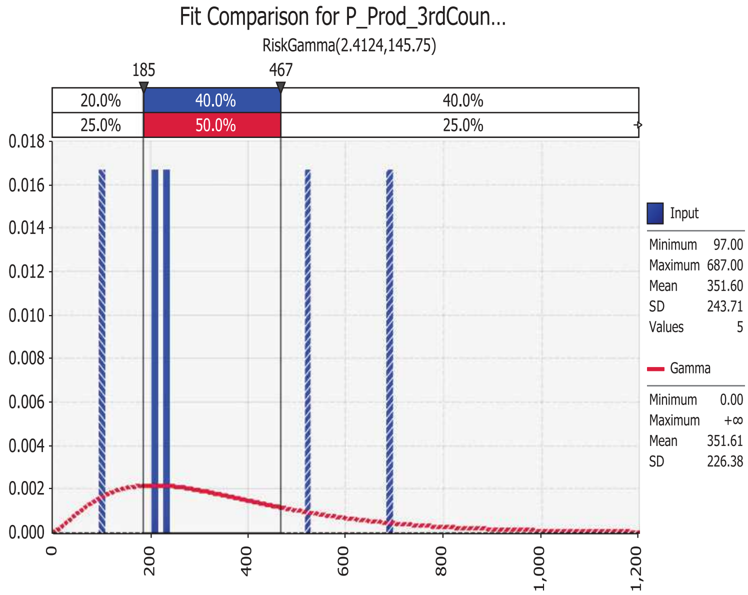
na: not available.
Data from EUROSTAT (online).

The imported seed potatoes from Canada have been allowed only into southern EU Member States (now Cyprus, Greece, Italy, Malta, Portugal and Spain) since 1981 under strict conditions.

Volume of seed potatoes imported from Canada and Switzerland is in the range of a few hundred tonnes per year and is very low (see Table D.2) when compared to the EU seed potato production which is estimated at around 2.7 million tonnes per year (see Table C.7 in the Appendix C).

Fitted distribution:

The best fitting distribution was a gamma distribution with a mean of 352 and a standard deviation of 226 tonnes of imported potatoes per year. The best estimate for the yearly import of seed potatoes from Canada and Switzerland is a median 304 with an interquartile range from 185 to 467 tonnes per year (Figure D.2).



The blue bars show EUROSTAT (online) data for the years 2010–2014 while the red curve is the smoothed distribution used in the model calculation.

Figure D.2: Yearly import (metric tonnes) of seed potatoes from Canada and Switzerland into the EU

D.1.2. Step 2: Percentage of infested fields within the third countries from which seed potatoes are imported

Seed potatoes may only be imported from certain provinces in Canada (New Brunswick and Prince Edward Island) and from Switzerland into the EU or parts of the EU as the introduction of seed potatoes is generally prohibited according to Annex III of Council Directive 2000/29/EC (see also Appendix A for further details).

Canada and Switzerland have reported the presence of *D. destructor*. In Switzerland the pest is present but only few occurrences have been reported (CABI, online). In Canada, *D. destructor* has been found in Ontario on organic garlic (Yu et al., 2012) and a few locations on Prince Edward Island where it is under official control (EPPO PQR, online; CABI, online; Personal communication from 9 November 2015 by Robert Favrin, National Manager, Plant Health Risk Assessment, Canadian Food Inspection Agency, Ottawa, Canada).

NPPOs report pest status in their territory according to ISPM No. 8 'Determination of pest status in an area'. For the purpose of this PRA, countries have been grouped in three classes. Details on these classes and background information can be found in Appendix A, Section A.3. Both countries from where seed potatoes can be imported (Canada and Switzerland) fall in pest status class 2. Therefore the same assumption applies to both countries.

The parameter values for pest status class 2 are defined by expert judgment in order to address the different levels of infestation as reported by countries. There is no information available that allows quantification on the proportion of *D. destructor* infested fields at present. By defining the proportion of infested fields and grouping countries according to their pest reporting, risks derived from different pest levels in a country may be addressed. When defining the parameter values, the Panel took into account the low number of intercepted commodities as stated in EUROPHYT (online) and the low incidence of the pest in fields used for tulip bulb production which may be the same fields as those for potato production (Personal communication by P. Knippels, 2016 see Appendix J). Both information sources suggest that only a small part of fields may be infested and this is reflected in the distribution of the parameter values chosen by the Panel. In case more detailed information on this parameter value becomes available, the parameter values may be adjusted.

With the current lack of information on pest distribution, the main purpose of defining parameter values for the percentage of infested fields is to compare percentages of infested fields of countries with different pest reports. The Panel defined the parameter values for pest status class 2 as follows:

Class 2: contains all countries reporting 'present, few occurrences' or 'present, restricted distribution'. In this class the median value for this pest is estimated by expert judgement to be 2%. The upper value is defined at 5% and the lower value at 1%.

Table D.3: Expert judgement on percentage of infested fields in different pest status classes

Percentage of infested fields within a country for pest status class 2[(a)]	
Quantile (Percentile)[(b)]	
Lower (1%)	1%
Q1 (25%)	1.5%
Median (50%)	2%
Q3 (75%)	3%
Upper (99%)	5%

(a): For definition of classes see Appendix A, Section A.3.
(b): 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'.

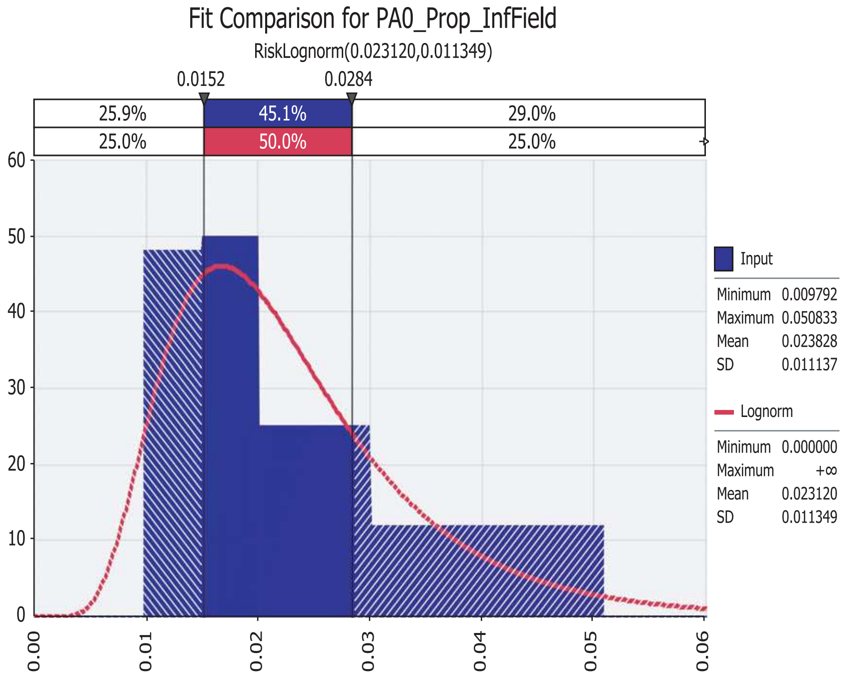
Baseline (A0)

Table D.4: Elicitation results and fitted distribution PA0_Prop_InfField
Fitted distribution: LogNormal(μ = 0.023120, σ = 0.011349)

Elicitation results PA0_Prop_InfField	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.0100	0.0150	0.0200	0.0300	0.0500
Fitted values	0.0070	0.0152	0.0208	0.0284	0.0612

Fitted distribution:

The best fitting distribution was a Log-Normal distribution with a mean of 2.3% infested fields and a standard deviation of 1.1% infested fields within the third countries from where seed potatoes are allowed to be imported into the EU. The best estimate for the percentage of infested fields is a median of 2.1% with an interquartile range from 1.5 to 2.8% (Table D.4 and Figure D.3).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.3: Proportion of infested fields in third Countries from which seed potatoes are allowed to be imported into the EU

D.1.3. Step 3: Proportion of infested tubers harvested from infested fields in third countries

Generally nematodes are not uniformly distributed within fields. Usually nematodes occur in patches or infestation foci (e.g. Been and Schomaker, 2000). Although there is a lack of *D. destructor*-specific data on horizontal within field distribution, patchy distribution of *D. destructor* may be assumed as has been stated for the closely related species *D. dipsaci* (Been and Schomaker, 2000). Even if a field is infested by *D. destructor* it is not likely that the whole field will be infested. Likewise, not all plants within an infested patch will become infested. A proportion of 30% infested tubers in a severely affected crop may be assumed (Sigareva et al., 2012) therefore not all tubers of a plant will become infested. Plant infestation depends on the characteristics of the nematode population and environmental factors including soil type and moisture. None of the information sources consulted on pest distribution (EPPO PQR, online; MS questionnaire, CABI, online), provide information at field level. There is no other information from, e.g. surveillance available and it has to be noted that uncertainty exists about the number of plants within a field that will become infested. Therefore, expert judgment was used to determine the following distribution of infestation values taking into account patchy distribution and only partial tuber infestation of a single plant by *D. destructor* even at high infestation levels.

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data on within field distribution of *D. destructor*. Deductions were derived as follows:

Lower: The lower percentile for patchiness of infestation in an infested field is assumed to be 0.1%, i.e. a nematode patch within a one hectare field of 10 m^2 exists. Within that patch not all tubers but at least 1% of tubers will become visibly infested. It is therefore considered unlikely that the mean abundance is less than 5 infested tubers harvested from 1 ha of an infested field.

Median: The median for patchiness of infestation in an infested field is assumed to be 1%, i.e. a nematode patch within a one hectare field of 100 m^2 exists. Within that patch not all tubers but at least 1% of tubers will become visibly infested. The median level of infestation was estimated as 50 infested tubers harvested from 1 ha of an infested field.

Upper: The upper percentile for patchiness of infestation in an infested field is assumed to be 10%, i.e. a nematode patch within a field of one ha of 1,000 m^2 exists. Within that patch not all tubers but at least 10% of tubers will become visibly infested. It is considered unlikely (1% chance) that the mean abundance is more than 5,000 infested tubers harvested from 1 ha of an infested field.

The Panel considers the following distribution of infestation values shown in Table D.5.

Table D.5: Proportion of infested tubers harvested from infested fields

Proportion of infested tubers harvested from infested fields in third countries		
Quantile (Percentile)	**Percentage of infested seed potato tubers in infested field[(a)]**	**Number of infested seed potatoes tubers per 1 ha[(b)]**
Lower (1%)	0.001%	5
Q1 (25%)	0.005%	25
Median (50%)	0.01%	50
Q3 (75%)	0.05%	250
Upper (99%)	1%	5,000

(a): Distribution used for the calculations.
(b): Under the assumption that 50,000 plants are grown per hectare and each plant produces 10 tubers, 500,000 tubers will be produced per hectare.

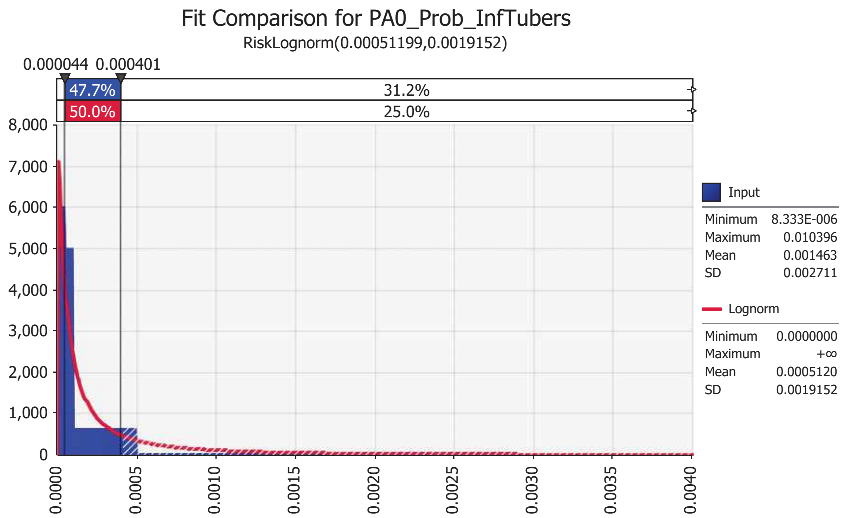
Baseline (A0)

Table D.6: Elicitation results and fitted distribution Prop_InfTubers Fitted distribution: LogNormal(μ = 0.00051199, σ = 0.0019152)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
PA0_Prop_InfTubers	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.000010	0.000050	0.000100	0.000500	0.010000
Fitted values	0.000003	0.000044	0.000132	0.000401	0.006077

Fitted distribution:

The best fitting distribution was a Log-Normal distribution with a mean of 0.05% infested tubers harvested from an infested field with a standard deviation of 0.19%. The best estimate of the percentage of infested tubers harvested from an infested field is a median of 0.013% with an interquartile range from 0.004 to 0.04% (Table D.6 and Figure D.4).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.4: Proportion of infested tubers harvested from an infested field

D.1.4. Step 4: Effectiveness of phytosanitary measures or certification schemes on pest abundance in the country of origin

At this step, a reduction factor is estimated which determines the proportion of infested tubers that will be removed due to sorting, culling, or downgrading in the country of origin. This step estimates the combined effects of all measures taken to ensure clean planting material destined for export including the effects of export inspections that are executed before the product leaves the country of origin.

Seed potatoes are the main pathway for *D. destructor* and therefore the pest is listed in several international certification schemes or standards (e.g. EPPO standard PM 4/28(1) (EPPO, 1999) or EPPO standard PM 8/1 (EPPO, 2004)). Certification requirements for seed potatoes in the country of origin may change pest abundance along the pathway. Certification schemes for seed potatoes are in place in Switzerland (WBF, 2013) and in Canada (CFIA, online). Certification schemes aim at the production of healthy seed potatoes and there is no doubt that healthy seed potatoes are the key element to control spread of this nematode (e.g. Sturhan and Brzeski, 1991). However, there is no quantitative information on the effectiveness of certification on pest abundance and the extent of detection of the pest and consequently action on the consignment is not known. Therefore the reduction factor is estimated by expert judgement.

Sampling potato lots is difficult and damaged tubers may not always be detected (Sigareva et al., 2012). From the number of interceptions (EUROPHYT, online), infestation levels in the majority of MSs appear to be quite low. As the proportion of infested tubers is low, detecting infested tubers will be very hard; hence the factor reduction in infestation level as a result of sorting, cleaning and culling can be small. Detection of symptoms during the growing season on aboveground plant parts (as part of certification) will almost be impossible except when there are severe infestations (Sigareva et al., 2012). In addition, symptomless tubers may escape detection by visual inspection.

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data demonstrating effectiveness of phytosanitary measures or certification schemes. Deductions were derived as follows:

Lower: The lower percentile for the effectiveness of phytosanitary measures or certification schemes expressed as a reduction factor is estimated at 40%. Even in cases where phytosanitary certification is not well implemented, it will not result in complete failure because of other phytosanitary inspections but the Panel considers that 60% of the pest population may enter the pathway under such conditions and this is expressed in the Table D.7 as the lower percentile.

Median: The median for the effectiveness of phytosanitary measures or certification schemes expressed as a reduction factor of the pest population level is estimated at 67% due to the difficulties in sampling bulk shipments and the difficulties in detecting latent infestations. Therefore one third of the pest population is expected to enter the pathway and this is expressed in the median percentile presented in Table D.7.

Upper: For the upper percentile it is assumed that exporting countries have a strong interest in maintaining their trade and therefore do their level best at pre-export inspection to meet the requirements of the importing countries. Based on this assumption, phytosanitary measures and certification may lead to the detection of most of the infested potato lots destined for export to the EU (90% effectiveness); this is reflected by the upper percentile for scenarios A0 and A1.

The two regulation scenarios (A0 and A1) have identical percentiles for the effectiveness of risk reduction options in the country of origin, because there is a general ban on import of seed potatoes to the EU which will be in place also when the pest-specific regulation for *D. destructor* is lifted and the risk reduction options in the third countries are unaffected by the EU legislation; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1). See also Appendix A for further details on assessment scenarios.

In addition to the two regulation scenarios A0 and A1, the Panel identified scenario A2 which entails stricter phytosanitary measures in third countries including requirements of production in pest-free places of production. Based on expert judgement pest-free places of production would increase the effectiveness of phytosanitary measures identified in scenarios A0 and A1 resulting in small improvements in the effectiveness, especially at the lower quantiles of effectiveness as is stated in Table D.7.

Table D.7: Effectiveness of phytosanitary measures or certification schemes on pest abundance along the pathway in the country of origin in three scenarios (A0, A1 and A2)

Effectiveness of phytosanitary measures or certification schemes on pest abundance in the country of origin							
Quantile[(a)] (Percentile)	**Reduction factor**			**Quantile (Percentile)**	**Multiplier**		
	A0-PW1	**A1-PW1**	**A2-PW1**		**A0-PW1**	**A1-PW1**	**A2-PW1**
Lower (1%)	0.4	0.4	0.7	Upper (99%)	0.6	0.6	0.3
Q1 (25%)	0.6	0.6	0.75	Q3 (75%)	0.4	0.4	0.25
Median (50%)	0.67	0.67	0.8	Median (50%)	0.33	0.33	0.2
Q3 (75%)	0.75	0.75	0.85	Q1 (25%)	0.25	0.25	0.15
Upper (99%)	0.9	0.9	0.9	Lower (1%)	0.1	0.1	0.1

(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.

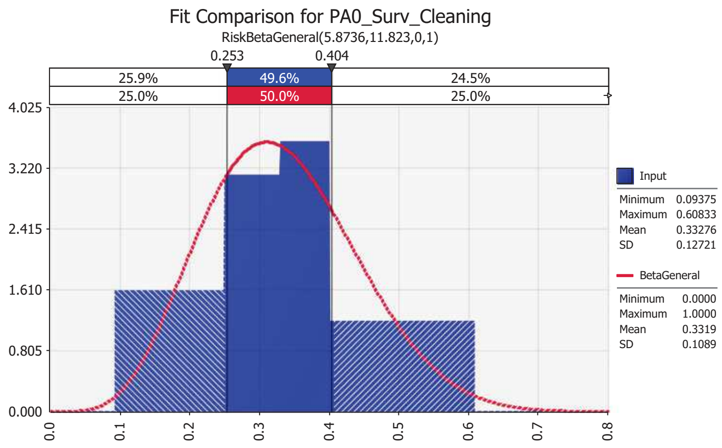
Baseline (A0)

Table D.8: Elicitation results and fitted distribution Surv_Cleaning
Fitted distribution: BetaGeneral(μ = 0.3319, σ = 0.1089, min = 0, max = 1)

Elicitation results	**Lower limit**	**1st Quartile**	**Median**	**3rd Quartile**	**Upper limit**
PA0_Surv_Cleaning	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.100	0.250	0.330	0.400	0.600
Fitted values	0.114	0.253	0.325	0.404	0.603

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean multiplier value for the effectiveness of phytosanitary measures or certification schemes of 0.33 and a standard deviation of 0.11. The best estimate of the multiplier value is a median of 0.33% with an interquartile range from 0.25 to 0.4% (Table D.8 and Figure D.5).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.5: Multiplier value for the effectiveness of phytosanitary measures or certification schemes on pest abundance in seed potato tubers produced in third countries

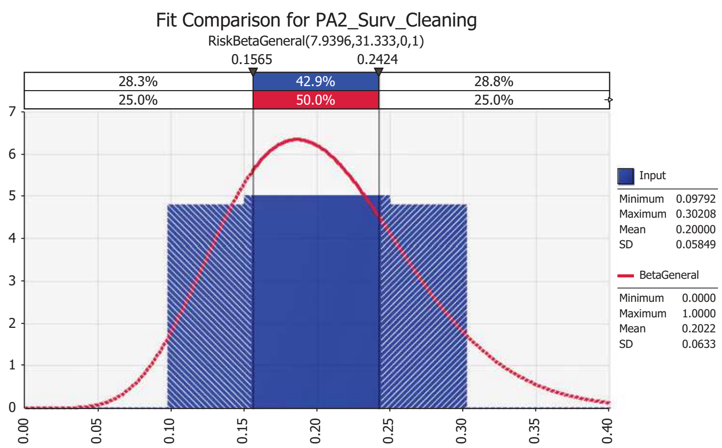
Scenario 2 (A2)

Table D.9: Elicitation results and fitted distribution PA2_Surv_Control
Fitted distribution: BetaGeneral(μ = 0.2022, σ = 0.0633, min = 0, max = 1)

Elicitation results PA2_Surv_Cleaning	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.100	0.150	0.200	0.250	0.300
Fitted values	0.079	0.157	0.197	0.242	0.369

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean multiplier value for the effectiveness of pest-free places of production in third countries of 0.2 and a standard deviation of 0.06. The best estimate of the multiplier value is a median of 0.19% with an interquartile range from 0.16 to 0.24% (Table D.9 and Figure D.6).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.6: Multiplier value for the effectiveness of pest-free places of production in third countries in addition to phytosanitary measures or certification schemes already in place

D.1.5. Step 5: Pest survival during transport and storage in third countries

Conditions during transport and storage will be controlled to avoid damage to plants for planting (including seed potatoes). Such conditions will not have an adverse effect on *D. destructor* but will also not allow significant development. If pests do not reproduce, their survival during transport should still be considered.

As noted in the Pest characterisation of *D. destructor* (EFSA PLH Panel, 2014), this nematode can survive at very low temperatures and can develop and reproduce at temperatures ranging from 5 to 34°C (Sturhan and Brzeski, 1991). Thus the probability of survival of *D. destructor* during transport and storage is high. The Panel does not expect multiplication of the pest during transport due to low transport temperatures which are not optimal temperature for pest multiplication at around 4–12°C (Transport information service, online). In addition short shipment time will not favour pest multiplication.

The Panel does also not expect multiplication of the pest during storage due to low storage temperatures despite longer storage periods. Potato storage in general will take place under controlled conditions. Appropriate cooling or heating devices and ventilation will be installed to maintain appropriate temperature. Humidity is also important during storage and is mainly controlled by controlling the temperature. Temperature will greatly influence nematode development.

After a drying and wound healing phase at 13–15°C for 10–14 days, conditions for most part of the storing period will not exceed 8–10°C (Canadian Horticultural Council, online; Voss and Hall, online). Seed potatoes will be stored at lower temperatures (4°C) than potatoes for fresh consumption or processing which will be stored at 4–6°C and 6–8°C, respectively. At these storage conditions, the nematodes will not multiply and therefore the multiplication factor changing the abundance during storage will be lower or equal to 1 (see Table D.10).

The optimal temperature for development of *D. destructor* is 20–27°C. At 6–10°C nematode development may take place but is greatly slowed down (Sturhan and Brzeski, 1991). Most serious damage in potato was observed at temperatures between 15 and 20°C (Sturhan and Brzeski, 1991); temperatures that should not be reached during current storage conditions. Spread of the nematode from one tuber to another is theoretically possible, but is not likely to occur under current transport and storage conditions.

Based on the information presented above, the Panel estimates that nematodes are in principal able to survive during transport and storage but that nematode multiplication will not occur because of low temperatures during transport and storage.

Lower: The lower percentile for survival is estimated at a survival rate of 75%. Some infested tubers going into transport and storage may become completely rotten if the level of infestation of a particular tuber is high. In such case, a rotten tuber will not allow nematode multiplication and hence will lead to death of this part of the nematode population (a 25% reduction). Temperatures during transport and storage that are higher than usual may also lead to a reduced survival rate and may lead to an increase in the nematode population which will in turn then lead to increase rotting even if the population is low.

Median: The median value for survival is estimated at 90%. In this case infestation levels are quite low (which will not lead to a complete loss) or conditions will not allow a continuation of the rotting process.

Upper: For the upper percentile it is assumed that the entire nematode population present in infested tubers will survive transport and storage but no multiplication will occur due to suboptimal temperatures for nematode development. Therefore, the upper limit is a multiplication (survival) factor of 1.

The Panel considers the following distribution of the effect of transport and storage on pest abundance as shown in Table D.10.

Table D.10: Pest survival during transport and storage in third countries

Pest survival during transport and storage in third countries		
Quantile (Percentile)	Multiplication factor	
	A0-PW1	A1-PW1
Lower (1%)	0.75	0.75
Q1 (25%)	0.8	0.8

Pest survival during transport and storage in third countries		
Quantile (Percentile)	**Multiplication factor**	
	A0-PW1	**A1-PW1**
Median (50%)	0.9	0.9
Q3 (75%)	0.95	0.95
Upper (99%)	1	1

The two regulation scenarios (A0 and A1) have identical percentiles for the effect of transport and storage on pest abundance, because transport and storage conditions are not affected by the EU legislation; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1).

