Pest risk assessment for the European Community: plant health: a comparative approach with case studies

Prima phacie

Identification and evaluation of risk reduction options: *Meloidogyne fallax*

December 2011

Van der Gaag[1] DJ, Viaene[2] N, Anthoine[3] A., Ilieva[4] Z, Karssen[1] G, Niere[5] B, Petrova[4] E, Wesemael[2] W

1 Plant Protection Service, Wageningen, the Netherlands
2 Institute for Agricultural & Fisheries Research, Merelbeke, Belgium
3 French Anses (French agency for food, environmental and occupational health & safety) – Plant Health Laboratory (LSV) – Angers, France
4 Plant Protection Institute, Kostinbrod, Bulgaria
5 Julius Kühn-Institute, Braunschweig, Germany

Summary

Risk reduction options were identified and evaluated for effectiveness to reduce the risk of entry and spread of *M. fallax*. A full risk assessment has been conducted in another document within the framework of EFSA project CFP/EFSA/PLH/2009/01.

Phytosanitary control of *M. fallax* is complicated by the following factors:

- *M. fallax* may be more widespread in the EU than presently known.
- *M. fallax* has a very wide host range and can easily be overlooked because it does not cause much damage and does not produce (clear) visible symptoms on many of its host plants.
- There are many pathways by which *M. fallax* may enter fields and areas that are not yet infested and there is a large trade volume of plants for planting and plant products that could be infested or infected.

For effective prevention of spread of *M. fallax* in the EU, intensive surveillance would be needed to determine the present distribution and to check for implementation of measures after an infestation have been found. The following options were considered:

- Isolation of infested fields. A black fallow period for at least 2 years or as long as needed for eradication where entering of fields is only allowed for weed control. This measure is highly effective for fields found infested but not all fields infested may be detected because of detection limits. The option is feasible at the local level but has a low feasibility in general because *M. fallax* is already present in several areas in the EU.
- A pest free area (PFA), pest free production place or site (PFPP) for the production of seed potatoes or testing of seed potatoes. This option is effective but may not fully prevent entry or spread by seed potatoes because of detection limits.
- A pest free area (PFA), pest free production place or site (PFPP) for the production of plants for planting other than seed potatoes. This option is effective but may not fully prevent entry or spread because of detection limits. Because of its very wide host range and uncertainties about the size of the host range, it was not possible to set up a full list of host plants. *M. fallax* cannot only be spread in roots of or soil attached to host plants but may also be spread in soil attached to non-host plants.
- The pest could also be spread through waste materials from products of host plants that can become infected or infested. Proper treatment of waste materials obtained during processing and packaging of such products may be more effective than a PFPP because pest freedom of a production place cannot be fully guaranteed due to detection limits.

In conclusion, phytosanitary measures can reduce the rate of spread of *M. fallax* but the likelihood of spread (likelihood of at least one event per year) remains medium or even high (depending on the extent of the present distribution in the EU) because of detection limits and the large trade volume. The measures will limit the use of agricultural fields in areas where *M. fallax* is already present.

Introduction

Meloidogyne fallax is presently a quarantine organism in the EU and regulated for all stages of its development (2000/29/EC, Annex IAII). Pest risk assessments of *M. fallax* have recently been prepared within the framework of EFSA project CFP/EFSA/PLH/2009/01 according to 2 different (experimental) methods, referred to as method 2b and method 4b. Various pathways for entry and spread were identified in these pest risk assessments and four main pathways were considered most relevant for spread from infested areas into non-infested areas in the EU and for entry from third countries. These **four main pathways** with their **sub-pathways** are:

1. Plants intended for planting of host plants with or without soil attached originating from areas where *M. fallax* is present. This pathway includes any propagation material except plants derived from tissue culture. Two sub-pathways,
    - **a.** seed potatoes
    - **b.** plants intended for planting of host plants other than seed potatoes,

   were distinguished taking into account the present EU legislation (directive 2000/29/EC) which includes specific measures for seed potatoes but not for other plants for planting.
2. Plants intended for planting of non-host plants with soil attached originating from areas where *M. fallax* is present. This pathway includes any propagation material except plants derived from tissue culture
3. Tubers, bulbs and roots of host plants (indicated as plant products) originating from areas where *M. fallax* is present and intended for consumption or processing. Two sub-pathways were distinguished,
    - **a.** waste water purified
    - **b.** waste water applied to a field,

   because practices related to waste water appeared to differ between EU-countries.
4. Soil attached to or associated with tubers, bulbs and roots of host plants originating from areas where *M. fallax* is present and intended for consumption or processing.

In both risk assessments (2b and 4b), the risk of *M. fallax* was assessed without considering the existing plant health legislation against the pest. In the present study, risk reduction options were identified and evaluated for effectiveness against *M. fallax* including the current requirements for *M. fallax* in the plant health directive 2000/29/EC.

Identification of risk reduction options

The EPPO decision-support scheme for Pest Risk Analysis (http://www.eppo.fr/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm) was used to help to identify risk reduction options and to evaluate if they are applicable for *M. fallax* (Table 1). The options PFA (pest free area), PFPP (pest free production place or site), testing, visual inspection and waste treatment were identified to reduce the likelihood of entry and spread of the pest (Table 1). The options influence different pathways (Table 2). The options "testing" was evaluated for seed potatoes and "visual inspection" for other plants for planting because these options are presently implemented by EU-countries (option I). A PFPP was evaluated for the production of plants for planting of host plants (option II), for all plants for planting (option III) and both for plants for planting and plant products (option IV). Option V included a PFPP for plants for planting and proper waste treatment for plant products. Soil-borne nematodes can be spread by any movement of the soil from an infested field, e.g. through machinery, shoes, equipment etc. Therefore, option VI considers the full isolation of an infested field combined with eradication measures (black fallow). The 6 options are considered in detail in the next paragraph.

Options that were not selected were "soil treatment", "commodity treatment" and "pre- or post-entry quarantine". Soil fumigation prior to sowing or planting of the crop can reduce the risk although not to zero (see the pest risk assessment). However, soil fumigants are presently not listed in the EU and were, therefore, not evaluated here. Post-entry quarantine is part of the testing method which is discussed under option I. Treatments that eliminate *M. fallax* and does not harm the plant or product are not available for most plants and products and were, therefore, not evaluated in this document.

Table 1: Evaluation of possible risk reduction options

Option	Reduction of risk	Comments
Resistant cultivars	Not available (yet)	Presently not available; maybe in the future for some host plant species but not for all.
Treatment of crop/soil, physical protection	yes	Soil fumigation can reduce the risk but soil fumigants are presently not listed in the EU. Biological soil disinfestation could be an option but is expensive (Runia *et al*., 2006; see also the pest risk assessment)
Pest free production place or site (PFPP)	yes	Natural spread over short (< 1 m) distances
Pest free area (PFA)	yes	Natural spread over short (< 1 m) distances
Trading plant (product) parts that cannot be infested/infected	no	The pathways include plant parts that can become infested/infected
Treatment of the commodity	yes/no	Not effective against nematodes present in the plant tissue except maybe for certain plants/plant products, e.g. hot water treatment for nematodes in flowers bulbs.
Visual inspection	yes/no	Can be present symptomlessly
Testing	yes	Effectiveness largely determined by sample size
Pre- entry or post-entry quarantine period	yes	Symptoms can be formed during incubation (can be included in testing method).
Limited distribution in time and/or space/limited use	no or hardly	Not relevant for *M. fallax*
Waste treatment	yes	Only effective for waste (incl. waste water)
Eradication	yes	Only feasible at the local level

Evaluation of options

The risk posed by each pathway after implementation of the different risk reduction options was evaluated by expert judgement and in case of option I supported by quantitative methods. The risk reduction options I-V were also evaluated by changing the rating levels (according to expert judgement) of the relevant questions in the risk assessment schemes of the two risk assessment methods 2b and 4b. The "new" risk (risk with option in place) was subsequently calculated by the models which combine the individual ratings and compared with the "old" risk with no measures in place (see for a description of these models the risk assessments method 2b and method 4b).

Below each option is described and evaluated. An overview of the different risk reduction options (RROs) is given in Table 2. Tables 3 and 4 indicate which questions in the 2 risk assessment methods were considered to be influenced by the different options. Figs 1-4 show the differences in risk outputs without and with measures in place according to the models used to combine ratings.

Option I: present EU-measures

In the present EU-legislation, specific measures are in place for seed potatoes (2000/29/EC, see also Annex II of the pest risk assessments). These measures include that seed potatoes should originate from a PFA (pest free area), PFPP (pest free production place) or should have been tested and found free of *M. fallax.* No specific measures are in place for other plants or products. Here, we evaluate the option: "testing" of seed potatoes and visual inspection of other plants and products because these are the measures which are presently implemented in some EU-countries where *M. fallax* is known to be present (see also Annex VI).

Option I influences:

- pathway 1a: seed potatoes
- pathway 1b: plants for planting of host plants other than seed potatoes
- pathway 3: plant products intended for consumption or processing
- pathway 4: soil attached to the products of pathway 3

Testing will allow *M. fallax* detection in seed potatoes but because of the limitation in sample size the method cannot fully prevent introduction or spread with seed potatoes. Based on a 200 tubers sampling regime per lot (EPPO, 2006) and assuming that (i) each infested potato will develop visible symptoms during this test and (ii) a random distribution of infested potatoes in the lot, the probability of false negatives can be calculated. For example, the probability of not detecting an infested lot in the case 1.5% of the seed potatoes are infested is about 5%. In case 10% of the seed potatoes are infested the chance of non-detection is extremely low: $7.1*10^{-8}$ %. Thus, in cases of low percentages of infested seed potatoes (1.5% or less), there is a chance of 5% or more that an infested lot will **not** be rejected. The likelihood of false negatives will, however, be higher for potato cultivars which do not express symptoms so readily. A PCR-test that is very sensitive and which can in principle detect a single nematode has also been implemented in the Netherlands. However, this PCR-test may be similar effective than the incubation method because only about 5-10% of the peel is removed from a single potato for testing. Peeling the whole potato would be very laborious. There is no information available about the percentage of infested seed potatoes in practice and hence it is difficult to assess how many seed potato lots could be accepted based on a false negative test.

Seed potatoes originating from a PFPP or PFA do not need to be tested. However, *M. fallax* may be more widespread than presently known (see risk assessment) and there is a risk that seed potatoes originating from areas or production places that are considered pest free could be infested.

Visual inspection is much less effective than testing. Plants and plant products can be infested without expressing symptoms (see also Annex I of the pest risk assessments). Visual inspection may detect only a very small proportion of infested lots due to the fact that some crops may be fully symptomless (also after an incubation period) or express only slight symptoms that may be easily overlooked during routine inspections (e.g. Den Nijs *et al*., 2004; Annex I of the pest risk assessments). There are no data to assess the effectiveness of visual inspection. Thus, visual inspection can reduce the risk of pathways 1 (plants for planting of host plants), 3 (plant products) and 4 (soil attached to the products of pathway 3) by detection and rejection of plants or product lots that have external symptoms but to a very limited extent.