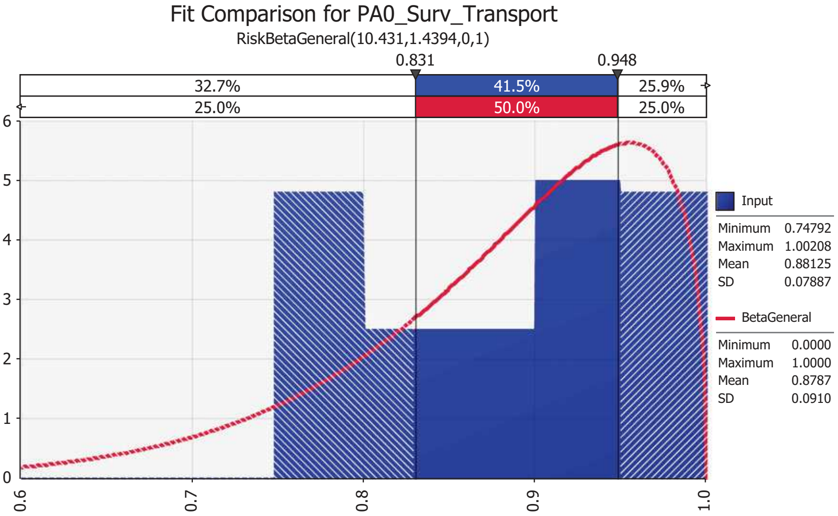
Baseline (A0)

Table D.11: Elicitation results and fitted distribution PA0_Survival_Transport
Fitted distribution: BetaGeneral(μ = 0.8787, σ = 0.0910, min = 0, max = 1)

Elicitation results PA0_Surv_Transport	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.750	0.800	0.900	0.950	1.000
Fitted values	0.593	0.831	0.900	0.948	0.995

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean pest multiplication factor of 0.88 and a standard deviation of 0.09. The best estimate of the pest multiplication factor is a median of 0.9% with an interquartile range from 0.83 to 0.95% (Table D.11 and Figure D.7).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.7: Pest multiplication factor for *D. destructor* during storage and transport in third countries

D.1.6. Step 6: Effectiveness of import inspection

Import inspections followed by appropriate measures after a positive finding may lower the proportion of infested seed potatoes in the trade flow. The Panel considers that import inspections are in principal suitable to reduce the number of infested lots (as a consequence of a positive result the lots may then be rejected, downgraded or destroyed). The extent to which infested lots are detected is not known but inspection cannot be 100% effective (see ISPM No. 23 'Guidelines for inspection', FAO, 2005). There have been only few interceptions of *D. destructor* in recent years but it is not known whether this is due to low pest prevalence along the pathway or because a lack of effective import inspection. As current legislation does not specify sampling and testing procedures, the Panel assumes that only visual inspections are carried out. Visual inspections, however, can only detect tubers which have symptoms of rot. Even cutting tubers might not increase detection levels (Sigareva et al., 2012). Symptomless tubers, i.e. latent infections, will therefore most likely escape detection by visual inspection. But even if rotting symptoms are present, there will still be difficulties in getting a representative sample to detect infested lots (see also ISPM No. 31 'Methodologies for sampling of consignments', FAO, 2008).

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data demonstrating effectiveness of import inspections. Parameter values are assumed to be identical to the estimation of effectiveness of certification schemes or phytosanitary measures (export certification). The same limitations apply to both types of inspections (i.e. difficulties in getting representative samples and detecting latent infections). For this reason, the explanation of the values follows the same line or reasoning for the lower, median and upper values (with the only difference that one type of inspection is done prior export and the other inspection is done at import).

Lower: The lower percentile for the effectiveness of import inspections is estimated at 40%. In case import inspections for *D. destructor* are not well implemented it will not result in complete failure because of other inspections e.g. for *Clavibacter michiganensis* ssp. *sepedonicus* or *Epitrix* spp. For Canadian seed potatoes, Commission Implementing Decision 2011/778/EU require that seed potatoes shall be free from *Clavibacter michiganensis* subsp. *sepedonicus*, PSTVd, and *Epitrix cucumeris*, *E. similaris*, *E. subcrinita* and *E. tuberis*. Therefore the Panel considers that a maximum of 60% of the pest population may enter the PRA area under such condition; this is reflected as the lower percentile for the effectiveness in Table D.12. Note that for the multiplier this is the upper percentile.

Median: The median for the effectiveness of import inspections is estimated at 67%. Due to the difficulties in sampling bulk shipments and the difficulties in detecting latent infestations, one third of the pest population is expected to enter the PRA area as is expressed in Table D.12.

Upper: The upper percentile for the effectiveness of import inspections is estimated at 90%. In this case import inspections are considered highly effective and almost all infested potato lots will be detected and very few (10%) infested potato lots are expected to enter the PRA area; this is expressed as the upper percentile in effectiveness in Table D.12. Note that for the multiplier this is the lower percentile.

The Panel considers that the two regulation scenarios (A0 and A1) have identical percentiles for the effectiveness of import inspection because import inspections of seed potato will still be in place even when the pest-specific regulation for *D. destructor* is removed. There is a general ban on import of seed potatoes to the EU which will be in place also when the pest-specific regulation for *D. destructor* is lifted. Also, other phytosanitary regulations will remain in place which is the case for import of the Canadian seed potatoes (see above). For seed potato from Switzerland the requirements of Commission Implementing Directive 2014/20/EU will apply and are considered to be equally effective for both scenarios. According to this Directive only 0.5% of seed potatoes by mass shall be affected by rots, other than brown or ring rot.

The fact that the two regulation scenarios (A0 and A1) have identical percentiles also means that the Panel does not consider the pest-specific regulations for *D. destructor* effective and that the additional effect will be marginal or not accessible to a quantified assessment.

The Panel considers the following distribution of the effectiveness of import inspection shown in Table D.12.

Table D.12: Effectiveness of import inspections for scenarios A0 and A1

Effectiveness of phytosanitary measures or certification schemes on pest abundance at import[(a)]					
Quantile (Percentile)	**Reduction factor**		**Quantile (Percentile)**	**Multiplier**	
	A0-PW1	**A1-PW1**		**A0-PW1**	**A1-PW1**
Lower (1%)	0.4	0.4	Upper (99%)	0.6	0.6
Q1 (25%)	0.6	0.6	Q3 (75%)	0.4	0.4
Median (50%)	0.67	0.67	Median (50%)	0.33	0.33
Q3 (75%)	0.75	0.75	Q1 (25%)	0.25	0.25
Upper (99%)	0.9	0.9	Lower (1%)	0.1	0.1

(a): The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

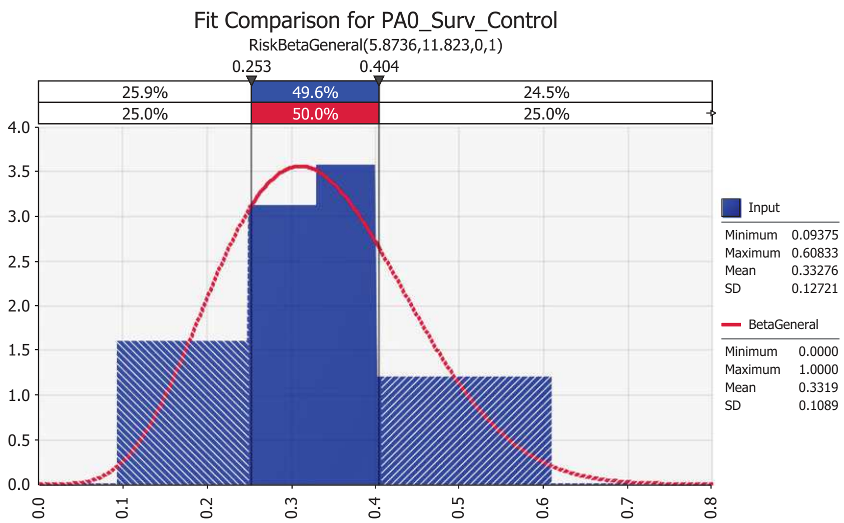
Baseline (A0)

Table D.13: Elicitation results and fitted distribution PA0_Surv_Control
Fitted distribution: BetaGeneral(μ = 0.3319, σ = 0.1089, min = 0, max = 1)

Elicitation results PA0_Surv_Control	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.100	0.250	0.330	0.400	0.600
Fitted values	0.114	0.253	0.325	0.404	0.603

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean multiplier for the effectiveness of import inspection of 0.33 and a standard deviation of 0.11. The best estimate of the multiplier value is a median of 0.33 with an interquartile range from 0.25 to 0.4 (Table D.13 and Figure D.8).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.8: Multiplier value for the effectiveness of import inspections to limit the introduction of *Ditylenchus destructor* into the EU

D.1.7. Step 7: Pest survival during transport and storage in the EU including planting

This step quantifies the probability that, after passing import inspection, infested potato tubers are transported, stored and finally planted, resulting in the transfer of *D. destructor* to the field. This step is very similar to step 4 as the main effects are considered survival during transport and storage in the EU, however, storage and transport will be much shorter than during step 4.

The multiplication factor for pest survival during transport and storage in the EU including planting is 1 for all scenarios (see Table D.14) because:

- transport and storage periods are short and pest survival in the infested planting material will not be affected.
- planting this material will lead to a successful transfer of the pest to the field.

The Panel considers that the two regulation scenarios (A0 and A1) have identical percentiles as transport, storage and planting activities are largely independent of phytosanitary regulations; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1). Pest survival will be 1 or so close to 1 that the Panel did not consider it justified to use other parameter values in the model calculations.

Table D.14: Pest survival during transport and storage in the EU including planting

Pest survival during transport and storage in the EU including planting		
Quantile (Percentile)	**Multiplication factor**	
	A0-PW1	**A1-PW1**
Lower (1%)	1	1
Q1 (25%)	1	1
Median (50%)	1	1
Q3 (75%)	1	1
Upper (99%)	1	1

No specific calculation was performed for this step as the multiplication factor was estimated as 1.

D.1.8. Results

Results are presented in Section 3.1.2 of the main document.

D.1.9. Uncertainty on entry via the seed potato pathway

More than 90% uncertainty in calculated entry is due to uncertainty about the proportion of infested potatoes harvested in infested fields. Other factors are of minor influence on uncertainty.

In the case of the entry process following import from Switzerland or Canada, 94% of the uncertainty in the number of infested potatoes that are planted is due to uncertainty in the proportion of infested potatoes harvested in infested fields. Three per cent of the uncertainty is due to the uncertainty in the proportion of infested fields in the third countries from which potatoes are imported, 2% is due to year by year variation in the trade volume, 1% is due to uncertainty in the effectiveness of cleaning and also 1% to uncertainty in the effectiveness of inspection.

Table D.15: Sensitivity analysis results

Rank	Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
1	PA0_Prob_InfTubers	0.70	0.48	94
2	P_Prod_3rdCountry	0.12	0.01	3
3	PA0_Prop_InfField	0.09	0.01	2
4	PA0_Surv_Control	0.06	0.00	1
5	PA0_Surv_Cleaning	0.06	0.00	1
6	PA0_Surv_Transport	0.02	0.00	0
		R^2	0.51	100

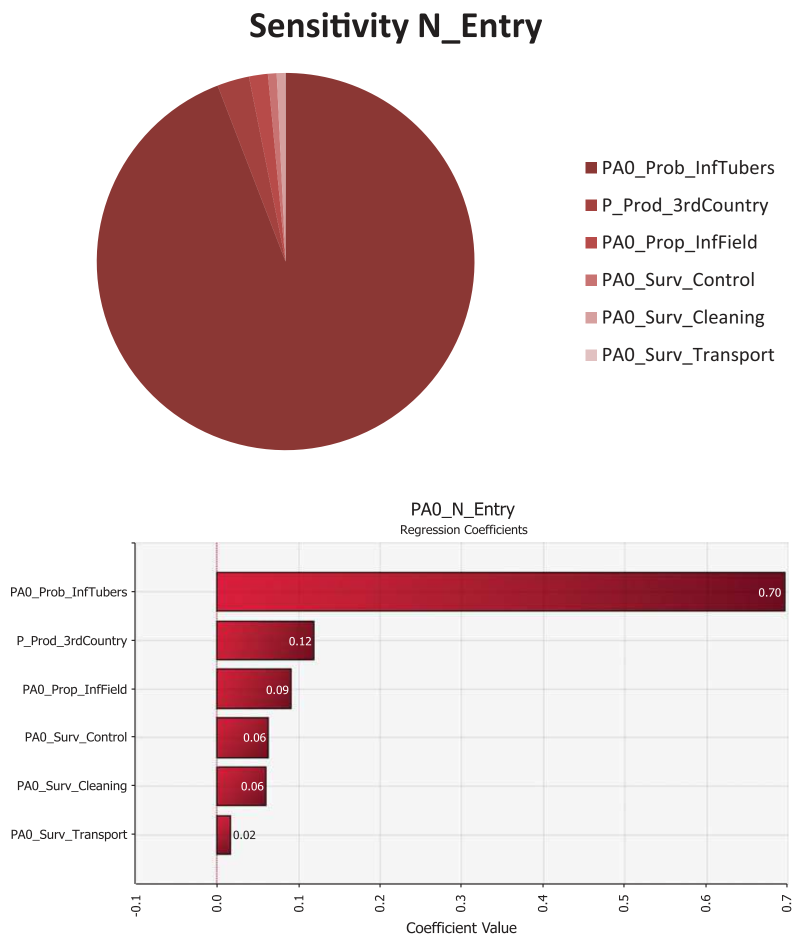


Figure D.9: Sensitivity analysis results

D.2. The entry model for the ornamental bulbs pathway

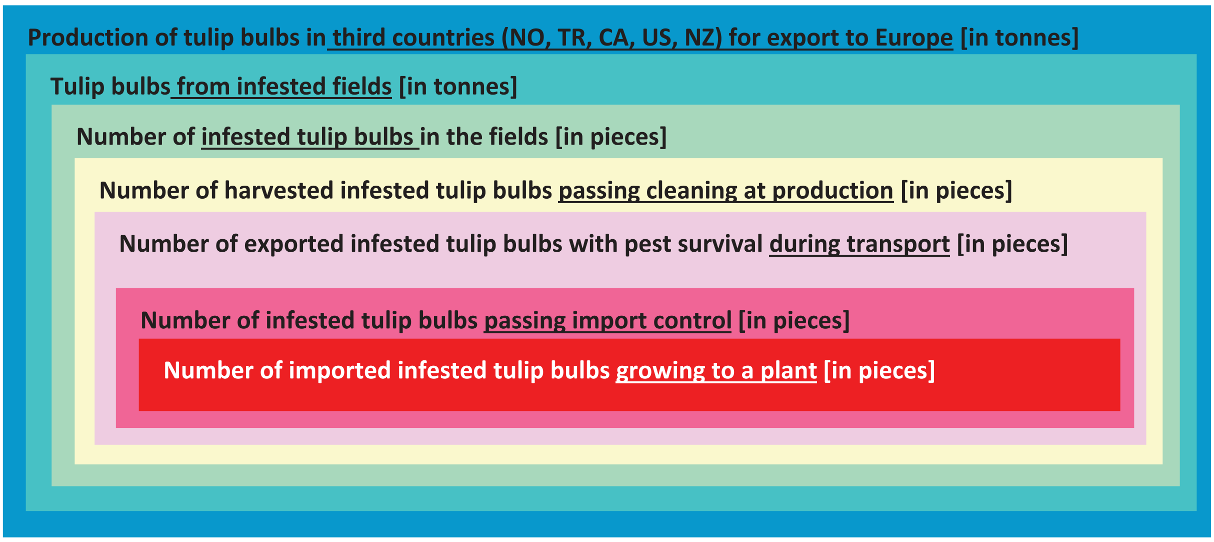


Figure D.10: Pictorial representation of the entry model for the ornamental bulbs pathway. See Figure B.4 for details

Table D.16: Parameter and model equation of the entry model for the ornamental bulbs pathway

Abbreviation	Explanation	Evidence
$Prod_{3rdCountry}$	Step 1: Production of tulip bulbs in infested third countries (NO, TR, CA, US, NZ) for export to Europe/Trade flow of seed potatoes from third countries	Tulip bulb import in 2010–2014
$Prop_{InfFields}$	Step 2: Proportion of infested fields in the third countries from which tulip bulbs are imported	Judgement
$Conv_{Pieces/tonne}$	Conversion: Conversion of production to number of tulip bulbs	
$Prop_{InfBulbs}$	Step 3: Proportion of infested tulip bulbs within an infested field in third countries	Judgement
$Surv_{Cleaning}$	Step 4: Proportion of infested tulip bulbs pathing cleaning, sorting and inspection at production site/(1−) Efficacy of phytosanitary measures or certification schemes on pest abundance in the country of origin	Judgement
$Surv_{Transport}$	Step 5: Proportion of infested tulip bulbs with survived pathogen during transport from third countries to Europe/Pest survival during transport and storage in third countries	Judgement
$Surv_{Control}$	Step 6: Proportion of infested tulip bulbs pathing import control at the EU border/(1−) Efficacy of import inspection	Judgement
Est_{Plant}	Step 7: Proportion of infested tulip bulbs growing to a new tulip plant/ Pest survival during transport and storage in the EU including planting	

NumberEnteredInfestedBulbs						
=		ImportTulipBulbs	*	ConversionToBulbs		
	*	ProportionInfestedFields 3rdCountries	*	ProportionInfestedTubers WithinFields3rdCountries	*	ProportionPassingCleaning
	*	SurvivalTransport	*	SurvivalControl	*	ProportionEstablished

D.2.1. Step 1: Trade flow of tulip bulbs from third countries

Tulips are imported from the following countries: Norway, Turkey, Canada, US, Chile and New Zealand. The pest is not present in Chile and therefore the imports from Chile are not considered in the Table D.17. Data from EUROSTAT (online) was used to assess the trade flow of tulip bulbs (see Table D.17).

Table D.17: Tulip bulb exports from New Zealand, Canada, USA, Norway and Turkey to the Netherlands (EUROSTAT,online, EU trade since 1988 by CN8: 0601 1030 = dormant tulip bulbs)

Trade of tulip bulbs from different countries to NL (metric tonnes)						
Year	**NZ**	**CA**	**US**	**NO**	**TR**	**SUM**
2010	1,043.4	:	5.0	16.5	n/a	1,065
2011	762.0	:	63.9	n/a	n/a	826
2012	891.4	23.7	48.5	n/a	n/a	964
2013	1,037.9	102.3	0.2	n/a	0.6	1,141
2014	1,232.3	24.8	3.2	n/a	n/a	1,260

NZ: New Zealand; CA: Canada; US: USA; NO: Norway; TR: Turkey; n/a: not available.

Fitted distribution:

The best fitting distribution was a Weibull distribution with a mean of 1,052 and a standard deviation of 152 tonnes of imported tulips bulbs per year. The best estimate is a median 1,067 with an interquartile range from 959 to 1,161 tonnes per year (Table D.17 and Figure D.11).

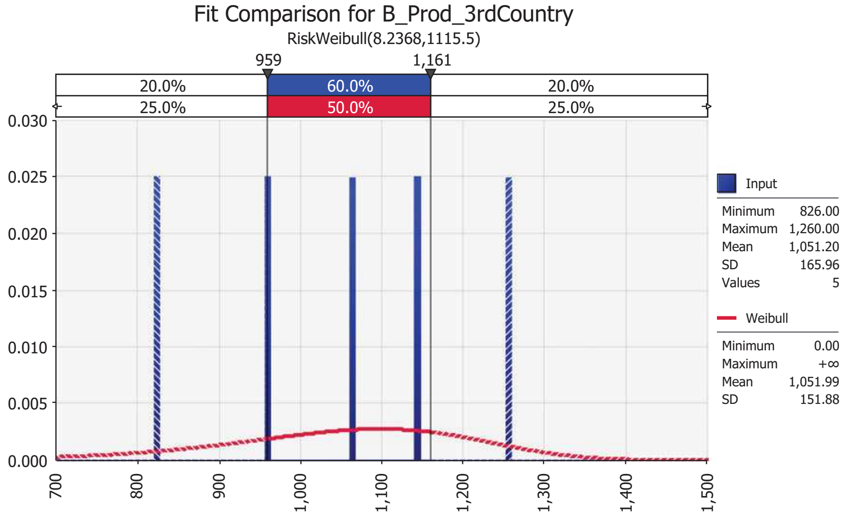


Figure D.11: Yearly import (metric tonnes) of tulips bulbs into the EU from third countries that report the presence of *D. destructor* according to EUROSTAT data and fitted distribution used in model calculations

D.2.2. Step 2: Percentage of infested fields within the third countries from which tulip bulbs are imported

With respect to the global world production and trade, tulips and lilies are economically the most important bulb flowers (Buschman, 2005). Lilies are not considered as host plant for *D. destructor*. For the assessment of the Pathway 2, the Panel focused on tulip bulbs because they are produced in greatest quantities and are commercially far more important than the other bulb flowers. EUROSTAT (online) and other statistical data are available for tulips allowing the quantification of the trade and production area.

The Netherlands is the largest producer of tulip bulbs representing 88% of the total world production area of tulip bulbs (10,800 ha). Tulip bulbs are also produced in 14 other countries worldwide (Buschman, 2005). Tulips had been imported into the EU in the period 2012–2014 from Norway, Turkey, Canada, USA, Chile, and New Zealand (EUROSTAT, online).

The countries where the pest is present reported the following pest status as shown in Table D.18.

Table D.18: The pest status in exporting countries

Country	Pest status according to EPPO PQR (online) (accessed on 17 March 2016)
Norway	Present, no details
Turkey	Present, distribution restricted
Canada	Present, few occurrences
USA	Present, restricted distribution
Chile	Not present
New Zealand	Present, restricted distribution

All countries from where tulip bulbs are imported fall therefore into class 2. For the purpose of this risk assessment the distribution of parameter values and the underlying assumptions as specified under Section D.1.2 of Appendix D (potato pathway) were used.

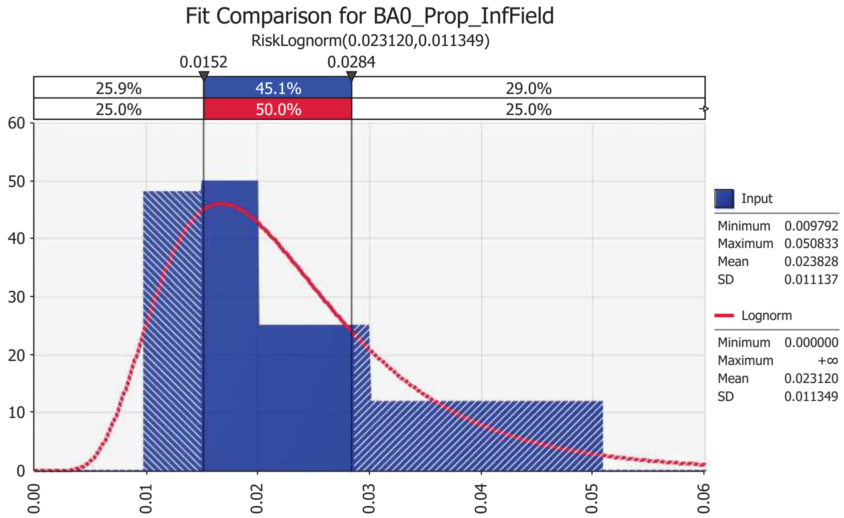
Baseline (A0)

Table D.19: Elicitation results and fitted distribution BA0_Prop_InfField
Fitted distribution: LogNormal(μ = 0.023120, σ = 0.011349)

Elicitation results BA0_Prop_InfField	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.0100	0.0150	0.0200	0.0300	0.0500
Fitted values	0.0070	0.0152	0.0208	0.0284	0.0612

Fitted distribution:

The best fitting distribution was a Log-Normal distribution with a mean of 2.3% infested fields and a standard deviation of 1.1% infested fields within the third countries from where tulips are imported into the EU. The best estimate for the percentage of infested fields is a median of 2.1% with an interquartile range from 1.5 to 2.8% (Table D.19 and Figure D.12).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.12: Proportion of infested fields in third Countries from which tulip bulbs are imported into the EU

D.2.3. Step 3: Proportion of infested bulbs harvested from infested fields in third countries

Generally nematodes are not uniformly distributed within fields and occur in patches or infestation foci. If a field is infested by the nematode not the whole field will be infested. Further specifications on underlying assumptions on proportion of infested fields can be found in Section D.1.3 on potato pathway of Appendix D. It is assumed that field infestations by *D. destructor* although not independent from cropping sequences and agricultural practices do not differ for fields used for the production of potato or tulip crops (in some cases they will be the same). The extent of field infestations (size and location of infestation foci) is not known and there had to be estimated.

Not all plants within the patches will be infested because infestation depends on different environmental factors including soil type and moisture. Uncertainty therefore also exists about the number of plants within the patch that will be infested.

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data on within field distribution. Deductions were derived as follows:

Lower: The lower percentile for patchiness of infestation in an infested field is assumed to be 0.1%, i.e. a nematode patch within a one hectare field of 10 m^2 exists. Within that patch not all bulbs but at least 1% of bulbs will become infested. It is therefore considered unlikely that the mean abundance is less than four infested tulip bulbs harvested from 1 ha of an infested field.

Median: The median for patchiness of infestation in an infested field is assumed to be 1%, i.e. a nematode patch within a one hectare field of 100 m^2 exists. Within that patch not all bulbs but at least 1% of tulip bulbs will become infested. The median level of infestation was estimated as 40 infested tulip bulbs harvested from 1 ha of an infested field.

Upper: The upper percentile for patchiness of infestation in an infested field is assumed to be 10%, i.e. a nematode patch within a field of one ha of 1,000 m^2 exists. Within that patch not all bulbs but at least 10% of tulip bulbs will become infested. It is considered unlikely (1% chance) that the mean abundance is more than 4,000 infested tulip bulbs harvested from 1 ha of an infested field. The estimation of the proportion of infested bulbs harvested from infested fields in third countries is shown in Table D.20.

Table D.20: Proportion of infested bulbs harvested from infested fields in third countries

Proportion of infested bulbs harvested from infested fields in third countries		
Quantile (Percentile)	**Percentage of infested bulbs in infested field**	**Number of infested bulbs per 1 ha[(a)]**
Lower (1%)	0.001%	4
Q1 (25%)	0.005%	20
Median (50%)	0.01%	40
Q3 (75%)	0.05	200
Upper (99%)	1%	4,000

(a): Conversion: An average weight of one tulip bulb is estimated to be 20 g. This means that one kilogram contains 50 tulip bulbs = 50,000 bulbs per tonne. According to Buschman (2005) 4.32 billion tulip bulbs are produced in the Netherlands where production area is estimated to be 10.800 ha. This means that 400,000 tulip bulbs are produced per one ha (=4.32 billions/10.800). The estimated production in tonnes per ha is therefore 8 tonnes/ha (400,000 bulbs per ha or 50,000 bulbs per tonne).

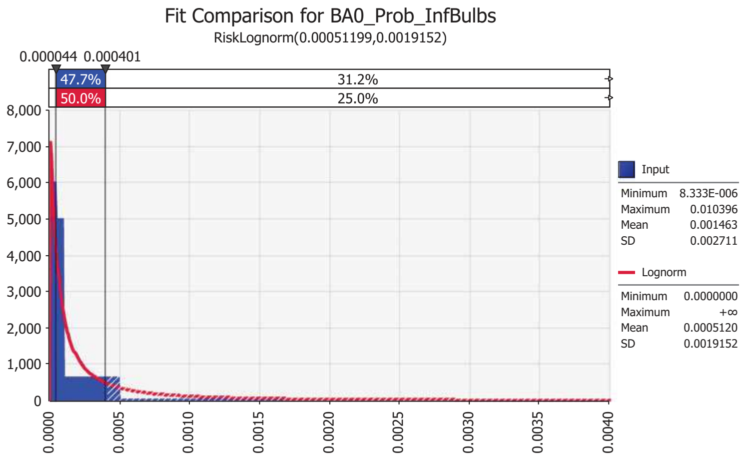
Baseline (A0)

Table D.21: Elicitation results and fitted distribution BA0_Prop_InfBulbs
Fitted distribution: LogNormal(μ = 0.00051199, σ = 0.0019152)

Elicitation results	**Lower limit**	**1st Quartile**	**Median**	**3rd Quartile**	**Upper limit**
BA0_Prop_InfBulbs	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.000010	0.000050	0.000100	0.000500	0.010000
Fitted values	0.000003	0.000044	0.000132	0.000401	0.006075

Fitted distribution:

The best fitting distribution was a Log-normal distribution with a mean of 0.05% infested tulip bulbs harvested from an infested field with a standard deviation of 0.19%. The best estimate is a median of 0.013% with an interquartile range from 0.004 to 0.04% (Figure D.13).



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure D.13: Proportion of infested tulip bulbs harvested from an infested field

D.2.4. Step 4: Effectiveness of phytosanitary measures or certification schemes on pest abundance in the country of origin

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data demonstrating effectiveness of phytosanitary measures or certification schemes. The assumptions and values as specified in Section D.1.4 (potato pathway) were also used for the flower bulb model. The explanation of the values used for the calculation at this step in scenarios A0, A1 and A3 are not repeated here as they can be found under Section D.1.4 of Appendix D.

At this step, the following additional RRO is included in the model calculations:

- Scenario A3: Specification that flower bulbs are produced in pest-free place of production according to ISPM No. 10 (FAO, 1999). This scenario is similar to the A2 scenario and therefore the same parameter values as specified in Table D.7 were used.

The two regulation scenarios (A0 and A1) have identical percentiles for the effectiveness of risk reduction options in the country of origin, because all flower bulbs are produced under certification scheme (Personal communication by P. Knippels, 2016, see Appendix J). It is acknowledged that legislation may have an effect on certification schemes (as it sets the limits in which to operate) but it is assumed that in the time horizon of 5 years the well established certification scheme will not change. Therefore, the same values are used for the scenarios with regulation (A0) and without regulation (A1).

Baseline (A0) and scenarios A1 and A3

The elicitation results and the fitted distributions are identical to the values and figures provided in Section D.1.4 of Appendix D and are therefore not repeated here.

D.2.5. Step 5: Pest survival during transport and storage in third countries

For pest survival during transport, see Section D.1.5 (potato pathway). The same assumptions were made to estimate the parameter values for pest survival on the flower bulb pathway and are therefore not repeated here. Pest abundance may increase during transportation. Survival or multiplication is thus considered at the level of infested flower bulbs. This number is not changing much during transport as no new bulbs are likely to become infested. If pests do not reproduce, their survival rate during transport should still be considered.

Baseline (A0)

The elicitation results and the fitted distribution are identical to the values and figures provided in Section D.1.5 of Appendix D and are therefore not repeated here.

D.2.6. Step 6: Effectiveness of import inspection

Import inspection and measures taken at import may lower the proportion of infested product in the trade flow. Inspection is effective if it picks out the infested lots, while admitting the uninfested ones.

The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data demonstrating effectiveness of phytosanitary measures or certification schemes. The values as specified in Section D.1.6 (potato pathway) were therefore also used for the flower bulb model and are therefore not repeated here. Although import requirements for potato and tulip bulbs are different (with the main difference being the import ban of potatoes into the EU), import requirements also apply to flower bulbs. Inspections on tulips will be carried out for *D. destructor* (in scenario A0) and the related species *D. dipsaci* (in scenarios A0 and A1). The assumptions and explanations for the estimated parameter values therefore follow the same line of reasoning specified for the potato pathway and are not repeated here. The two regulation scenarios (A0 and A1) have identical percentiles for the effectiveness of import inspection, because import inspection (only visual, no sampling and testing requirement) will remain in place for other pests. For instance, at the moment there is a pest-specific regulation for *D. dipsaci* still in place (Annex IIAII of Council Directive2000/29/EC). Therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1).

Baseline (A0)

The elicitation results and the fitted distribution are identical to the values and figures provided in Section D.1.4 of Appendix D and are therefore not repeated here.

D.2.7. Step 7: Pest survival during transport and storage in the EU including planting

The next step quantifies the probability that, following entry, and after passing import inspection, infested tulip bulbs are planted, resulting in the transfer of the nematode to the field. This step is very similar to step specified in Section D.1.7 of the potato pathway as the main effects are considered survival during transport and storage in the EU. Pest survival will be 1 or so close to 1 that the Panel did not consider it justified to use other parameter values in the model calculations. This step also uses the same parameter values as specified in Table D.14 for the model calculations and they are therefore not repeated here. The multiplication factor for pest survival during transport and storage in the EU including planting is one for all scenarios because:

- transport and storage periods are short and pest survival in the infested planting material will not be affected,
- planting this material will lead to a successful transfer of the pest to the field.

The Panel considers that the two regulation scenarios (A0 and A1) have identical percentiles as transport, storage and planting activities are largely independent of phytosanitary regulations; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1).

No calculation was performed for this step as the multiplication factor was estimated as 1.

D.2.8. Results

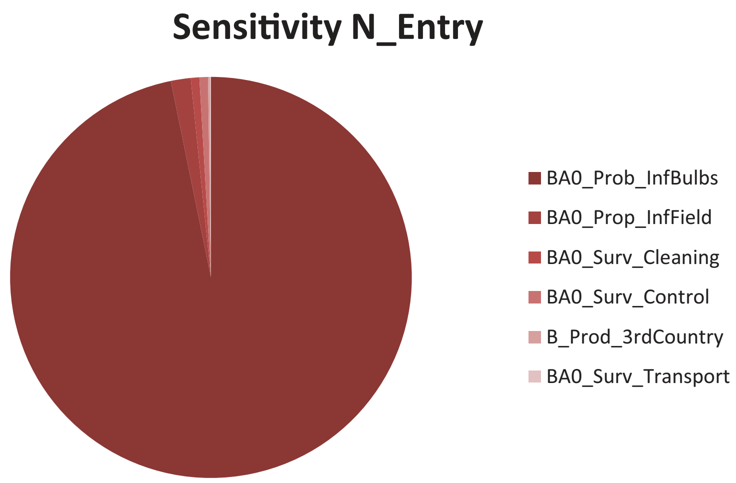
Results are presented in Section 3.1.4 of the main document.

D.2.9. Uncertainty on entry via the flower bulb pathway

Uncertainty in the proportion of bulbs from infested fields that are infested with *D. destructor* is responsible for 97% of the uncertainty in calculated entry. Smaller contributions to uncertainty are due to uncertainty in the proportion of infested fields in the country of origin (2%), and the effectiveness of cleaning in the country of origin and the effectiveness of import inspection at the EU border (both 1%).

Table D.22: Sensitivity analysis

Rank	Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
1	BA0_Prob_InfBulbs	0.82	0.67	97
2	BA0_Prop_InfField	0.11	0.01	2
3	BA0_Surv_Cleaning	0.07	0.00	1
4	BA0_Surv_Control	0.07	0.00	1
5	B_Prod_3rdCountry	0.03	0.00	0
6	BA0_Surv_Transport	0.02	0.00	0
		R^2 =	0.69	100



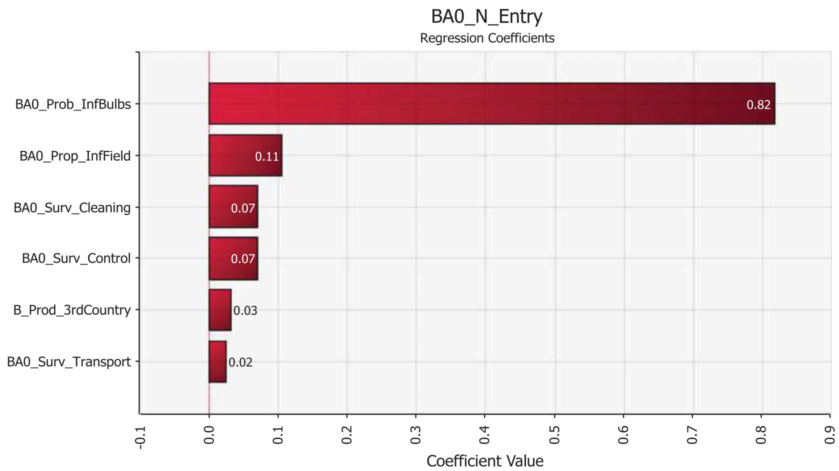


Figure D.14: Sensitivity analysis results

Appendix E – Additional information and parameter estimation for establishment

E.1. Establishment

Table E.1 shows the distribution of the probability of establishment of *D. destructor* for different scenarios as assessed by the Panel. Because the pest is present inside host tissue (potato or tulip) and the host will be planted in an environment suitable for plant establishment, there is no reason to expect that *D. destructor* will not establish. Therefore, pest establishment will be 1 or so close to 1 that the Panel did not consider it justified to use other parameter values in the model calculations.

The Panel considers that the two regulation scenarios (A0 and A1) have identical percentiles as establishment is independent of phytosanitary regulations; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1).

Table E.1: Probability of establishment of *D. destructor*

Probability of establishment of *D. destructor*				
Quantile (Percentile)	**Probability of establishment**			
	A0-PW1	**A0-PW2**	**A1-PW1**	**A1-PW2**
Lower (1%)	1	1	1	1
Q1 (25%)	1	1	1	1
Median (50%)	1	1	1	1
Q3 (75%)	1	1	1	1
Upper (99%)	1	1	1	1

No calculations were performed because the factor is 1 for all assessments.

Appendix F – Additional information and parameter estimation for spread

F.1. The spread model for seed potato pathway

The Panel assessed the spread of *D. destructor* in the context of the following successive steps (see the spread model below).

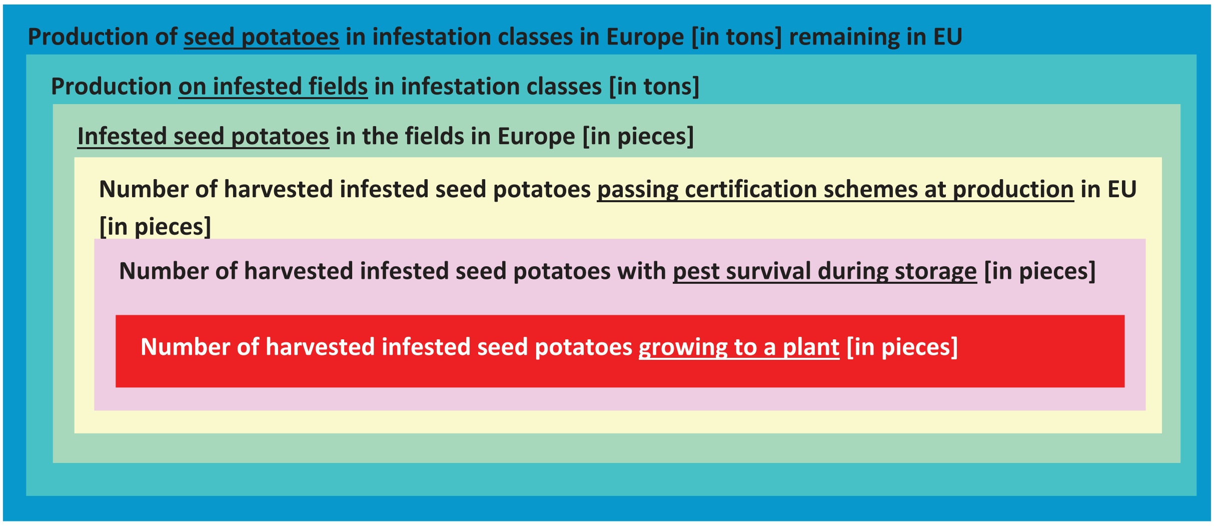


Figure F.1: Pictorial representation of the spread model for seed potato pathway. See Figure B.2 for detailed explanation

Table F.1: Parameter and model equation of the spread model for seed potato pathway

Abbreviation	Explanation	Evidence
I	Index: Infestation class	Table C.1
$Prod_{Seedpot,I}$	Step 1: Production of seed potatoes in infestation class I remaining in EU	Table C.7 ESCAA, (online), EUROSTAT (online)
$Prop_{InfFields,I}$	Step 2: Proportion of infested fields in countries of infestation class I	Judgement
$Conv_{Pieces/ha}$	Conversion: Conversion of production weight to number of seed potatoes	Table C.13
$Prop_{InfTubers,EU}$	Step 3: Proportion of infested seed potatoes harvested from infested fields in Europe	Judgement
$Surv_{Certification,EU}$	Step 4: Proportion of infested seed potatoes pathing certified production/(1−) Efficacy of phytosanitary measures and certification schemes on pest abundance in the planting material in the EU	Judgement
$Surv_{Storage,EU}$	Step 5: Proportion of infested seed potatoes with survived pathogen during storage in EU/Pest survival during storage in the EU	Judgement
Est_{Plant}	Step 6: Proportion of infested seed potatoes growing to a new potato plant/Pest survival during transport in the EU including planting/Pest survival during transport in the EU including planting	As in the ENTRY model

NumberSpreadInfestedTubers						
=	(	ProductionSeedPotatoesForEUClass1	*	ProportionInfestedFieldsClass1		
	+	ProductionSeedPotatoesForEUClass2	*	ProportionInfestedFieldsClass2		
	+	ProductionSeedPotatoesForEUClass3	*	ProportionInfestedFieldsClass3	)	
	*	ConvertionToTubers	*	ProportionInfestedTubersWithin FieldsEU		

	*	SurvivalPCertificationScheme	*	SurvivalStorage	*	Proportion Established
+		NumberEnteredInfestedTubers				

F.1.1. Step 1 for spread: EU seed potato production produced and planted in the EU

According to European Seed Certification Agencies Association (ESCAA, online) http://www.escaa.org/index/action/page/id/9/title/certified-seed-quantities), the Netherlands is the largest seed potato producer in the EU with (34% of EU acreage) followed by France (16%), Germany (15%) and UK (13%) (see Appendix C, Table C.4). These four countries represent almost 80% of the whole EU production areas of seed potatoes in the EU. For the purpose of this risk assessment it is estimated that an average 25 tonnes of seed potato tubers is produced per one ha, which means that altogether 2,719,493 tonnes of potato seeds are produced in the EU (see Table C.7). According to the estimated quantities of seed potato production in PRA area presented in the Appendix C, Table C.7, 25% of the EU seed potatoes are exported to third countries. It is therefore estimated that intra-EU trade of seed potatoes represents 75% of the total EU production.

Table F.2: Area used for the production of seed potato in (in ha) in the EU Member States

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area of seed potatoes (ha)					
NL	35,596.0	37,136.9[(a)]	37,606.7	37,235.1	38,109.8	37,136.9
Class 1	**35,596.0**	**37,136.9**	**37,606.7**	**37,235.1**	**38,109.8**	**37,136.9**
AT	1,585.0[(a)]	1,585.0[(a)]	1,585.0[(a)]	1,585.0[(a)]	1,585.0	1,585.0
BE	2,323.1	2,177.9	2,038.3	2,130.7	2,332.4	2,200.5
BG	308.0	440.0	243.0	189.0	280.0	292.0
CZ	2,609.7	3,194.7	2,441.0	3,172.7	3,012.8	2,886.2
DE	16,142.6	16,296.8	15,512.7	15,769.6	16,056.8	15,955.7
EE	277.1	348.7	250.1	261.7	290.9	285.7
EL	405.9[(a)]	588.5	558.0	240.2	236.9	405.9
FR	16,417.6	16,877.6	16,737.9	17,380.0	18,447.4	17,172.1
HU	255.2	228.2	331.7	193.0	210.0	243.6
IE	700.0	500.0	460.0	329.0	238.0	445.4
LT	205.2	286.6	177.2	129.4	177.2	195.1
LU	401.6	404.0	395.0	465.4	379.3	409.1
LV	286.0	250.0	280.4	252.6	356.6	285.1
MT	0.0	0.0	0.0	0.0	0.0	0.0
PL	5,184.8	5,336.2	5,330.7	4,758.9	5,243.2	5,170.8
RO	482.0	614.0	283.0	318.0	555.7	450.5
SE	1,250.7	1,079.2[(a)]	1,102.4	964.6	999.0	1,079.2
SK	559.7	635.2	573.9	499.8	505.0	554.7
UK	14,253.1[(a)]	14,412.6	14,046.0	14,022.9	14,530.8	14,253.1
Class 2	**63,647.3**	**65,255.2**	**62,346.3**	**62,662.5**	**65,437.0**	**63,869.7**
CY	88.0	119.6	98.6	82.5	105.3	101.5
DK	4,040.3[(a)]	4,040.3[(a)]	4,379.0	3,742.0	4,000.0	4,040.3
ES	2,731.2	2,685.2	2,652.0	843.8	2,228.1[(a)]	2,228.1
FI	1,206.0	1,143.0	1,118.0	1,080.0	1,073.0	1,103.5
HR	138.5	61.2	63.5	63.7	73.8	65.6
IT	179.4	186.2	167.9	129.4	140.6	156.0
PT	0.0	0.0	0.0	0.0	0.0	0.0
SI	40.3	48.2	47.0	40.0	30.0	41.3

Country	Year					Average
	2010	2011	2012	2013	2014	
	Production area of seed potatoes (ha)					
Class 3	**8,423.7**	**8,283.7**	**8,526.0**	**5,981.4**	**7,650.8**	**7,773.1**
EU28	**107,667.0**	**110,675.8**	**108,479.0**	**105,879.0**	**111,197.6**	**108,779.7**

(a): Missing value imputed by average of remaining years.
Source: ESCAA, online: http://www.escaa.org/index/action/page/id/9/title/certified-seed-quantities

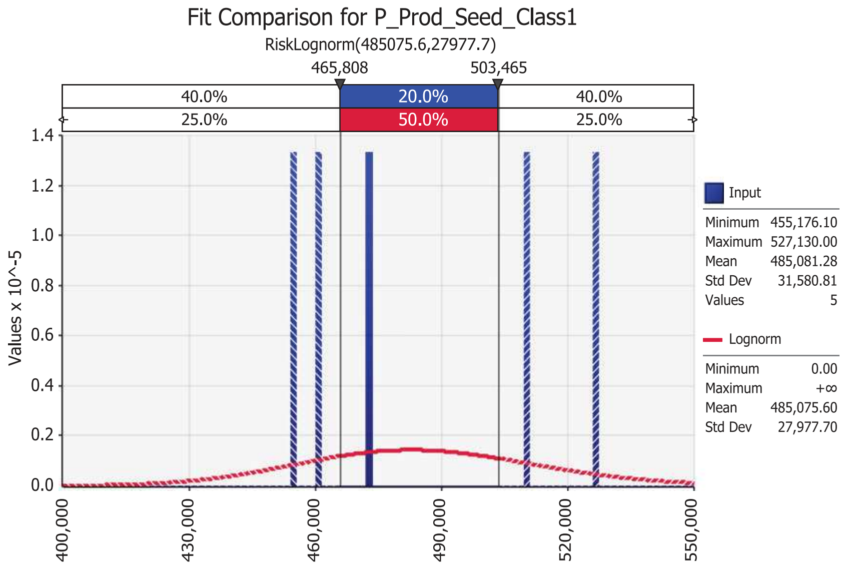
Table F.3: Empirical data on seed potato production in the EU for infestation classes remaining inside the EU (see Table C.7)

Seed potato production in the EU remaining inside the EU (tonnes)			
Year	**Class 1**	**Class 2**	**Class 3**
2010	472,319.3	1,433,935.3	173,722.0
2011	461,266.7	1,441,076.4	168,809.8
2012	527,130.0	1,366,618.4	182,141.6
2013	509,514.3	1,372,887.2	113,639.1
2014	455,176.1	1,430,938.9	157,429.3

Fitted distribution:

Class 1

Volume of seed potatoes produced in Class 1 and planted inside the PRA area is in the range of 485,081 tonnes per year. The best fitting distribution was a Log-Normal distribution with a mean of 485,076 and a standard deviation of 27,978 tonnes of seed potatoes produced in Class 1 MS per year.

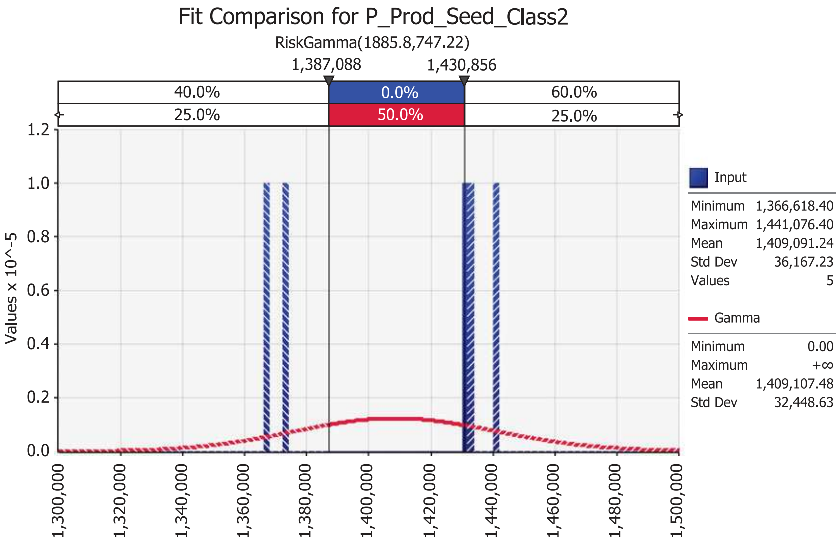


The blue bars show data (see Appendix C, Table C.7) for the years 2010–2014 while the red curve is the smoothed distribution used in the model calculation

Figure F.2: Volume of seed potatoes produced in Class 1 and remaining inside of the PRA area

Class 2

Volume of seed potatoes produced in Class 2 and planted in the PRA area is in the range of 1.4 million tonnes per year. The best fitting distribution was gamma distribution with a mean of 1,409,107 and a standard deviation of 32,448 tonnes of seed potatoes produced in Class 2 per year per year.

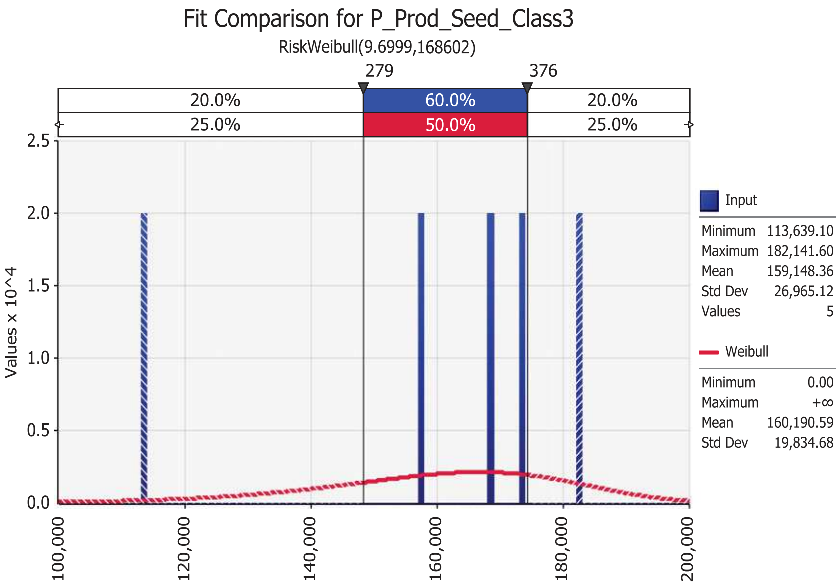


The blue bars show (see Appendix C, Table C.7) for the years 2010–2014 while the red curve is the smoothed distribution used in the model calculation

Figure F.3: Volume of seed potatoes produced in Class 2 and remaining inside of the PRA area

Class 3

Volume of seed potatoes produced in Class 3 and planted in the PRA area is in the range of 159,148 tonnes per year. The best fitting distribution was Weibull distribution with a mean of 160,191 and a standard deviation of 19,834 tonnes of seed potatoes produced in Class 3 per year.