Model output
The rating level of the questions concerning the likelihood of detection or surviving phytosanitary procedures in each method was changed (Tables 3, 4). The rating for the likelihood of association was also changed for pathway 1a (seed potatoes) because growers are expected to avoid fields that are infested because of the risk that the lot will be rejected after testing (Plant Protection Service, 2009). Visual detection has such a low efficiency that the likelihood of association was not changed (there is a low risk of rejection). The other rating levels were considered unaffected. According to method 2b, testing of seed potatoes clearly reduces the risk but visual detection does not (Figs. 1,3). According to method 4b, testing reduced the risk but visual inspection did not. Note that according to both methods the risk with testing is still fairly high (medium risk). The assessors agree with this "medium residual risk" because of the detection limits: testing certainly reduces the rate of spread but there remains a "medium risk" that at least one infested lot will not be detected every year.

Option II: Pest free production place (PFPP) for plants for planting of hosts
Option II includes that plants for planting of host plants should originate from a PFA or PFPP. The least effective option (PFPP) is evaluated here.

Option II influences pathways 1a and 1b but not the other pathways (non-hosts or products intended for consumption or processing).

In principle, the likelihood of association of *M. fallax* with the pathway from a PFPP is zero. However, in an area where the pest is present, absence of the pest cannot be fully guaranteed by sampling and testing of plant and/or soil samples for the same reason as mentioned above for testing of seed potatoes (option I). Therefore, the likelihood of association will not be zero. The likelihood that a field is indeed free of the pest based on a negative test result will largely depend on the inspection and testing regime and the buffer zone used around a finding. The present EU-requirements to determine if a production place is free of the pest are:

— the place of production has been found free from *Meloidogyne fallax* Golden *et al*. (all populations), based on an annual survey of host crops by visual inspection of host plants at appropriate times and by visual inspection both externally and by cutting of tubers after harvest from potato crops grown at the place of production.

These requirements are insufficient to guarantee pest freedom of the production place because of the possibility of latent infections in several host plants and/or poor expression of symptoms. Symptoms will largely be affected by the temperature during the growing season and especially the host plant species (see Annex I and V of the pest risk assessments). For higher detection levels, visual inspections should, therefore, be combined with testing of plant and soil samples. Samples should be taken during the growing season or preferably directly after harvest of the susceptible host crop because in the absence of a host plant the *M. fallax* population will decrease rapidly in soil. A difficulty concerning this option is that it is not always known if a crop plant species or genotype is a non-host or resistant against *M. fallax*.

A PFPP could be similar effective as testing of plants (e.g. option I for seed potatoes) but could also be more or less effective depending on the intensity of the testing regimes used for testing of the plants (option I) and the production place. It may also be that testing will be more effective because growers will avoid fields that are known or suspected to be infested because they do not want to run the risk that their lot will be rejected.

Model output
The rating level of the questions concerning the likelihood of association in each of methods 2b and 4b were changed for pathways 1a and 1b (Tables 3, 4). The other rating levels were considered unaffected by option II. According to both methods, option II (PFPP) reduces the risk of pathways 1a and 1b (Figs 1,2). If we compare option I (testing) and II (PFPP), then testing is more effective than a PFPP according to method 2b. This higher effectiveness is obtained because testing affects both the likelihood of association and the likelihood to remain undetected while a PFPP only reduces the likelihood of association (Fig. 1). According to method 4b, testing is about similarly effective as a PFPP. In method 4b, changing the rating of the question on the likelihood of surviving phytosanitary procedures from very high (100% will survive) to medium (the likelihood to remain undetected by

"testing") hardly influenced the risk (Fig. 5). This despite the fact that the difference between "medium" (0.1 -1% remains contaminated) and "very high" (>10% remains contaminated) is more than a factor 10. The assessors, therefore, do not agree with the way the 4b-model combines the ratings in the entry part of the 4b - risk assessment scheme.

Option III: Pest free production place (PFPP) for plants for planting of host and non-hosts

Option III includes that plants for planting of host and non host plants should originate from a PFA or PFPP. The least effective option is evaluated: "PFPP".

This option influences pathway 1a and 1b (see option II) and pathway 2 but not pathways 3-4 (plant products intended for consumption or processing and the soil attached to these products).

This option will hardly be more effective than option 2 because pathways 1a and 1b (host plants) are much more relevant than pathway 2 (non-host plants) even after implementation of risk reduction option I and/or II.

Note that *M. fallax* has a very wide host range and many host plant species may not have been identified (Annex I). Thus, with the present knowledge it is not possible to provide a (full) list of non-host plants (see also the analysis of pathway 2 in the two risk assessments of *M. fallax* conducted within the same EFSA project Prima Phacie).

Model output

The calculated risk of pathway 2 remained unaffected because the relevant question already had the lowest rating level (Table 4). The model output was the same as for option II (see above).

Option IV: Pest free production place (PFPP) for plants and products

Option IV includes that all plants of host and non host plants, including plants intended for planting and plant products intended for consumption of processing, should originate from a PFA or PFPP. The least effective option (PFPP) of these two is evaluated here. This option is the same as option III for pathways 1a and 1b and 2 but in addition also reduces the risk of pathways 3 and 4.

Model output

The rating level of the likelihood of association was decreased (Tables 3,4). According to method 2b, a PFPP reduced the risk but to limited extent: the risk remains about "medium". The reason for this is that the likelihood of association was already low without measures in place and further reduction has little effect on the outcome of the model used. A zero chance of association is unlikely because of detection limits as discussed above. Also according to method 4b, a PFPP reduces the risk but to limited extent. The assessors agree that there remains a medium residual risk that an infested field will not be detected and plant products that can become infested/infected will be traded from such fields.

Option V: Pest free production place (PFPP) for plants, proper waste treatment for products

Option V includes different requirement for plants for planting of host and non host plants and plant products intended for consumption or processing:

- plants for planting of host and non-host plants should originate from a PFA or PFPP (same as for option III and IV)
- plant products intended for consumption or processing: waste products from plant products intended for consumption or processing should be treated properly (phytosanitary safe) by industry.

A PFPP for plants for planting has been discussed above. A phytosanitary safe treatment of waste from plant products could include purification of the waste water and composting, burning or heat treatment of any other waste product. Sanitation of infested soil and/or finding phytosanitary safe destinations may be difficult. Biofumigation or inundation of the waste soil may be a solution but needs experimental testing.

Option V is the same as options III and IV for pathways 1 and 2 (plants for planting), but different for pathways 3 and 4. Option V influences the likelihood of transfer of pathways 3 and 4 but not the

likelihood of arrival. The pest will arrive at the processing/packaging industry but the likelihood of transfer will be reduced by treating of the waste products. Option V could reduce the risk of pathways 3 and 4 more than option IV when waste is treated properly (phytosanitary safe). There is an uncertainty about the distribution of *M. fallax* in and outside the EU. The risk of spread and entry will, therefore, mostly be reduced if all waste material from plant products that can potentially be infected or infested is treated.

Note that option V does not reduce (whereas option IV does) the risk in cases consumers would use ware potatoes as seed potatoes and/or would not treat their waste properly (e.g. apply potato peels to soil in stead of composting or putting them in a waste bin). It also does not prevent spread due to losses of soil during transport from the field and incorrect implementation of waste treatments.

Model output
The rating level of the questions concerning the likelihood of transfer in each of methods 2b and 4b were changed for pathways 3b and 4 (Tables 3, 4). Model outputs for pathways 1a and 1b were the same as for option II (see above). Outputs for pathways 2 and 3a did not change (Table 4).

According to both method 2b and 4b, waste treatment strongly reduces the risk of entry and transfer via pathways 3 and 4 (Fig. 3). Waste treatment had a larger effect than a PFPP (option IV) according to the model. This may also be the case because waste treatment independent if a lot is infested or not, avoid the chance that infestations remain undetected as with the PFPP-option.

Option VI: isolation of infested fields
None of the options discussed above (I-V) reduces the risk of (more local) spread through soil attached to machinery, tools, shoes etc. The highest risk reduction would be obtained by demarcating an infested field or area and limit the entrance of people, machinery etc. as much as possible to avoid any spread by movement of soil. The field should be kept fallow (black) and only be entered for weed control measures and according to strict hygienic procedures. The black fallow period needed to fully eradicate the pest is not known. It may be 2 or more years (see also risk assessment method 2b, question 5.01). This option is highly effective in reducing spread of *M. fallax* and more effective than options I-V once a field has been found infested. However, as for option II its effectiveness will be limited by the intensity of the inspection and testing regime to detect any infested field in time before spread could have occurred.

Conclusion of the effectiveness of RROs

Risk reduction options were identified and evaluated for effectiveness to reduce the risk of entry and spread of *M. fallax*. A full risk assessment has been conducted in another document within the framework of EFSA project CFP/EFSA/PLH/2009/01.

Phytosanitary control of *M. fallax* is complicated by the following factors:

- *M. fallax* may be more widespread in the EU than presently known.
- *M. fallax* has a very wide host range and can easily be overlooked because it does not cause much damage and does not produce (clear) visible symptoms on many of its host plants.
- There are many pathways by which *M. fallax* may enter fields and areas that are not yet infested and there is a large trade volume of plants for planting and plant products that could be infested or infected.

For effective prevention of spread of *M. fallax* in the EU, intensive surveillance would be needed to determine the present distribution and to check for implementation of measures after an infestation have been found. The following options were considered:

- Isolation of infested fields. A black fallow period for at least 2 years or as long as needed for eradication where entering of fields is only allowed for weed control. This measure is highly effective for fields found infested but not all fields infested may be detected because of detection limits. The option is feasible at the local level but has a low feasibility in general because *M. fallax* is already present in several areas in the EU.
- A pest free area (PFA), pest free production place or site (PFPP) for the production of seed potatoes or testing of seed potatoes. This option is effective but may not fully prevent entry or spread by seed potatoes because of detection limits.
- A pest free area (PFA), pest free production place or site (PFPP) for the production of plants for planting other than seed potatoes. This option is effective but may not fully prevent entry or spread because of detection limits. Because of its very wide host range and uncertainties about the size of the host range, it was not possible to set up a full list of host plants. *M. fallax* cannot only be spread in roots of or soil attached to host plants but may also be spread in soil attached to non-host plants.
- The pest could also be spread through waste materials from products of host plants that can become infected or infested. Proper treatment of waste materials obtained during processing and packaging of such products could be more effective than a PFPP because pest freedom of a production place cannot be fully guaranteed due to detection limits.

In conclusion, phytosanitary measures can reduce the rate of spread of *M. fallax* but the likelihood of spread (likelihood of at least one event per year) remains medium or even high (depending on the extent of the present distribution in the EU) because of detection limits and the large trade volume. The measures will limit the use of agricultural fields in areas where *M. fallax* is already present.

References

See separate document “References and annexes to pest risk assessment of *Meloidogyne chitwoodi* (method 2) and *M. fallax* (method 2b and 4b)”.