The blue bars show (see Appendix C, Table C.7) for the years 2010–2014 while the red curve is the smoothed distribution used in the model calculation

Figure F.4: Volume of seed potatoes produced in Class 3 and remaining inside of the PRA area

F.1.2. Step 2 for spread: Percentage of infested fields within the EU

Uncertainty about the presence of *D. destructor* in seed potatoes produced in MS exists due to the lack of survey data specifying the pest presence at field level. Pest reports from MS differ and it may therefore be justified to group MS according to their reported pest status in three classes as specified in Appendix A, Section A.3. As specified in Section A.3 of Appendix A, a distinction will be made for the statements 'present, few occurrences' or 'present, restricted distribution' and 'present, wherever host crops are grown' Based on the pest status reported by the MSs, the distribution of the pest may therefore be considered highest in Class 1 MS, followed by MSs classified in the Class 2 and Class 3. This is reflected in the different distribution as specified in Table F.4.

The parameter values for each class are defined by expert judgment in order to address the possibly different levels of infestation as reported by countries. There is no information available that allows quantification on the proportion of *D. destructor* infested fields at present. By defining the proportion of infested fields and grouping countries according to their pest reporting, risks derived from different pest levels may be addressed. In case more detailed information becomes available estimated parameter values may be adjusted.

Class 1: contains all countries reporting 'present in all parts of the country' (not applicable for this PRA) or 'resent, wherever host crops are grown'. In this class the median value for this pest is determined by expert judgement to be 3%. The upper value is defined at 10%. This may be particularly justified when all or most parts of a country are suitable for host plant production.

Class 2: contains all countries reporting 'present, few occurrences' or 'present, restricted distribution'. No distinction will be made within the categories 'present, few occurrences' or 'present, restricted distribution'; in these cases the median value for this nematode is defined by expert judgement at 2% and the upper value is defined at 5%. Overall, parameter values are lower than in class 1 reflecting the different pest status reports.

Class 3: contains all countries reporting 'absent'. Since no country reported the pest absence based on specific surveillance the median was estimated at 0.001% and the upper value at 0.05% reflecting that there is a small chance of the pest presence which may have remained unnoticed partly because no surveys were conducted.

Table F.4: Estimated percentage of infested fields within the EU

Percentage of infested fields within pest status classes 1–3[(a)]			
Quantile (Percentile)	**Class 1**	**Class 2**	**Class 3**
Lower (1%)	1%	1%	0%
Q1 (25%)	1.5%	1.5%	0.0001%
Median (50%)	3%	2%	0.001%
Q3 (75%)	5%	3%	0.015%
Upper (99%)	10%	5%	0.050%

(a): For definition of classes see Appendix A.

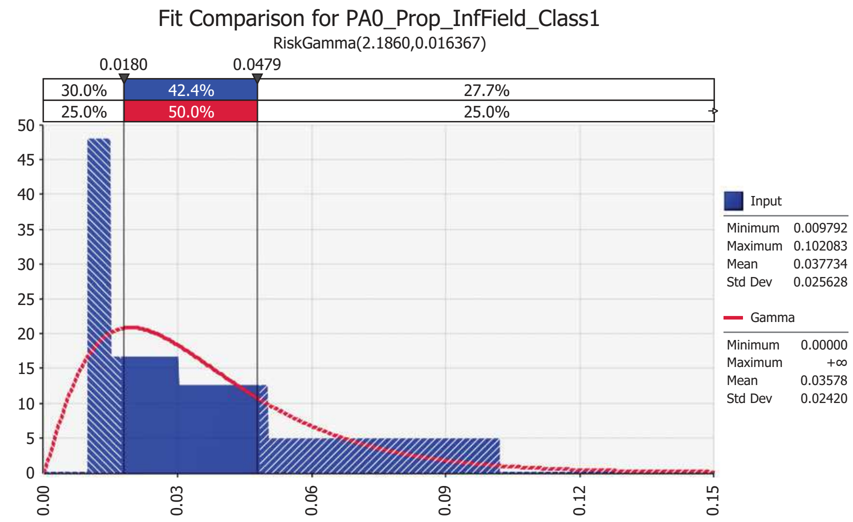
Fitted distribution:

Class 1

The best fitting distribution was a gamma distribution with a mean of 3.6% infested fields and a standard deviation of 2.4% infested fields within the Class 1. The best estimate for the percentage of infested fields within the Class 1 is a median of 3% with an interquartile range from 1.8 to 4.8%.

Table F.5: Elicitation results and fitted distribution PA0_Prop_InfField_Class1
Fitted distribution: Gamma(μ = 0.03578, σ = 0.0240)

Elicitation results	**Lower limit**	**1st Quartile**	**Median**	**3rd Quartile**	**Upper limit**
PA0_Prop_InfField_Class1	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.0100	0.0150	0.0300	0.0500	0.1000
Fitted values	0.0031	0.0180	0.0305	0.0479	0.1142



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

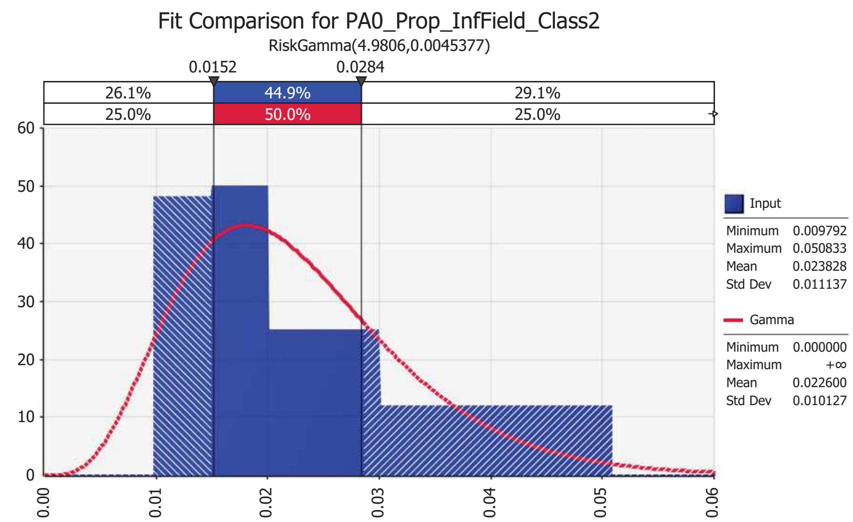
Figure F.5: Proportion of infested fields in Class 1

Class 2

The best fitting distribution was a gamma distribution with a mean of 2.2% and a standard deviation of 1% infested fields within the Class 2. The best estimate for the percentage of infested fields within the Class 2 is a median of 2% with an interquartile range from 1.5 to 2.8%.

Table F.6: Elicitation results and fitted distribution PA0_Prop_InfField_Class2
Fitted distribution: Gamma(μ = 0.022600, σ = 0.010127)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
PA0_Prop_InfField_Class2	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.0100	0.0150	0.0200	0.0300	0.0500
Fitted values	0.0058	0.0152	0.0211	0.0284	0.0525



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

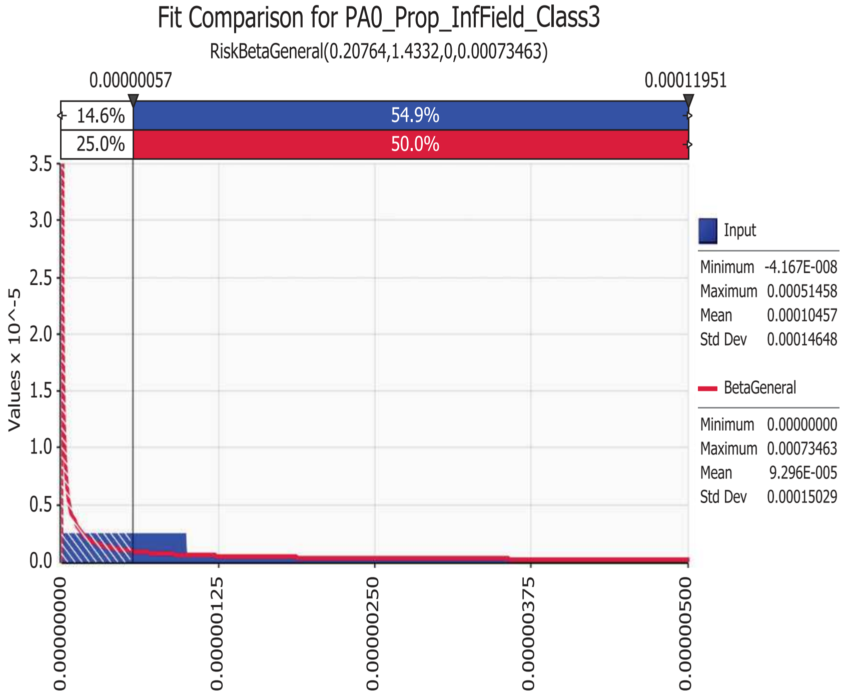
Figure F.6: Proportion of infested fields in Class 2

Class 3

The best fitting distribution was generalised beta distribution with a mean of 0.001% and a standard deviation of 0.01% infested fields within the Class 3. The best estimate for the percentage of infested fields within the Class 3 is a median of 0.0016% with an interquartile range from 0.00006 to 0.012%.

Table F.7: Elicitation results and fitted distribution PA0_Prop_InfField_Class3
Fitted distribution: GenBeta(μ = 0.00009296, σ = 0.00015029, min = 0, max = 0.00073463)

Elicitation results PA0_Prop_InfField_Class3	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0	0.0000010	0.000010	0.000150	0.000500
Fitted values	1 E-13	0.0000006	0.000016	0.000120	0.000634



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure F.7: Proportion of infested fields in Class 3

F.1.3. Step 3 for spread: Proportion of infested tubers harvested from infested fields in the EU

Generally nematodes are not uniformly distributed within fields. Usually the nematodes occur in patches or infestation foci. If a field is infested by the nematode not the whole field will be infested.

Not all plants within the patches will be infested because infestation depends on different environmental factors including soil type and moisture. Uncertainty exists about the number of plants within the patch that will be infested. General considerations have been specified in Appendix D, Section D.1.3. The assumptions and explanations for the estimated parameter values therefore follow the same line of reasoning specified for the potato pathway (Section D.1.3 of Appendix D) and are not repeated here.

Baseline (A0)

The elicitation results and the fitted distribution are identical to the values and figures provided in Section D.1.3 of Appendix D and are therefore not repeated here.

Scenarios (A2, A6)

All scenarios are using the Baseline values.

F.1.4. Step 4 for spread: Effectiveness of phytosanitary measures and certification schemes on pest abundance in the planting material in the EU

International certification schemes are available independently of Council Directive 2000/29/EC or Commission implementing Directive 2014/20/EU such as those from the European and Mediterranean Plant Protection Organization (EPPO). Although not legally binding, these EPPO Standards concern quality of seed potatoes (PM 4/28(1) (Certification scheme for seed potatoes, EPPO, 1999) and PM 8/1 (Commodity standard for potato, EPPO, 2004)). Those standards refer to *D. destructor* and seed material must not known to be infected with *D. destructor*.[22]

Since there are no specific requirements for sampling and testing in Council Directive 2000/29/EC to detect *D. destructor*, latent infections will most likely not be detected under the current regulation specific to *D. destructor*. Therefore, it is unclear how current regulation will reduce spread of latently infected tubers. Tubers with rotting symptoms may be detected but if tubers rot leads to rejection of the potato lot which will then interrupt the pathway. This may effectively be achieved with, e.g. Commission Implementing Directive 2014/20/EU.

The Panel considers that implementing standards in certification schemes, e.g. EPPO standard PM 4/28(1) – certification scheme for seed potatoes (EPPO, 1999), industry schemes (e.g. BKD, 2016) and carrying out the measures provided in the Commission Implementing Directive 2014/20/EU fulfil minimum conditions for the production of healthy planting material.

However, despite of phytosanitary certification in place, representative sampling of potato lots is difficult and even damaged tubers may not be detected. Moreover symptomless tubers may escape detection by visual inspection. The Panel therefore estimates that certain part of the pest population is expected to enter the pathway. Even in case the phytosanitary certification is not well implemented, it will not result in complete failure because of other phytosanitary inspections e.g. for *Clavibacter michiganensis* ssp. *sepedonicus*.

The assumptions and explanations for the estimated parameter values follow the same line of reasoning specified for the potato pathway (Section D.1.4 of Appendix D) and are not repeated here.

Baseline (A0)

The elicitation results and the fitted distribution are identical to the values and figures provided in Section D.1.4 of Appendix D and are therefore not repeated here.

Scenarios (A2, A6)

All scenarios are using the Baseline values.

F.1.5. Step 5 for spread: Pest survival during transport and storage in the EU including planting

For pest survival during transport, see Section D.1.7 and Section D.1.5 of Appendix D (potato pathway). The same assumptions were made to estimate the parameter values for pest survival and are therefore not repeated here.

Baseline (A0)

The elicitation results and the fitted distribution are identical to the values and figures provided in Section D.1.5 of Appendix D and are therefore not repeated here.

Scenarios (A2, A6)

All scenarios are using the Baseline values.

F.1.6. Results

Results are presented in Section 3.3.2 of the main document.

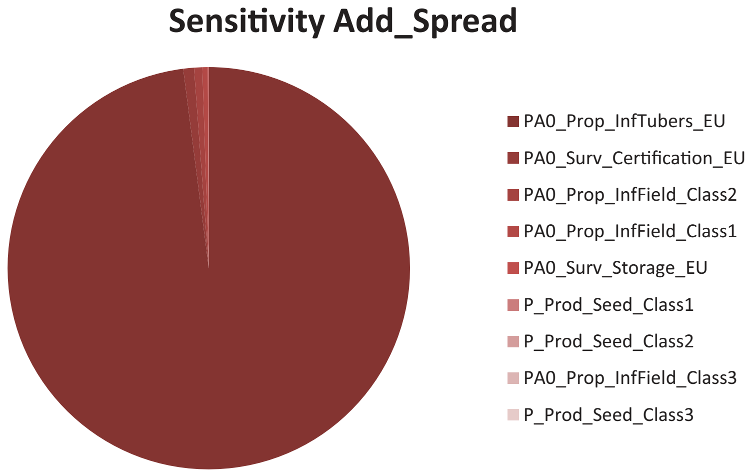
[22] It is not clear whether the standards will be changed in case *D. destructor* is removed from 2000/29/EC Annex IIAII.

F.1.7. Uncertainty on spread for the potato pathway

In the case of the intra-European trade in seed potato, 98% of the uncertainty is due to uncertainty in the proportion of infested seed tubers that are harvested from production fields that are infested with *D. destructor.* A further 1% is due to uncertainty in the proportion of infested fields (estimated for 3 classes of countries) and the effectiveness of certification to reduce the infestation level.

Table F.8: Sensitivity analysis

Rank	Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
1	PA0_Prop_InfTubers_EU	0.89	0.79	98
2	PA0_Surv_Certification_EU	0.08	0.01	1
3	PA0_Prop_InfField_Class2	0.07	0.01	1
4	PA0_Prop_InfField_Class1	0.06	0.00	0
5	PA0_Surv_Storage_EU	0.02	0.00	0
6	P_Prod_Seed_Class1	0.00	0.00	0
7	P_Prod_Seed_Class2	0.00	0.00	0
8	PA0_Prop_InfField_Class3	0.00	0.00	0
9	P_Prod_Seed_Class3	0.00	0.00	0
		R^2 =	0.80	100



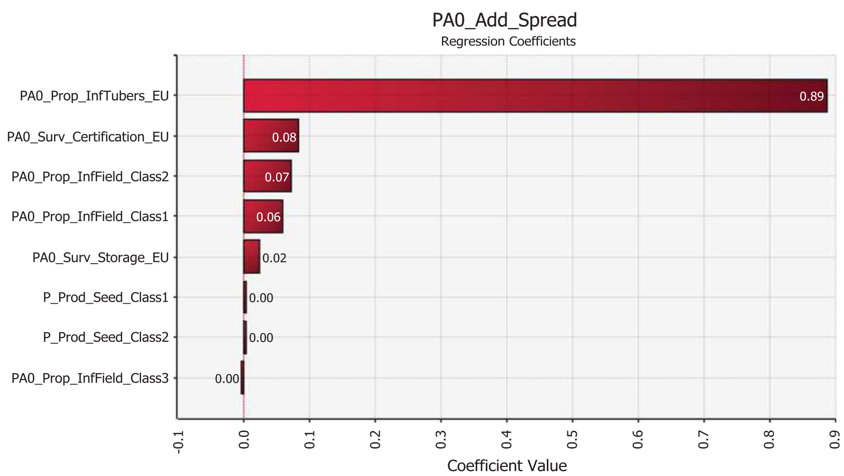


Figure F.8: Sensitivity analysis results

F.2. The spread model for ornamental bulbs

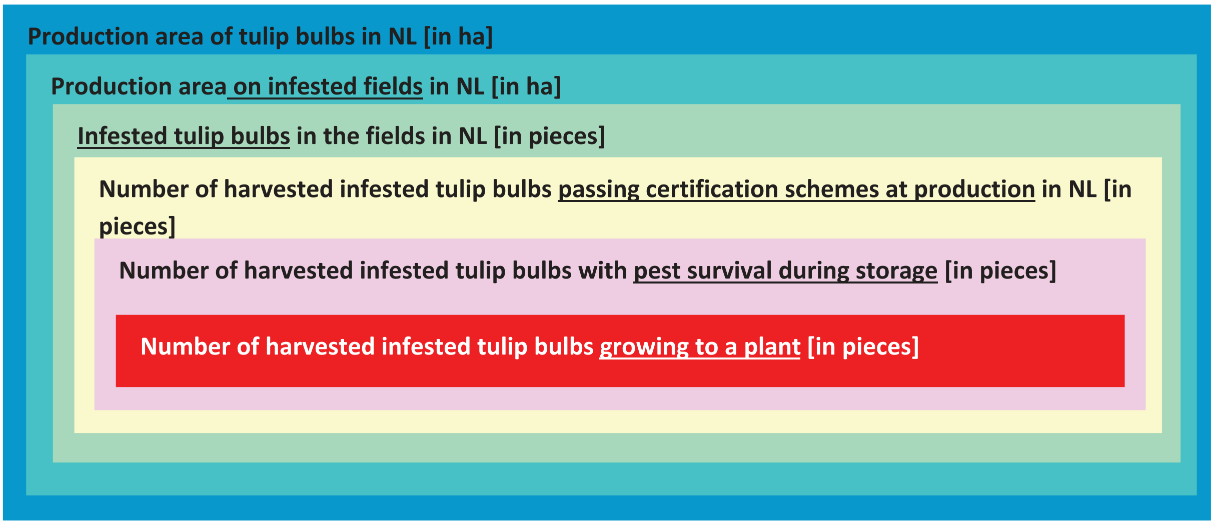


Figure F.9: Pictorial representation of the spread model for ornamental bulbs pathway. See Figure B.5 for detailed explanation

Table F.9: Parameter and model equation of the spread model for ornamental bulbs

Abbreviation	Explanation	Evidence
$Prod_{Tulips,NL}$	Step 1: Production of tulip bulbs in the NL for intra-EU trade	CBS (online), EUROSTAT (online)
$Prop_{InfFields}$	Step 2: Proportion of infested fields in the NL	
$Conv_{Pieces/tonne}$	Conversion: Conversion of production to number of tulip bulbs	Constant: = 50,000/tonne
$Prop_{InfBulbs,NL}$	Step 3: Proportion of infested tulip bulbs harvested from infested fields in the NL	
$Surv_{Certification,NL}$	Step 4: Proportion of infested tulip bulbs pathing certified production/(1−) Efficacy of phytosanitary measures and certification schemes on pest abundance in the planting material in the NL	
$Surv_{Storage,NL}$	Step 5: Proportion of infested tulip bulbs with survived pathogen during storage in the EU/Pest survival during storage in the NL	
Est_{Plant}	Step 6: Proportion of infested tulip bulbs growing to a new potato plant/Pest survival during transport in the EU including planting/Pest survival during transport in the EU including planting	As in the ENTRY model

NumberSpreadInfestedBulbs						
=		ProductionTulipBulbsForEUInNL	*	ProportionInfestedFieldsNL		
	*	ConversionToBulbs	*	ProportionInfestedBulbs WithinFieldsNL		
	*	SurvivalCertificationScheme	*	SurvivalStorage	*	ProportionEstablished
+		NumberEnteredInfestedBulbs				

F.2.1. Step 1 for spread: Tulip bulb production in the Netherlands

The Netherlands is the world's largest producer of tulip bulbs. Tulip bulbs are grown on more than 10,000 ha, which represents 88% of world production area followed by Japan (300 ha, 2.5%), France (293 ha, 2.4%), Poland (200 ha, 1.6%), Germany (155 ha, 1.3%) and New Zealand (122 ha, 1%) (Buschman, 2005). Therefore only spread of the pest from the Netherlands is considered.

According to Buschman (2005) 25% of tulip bulbs of Dutch production are exported to third countries. The other values are expert judgement expressing uncertainty about yearly fluctuations in trade.

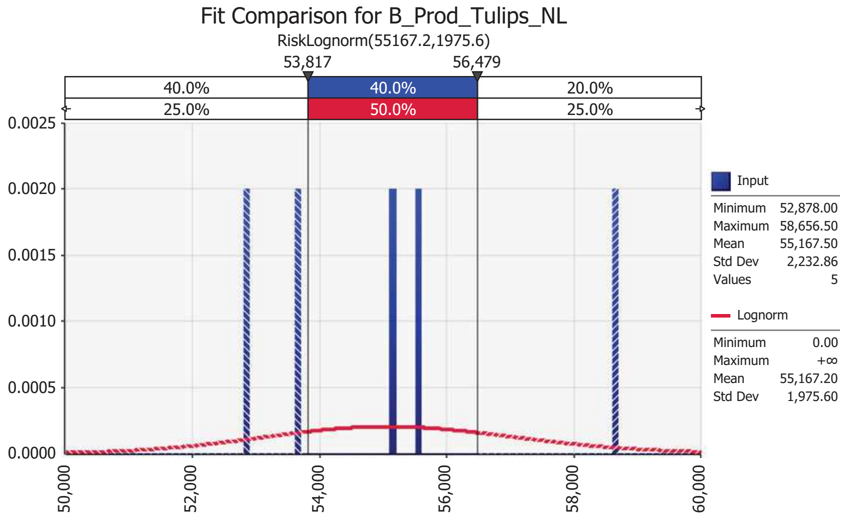
Table F.10: Tulip bulb production in NL for intra-EU trade

Tulip bulb production in NL exported or remaining inside the EU					
Year	**Tulip bulb production area in NL**	**Production of tulips bulbs in NL converted from area**	**Export of tulip bulbs from NL to outside of the EU**	**Remaining tulip bulbs inside the EU**	**Percentage of remaining tulip bulbs inside the EU**
	(ha)	**(tonnes)**	**(tonnes)**	**(tonnes)**	**(%)**
2010	11,400	91,200	35,682.5	55,517.5	61
2011	11,860	94,880	36,223.5	58,656.5	62
2012	11,250	90,000	36,383.4	53,616.6	60
2013	11,350	90,800	37,922.0	52,878.0	58
2014	11,440	91,520	36,351.1	55,168.9	60

Conversion: An average weight of one tulip bulb is estimated to be 20 g. This means that one kilogram contains 50 tulip bulbs = 50,000 bulbs per tonne. According to Buschman (2005) 4.32 billion tulip bulbs are produced in the Netherlands where production area is estimated to be 10.800 ha. This means that 400,000 tulip bulbs are produced per one ha (= 4.32 billions/ 10.800). The estimated production in tonnes per ha is therefore 8 tonnes/ha (400,000 bulbs per ha/50,000 bulbs per tonne). Calculated from Tables C.16 and C.17.

Fitted distribution:

The best fitting distribution was log-Normal distribution with a mean of 55,167 and a standard deviation of 1,976 tonnes of tulip bulbs produced in The Netherlands per year. According to the model calculation the best estimate for the yearly production of tulip bulbs in the Netherlands is a median of 55,167 with an interquartile range from 53,817 to 56,479 tonnes per year.



The blue bars show data (Appendix C, Table C.16) for the years 2010–2014 while the red curve is the smoothed distribution used in the model calculation.

Figure F.10: Tulip bulb production in the Netherlands

F.2.2. Step 2 for spread: Percentage of infested fields in the Netherlands

The pest status of *D. destructor* in the Netherlands is declared by the Dutch National Plant Protection Service as 'present, in all parts of the area where host crops are grown' (MS Questionnaire, EPPO PQR online; CABI online). Member States in Class 1 are considered to have a higher percentage of infested fields than MSs in Class 2 or 3 because of the reported pest status (see Section 3.1.1 and Appendix F, Section F.1.2). The parameter values for each class are defined by expert judgment in order to address the possibly different levels of infestation as reported by countries (see also

Section F.1.2 of Appendix F). There is no information available that allows quantification on the proportion of *D. destructor* infested fields at present. Parameter values are presented in Section F.1.2 and are therefore not repeated here.

F.2.3. Step 3 for spread: Proportion of infested bulbs harvested from infested fields in the Netherlands

Generally nematodes are not uniformly distributed within fields. Usually the nematodes occur in patches or infestation foci. If a field is infested by the nematode not the whole field will be infested. Not all plants within the patches will be infested because infestation depends on different environmental factors including soil type and moisture. Uncertainty exists about the number of plants within the patch that will be infested. General considerations have been specified in Appendix D, Section D.2.3. The assumptions and explanations for the estimated parameter values therefore follow the same line of reasoning specified for the potato pathway (Section D.2.3 of Appendix D) and are not.

Scenarios (A3, A5, A6)

All scenarios are using the Baseline values.

F.2.4. Step 4 for spread: Effectiveness of phytosanitary measures or certification schemes on the pest abundance in production fields in the Netherlands

Certification schemes such as those from the European and Mediterranean Plant Protection Organization (EPPO) are available. Industry standards on certification are also available (BKD, 2016) in the Netherlands. It is acknowledged that certification schemes might be influenced by current legislation; however, within the time horizon (5 years) changes in the legislation and subsequently removal of the pest from the certification schemes/requirement is not expected. If the industry requirements for certification schemes for tulip bulbs are considered effective in reducing the pest population, the probability of the presence of the nematode on harvested tulip bulbs is reduced. Even in case the phytosanitary certification is not well implemented, it will not result in complete failure. The explanation for the lower and upper limits and the median are based on expert judgement due to the lack of data demonstrating effectiveness of phytosanitary measures or certification schemes. The assumptions and values as specified in Section D.1.4 (entry for the potato pathway) were also used for the flower bulb model and are therefore not repeated here. However, parameter values are presented in Table F.11 because an additional scenario A4 is included for the model calculations.

The Panel considers the following distribution of effectiveness of phytosanitary measures or certification schemes on the pest abundance in production fields in the Netherlands (see Table F.11).

Table F.11: Effectiveness of phytosanitary measures or certification schemes on the pest abundance in production fields in the Netherlands in three scenarios (A0, A1 and A4). 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 y factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa

Effectiveness of phytosanitary measures or certification schemes on pest abundance in the Netherlands							
Quantile (Percentile)	**Reduction factor**			**Quantile (Percentile)**	**Multiplier**		
	A0-PW2	**A1-PW2**	**A4-PW2**		**A0-PW2**	**A1-PW2**	**A4-PW2**
Lower (1%)	0.4	0.4	0.8	Upper (99%)	0.6	0.6	0.2
Q1 (25%)	0.6	0.6	0.85	Q3 (75%)	0.4	0.4	0.15
Median (50%)	0.67	0.67	0.9	Median (50%)	0.33	0.33	0.1
Q3 (75%)	0.75	0.75	0.95	Q1 (25%)	0.25	0.25	0.05
Upper (99%)	0.9	0.9	0.999	Lower (1%)	0.1	0.1	0.001

The two regulation scenarios (A0 and A1) have identical percentiles for the initial pest density because Council Directive 98/56/EC also concerns the health statues of propagating material of flower bulbs and will be in place also when pest-specific legislation for *D. destructor* is lifted; therefore the same values are used for the scenarios with regulation (A0) and without regulation (A1).

At this step in scenario A4 following additional RROs (requirement for pest-free area according to ISPM No 4, FAO, 1995) are included compared to scenario A0. Pest-free areas represent a RRO that can limit spread of a pest and guarantee that plants for planting originated from the non-infested areas are actually pest free. The effectiveness and the feasibility of this measure is considered high. To maintain a pest-free area, extensive surveillance programme is needed.

Baseline (A0)

The elicitation results and the fitted distribution for A0 and A1 are identical to the values and figures provided in Section D.1.4 of Appendix D and are therefore not repeated here.

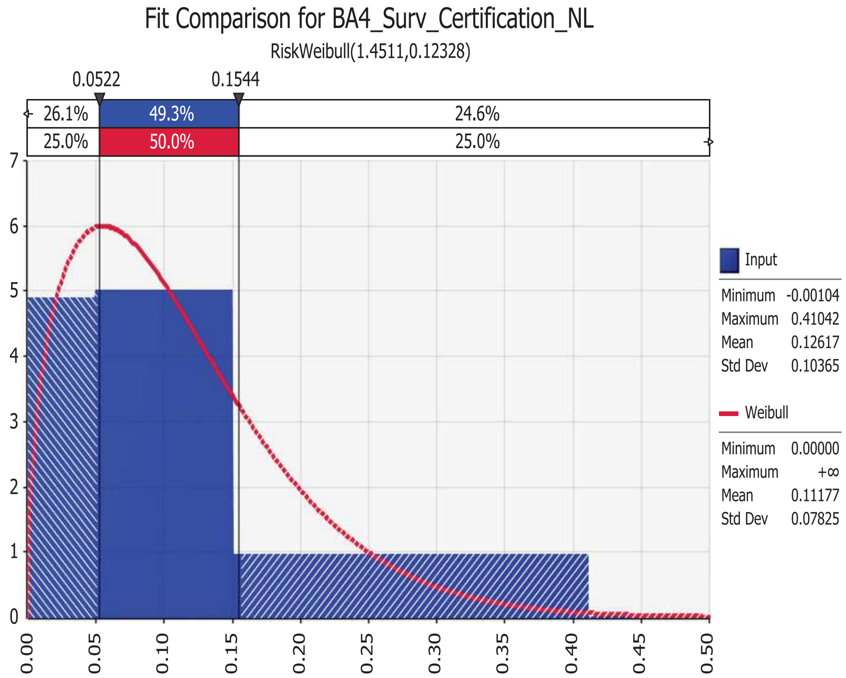
Scenario 4 (A4)

Table F.12: Elicitation results and fitted distribution BA5_Surv_Certification_NL
Fitted distribution: Weibull(μ = 0.11177, σ = 0.07825)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
BA4_Surv_Certification_NL	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.0010	0.0500	0.1000	0.1500	0.2000
Fitted values	0.0052	0.0522	0.0958	0.1544	0.3531

Fitted distribution:

The best fitting distribution was a Weibull distribution with a mean multiplier value for the effectiveness of pest-free places of production in the EU of 0.1 and a standard deviation of 0.07. The best estimate of the multiplier value is a median of 9.5% with an interquartile range from 5 to 15%.



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure F.11: Multiplier value for the effectiveness of pest-free places of production in the EU in addition to phytosanitary measures or certification schemes already in place

Other scenarios (A3, A5)

All other scenarios are using the Baseline values.

F.2.5. Step 5 for spread: Pest survival during transport and storage in the EU including planting

Storage conditions for tulip bulbs:

For pest survival during transport and storage, see Section 3.1.1 and Section D.1.5 of Appendix D (potato pathway). The Panel considers that the storage conditions of tulips are similar to those of potatoes and pest development will be therefore considered similar to the situation under storage of potatoes. The same assumptions were made to explain the estimated parameter values for pest survival and are therefore not repeated here. However, parameter values are presented in Table F.13 because an additional scenario A5 (hot water treatment) is included for the model calculations.

The Panel considers the following distribution of pest survival during transport and storage in the EU including planting (see Table F.13).

Table F.13: Pest survival during transport and storage in the EU including planting

Pest survival during transport and storage in the EU[(a)]			
Quantile (Percentile)	Multiplication factor		
	A0-PW2	A1-PW2	A5-PW2
Lower (1%)	0.75	0.75	0.01
Q1 (25%)	0.8	0.8	0.02
Median (50%)	0.9	0.9	0.05
Q3 (75%)	0.95	0.95	0.08
Upper (99%)	1	1	0.1

(a): This include changes in abundance between harvest and storage as well.

Transport and storage conditions are not part of any phytosanitary measure and therefore have identical values for scenarios A0 and A1.

At this step in scenario A5, following additional RRO (hot water treatment) is included compared to scenario A0. The Panel estimates that only 5% of the nematodes (median value) will survive hot water treatment. Survival might be 1% for the lower but not more than 10% for the upper value. The justification for this effectiveness is deducted from reported effects of hot water treatment on nematodes. The nematodes which are present inside of tulip bulbs may be successfully destroyed by dipping in hot water at chosen temperatures (43.3°C) for a period (4 h) that is long enough to kill all viable nematodes (Whitehead, 1998; Muthaiyan, 2009). Pretreatment storage for 2–3 weeks at 30°C is recommended to prevent damage due to this RRO because tulips differ in sensitivity to hot water and some varieties may be injured during this treatment (Whitehead, 1998; Muthaiyan, 2009; CABI, online). In case of tulips, hot water treatment is not used very often in the Netherlands because tulip bulbs can be very easily injured by hot water (Personal communication by P. Kleijn, 2016 see Appendix J).

Baseline (A0)

The elicitation results and the fitted distributions are identical to the values and figures provided in Section D.1.5 of Appendix D and are therefore not repeated here.

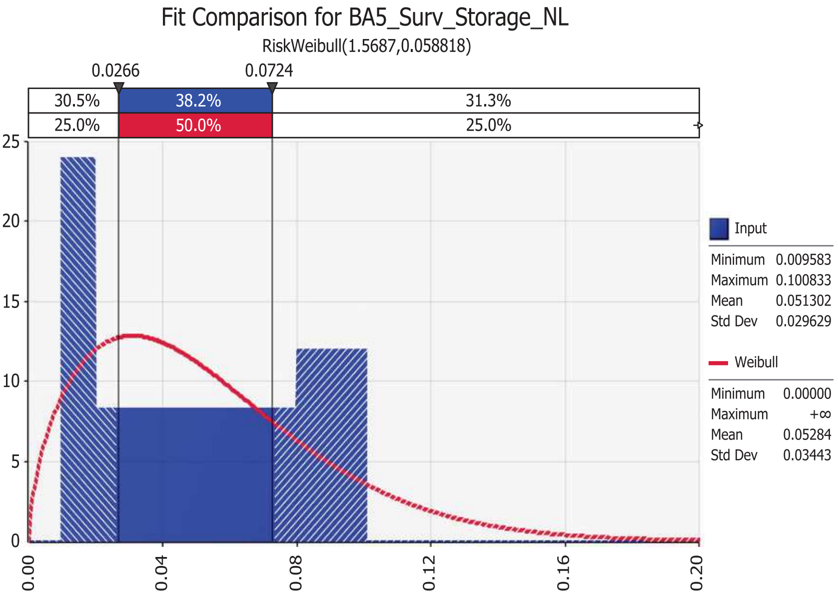
Scenario 5 (A5)

Table F.14: Elicitation results and fitted distribution BA5_Surv_Storage_NL
Fitted distribution: Weibull(μ = 0.05284, σ = 0.03443)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
BA5_Surv_Storage_NL	(1%)	(25%)	(50%)	(75%)	(99%)
Expert consensus	0.010	0.020	0.050	0.080	0.100
Fitted values	0.008	0.027	0.047	0.072	0.156

Fitted distribution:

The best fitting distribution was Weibull distribution with a mean multiplier factor for pest survival during hot water treatment of 0.05 and a standard deviation of 0.03. The best estimate of the multiplier value is a median of 4.7% with an interquartile range from 2.7 to 7.2%.



The blue bars show the expert judgment while the red curve is the smoothed distribution used in the model calculation.

Figure F.12: Multiplier value for the effectiveness of hot water treatment

Other scenarios (A3, A4)

All other scenarios are using the Baseline values.

F.2.6. Results

Results are presented in Section 3.3.4 of the main document.

F.2.7. Uncertainty on spread for the flower bulb pathway

Uncertainty in the predictions is for 95% attributable to uncertainty in the proportion of infested tulip bulbs that are harvested from infested fields. Four per cent of the uncertainty is attributed to uncertainty in the proportion of infested fields, while the effectiveness of certification contributes 1%.

Table F.15: Sensitivity analysis

Rank	Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
1	BA0_Prop_InfTulips_NL	0.80	0.64	95
2	BA0_Prop_InfField_NL	0.16	0.03	4
3	BA0_Surv_Certification_NL	0.08	0.01	1
4	BA0_Surv_Storage_NL	0.03	0.00	0
5	B_Prod_Tulips_NL	0.01	0.00	0
6	BA0_Prob_InfBulbs	0.01	0.00	0
7	B_Prod_3rdCountry	0.00	0.00	0
8	BA0_Surv_Transport	0.00	0.00	0
9	BA0_Surv_Cleaning	0.00	0.00	0
10	BA0_Prop_InfField	0.00	0.00	0
11	BA0_Surv_Control	0.00	0.00	0
		R^2 =	0.67	100

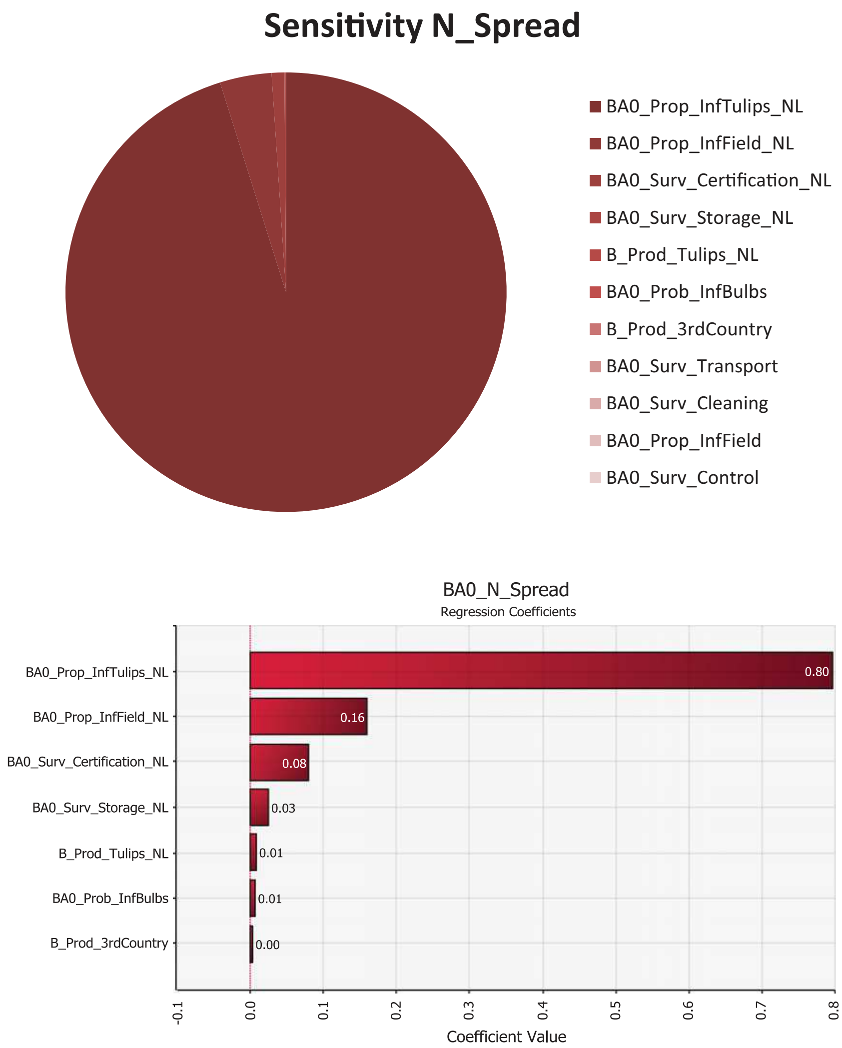


Figure F.13: Sensitivity analysis results

Appendix G – Additional information and parameter estimation for impact

G.1. The impact model for the potato pathway

Two types of losses are included in the impact model for the potato pathway:

- yield loss due to infestation via soil
- yield loss due to infestation of the seed.

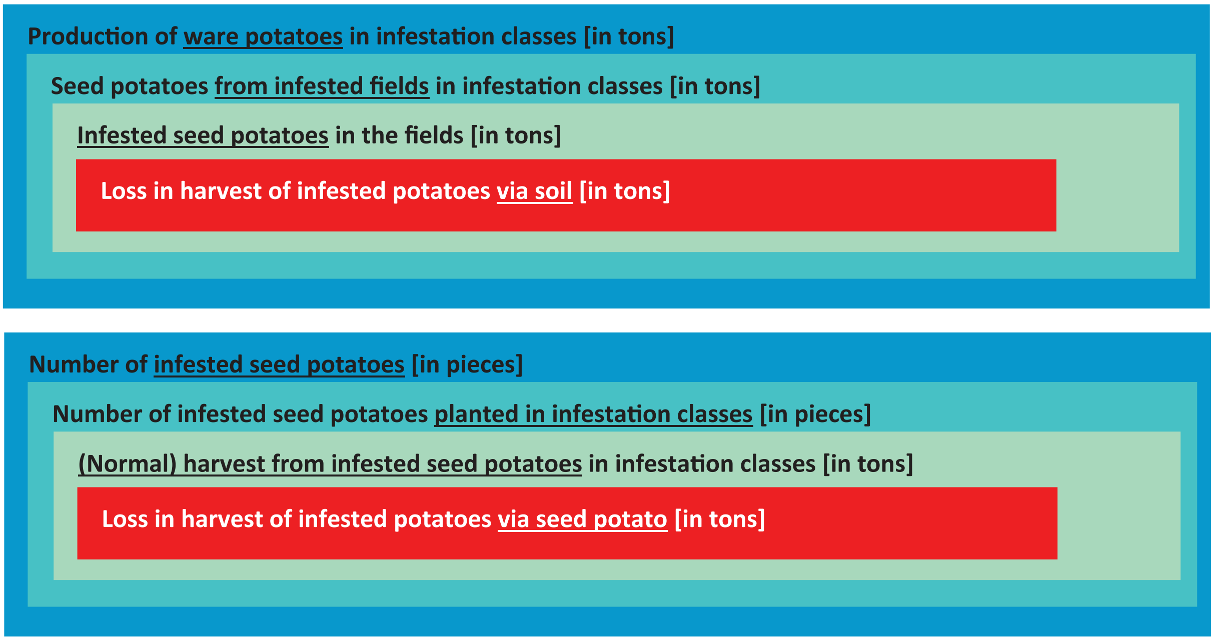


Figure G.1: Pictorial representation of the impact model for the potato pathway. See Figure B.3 for detailed explanation

Table G.1: Parameter and model equation of the impact model

Abbreviation	Explanation	Evidence
I	Index: Infestation class	Table C.1
$Prod_{Warepot,I}$	Step 1: Production area of ware potatoes in infestation class I	Table C.8
$Prop_{InfFields,I}$	Step 2: Proportion of infested fields in countries of infestation class I	As in Table F.4
$Prop_{InfTubers,EU}$	Step 3: Proportion of infested seed potatoes within a field in Europe	As in Table D.5
$Loss_{SoilInfection}$	Step 4: Production loss for tubers infested via soil/Yield loss in potatoes	
$Surv_{Soil}$	Step 4RRO: (only scenario A7, A8) Proportion of nematodes surviving soil treatments/(1−) Efficacy of soil treatment	
$Prop_{WarepotArea,I}$	Step 5: Average proportion of production area for ware potatoes in infestation class I	Table C.8
$Productivity_{Warepot,I}$	Step 6: Productivity of ware potato production in infestation class I	Table C.10
$Loss_{SeedInfection}$	Step 7: Production loss for tubers infested via seed potatoes	

LossProductionWarePotatoes					
=	(	ProductionWarePotatoesClass1	*	ProportionInfestedFieldsClass1	
	+	ProductionWarePotatoesClass2	*	ProportionInfestedFieldsClass2	
	+	ProductionWarePotatoesClass3	*	ProportionInfestedFieldsClass3	)
	*	ProportionInfestedTubersWithinFieldsEU	*	SurvivalSoilTreatment	
	*	RelativeLossPerInfestedTuberViaSoil			
+		NumberSpreadInfestedTubers			
	* (	RelativeProductionAreaWarePotatoesClass1	*	ProductivityPerPlantClass1	

	+	RelativeProductionAreaWarePotatoesClass2	*	ProductivityPerPlantClass2		
	+	RelativeProductionAreaWarePotatoesClass3	*	ProductivityPerPlantClass3	)	
+		RelativeLossPerInfestedTuberViaSeed				

Yield loss due to infestation via soil

For the assessment of yield loss due to infestation of the soil, the number of infested plants grown on infested land in the EU is estimated on the basis of assessments made in the spread section on 'Percentage of infested fields (in ha)' (see Appendix F, Table F.4) and this percentage is related to the area under potato cultivation and on 'Proportion of infested plants grown on an infested area (ha)' (see Appendix F, Section F.1.3 and Table D.5).

The yield loss resulting from a nematode infestation of a healthy seed potato tuber planted in an infested field is assessed. Healthy tubers are the standard planting material whereas nematode-infested tubers are the exception. Plant growth may be impaired by the presence of the nematodes in the soil. As a consequence tuber weight may be reduced. However, this impairment will be affected by several factors of which the initial nematode density is the most important (see justification of the percentiles).

The explanation for the lower and upper limits and the median for yield loss via soil infestation are based on damage reported in the literature and adjusted by expert judgement as stated below.

Lower: When conditions are not suitable for nematode development (to build up of damaging population levels) damage may not occur or has not been reported even in the case of the reported presence of the nematode in fields. Therefore the lower percentile has been assessed as 0% for yield losses due to infestation via soil.

Median: The median yield loss is estimated at 15% for yield losses due to infestation via the soil. Depending on nematode population density in the soil, yield losses (reported as weight reduction only) may be in the range of 17–34% under greenhouse conditions (Mwaura et al., 2015); the lower value reported was chosen as the median.

Upper: The upper percentile was estimated at 70% because, healthy seed potatoes planted in nematode-infested fields resulted in 41–70% damaged potato crops (Andersson, 1971); this is considered an extreme report and has not been confirmed in recent years. At higher densities (500 nematodes inoculated onto a single tuber) losses may – depending on potato variety – reach 28–86% under greenhouse conditions (Mwaura et al., 2014). Therefore, 70% was chosen as the upper value.

Yield loss due to infestation of the seed

The model for impact assessment also considers that infested tubers are spread and consequently planted in fields as specified in the spread section of this opinion. For the model, the pest status of the field will not be considered as every infested tuber planted will result in an affected plant (see establishment section). Although short distance movement of nematodes is possible and may lead to an infestation of surrounding plants, this is not considered for this assessment as the main effects are expected to occur on the initially infested plant. The distribution of infested tubers moved (see Section 3.3) was used to calculate the number of plants affected by *D. destructor*. Those affected plants will suffer yield losses. Based on literature reports on damage (Andersson, 1967; Mwaura et al., 2014, 2015), the Panel considers the following distribution of the values estimating yield losses in ware potatoes (quantifying yield losses at the plant level) due to *D. destructor*:

The explanation for the lower and upper limits and the median for yield loss via seed infestation are based on damage reported in the literature and adjusted by expert judgement as stated below.

Lower: The lower value for yield losses due to infection of the seed is at 30% loss considered to be considerably higher than when potato are infested via soil since nematodes are already present within the mother tubers (Andersson, 1967).

Median: The median yield loss is estimated at an intermediate level at 55% for yield losses due to infestation of seed potatoes (Andersson, 1967).

Upper: Yield losses due to infection of the seed may in contrast reach 100% when conditions are favourable for nematode development as has been reported by Andersson (1967).

Table G.2: Yield loss in potato due to tuber weight reduction and/or culling of rotten tubers

Yield loss in potato due to tuber weight reduction and/or culling of rotten tubers		
Quantile (Percentile)	**Yield loss due to infestation via the soil (in %)**	**Yield loss due to infestation of the seed (in %)**
Lower (1%)	0	30
Q1 (25%)	10	40
Median (50%)	15	55
Q3 (75%)	20	70
Upper (99%)	70	100

G.1.1. Step 1: Production area of ware potatoes in different infestation classes (ProdWarepot,I)

To assess the impact of *D. destructor* to the production of ware potato, the PRA area was divided into three classes representing different infestation level as it was presented in the Appendix C, Table C.1. Empirical data on ware potato production in the PRA area for infestation classes are shown in the Table G.3.