Table 2: Evaluation of risk reduction options by assessors; each option influences the likelihood of entry from third countries and spread within the EU			
Option/description	**Affects pathway no.[1]**	**Effectiveness**	**Technical feasibility of measure**
I. present EU-measures: - seed potatoes; testing/PFPP/PFA - visual inspection other plants and plant products	1a (testing) 1b (visual) 3,4 (visual)	Testing will detect most infested lots. In case of low pest incidence there is a significant chance (>5%) on false negative tests. Seed potatoes originating from areas or production places considered to be pest free might be infested because *M.fallax* may be more widespread than presently known. Visual detection may only detect a very small proportion of infested lots. Many host plants do not or poorly express symptoms.	Testing of seed potatoes is feasible: measures are already in place Visual inspection is time consuming and not very effective.
II. Pest free production place (PFPP) for plants intended for planting of host plants	1	A PFPP cannot be guaranteed for 100% because of limitations of soil sampling and testing. A PFPP may be similar effective as testing of seed potatoes (option I). However, depending on the sample size, sampling time, testing method and size of buffer zone used around a finding, a PFPP could be more or less effective. With testing, growers will probably avoid infested fields which could make testing more effective.	Difficult: intensive sampling and testing needed. Wide host range: limited use of infested fields. It is not always known which plant species are non-hosts and could be excepted.
III. Pest free production place (PFPP) for plants intended for planting of host plants and non-host plants[2]	1,2	Hardly more effective than option II because pathways 1a and 1b (host plants) are much more relevant than pathway 2 (non-host plants) probably also after implementation options I and/or II. This option cannot fully prevent entry and spread because of limitations to accuracy of soil sampling and testing (see option II).	Difficult: intensive sampling and testing needed. Limited use of infested fields: no production possible of plants for planting.
IV. Pest free production place (PFPP) for plants intended for planting of host plants and plant products harvested from soil	1,2,3,4	More effective than option II and III because it also reduces the risk associated with infested end products (e.g. ware potatoes, carrots, sugar beets etc). This option cannot fully prevent entry and spread because of limitations to soil sampling and testing (see also option II).	Difficult: intensive sampling and testing needed. Very limited use of infested fields.
V. Pest free production place (PFPP) for plants intended for planting of host plants and non-host plants; plant products harvested from soil: proper waste treatment during processing and packaging	1,2,3,4	May be more effective than option IV in case all waste material from plant products that can potentially be infected or infested is treated. However, this option does not reduce the risk of transfer by consumers, e.g. use of ware potatoes as seed potatoes	See option III for PFPP. Treatment of waste: sanitation of infested waste soil and/or finding phytosanitary safe destinations for infested soil could be difficult. Uncertain how easy purification of water could be implemented in the different EU-countries.
VI. Isolation of fields. Eradication	All pathways	Highly effective.	Difficult: intensive sampling and testing needed. No use of infested fields for several years. Intensive weed control needed. Fallow period needed for eradication unknown.

[1] Pathway 1a: seed potatoes; Pathway 1b: plants for planting of host plants other than seed potatoes;
Pathway 2: plants for planting of non-host plants;
Pathway 3: plant products of host plants grown in soil and intended for consumption or processing; Pathway 4: waste soil attached to the products of pathway 3

[2] Note that *M. fallax* has a very wide host range and it is not possible to provide a full list of non-host plants

Table 3: Influence of 5 risk reduction options (RRO) on the rating levels of questions in the entry part of risk assessment method 2b				
		Ratings (uncertainty between brackets)[1]		
Risk reduction option	**Pathways affected**	**Question**	**Without RRO**	**With RRO**
I. current EU-measures (testing of seed potatoes, visual inspection other products)	1a seed potatoes	2.04: association 2.09: enter undetected	Unlikely (medium) Very likely (low)	Very unlikely (medium) Moderately likely (high)
	1b plants for planting of hosts other than seed potatoes	2.09: enter undetected	Very likely (low)	Very likely (medium)
	3 products for consumption or processing	2.09: enter undetected	Very likely (low)	Very likely (medium)
	4 waste soil attached to products for consumption or processing	2.09: enter undetected	Very likely (low)	Very likely (medium)
II. Pest free production place (PFPP) for plants intended for planting of host plants	1a seed potatoes	2.04: association	Unlikely (medium)	Very unlikely (medium)
	1b plants for planting of hosts other than seed potatoes	2.04: association	Unlikely (medium)	Very unlikely (medium)
III. Pest free production place (PFPP) for plants intended for planting of hosts and non-hosts	1a and 1b: see option II			
	2 plants for planting of non-hosts	2.04: association	Very unlikely (low)	Very unlikely (low)
IV. Pest free production place (PFPP) for plants intended for planting of host plants and plant products harvested from soil	1a, 1b and 2: see options II and III			
	3 products for consumption or processing	2.04: association	Unlikely (medium)	Very unlikely (medium)
	4 waste soil attached to products for consumption or processing	2.04: association	Unlikely (medium)	Very unlikely (medium)
V. Pest free production place (PFPP) for plants intended for planting of host plants and non-host plants; plant products harvested from soil: proper waste treatment during processing and packaging. This option does not reduce the risk of transfer by consumers, e.g. use of ware potatoes as seed potatoes	1a, 1b and 2: see options II and III			
	3a products for consumption or processing, waste water purified	2.10: transfer	Very unlikely (low)	Very unlikely (low)
	3b products for consumption or processing, waste water applied to field	2.10: transfer	Likely (medium)	Very unlikely (low)
	4 waste soil attached to products for consumption or processing	2.10: transfer	Likely (high)	Very unlikely (low)

[1] Uncertainty due to possible incorrect implementation of measures is not included
[2] Note that option V does not reduce the risk of transfer by consumers, e.g. use of ware potatoes as seed potatoes