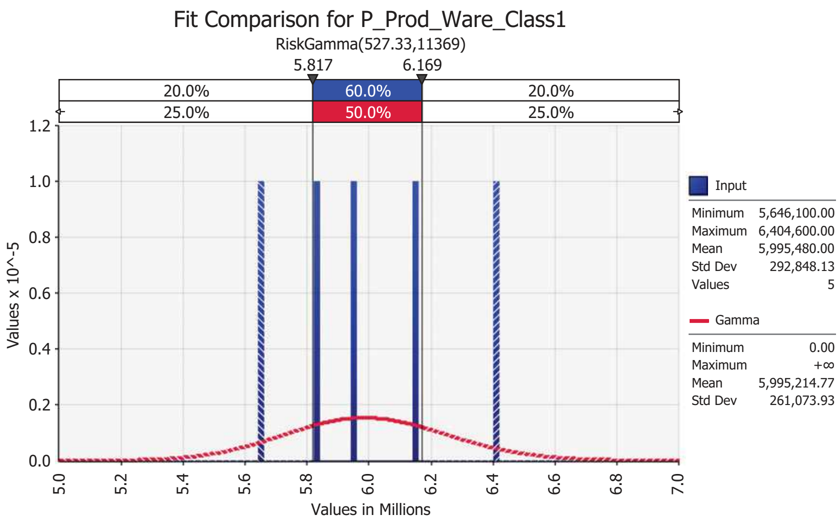
Table G.3: Empirical data on ware potato production in the EU for infestation classes (see Table C.10)

Ware potato production in different infestation classes within the EU (tonnes)				
Year	**Class 1**	**Class 2**	**Class 3**	**Sum**
2010	5,953,600	41,286,900	6,407,600	53,648,100
2011	6,404,600	46,622,300	6,857,900	59,884,800
2012	5,825,800	38,999,600	6,382,600	51,208,000
2013	5,646,100	39,212,200	6,376,100	51,234,400
2014	6,147,300	43,909,800	6,198,300	56,255,400

Fitted distribution:

Class 1

Volume of ware potatoes produced in the Netherlands (Class 1) is in the range of 6 million tonnes per year (see Table G.3). The best fitting distribution was a gamma distribution with a mean of 5,995,214 and a standard deviation of 261,937 tonnes of ware potatoes produced in Class 1 per year (Figure G.2).

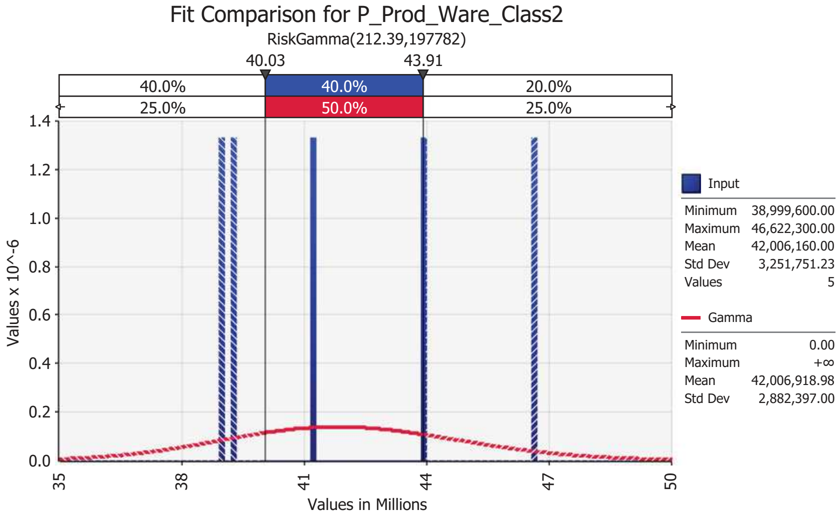


The blue bars show data for the years 2010–2014 (see Table C.10) while the red curve is the smoothed distribution used in the model calculation.

Figure G.2: Yearly production (metric tonnes) of ware potatoes in Class 1

<u>**Class 2**</u>

Production of ware potatoes in Class 2 is estimated to be 42 million tonnes per year (see Table G.3). The best fitting distribution was a gamma distribution with a mean of 42,006,918 and a standard deviation of 2,882,397 tonnes of ware potatoes produced in Class 2 per year (Figure G.3).

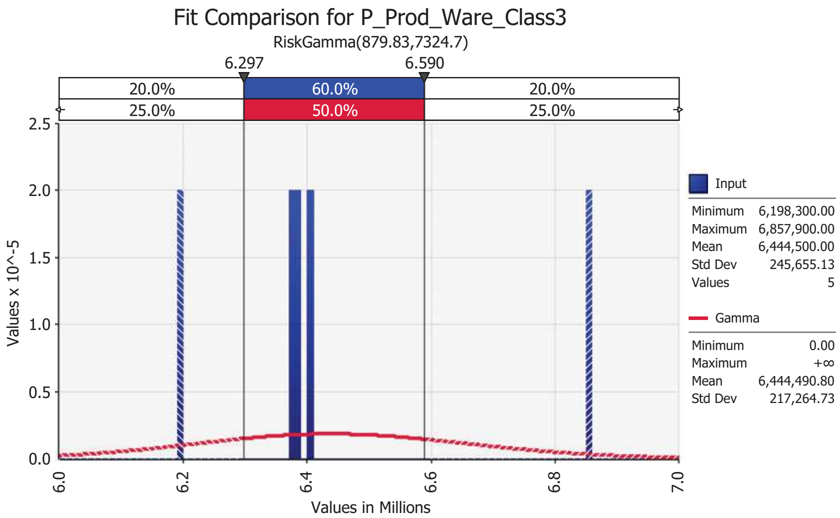


The blue bars show data for the years 2010–2014 (see Table C.10) while the red curve is the smoothed distribution used in the model calculation.

Figure G.3: Yearly production (metric tonnes) of ware potatoes in Class 2

<u>**Class 3**</u>

Production of ware potatoes in Class 3 is in the range of 6.4 million tonnes per year (see Table G.3). The best fitting distribution was a gamma distribution with a mean of 6,444,490 and a standard deviation of 217,264 tonnes of ware potatoes produced in Class 3 per year (Figure G.4).



The blue bars show data for the years 2010–2014 (see Table C.10) while the red curve is the smoothed distribution used in the model calculation.

Figure G.4: Yearly production (metric tonnes) of ware potatoes in Class 3

G.1.2. Step 2: Proportion of infested fields in countries of infestation (PropInfFields,I)

The distributions (I = Class 1, 2 and 3) of the second step in the spread model (see Appendix F) are used in this step for the model calculation.

G.1.3. Step 3: Proportion of infested seed potatoes within a field in Europe (PropInfTubers,EU)

The distribution of the third step in the spread model (see Appendix F) is used here for the model calculation.

G.1.4. Step 4: Production loss for tubers infested via soil (LossSoilInfection)

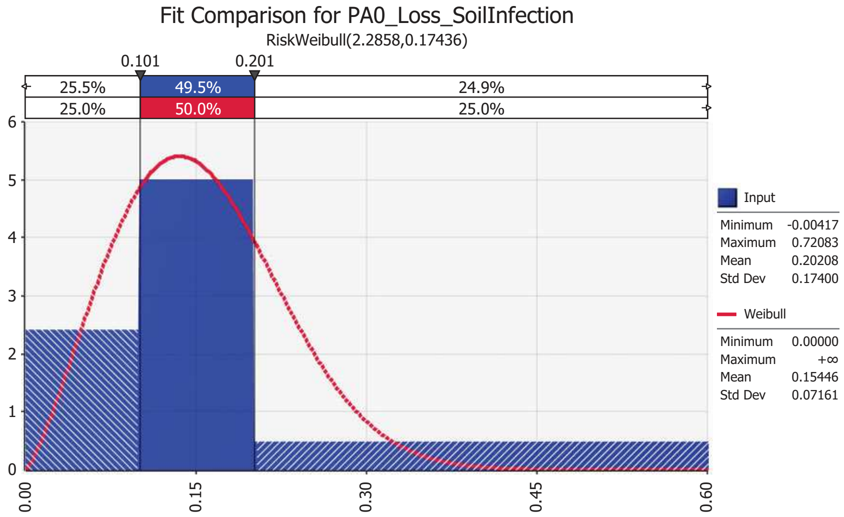
Baseline (A0)

Table G.4: Elicitation results and fitted distribution PA0_LossSoilInfection
Fitted distribution: Weibull(μ = 0.15446, σ = 0.07161)

Elicitation results PA0_LossSoilInfection	Lower limit (1%)	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	Upper limit (99%)
Expert consensus	0.000	0.100	0.150	0.200	0.700
Fitted values	0.023	0.101	0.149	0.201	0.340

Fitted distribution:

The best fitting distribution was a Weibull distribution with a mean yield loss of 15% and a standard deviation of 7%. The best estimate of the production loss of potato tubers due to soil infestation is a median of 15% with an interquartile range from 10 to 20% (Table G.4 and Figure G.5).



The blue bars show the expert judgement while the red curve is the smoothed distribution used in the model calculation.

Figure G.5: Proportion of potato production loss as a result of planting healthy seed potatoes in infested soil

G.1.4.1. Step 4 – RRO: Proportion of nematodes surviving soil treatments (SurvSoil)

Chemical soil treatment was included as an additional RRO at this step in the model. The effectiveness of chemical soil treatment (fumigation) against *D. destructor* is considered between 60% and 95% (Table G.5).

The explanation for the lower and upper limits and the median for the effectiveness of chemical soil treatments are based on literature reports (Safjanov, 1966 cited in Decker, 1969) and adjusted by expert judgment. Recent reports are not available probably due to the low relevance of this pest and reduced availability of chemical soil treatments. It should be noted that chemical soil treatment will only be effective in the top soil layer (approximately 0–30 cm depth) and that nematode populations at greater depths will not be affected. Those parts of the nematode population provide a reservoir for recolonisation of the previously fumigated soil.

Lower: The lower value for the effectiveness of soil fumigation was estimated at 60% considering the fact that soil treatments may not be properly applied (dosage, application method, soil moisture, temperature) and therefore the full potential of the treatment cannot be achieved.

Median: The median was estimated at 80% effectiveness taking into account that effectiveness of soil fumigation may depend on soil moisture conditions, application method and equipment (prevention of evaporation of the fumigant) and other factors. Although the Panel generally considers soil treatments to be effective, it also takes into account that effectiveness reported in the literature may be overrated and therefore a slightly lower value than 90% is estimated.

Upper: The upper value for the effectiveness of soil fumigation was estimated at 95% reflecting the high effectiveness reported in the literature.

Table G.5: Effectiveness of chemical soil treatment (scenario A6-PW1)

Effectiveness of chemical soil treatment (scenario A6-PW1)			
Quantile (Percentile)	Effectiveness in %	Quantile (Percentile)	Multiplier[(a)]
	A6-PW1		A6-PW1
Lower (1%)	60	Upper (99%)	0.05
Q1 (25%)	70	Q3 (75%)	0.1
Median (50%)	80	Median (50%)	0.2
Q3 (75%)	90	Q1 (25%)	0.3
Upper (99%)	95	Lower (1%)	0.4

(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 factor.

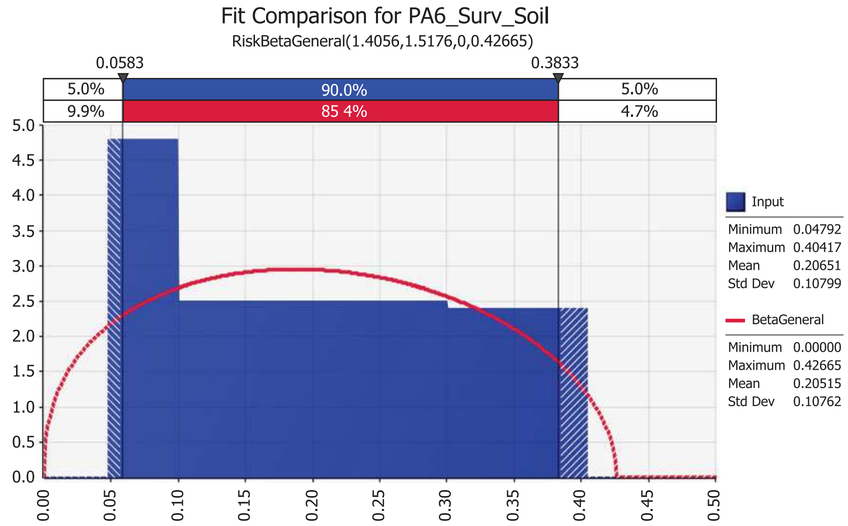
Scenario (A6)

Table G.6: Elicitation results and fitted distribution PA6_SurvSoil
Fitted distribution: (μ = 0.2100, σ = 0.1208, min = 0, max = 1)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
PA6_SurvSoil	(1%)	(25%)	(50%)	(75%)	(99%)
Expert consensus	0.050	0.100	0.200	0.300	0.400
Fitted values	0.011	0.117	0.203	0.292	0.411

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean multiplier value of 0.2 and a standard deviation of 0.1. The best estimate of the multiplier value is a median of 0.20% with an interquartile range from 0.12 to 0.29% (Table G.6 and Figure G.6).



The blue bars show the expert judgement while the red curve is the smoothed distribution used in the model calculation.

Figure G.6: Multiplier value for the effectiveness of a chemical soil treatment expressed as the proportion of nematodes surviving soil treatment

Baseline and other scenarios (A0, A2)

All other scenarios are not using this factor.

G.1.5. Step 5: Average proportion of production area for ware potatoes in different infestation classes (PropWarepotArea,I); I = 1,2,3

Table G.7: Empirical data on proportion on average production area of ware potatoes (see Appendix C, Figure C.2)

Infestation class	Production area of ware potatoes (ha)	
Class 1	118,503	7%
Class 2	1,343,648	79%
Class 3	228,495	14%
EU28	1,690,646	100%

G.1.6. Step 6: Productivity of ware potato production in infestation class I (I = 1,2,3) (ProductivityWarepot,I)

Productivity of potato was assessed as yield (in tonnes) per seed potato.

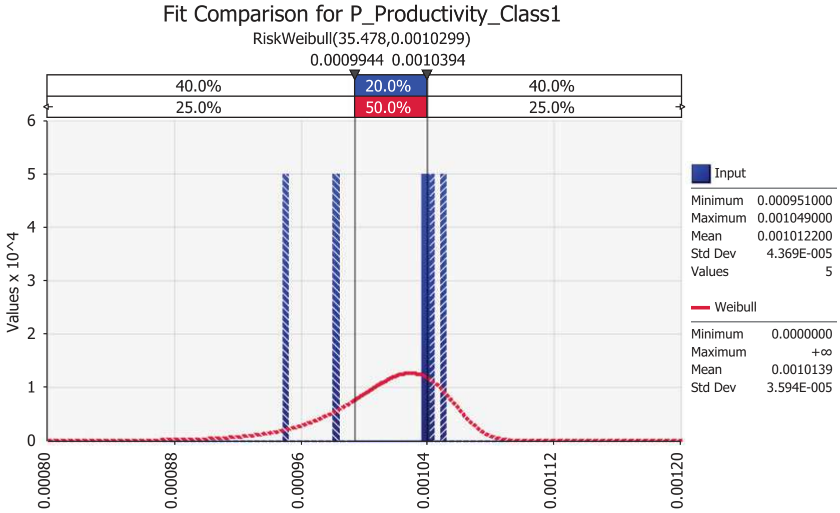
Table G.8: Productivity of ware potato production in (tonnes/seed potato)

Productivity of ware potato production in (tonnes/seed potato)				
Year	**Class 1**	**Class 2**	**Class 3**	**Average EU**
2010	0.000981	0.000580	0.000534	0.000601
2011	0.001049	0.000646	0.000559	0.000661
2012	0.001037	0.000577	0.000566	0.000606
2013	0.000951	0.000607	0.000571	0.000627
2014	0.001043	0.000729	0.000595	0.000735

Fitted distribution:

Class 1

The best fitting distribution was a Weibull distribution with a mean productivity (yield in tonnes per seed potato) of 0.001 and a standard deviation of 0.00004. The best estimate of productivity is a median 1.019 with an interquartile range from 0.994 to 1.039 kg per seed potato (Table G.8 and Figure G.7).

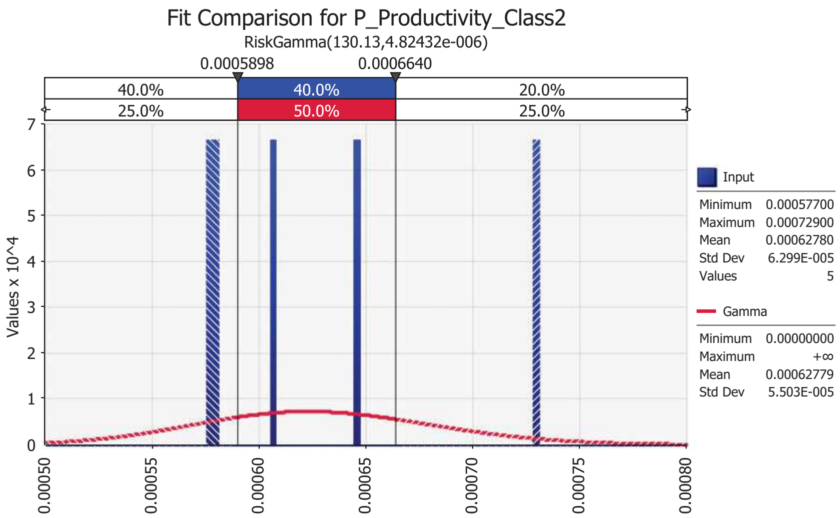


The blue bars show the calculations of productivity based on empirical data (see Table C.12) while the red curve is the smoothed distribution used in the model calculation.

Figure G.7: Estimated productivity expressed as yield (in tonnes) per seed potato of potato within Class 1

Class 2

The best fitting distribution was a gamma distribution with a mean productivity (yield in tonnes per seed potato) of 0.0006 and a standard deviation of 0.00005. The best estimate of productivity is a median 0.626 with an interquartile range from 0.590 to 0.664 kg per see potato (Table G.8 and Figure G.8).

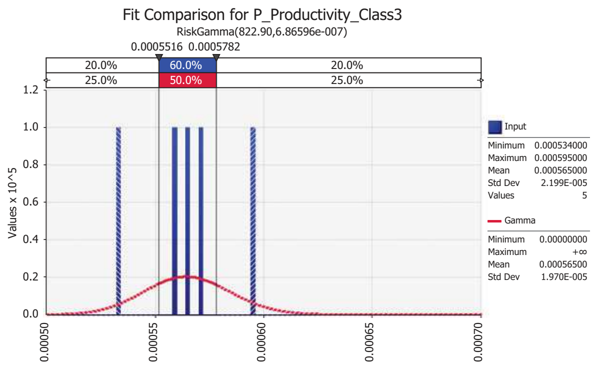


The blue bars show the productivity based on empirical data (see Table C.12) while the red curve is the smoothed distribution used in the model calculation.

Figure G.8: Estimated productivity expressed as yield (in tonnes) per seed potato of potato within Class 2

Class 3

The best fitting distribution was a gamma distribution with a mean productivity (yield in tonnes per seed potato) of 0.0005 and a standard deviation of 0.00002. The best estimate of productivity is a median 0.565 with an interquartile range from 0.552 to 0.578 kg per seed potato (Table G.8 and Figure G.9).



The blue bars show the productivity based on empirical data (see Table C.12) while the red curve is the smoothed distribution used in the model calculation.

Figure G.9: Estimated productivity expressed as yield (in tonnes) per seed potato of potato within Class 3

G.1.7. Step 7: Production loss for tubers infested via seed potatoes (LossSeedInfection)

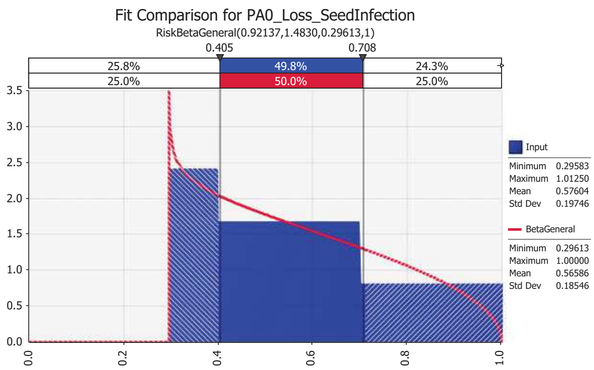
Baseline (A0)

Table G.9: Elicitation results and fitted distribution PA0_Loss_SeedInfection
Fitted distribution: GeneralBeta(μ = 0.56586, σ = 0.18546, min = 0.29613, max = 1)

Elicitation results	Lower limit	1st Quartile	Median	3rd Quartile	Upper limit
PA0_Loss_SeedInfection	**(1%)**	**(25%)**	**(50%)**	**(75%)**	**(99%)**
Expert consensus	0.300	0.400	0.550	0.700	1.000
Fitted values	0.299	0.405	0.504	0.708	0.966

Fitted distribution:

The best fitting distribution was a generalised beta distribution with a mean yield loss of 57% and a standard deviation of 19%. The best estimate of the production loss of potato tubers due to the planting of infested seed potato is a median of 50% with an interquartile range from 41 to 7% (Table G.9 and Figure G.10).



The blue bars show the expert judgement while the red curve is the smoothed distribution used in the model calculation.

Figure G10: Proportion of potato production loss as a result of planting infested seed potatoes

G.1.8. Results

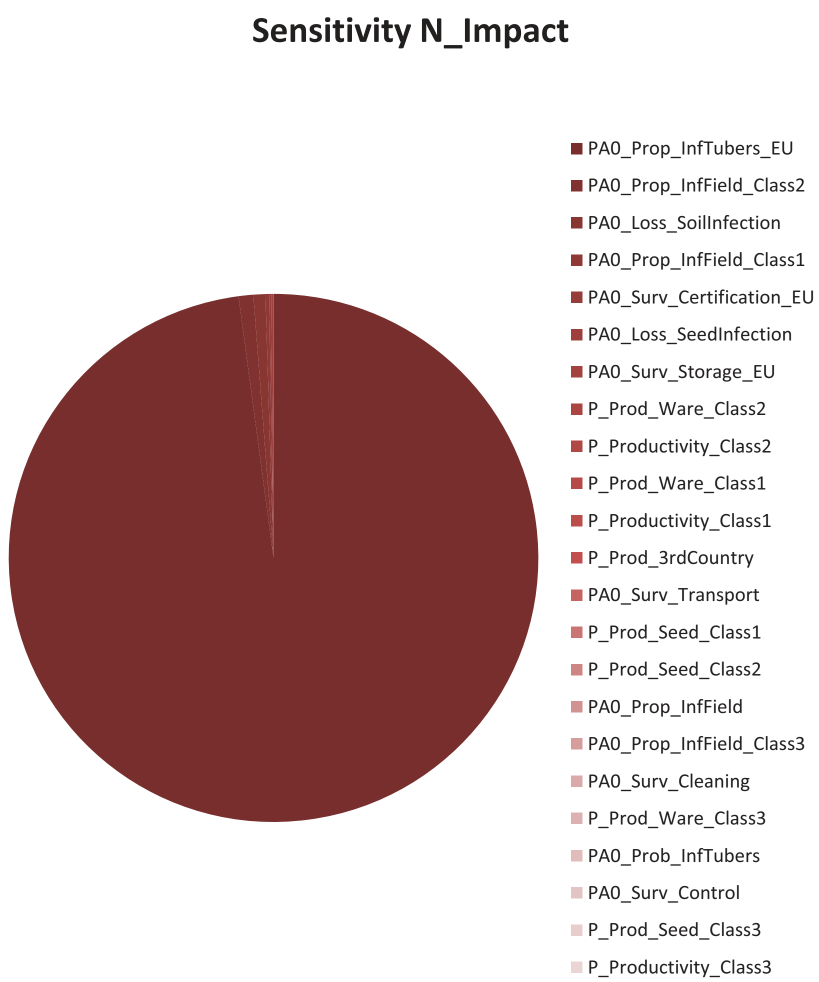
Results are presented in Section 3.4.5 of the main document.

G.1.9. Sources of uncertainty in the estimation of impacts in potato

Ninety-eight per cent of the uncertainty in the quantitative yield loss of potatoes is due to uncertainty in the proportion of infested potatoes harvested in infested fields. All other factors contribute 2% or less to uncertainty. This indicates that the impact pathway via the soil is substantially more important than the impact pathway via seed potatoes.

Table G.10: Sensitivity analysis results

Rank	Parameter	Regression coefficient	R^2 partition	Percentage of uncertainty
1	PA0_Prop_InfTubers_EU	0.86	**0.74**	**98**
2	PA0_Prop_InfField_Class2	0.08	**0.01**	**1**
3	PA0_Loss_SoilInfection	0.07	**0.01**	**1**
4	PA0_Prop_InfField_Class1	0.04	**0.00**	**0**
5	PA0_Surv_Certification_EU	0.03	**0.00**	**0**
6	PA0_Loss_SeedInfection	0.03	**0.00**	**0**
7	PA0_Surv_Storage_EU	0.01	**0.00**	**0**
8	P_Prod_Ware_Class2	0.01	**0.00**	**0**
9	P_Productivity_Class2	0.01	**0.00**	**0**
10	P_Prod_Ware_Class1	0.01	**0.00**	**0**
11	P_Productivity_Class1	0.00	**0.00**	**0**
12	P_Prod_3rdCountry	0.00	**0.00**	**0**
13	PA0_Surv_Transport	0.00	**0.00**	**0**
14	P_Prod_Seed_Class1	0.00	**0.00**	**0**
15	P_Prod_Seed_Class2	0.00	**0.00**	**0**
16	PA0_Prop_InfField	0.00	**0.00**	**0**
17	PA0_Prop_InfField_Class3	0.00	**0.00**	**0**
18	PA0_Surv_Cleaning	0.00	**0.00**	**0**
19	P_Prod_Ware_Class3	0.00	**0.00**	**0**
20	PA0_Prob_InfTubers	0.00	**0.00**	**0**
21	PA0_Surv_Control	0.00	**0.00**	**0**
22	P_Prod_Seed_Class3	0.00	**0.00**	**0**
23	P_Productivity_Class3	0.00	**0.00**	**0**
		R^2 =	**0.75**	**100**



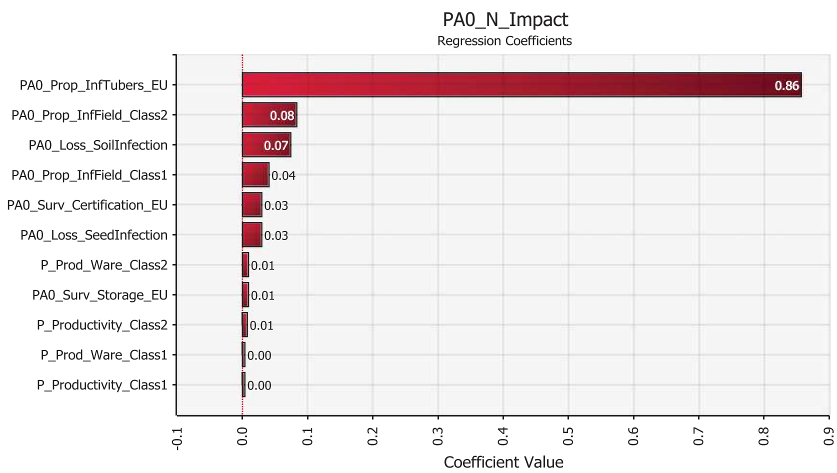


Figure G.11: Sensitivity analysis results

Appendix H – Risk reduction options

H.1. Identification of risk reduction options to reduce the probability of entry and establishment

In this section, the risk reduction options to reduce the probability of introduction (entry and establishment) have been identified, distinguishing between those that would be applied at the country of origin (pre-entry measures, a–f) and those that can be applied at the point of entry (post-entry measures, f–j).

a) Prohibition of entry into the EU of all *D. destructor* host plants for planting
b) Extension of the regulatory status of *D. destructor*
c) Limit import to material produced in pest-free places of production
d) Phytosanitary certification: statutory import requirements for the consignment
e) Certification schemes: quality requirements (private standards) for the consignment
f) Treatment of the commodity
g) Visual inspection at point of entry
h) Testing at point of entry
i) Limiting the final use of the imported consignment or restricting distribution to certain parts of the EU
j) Eradication of infected plants (destruction of the consignments)
k) Sanitation of place/site of production following an outbreak

H.1.1. Evaluation of risk reduction options to reduce the probability of entry and establishment

Here, the Panel identified and evaluate the risk reduction options to reduce the probability of entry and establishment. It should be stressed that, the potential effect of the risk reduction options relating to the probability of entry of *D. destructor* in the EU is limited because this nematode is sporadically already present in the majority of the EU MSs.

a) Prohibition of entry into the EU of all *D. destructor* host plants for planting

Restrictions on imports would reduce the probability of introduction of *D. destructor* carried on tubers, bulbs, rhizomes and corms intended for planting. The pest is, however, already present in majority of MSs and introduction of new populations would not significantly contribute to the abundance of this pest. Furthermore, no races were recognised for *D. destructor* so far therefore it is not expected that new populations would increase the biological diversity of the pest.

b) Extension of the regulatory status of *D. destructor*

The strength of phytosanitary measures should be greater only for high impact plant pests. The list of *D. destructor* host plants (flower bulbs and corms) which are listed in Annex II, Part A, Section II of Council Directive 2000/29/EC may be extended with some other host plants with an underground propagative part, e.g. *Allium cepa* and *Allium sativum*. With respect to the fact that *D. destructor* is not considered as high impact pest and because it is already present in majority of MSs and introduction of new populations would not greatly contribute to the abundance and diversity of this pest, the Panel considers this measure as unnecessary.

c) Limit import to material produced in pest-free places of production

According to ISPM No. 10 (FAO, 1999), pest-free place of production is "a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period". Documentation showing that the consignment originates from the places of production that are free of *D. destructor* may be required from the exporting country.

d) Phytosanitary certification: statutory import requirements for the consignment

The phytosanitary certificate issued by the exporting country may be specifically required to be accompanied with an additional statement that exported host plants of *D. destructor* have been found to be free from the nematode. The importing countries can determine the conditions under which the exporting countries can satisfy these requirements and may involve inspections in growing season and tests on soil or crop samples.

e) Certification schemes: quality requirements (private standards) for the consignment

Importing companies may require that imported consignments are free from *D. destructor*. These requirements must be supported by certification systems. In the Netherlands, for example, the quality of flower bulbs and their possible infection with diseases are visually checked by the Flower Bulb Inspection Service (*Bloembollenkeuringsdienst;* BKD), which performs also import and export inspections and laboratory analyses (Personal communication by P. Knippels, 2016 see Appendix J). The quality control is an essential fact for the further process of flower bulbs and is therefore on high quality level. The import and export inspections as well as export certification is performed also by the Netherlands Food and Consumer Product Safety Authority (*Nederlandse Voedsel- en Warenautoriteit*; NVWA).

f) Treatment of the commodity

If live *D. destructor* is detected only consignments of flower bulbs may be treated to eliminate the pest. Infected flower bulbs may be treated with hot water and/or chemicals to efficiently destroy any pests which are present inside of bulb scales.

g) Visual inspection at point of entry

Visual inspections of potato seeds and flower bulbs at point of entry are only relevant when the symptoms are visible (the presence of the rotten potatoes/bulbs). Visually detected infected (rotten) plants for planting have to be removed and destroyed. The effectiveness of this measure is considered low because it is difficult to detect *D. destructor* early infections of seed potatoes/flower bulbs. Infected plants do not show typical symptoms and are often not visible to the naked eye in the early phase. Damage aggravate over time. In general, visual inspection is common practice for import control, therefore its feasibility is high.

h) Testing at point of entry

D. destructor can be detected at point of entry using EPPO diagnostic protocols PM 7/119 (EPPO, 2013) for extraction of nematodes and PM 7/87(1) (EPPO, 2008) for identification of *Ditylenchus destructor* (EPPO, 2008). The probability of detecting this nematode in the consignment is limited by size of the sampling lot (only random samples can be tested) and incidence of the pest.

i) Limiting the final use of the imported consignment or restricting distribution to certain parts of the EU

To minimise the possibility of introduction of *D. destructor* from countries where it is present the use of the imported consignments may be limited, e.g. the imported tulip bulbs are distributed to professional flower growers only or distributed to end consumers; the flower bulbs are only in the period October–December, when no bulbs are available for flowering in the EU (the Netherlands).

j) Eradication of infected plants/destruction of the consignments

If *D. destructor* is intercepted/detected in consignment at point of entry, all plants may be destroyed to eliminate all potential sources of infections and to prevent further spread of this nematode. The effectiveness and feasibility of this option is considered high with low uncertainty. To remove and destroy only infected tubers/bulbs, the consignment may be re-sorted. In this case, the effectiveness and feasibility is considered low to moderate with moderate uncertainty due to symptomless tubers/bulbs that may be overlooked. Because *D. destructor* is already present in the majority of MSs and because introduction of new populations would not greatly increase the abundance and diversity of this pest, this measure is considered unnecessary.

k) Sanitation of place/site of production following an outbreak

Apart from not growing potato and other host plants, no cultural practices and control measures may be applied in order to prevent the establishment of *D. destructor* or to eradicate it once being present in a field.

H.1.2. Summary of risk reduction options to reduce the probability of introduction

Table H.1: Summary of risk reduction options to reduce the probability of introduction

Identified risk reduction options	Effectiveness	Uncertainties	Feasibility	Comments	Considered in scenarios
Prohibition of import of all listed host plants for planting	High	Low	Low to moderate	This option is considered unnecessary, because *D. destructor* is already present in the EU	–
Extension of the regulatory status of *D. destructor*	Low	Moderate	Moderate to high	This option is considered unnecessary, because *D. destructor* is already present in the EU. However, if all current measures listed in the Council Directive 2000/29/EC and certification system were removed this option would have a high effectiveness	–
Limit import to material produced in pest-free places of production	Moderate	Moderate	Moderate	Effectiveness of this measure is influenced by inspection method (visual examination or laboratory testing)	A2-PW1 and A3-PW2
Phytosanitary certification: statutory import requirements for the consignments	Moderate to high	Low	High	Sampling and testing procedures influence the effectiveness of this measure	All scenarios
Certification schemes: quality requirements (private standards) for the consignment	Moderate to high	Low	High	Effectiveness as above, but no statutory basis for companies to comply with requirements	All scenarios
Treatment of the commodity	Moderate to high	Moderate	Moderate	The option has to be performed with caution due to possible phytotoxicity	–
Visual inspection at point of entry	Low to moderate	Moderate	High	Effectiveness of visual inspections is limited due to the possible presence of symptomless plants	All scenarios
Testing at point of entry	Moderate to high	Low	Moderate	Effectiveness of testing is much better than visual inspections, but detecting the nematode in the consignment is limited by size of the sampling lot	–
Limiting the final use of the imported consignment or restricting distribution to certain parts of the EU	Moderate	Moderate	Moderate to high	–	–
Eradication of infected plants/destruction of the consignments	Low to high	Low	Low to high	Effectiveness is low in case of destroying only limited number of tubers/bulbs but practical is not feasible Very effective option in case of the destruction of the whole consignment	–
Sanitation of place/site of production following outbreak	Low	Low	Low	–	–

H.2. Identification of risk reduction options to reduce the probability of spread and impact

In this section, the risk reduction options to reduce probability of spread and impact have been identified considering both, the European populations of *D. destructor* as well as non-European populations, should they enter the EU.

a) Maintain a pest-free area (protected zone status)
b) Certification of planting material
c) Official surveillance in potato and flower bulbs fields
d) Visual inspection and/or testing seed potatoes and flower bulbs to determine the health status of the plants
e) Host plant resistance
f) Agrotechnical/cultural control methods
    - Crop rotation
    - Weed management (including volunteer potato control) and removal of *D. destructor* host plant residues (e.g. potato)
g) Hygiene measures
    - Restricting the movement of equipment and tools to one location
    - Chemical disinfection of equipment and small tools
    - Cleaning/sanitation of machinery)
h) Chemical treatments (including soil fumigation before planting)
i) Hot water treatment
j) Steaming of soil
k) Anaerobic soil disinfestation/biofumigation
l) Inundation
m) Surveillance for *D. destructor* symptoms and/or testing
n) Sanitation of place/site of production following an outbreak

H.2.1. Evaluation of risk reduction options to reduce the probability of spread and impact

Here, the Panel identified and evaluated the risk reduction options to reduce the probability of spread and impact of *D. destructor*.

a) Maintain a pest-free area (EU protected zone status)

According to ISPM No. 4 (FAO, 1995), pest-free area is "an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained". Despite the fact that *D. destructor* has been reported to have limited distribution in the majority of MSs it has never been observed in the following eight MSs: Croatia, Cyprus, Denmark, Finland (intercepted only), Italy (intercepted only), Portugal, Slovenia and Spain (MS Questionnaire; EPPO PQR, online). There is no EU requirement for surveys to detect *D. destructor* and no systematic surveys are reported to be carried out at the MS level; therefore, information on the presence and distribution of this pest on both the EU and national level is unreliable. To obtain a realistic insight into the status of the pest in a country and to identify and maintain a pest-free area, extensive surveillance programme is needed. Pest-free areas represent a pest reduction option that can limit spread of a pest and guarantee that plants for planting originated from the non-infested areas are actually pest free. The effectiveness and the feasibility of this measure is considered high.

b) Certification of planting material

Crucial to the prevention of *D. destructor* introduction and further spreading into non-infested areas is the use of certified planting material (including seed potato and flower bulbs). Certification schemes for seed potatoes as well as for bulb flowers are in place in the MSs and may contribute to the detection and elimination of infested planting material prior to distribution. However, if the requirements of phytosanitary certificate are based only on visual inspection, the effectiveness of the measure would be low and some symptomless tubers would escape detection. It is therefore expected that the infected planting material will enter the pathway and will be spread. If the requirements for issuing phytosanitary certificates are based on visual inspection, sampling and laboratory testing, the effectiveness would be higher.

c) Official surveillance in potato and flower bulbs fields

Official surveillance of *D. destructor* in potato and flower bulb fields based on visual inspections and laboratory testing may be a valuable RRO tool contributing to nematode free production fields and pest-free planting material. The effectiveness of visual inspection depends on expert knowledge and may be in case of *D. destructor* low due to the potential presence of symptomless tubers/bulbs. Laboratory testing may increase the effectiveness of the official surveillance.

d) Visual inspection and/or testing seed potatoes and flower bulbs to determine the health status of the plants

In case that the official certification schemes are not organised (e.g. farm-saved seed potatoes are not produced under a certification scheme), the producers may voluntarily decide to limit crop infestation by visual inspection, sorting and removing of all potentially infected (rotten) potato tubers or flower bulbs from contaminated lots.

e) Host plant resistance

The use of resistant cultivars is recognised as the most effective control option for managing many important plant pests and diseases, although these options are not always available. Unfortunately, only partial resistance to *D. destructor* has been observed in some potato cultivars so far (Whitehead, 1998) and resistance to this nematode is more exception than the rule. No resistance data for bulb flowers was found.

f) Agrotechnical/cultural control methods

Several methods, such as crop rotation, weed management (including volunteer potato control) and removal of *D. destructor* host plant residues (e.g. potato), are available and may reduce detrimental effect of this nematode. Crop rotation has been demonstrated as one of the most powerful techniques of sustainable crop production that can diminish pest pressure by breaking its reproductive cycle (see Section 3.2.3). Managing *D. destructor* by crop rotation is considered less feasible due to the wide host range of this nematode, but nevertheless there are some reports that 3- to 4-year crop rotation can considerably decrease the population of this species (Kiryanova and Krall, 1971; Abylova and Vasilevskii, cited in Whitehead, 1998). Weed control and removal of *D. destructor* host plant residues is also important risk reduction option because weeds can serve as alternative hosts of this nematode.

g) Hygiene measures

To prevent moving the nematode from one field to another by infected soil and plant debris the following measures may be recommended:

- Restricting the movement of equipment and tools to one location
- Chemical disinfection of equipment and small tools
- Cleaning/sanitation of machinery

Such measures are considered to reduce the spread of *D. destructor* effectively, but their technical feasibility is questionable.

h) Chemical treatments (including soil fumigation before planting)

Nematicides and soil fumigation can effectively suppress populations of *D. destructor.* Their use is highly restricted due to the requirements of EU Directive 91/414/EEC[23]. At the moment, several compounds/active substances are available (EU, online).

i) Hot water treatment

Hot water treatment of infested flower bulbs is commonly used to destroy any pests which are present inside of bulb scales. Infested bulbs and tubers may be freed from nematodes, including *D. destructor* that may be present within these organs by dipping them in hot water at chosen

[23] Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market. OJ L 230, 19.8.1991, p. 1–32.

temperatures for a period that is long enough to kill all viable nematodes (Whitehead, 1998). It was reported that *D. destructor* may be controlled by dipping of dormant iris and other flower bulbs in hot water at 43.6°C for 3 h (Sturhan and Brzeski, 1991). According to Thorne (1961), *D. destructor* may be almost completely exterminate from infested iris bulbs by dipping them for 3 h in hot (43.5°C) water that contain formaldehyde After such treatment, the bulbs should be cooled and dried by spreading out in a well-ventilated place. However, some varieties may be injured during this treatment (CABI, online).

D. destructor may also be efficiently controlled by dry heat treatment (e.g. dry storage of harvested garlic at temperatures of 34–36°C for 12–17 days greatly decreased the *D. destructor* population in the tissues) (Fujimura et al., 1989). Hot water treatment is not used to control the nematode in seed potato (Mai et al., 1981).

j) Steaming of soil

Steaming of soil is a well established and effective method used to eliminate soil inhabiting harmful organisms (including nematodes) from soil (Neshev et al., 2008). Due to high costs, pest control inconsistencies and energy wastefulness, steam is currently not used in the open fields. In addition, many other undesirable side effects may arise, e.g. complete elimination of all soil microorganisms which leads to increased soil aggregation and destruction of soil structure and releasing of toxic breakdown substances of organic matter and releasing of minerals at toxic levels from organisms. Adverse effects on beneficial organisms in the soil can create a biological vacuum and opportunities for colonisation of other organisms (Neshev et al., 2008). Steaming may therefore only be used against D. destructor within the soil or substrate in protected areas (e.g. greenhouses, Yunlong et al., 2013). The effectiveness of this measure is considered high; its feasibility is high under protected cultivation and low in the open fields.

k) Anaerobic soil disinfestation/biofumigation

This RRO is not proven to be effective against *D. destructor* (no data available) but is effective against other species (Salem and Mahdy, 2015; Youssef, 2015) and thus could work also against *D. destructor.*

l) Inundation

Soil-borne nematodes can be effectively managed by flooding. The key factor of this control measure is the length of inundation. The soil where certain pests are present has to be flooded for several weeks or months. However, the duration of flooding, which is necessary for the control of the pest fluctuates during the growing season. To maximise the effect of inundation to control *D. dipsaci*, it is necessary to achieve soil temperatures around 17°C or higher (Kos, 2015). 6–8 or even 10 weeks is needed to achieve good results against *D. dipsaci* in summer; longer period of inundation is needed to achieve the same effect when soil temperatures are lower (Kos, 2015). According to Whitehead (1998), *D. dipsaci* can effectively be controlled by 9 weeks flooding in the Netherlands. However, the effectiveness of the inundation is not the same for all nematode species. Kos (Kos, 2015) reported controlling activity against *D. dipsaci* as well and against *D. destructor* as moderate. Inundation is used quite often in the cultivation of flower bulbs as sustainable way for control of nematodes (Kos, 2015). This RRO can only be used in areas where there is enough water and where configuration of the terrain is suitable (the land should not be inclined) (Whitehead, 1998).

m) Surveillance for *D. destructor* symptoms and/or testing

Surveillance programs are needed to obtain a realistic insight into the prevalence of the pest and into a health status of the (even symptomless) crops. Based on the information provided by monitoring and testing, the growers can determine what actions can be taken against the pest. In general, *D. destructor* do not cause recognisable aboveground symptoms, although heavily infected plants may be weaker with smaller and deformed leaves (Esser and Smart, 1977). Early infections can be detected by visual inspection of tubers/bulbs, however light infections may be easily overlooked. Tubers/bulbs should be therefore cut or peeled for discovering the lesions (necrosis) caused by this nematode. At the later, *D. destructor* may cause discoloration and rotting of plant tissue. For precise species identification morphological examination using microscope is needed.

n) Sanitation of place/site of production following an outbreak

Apart from not growing potato and other host plants, no cultural practices and control measures may be applied in order to prevent the establishment of *D. destructor* or to eradicate it once being present in a field.

H.2.2. Summary of risk reduction options to reduce the probability of spread and impact

Table H.2: Summary of risk reduction options to reduce the probability of spread and impact

Identified measure	Effectiveness	Uncertainties	Feasibility	Comments	Considered in scenarios
Maintain pest-free area (protected zone status)	Moderate to high	Medium	Low	–	A4-PW2
Certification of planting material	Moderate	Medium	High	Effectiveness is rated low if the option only based on visual inspections	All scenarios
Official surveillance in potato and flower bulbs fields	Moderate	Low	Low	–	A2-PW1, A3-PW2 and A4-PW2
Visual inspection and/or testing seed potatoes and flower bulbs to determine the health status of the plants	Moderate	Low	Moderate	Low if only visual inspection is in place	–
Host plant resistance	High	Low	Negligible to low	Resistant varieties (potato, bulb flowers) are not available so far	–
Agrotechnical/cultural control methods	Moderate	Moderate	High	Crop rotation is difficult and less effective as this nematode is polyphagous. Precise weed control is important due to wide host range of *D. destructor* and may help to decrease pest population efficiently. Crop rotation is more effective in combination with weed control	–
Hygiene best practice	Moderate	Moderate	Low to moderate	–	–
Chemical treatments (including soil fumigation before planting)	High	Low	Moderate to high	Use of chemicals can be very effective but expensive	A6-PW1
Hot water treatment	High	Low to moderate	Moderate to high	Only applicable for flower bulbs	A5-PW2
Steaming of soil	High	Low to moderate	Moderate	–	–
Anaerobic soil disinfestation/ biofumigation	Moderate	High	Moderate	–	–
Inundation	High	Moderate	Low to moderate	It can only be used in areas where enough water is available and configuration of the terrain is suitable (e.g. NL – flower bulb production)	–
Surveillance for *D. destructor* symptoms and/or testing	Moderate	Moderate	Moderate	–	–
Sanitation of place/site of production following outbreak	Low	Low	Low	–	–

H.3. Synthetic analysis of the current situation

The current regulation (Council Directive 2000/29/EC Annex II, Part A, Section II) prohibits the introduction into and spread within the MSs of *Ditylenchus destructor* Thorne infected flower bulbs and corms of *Crocus* L., miniature cultivars and their hybrids of the genus *Gladiolus* Tourn. Ex L., such as *Gladiolus callianthus* Marais, *Gladiolus colvillei* Sweet, *Gladiolus nanus* hort., *Gladiolus ramosus* hort., *Gladiolus tubergenii* hort., *Hyacinthus* L., *Iris* L., *Trigridia* Juss, *Tulipa* L., intended for planting, and potato tubers (*Solanum tuberosum* L.), intended for planting.

In addition, *D. destructor* host plants are regulated in Annex IIIA of Council Directive 2000/29/EC as regards import prohibitions for the entire EU for specific commodities, as well as in Annex VAI, VAII and VBI as commodities subject to plant health inspections and phytosanitary certificate or plant passport.

Lastly, some of the host plants of *D. destructor* are also regulated under the Directives on the marketing of vegetable propagating and planting material, other than seed (Council Directive 2008/72/EC[24]); marketing of fruit plant propagating material and fruits plants intended for fruit production (Council Directive 2008/90/EC[25]); marketing of seed potatoes (Council Directive 2002/56/EC[26]); marketing of seed of oil and fibre plants (Council Directive 2002/57/EC[27]); marketing of fodder plant seed (Council Directive 66/401/EEC[28]); marketing of cereal seed (Council Directive 66/402/EEC[29]); and marketing of propagating material of ornamental plants (Council Directive 98/56/EC[30]). *D. destructor* is listed in the marketing Commission Directive 93/49/EC[31] on ornamentals as a Regulated Non-Quarantine Pest (RNQP) with a 'substantially free from' tolerance level.

These regulations have some limitations, two of which have been identified by the Panel:

- Visual inspection might be effective, however, symptomless (not rotten) tubers may escape detection
- The current EU legislation on *D. destructor* limits restrictive measures to certain bulb flowers and potato. In fact, besides in the Directive listed plants, several other plant species for planting (e.g. *Allium* ssp.) have been reported as natural hosts of this nematode; for more detail, see Section 3.2.2 on host range.

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24 Council Directive 2008/72/EC of 15 July 2008 on the marketing of vegetable propagating and planting material, other than seed. OJ L 205, 1.8.2008, p. 28–39.

25 Council Directive 2008/90/EC of 29 September 2008 on the marketing of fruit plant propagating material and fruit plants intended for fruit production. OJ L 267, 8.10.2008, p. 8–22.

26 Council Directive 2002/56/EC of 13 June 2002 on the marketing of seed potatoes. OJ L 193, 20.7.2002, p. 60–73.

27 Council Directive 2002/57/EC of 13 June 2002 on the marketing of seed of oil and fibre plants. OJ L 193, 20.7.2002, p. 74–97.

28 Council Directive 66/401/EEC of 14 June 1966 on the marketing of fodder plant seed. OJ 125, 11.7.1966, p. 2298–2308.

29 Council Directive 66/402/EEC of 14 June 1966 on the marketing of cereal seed. OJ 125, 11.7.1966, p. 2309–2319.

30 Council Directive 98/56/EC of 20 July 1998 on the marketing of propagating material of ornamental plants. OJ L 226, 13.8.1998, p. 16–23.

31 Commission Directive 93/49/EEC of 23 June 1993 setting out the schedule indicating the conditions to be met by ornamental plant propagating material and ornamental plants pursuant to Council Directive 91/682/EEC. OJ L 250, 7.10.1993, p. 9–18.

Appendix I – Further specification on host range

Plants listed in Annex IIAII a) point 3 of Council Directive 2000/29/EC and of host plants with a vegetative underground propagating part listed in the Pest Categorisation of *D. destructor* (EFSA PLH Panel, 2014) are listed in Table I.1.