Table 4: Influence of 5 risk reduction options (RRO) on the rating levels of questions in the entry part of risk assessment method 4b				
Risk reduction option	**Pathways affected**	**Ratings [1]**		
		Question	**Without RRO**	**With RRO**
I. current EU-measures (testing of seed potatoes, visual inspection other products)	1a seed potatoes	2.01 association	Very low 40% Low 60%	Very low 60% Low 40%
		2.04 surviving phytosanitary procedures	Very high 100%	Very low 5% Low 30% Medium 40% High 25%
	1b plants for planting of hosts other than seed potatoes	2.04 surviving phytosanitary procedures	Very high 100%	High 20% Very high 80%
	3 products for consumption or processing	2.04 surviving phytosanitary procedures	Very high 100%	High 20% Very high 80%
	4 waste soil attached to products for consumption or processing	2.04 surviving phytosanitary procedures	Very high 100%	High 20% Very high 80%
II. Pest free production place (PFPP) for plants intended for planting of host plants	1a seed potatoes	2.01 association	Very low 40% Low 60%	Very low 70% Low 30%
	1b plants for planting of hosts other than seed potatoes	2.01 association	Very low 40% Low 60%	Very low 70% Low 30%
III. Pest free production place (PFPP) for plants intended for planting of hosts and non-hosts	1a and 1b: see option II			
	2 plants for planting of non-hosts	2.01 association	Very low 100%	Very low 100%
IV. Pest free production place (PFPP) for plants intended for planting of host plants and plant products harvested from soil	1a, 1b and 2: see options II and III			
	3 products for consumption or processing	2.01 association	Very low 40% Low 60%	Very low 70% Low 30%
	4 waste soil attached to products for consumption or processing	2.01 association	Very low 40% Low 60%	Very low 70% Low 30%
V. Pest free production place (PFPP) for plants intended for planting of host plants and non-host plants; plant products harvested from soil: proper waste treatment during processing and packaging. This option does not reduce the risk of transfer by consumers, e.g. use of ware potatoes as seed potatoes	1a, 1b and 2: see options II and III			
	3a products for consumption or processing, waste water purified	2.06 transfer	Very low 80% Low 20%	Very low 80% Low 20%
	3b products for consumption or processing, waste water applied to field	2.06 transfer	Very low 5% Low 15% Medium 30% High 40% Very high 10%	Very low 80% Low 20%
	4 waste soil attached to products for consumption or processing	2.06 transfer	Very low 5% Low 15% Medium 30% High 40% Very high 10%	Very low 80% Low 20%

[1] Ratings (% likelihood) spread over 5 categories (very low, low, medium, high, very high)

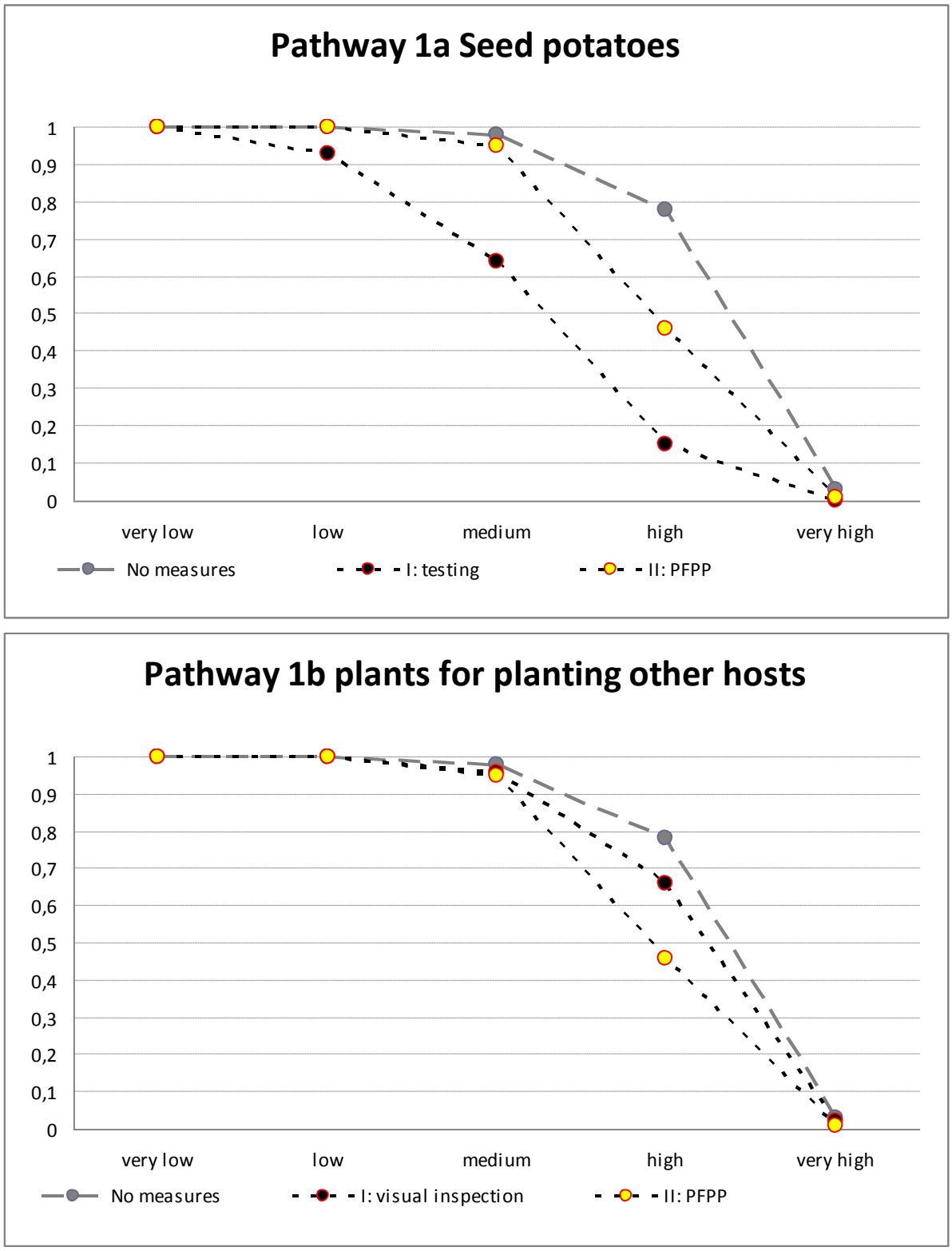


Fig. 1. Effect of options I (testing of seed potatoes and visual inspection of other plants for planting) and II (PFPP = pest free production place) on entry risk by trade of seed potatoes (1a) and plants for planting of other host plants (1b) as calculated by method 2b. The greater the area under the curve (i.e.to the left of the line), the greater the risk (see also text).