Table I.1: Cultivated host plants of *D. destructor* with an underground vegetative part used for propagation

Common name	Latin name	Listed in Annex IIAII of Council Directive 2000/29/EC
Gladioli	*Gladiolus* spp.	Yes
Hyacinths	*Hyacinthus orientalis*	Yes
Bulbous iris	*Iris* spp.	Yes
Tulips	*Tulipa* spp.	Yes
Onion[(a)]	*Allium cepa*	No
Garlic	*Allium sativum*	No
Begonias	*Begonia* spp.	No
Dahlias	*Dahlia* spp.	No
Strawberry	*Fragaria ananassa*	No
Hop	*Humulus lupulus*	No
Rhubarb	*Rheum rabarbarum*	No

(a): May be cultivated from seed or bulbs.

Their host status was assessed based on a literature search in ISI Web of Knowledge in order to answer the question whether the plants listed in Table I.1 are host plants and whether this was supported by data from literature.

The following search terms were used in the advanced literature search function of ISI Web of Knowledge with the following settings: Timespan = All years and Search language =Auto (http://apps.webofknowledge.com/WOS_AdvancedSearch_input.do?SID=Q2M2R9jDSilmfX15mMm&product=WOS&search_mode=AdvancedSearch).

Table I.2: Number of references found using the following search terms in ISI Web of Knowledge

No.	Search term	Results
1	TS= (destructor AND allium) NOT TS=Peronospora	70
2	TS= (destructor AND crocus)	11
3	TS= (destructor AND hyacinth*)	18
4	TS= (destructor AND tulip*)	55
5	TS= (destructor AND gladiolus)	28
6	TS= (destructor AND iris)	56
7	TS= (destructor AND tigridia)	3
8	TS= (destructor AND dahlia)	18
9	TS= (destructor AND humulus)	27
10	TS= (destructor AND hop)	36
11	TS= (destructor AND tropaeolum)	2
12	TS= (destructor AND rheum)	6
13	TS= (destructor AND rhubarb)	7
14	TS= (destructor AND narcis*) NOT TS=Peronospora	27
15	TS= (destructor AND Fragaria)	39
16	TS= (destructor AND begonia)	6
References after automatic duplicate removal, manual deletion of references with incomplete citation (missing titles, journals etc.) and deletion of references considered not relevant[(a)]		87

(a): References considered not relevant contained: all references dealing with mites, mycoflora/fungi (in particular Peronospora), classification schemes (e.g. EPPO) or data sheets (incl. CABI, online), leaflets.

All records were exported to and processed with EndNote X7. Using the function 'Find duplicates', duplicate references were deleted. References prior 1945 were excluded as they were not expected to be found during the search (note: *D. destructor* was described in 1945). References dealing with mites, insects, mycoflora or fungi in general (in particular *Peronospora*), classification schemes such as EPPO standards or data sheets such as CABI (online), or general leaflets were excluded. Citations with incomplete information on type of publication were also deleted. A total of 87 references was left in the database and titles or abstracts were screened to check whether the information provided was relevant to the question on host status of a given plant genus.

Most reports considered were produced in the 1950s until 1980 (about three quarters of references in the database) and those mostly concerned flower bulbs such as iris, dahlia and crocus as well as potatoes (which were not part of the search). A number of them were reports of the pest on hosts in yearbooks such as the Annual reports of the Laboratory for Flower Bulb Research, Lisse or the reports from the Dutch National Plant Protection Organisation ('Gewasbescherming'). Although not all details on the host–parasite relationship were available through these publications, the fact that the presence *D. destructor* received attention on a certain host plant was considered evidence for the host status. In the period 1981–1990, there were only eight reports but a new host, garlic, was described. Hop as a host plant also received attention during that period, although hop was already reported by Goodey (1952) as a host. In the years following 1990 until now, 14 reports in the database focused mainly on garlic and hop with the majority of publications dealing with molecular identification within the genus *Ditylenchus*.

The large number of references retrieved for the search term combination regarding onion was mainly due to the fact that other pests with the species name 'destructor' were not excluded by the search term combination despite exclusion of 'Peronospora'. Searches for onion as a host plants did not corroborate the statement made by Esser (1985). Gubina (1988) does not list onion as a host plants.

Summaries of the findings are presented in Tables I.3 and I.4.

Table I.3: Summary of literature search on host plants of *D. destructor* listed in Annex IIAII a) point 3 of Council Directive 2000/29/EC

Host plant	Evidence host plant	Evidence non-host plant	Conclusion
Crocus	Oostenbrink (1959): Statement that few corms were attacked by *D. destructor* Slootweg (1961): Hot water treatment of *D. destructor* infected crocus Laboratorium voor Bloembollenonderzoek (1977): Studies on *D. destructor* on crocus Laboratorium voor Bloembollenonderzoek (1980): Studies on hot water treatment of tulips and crocus for control of *D. destructor* Winter (1980): Aldicarb to control *D. destructor* in soil		*Crocus* is a host plant
Gladiolus		Smart (1959): Decaying roots of a gladiolus bulb. The nematodes from *Gladiolus* were probably feeding on fungi rather than on the roots Goodey (1952): Inconclusive evidence of *Gladiolus* as host; Gladiolus not affected in first year but *D. destructor* was able to multiply after storage (maybe on Botrytis?)	Unclear status but *Gladiolus* is most likely not a host plant
Hyacinthus	Hastings et al. (1952): Authors mention bulb nematode of iris, narcissus and hyacinth (indistinguishable morphologically from *D. destructor*) Milkova and Katalan-Gateva (1984): List tulip and hyacinth as host (only abstract available)		*Hyacinthus* is probably a host plant
Iris	Goodey (1950): Statement that there was 'conclusive' evidence as host Goodey (1951): Evidence as host provided Goodey (1952): *Iris* is host for *D. destructor* Oostenbrink (1953): Report of D. destructor on iris Bosher (1953): Potatoes affected by *D. destructor* previously planted with 'iris bulb nematode' Kuiper and Silver (1959): *D. destructor* on iris, *Tigridia pavonia*, *Tulipa praestans* and *T. saxatilis* Bosher (1960): *D. destructor found* in an iris plantation Wu (1960): Morph. investigation on *D. destructor* from iris and dahlia Laboratorium voor Bloembollenonderzoek (1973): Warm water treatment for the control of *D. destructor* on iris Laboratorium voor Bloembollenonderzoek (1974): Hot water treatment effective against *D. destructor* on *Tulipa praestans* and on irises Hastings et al. (1952): Authors mention bulb nematode of iris, narcissus and hyacinth (iris: indistinguishable morphologically from *D. destructor* from potato). (only abstract available but not conclusive)		*Iris* is a good host plant

Host plant	Evidence host plant	Evidence non-host plant	Conclusion
	Slootweg (1958): Report that HWT is effective against *D. destructor* in iris and that tulip is affected by *D. destructor* Os (1970): Mentions that iris is inspected for *D. destructor* Maggenti and Hart (1975): *D. destructor* on iris Nakanishi (1979): Control of *D. destructor* on iris Matsushita et al. (1981): Symptoms of *D. destructor* on iris but no symptoms on tulip Haglund (1983): Nematicide control of *D. destructor* on iris		
Tigridia (*Trigridia*)	Kuiper and Silver (1959): *D. destructor* on iris, *Tigridia pavonia*, *Tulipa praestans* and *T. saxatilis*		*Tigridia* is most likely a host plant
Tulipa	Slootweg (1958): Report that HWT is effective against *D. destructor* in iris and that tulip is affected by *D. destructor*? Slootweg (1963): Soaking bulbs of *Tulipa praestans* Fuselier in AC 18133 gave some control of *D. destructor*, but the result was less effective than that with hot water treatment Laboratorium voor Bloembollenonderzoek (1980): Studies on hot water treatment of tulips and crocus for control of *D. destructor* Laboratorium voor Bloembollenonderzoek (1974): Hot water treatment effective against *D. destructor* on *Tulipa praestans* and on irises Milkova and Katalan-Gateva (1984): Confirmation of tulip and hyacinth as host Kuiper and Silver (1959): *D. destructor* on *Iris*, *Tigridia pavonia*, *Tulipa praestans* and *T. saxatilis*	Matsushita et al. (1981): Symptoms of *D. destructor* on iris but no symptoms on tulip	*Tulipa* is a host plant
Potato	(Not included in search)		

Table I.4: Summary of literature search on host plants of Ditylenchus destructor not listed in Annex IIAII a) point 3 of Council Directive 2000/29/EC

Host plant	Evidence host plant	Evidence non-host plant	Conclusion
Rhubarb	Dern (1966): Rhubarb is damaged by *D. destructor* Brinkman (1977): *D. destructor* damaged the fleshy roots causing the formation of loose dark-brown tissue on the surface Plantenziektenkundige Dienst, Wageningen (1977): *D. destructor* caused rotting of rhubarb stems and petioles		Rhubarb is a host plant
Hop	Goodey (1952): hop is host for *D. destructor* Katalan-Gateva and Konstantinova-Milkova (1973): *D. destructor* found in hop roots of 2 cultivars (BG) Katalan-Gateva and Konstantinova-Milkova (1975): *D. destructor* found in 83% of samples. Cultivar difference in susceptibility (BG) Katalan-Gateva and Milkova (1979): *D. destructor* was the dominant nematode species found in hop (BG) Foot and Wood (1982): *D. destructor* infecting hop in NZ Gaar and Cermak (2013): *D. destructor* found in hop (CZ) Vostrel et al. (2012): Hop mortality in Bohemia and Moravia also caused among others by *D. destructor* (CZ) Goodey (1952): hop is host for *D. destructor*		Hop is a host plant Skarbilovich (1972) described a new species: *D. humuli*. Skarbilovich (1980) found that *D. humuli* does not cause disease in potato but *D. humuli* is similar to *D. destructor* (more than to *D. dipsaci*)
Garlic	Fujimura et al. (1986): Garlic described as new host for *D. destructor* (Japan) Fujimura et al. (1989): Treatments for *D. destructor* infested garlic (Heat treatment) Yang et al. (1995): Title: 'The symptom and control of *Ditylenchus destructor* on garlic' (Chinese publication, only title available) Yu et al. (2012): First record of *D. destructor* on garlic in Canada German and Sagitov (1983): Mention onion and garlic as hosts		Garlic is host plant
Onion	German and Sagitov (1983): Mention onion and garlic as hosts	Safyanov (1965): strawberry and onion are mentioned as non-hosts	Unclear host status (few records available)
Dahlia	Smart (1959): *D. destructor* isolated from tuberous roots of Dahlia Jensen et al. (1958): *D. destructor* found in dahlia roots Wu (1960): morph. investigation on *D. destructor* from iris and dahlia		*Dahlia* is a host plant
Narcissus	Hastings et al. (1952): Authors mention bulb nematode of *Iris*, *Narcissus* and hyacinth (indistinguishable morphologically from *Ditvlenchus destructor*). Abstract not conclusive		Unclear host status

Host plant	Evidence host plant	Evidence non-host plant	Conclusion
Fragaria	Smirnova and Koev (1976): Title is on control of *D. destructor* in strawberry seedbeds Metlitskii (1972): *D. destructor* from potato produced symptoms on strawberry	Safyanov (1965) (strawberry and onion are mentioned as non-hosts)	Doubtful host
Begonia		Goodey (1952): Begonia is not a host for *D. destructor* but for *D. dipsaci*	Not host

Appendix J – Hearing experts

J.1. Replies to questions by hearing experts

On 7 June 2016 a hearing was conducted with Ms Prisca Kleijn, director of the Royal General Bulb Growers' Association (Koninklijke Algemeene Vereeniging voor Bloembollencultuur) and Mr Peter Knippels, senior adviser of Flower Bulb Inspection Service (Bloembollenkeuringsdienst, BKD) in Lisse, the Netherlands.

The hearing experts have answered in writing the questions that had been sent to them by the Working Group (WG) beforehand and during the hearing gave oral clarification on the written answers and further oral questions from the WG members. Following the hearing, the hearing expert received the draft minutes of the questions and answers and the opportunity was given to correct or complement the information. The questions and answers are provided below.

J.1.1. Prisca Kleijn – Questions and Answers

1) What is the production area and the production volume of the different flower bulb species in the Netherlands?
The total production area of flower bulbs in the Netherlands is about 22.000 ha.
To assess the production volume of the different flower bulb species is very difficult due to different species and varieties.
The most important species are tulips followed by Lilies (4.200 ha), Daffodils (1.447 ha) and Hyacinths (1.290 ha).

2) Where are the main areas for flower bulb production in the Netherlands? Please specify the acreage and percentage of total production. What are the reasons for concentration in certain areas if applicable?
The main bulb production area is the western part of the Netherlands (Province Noord- en Zuid-Holland and Flevoland) due to climate, water and soil conditions. About 75% is grown in the western part of the Netherlands.
Tulips are mainly grown in Western part of the Netherlands as mentioned above with approximate distribution: 1/3 N Holland, 1/3 Z Holland, 1/3 Flevoland.
Sandy soils are preferred for flower bulbs (especially for Hyacinths and Daffodils) production because they cause no damage during harvesting. In Flevoland, tulips are grown also on clay soil.

3) Concerning Dutch tulip bulbs production, could you fill the following table? Please be also so kind to let us know if 20 g per tulip bulb is a reasonable estimate or please give us a range of possible weight of a tulip bulb.

Dutch tulip bulbs production		
Year	***Production area in ha***	***Estimated production (tons per ha)***
2007	*10.739*	–
2008	*11.390*	–
2009	*11.727*	–
2010	*11.398*	–
2011	*11.861*	–

The Estimated production is very difficult to indicate. It depends on the bulb cultivar, the size of the harvested bulbs, the season and soil type. The average production per ha is about 2.4 million tulips. More information on production: https://www.cbs.nl/nl-nl*.*
20 g per tulip bulb is indeed a reasonable estimated weight.

4) To which Member States are bulbs distributed which have been imported into the Netherlands from third countries? Does the cultivation of the imported bulbs take place in open field or in protected production place?
Most of the imported bulbs are used by professionals in the Netherlands for flower production or propagation material. Most of the flower production takes place in greenhouses.

Most important import are lilies in winter season when own production is not available. In general the imports are relatively low. The tulip bulbs are imported at very low level from New Zealand only in period out of season. The bulbs are imported from other countries to grow flowers from them. The flowers are grown in glasshouses and the waste (=rest of the bulbs) is composted on the premises under strict conditions (e.g. reaching sufficient temperature to kill pathogens).

5) Are the bulbs then sold to final consumers or are they used for propagation/multiplication purposes for plants for planting? Can you estimate the ratio of these two different uses?
The imported bulbs are not sold to final consumers; they are uses by professionals for flower production (+/−90%) or propagation material (+/−10%).

6) What requirements of the industry do imported flower bulbs have to meet? Please provide us with supporting documents if possible. How is supervision carried out in third countries?
The requirements for imported bulbs are mentioned in EU directive 2000/29/EC and 98/56/EC.
The Netherlands does not supervise the production in third countries this is the responsibility of the third country. The bulbs when imported have to fulfil the requirements as specified above and the Netherlands checks the quality and plant health status.

7) What nematodes specific requirements are in place for production of flower bulbs in a) the Netherlands and b) third countries? At which level inspection, sampling and testing requirements are carried out (e.g. fields or lots/consignments)? What nematode specific control measures are used to treat the bulbs (e.g. hot water treatment)? Are these measures applied routinely? Are they applied in the Netherland or in third countries production under Dutch supervision? In which stage of the flower bulb production process are these measures applied?
Dutch growers apply hot water treatment, crop rotation and/or inundation if requested or needed. These measures are not always applied routinely and are used in different stages of the flower bulb production.
Tulips can be very easily damaged by hot water treatment; hence this treatment is not often used. For Daffodils the hot water treatment is used routinely for other pests (e.g. Ditylenchus dipsaci) every 2/3 years.
Flooding of fields is used frequently by tulip growers. This is against nematodes in general. Inundation is done after tulip harvest in between crop rotation every 3/4 years as a part of crop rotation. It is done in summer time to have a sufficient temperature for effectiveness of the measure.
There is an advice of the Wageningen University and Research regarding the inundations available to growers.
http://edepot.wur.nl/151068 *(only available in Dutch)*

8) What other risk reduction options are used/applied in the Netherlands in flower bulbs production? What are the main target pests or pathogens? Are they considered effective?
Against nematodes there are no other measures then the ones mentioned under question 7. The measures are considered effective. Metam sodium is allowed, but under very strict conditions due to environmental concerns, e.g. not close to homes or schools. Therefore, in practice, metam sodium cannot be used. Oxamyl (Vydate) cannot be used under most circumstances because of restrictions. It can sometimes be used in lilies, but not this year because it is not available. There is no a specific guidance on use of nematicides as only approved nematicides can be used.

9) What are the crop rotations used for the production of flower bulbs in the Netherlands? Please specify the main standard crop rotations only.
Crop rotation is needed to remain a healthy soil (1:5)
The main crops in rotation with flower bulbs are: potatoes, sugar beet, vegetables (e.g. cauliflower, cabbage), perennials, plants of other families, maize (in combination with lilies but not with tulips – maize is not grown in western part of the Netherlands). Cereals are not grown/cultivated in the crop rotation with flower bulbs.

10) Are risk reduction options used/applied in the Netherlands in other flower bulb species different from those in tulips?
Against nematodes there are no other risk reduction options than the ones applied in tulips. For the other flower bulbs the same technology is used (inundation, hot water treatment, crop rotation, nematicide (nematicide not this year).

11) What soil treatments are used in flower bulb production in the Netherlands? Which is the main reason for applying soil treatment?
The main reason for applying soil treatment such as flooding the production site (inundation) and crop rotation is to remain a healthy soil. There are no chemical treatments available or allowed.
There are no additional requirements above the requirements of the EU or third countries.

12) What are the storage conditions of flower bulbs? Please specify the periods and durations. Please be so kind to provide us with an example of a scheme for storage conditions of flower bulbs if possible.
The storage condition of the different flower bulbs divers strongly. There is not one specific condition. For example lilies need different conditions than tulips or daffodils.
There are no standard storage conditions. The storage conditions depends on the cultivar and the place where the bulbs are used, e.g. for greenhouses and export; for each cultivar are needed different conditions. Also a period of cold is needed during storage.
In general the storage conditions for lilies are near 0°C and for tulip bulbs between 2 and 6°C (below 10°C).
The tulip bulbs storage duration under field condition production is in general 1–2 months (e.g. in the Netherlands the tulip bulbs are harvested third week in June, sold in August and planted in October).
Unfortunately I cannot provide an example of a scheme.

13) Are there any special measures against *Ditylenchus destructor*?
No, there are no special measures against Ditylenchus destructor.

14) Is *Ditylenchus destructor* (still) considered an actual or potential pest in flower bulbs?
Ditylenchus destructor is not considered a problem in flower bulbs.

J.1.2. Peter Knippels – Questions and Answers

1) What certification schemes are implemented for different flower bulb species produced in the Netherlands? Please specify the plant species (or genera) and provide us with the documents or a link to the relevant documents.
The Flower Bulb Inspection Service (BKD) has implemented a classification scheme for all flower bulbs, except for Nerine and Freesia. These schemes are published on the website of the BKD: http://www.bkd.eu/uitvoeringsrichtlijnen*. In these schemes are besides quality aspects also EU-quarantine pests mentioned.*

2) How are the inspections during the production process of flower bulbs performed? Please consider the different stages (from pre-planting to harvest and storage). Please specify procedures for sampling, visual inspection, laboratory tests if applicable.
All flower bulbs grown in the Netherlands by commercial producers are inspected visually at least once during the growing period in the field. During the visual inspection at least 10% of the area of each lot is inspected.
From experience we know that symptoms of Ditylenchus destructor are most easily seen at flowering. Crocus is inspected March/April, tulips April/May, it depends on the species and the variety. The inspections combine quarantine and quality diseases. For most crops we do two field inspections. One is done during flowering. The other one is done either before or after flowering. Most inspections are done in the period March-May. The pattern in the field is such that the inspectors see all the corners of the lot.
Field inspection is always done. Inspection after harvest (dry bulb inspection) is only done upon indication. Indications are:
    a) *obligatory dry bulb inspection in the case Ditylenchus destructor was found during field inspection;*

b) *the bulbs are meant for export to third countries.*

All inspectors are trained on inspection procedures and symptomatology of the relevant pests (induction and yearly trainings, manuals with pictures available).

3) At which level are inspections carried out, i.e. fields, lots or consignments? Please specify units (area, volume, weight, numbers). Are all fields, lots or consignments tested?
The planted lots are visually inspected in the field. A lot is a certain area of one variety or species of one genus planted on one field. There is no minimum or a maximum area limit for a lot.

4) Which agencies and laboratories are involved in the implementation of the certification schemes? Please specify their roles and reporting lines.
If the BKD detects plants with symptoms of Ditylenchus destructor during the field inspection the plants with symptoms are taken out of the soil and sent to the NRC of the NVWA for diagnosis. The NRC diagnoses the sample and reports the results to the BKD. The BKD informs the producer.

5) How is the NPPO of the Netherland involved in the certification of flower bulbs? Which NPPO agencies, e.g. NVWA, are involved? Please specify their roles.
The quality schemes of flower bulbs are enforced by the BKD. The EU-quarantine pests are part of the quality schemes. The inspection methods, registration, sampling of infected plants and measures are based on EU and national legislation and specific directives of the NVWA. In the case of EU-quarantine pests, the NVWA is the ordering party for the BKD.

6) What are the inspection requirements for imported flower bulbs intended for a) intra-EU trade or b) further propagation in the Netherlands? Please specify the plant passport requirements for flower bulbs.
The requirements for imported bulbs are indifferent from the use of the bulbs. All imported bulbs must meet the requirements of plant passport as stated in the Directive 92/105/EEG of 3 December 1992.

7) What additional requirements of the industry do imported flower bulbs have to meet? Please provide us with supporting documents if possible. How is supervision carried out in third countries?
There are no additional requirements for imported flower bulbs other than the EU-legislation. There is no supervision carried out in third countries.

8) What are the inspection requirements for flower bulbs intended for export to third countries? Are these different from requirements for intra-EU trade?
The requirements for bulbs intended for export to third countries are the same as for use inside the EU.

9) What are the specific requirements required under the certification schemes for tulip (if different from other species)?
There are no special requirements for tulips in de inspection schemes of the BKD.

10) Which nematode specific requirements (inspection, sampling and testing) for flower bulbs are in place?
The inspection method of the BKD in the field is a visual inspection on all diseases, including nematodes. The other aspects are mentioned under questions 2, 3 and 4.

11) How often was *Ditylenchus destructor* detected in flower bulbs (fields or lots or consignments) during the last decades? Has the number of detections increased or decreased over the last decades? What reasons have been identified or suspected for either increase of decrease?
In Annex IIAII of 200/29/EG, flower bulbs are mentioned which have to be inspected on Ditylenchus destructor. Lots of these flower bulbs are visually inspected in the field.
The number of detections has decreased in the last decades. The most detections were during the field inspections. A limited number of detections are found during the dry bulb inspections as a part of the export inspections. Ditylenchus destructor is detected in lots of Crocus and Tulipa.
The number of detections in the field inspections 2015

Crocus: 2 out of 617 inspected lots
Tulipa: 0 out of 16.060 inspected lots
The number of detections during the inspection of bulbs after harvesting:
Crocus: 11 out of 617 inspected lots.

12) What measures are taken when *Ditylenchus destructor* is found?
In case Ditylenchus destructor is found during an inspection in the field, the BKD rejects the lot and a document with measures is issued to the producer. It is the responsibility of the growers to take/perform the measures.
The measures are
   a) *the lot can only be traded for consumer destination within the EU after the lot has been re-inspected after harvesting and during this inspection no symptoms of nematodes are found;*
   b) *the propagation material can only be used for replanting after a hot water treatment done by the producer. The other possibility is destruction of this lot.*
   The re-inspection after harvesting in performed according to the same procedure as the first inspection (per lot a sample of 400 bulbs (tulip) or 200 bulbs (crocus) is visually inspected).

13) What measures are taken when *Ditylenchus destructor* is not found?
In the case no Ditylenchus destructor is found, the BKD issues the plant passport.

14) Are there routine treatments (e.g. hot water, application of plant protection products) for consignments? When are those measures applied? Please consider plants produced in the Netherlands and in third Countries where flower bulbs are produced under Dutch supervision.
This is described under question 12. The BKD is not involved in the production of flower bulbs in other countries than the Netherlands.

15) What is the crop rotation used for flower bulbs production in the Netherlands? Are flower bulbs grown in rotation with a) seed or b) ware potatoes?
The general crop rotation is one every 5 years bulb production for a specific bulb crop. In certain areas of the Netherlands fields are only used for bulb production. The rotation is then only with other bulbous crops. Bulbs are in some parts of the country grown in rotation with seeds or ware potatoes.
The fields itself are not tested for pests as a part of the official inspection procedures. Only the cultivated crops are sampled and inspected (inspection of the crop in the field). In case of Ditylenchus destructor there are no regulations for soil treatment.

16) What soil treatments are used in flower bulb production in the Netherlands? Which is the main reason for applying soil treatment?
The BKD is not involved in the soil treatments for bulb production. This is up to the producers. The main reasons for applying soil treatment are nematodes, weeds and fungi.

17) What risk reduction options are used/applied in the Netherlands in tulip production? Are they considered effective?
The BKD has no information on this aspect.

18) Are risk reduction options used/applied in the Netherlands in other flower bulb species different from those in tulips?
The BKD has no information on this aspect.