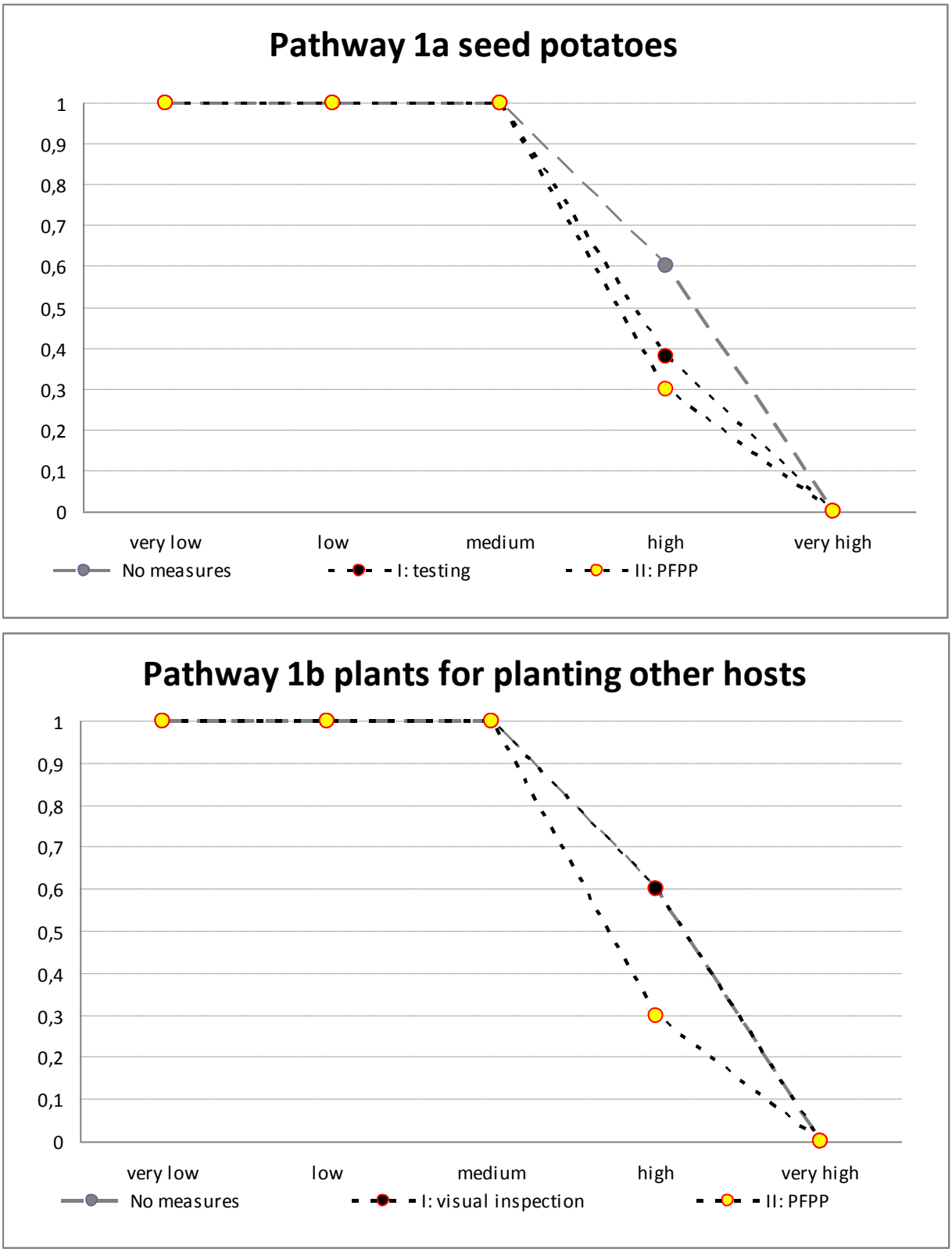
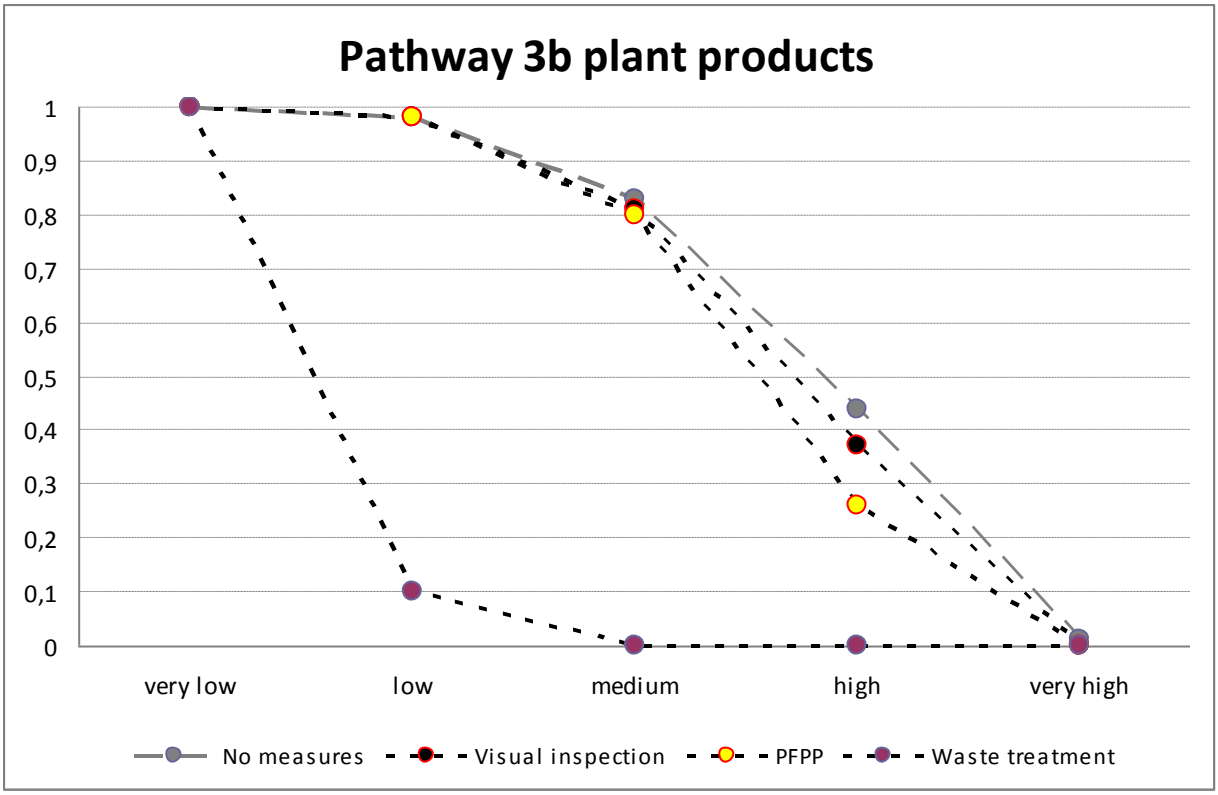


Fig. 2. Effect of options I (testing of seed potatoes and visual inspection of other plants for planting) and II (PFPP = pest free production place) on entry risk by trade of seed potatoes (1a) and plants for planting of other host plants (1b) as calculated by method 4b. The greater the area under the curve (i.e.to the left of the line), the greater the risk (see also text).



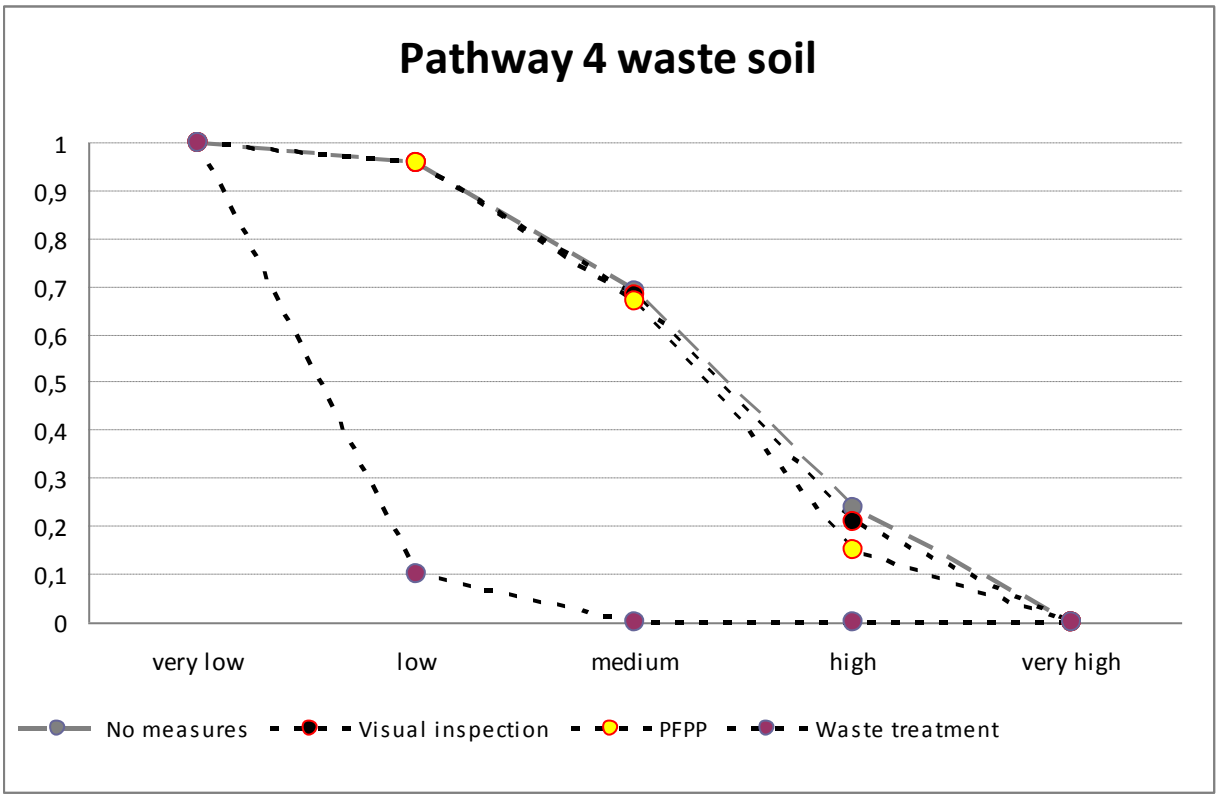


Fig. 3. Effect of visual inspection, PFPP and waste treatment on entry risk by trade of tubers, bulbs and roots of host plants intended for consumption of processing (3b) and waste soil attached to these products (4) as calculated by method 2b. The greater the area under the curve (i.e.to the left of the line), the greater the risk (see also text).

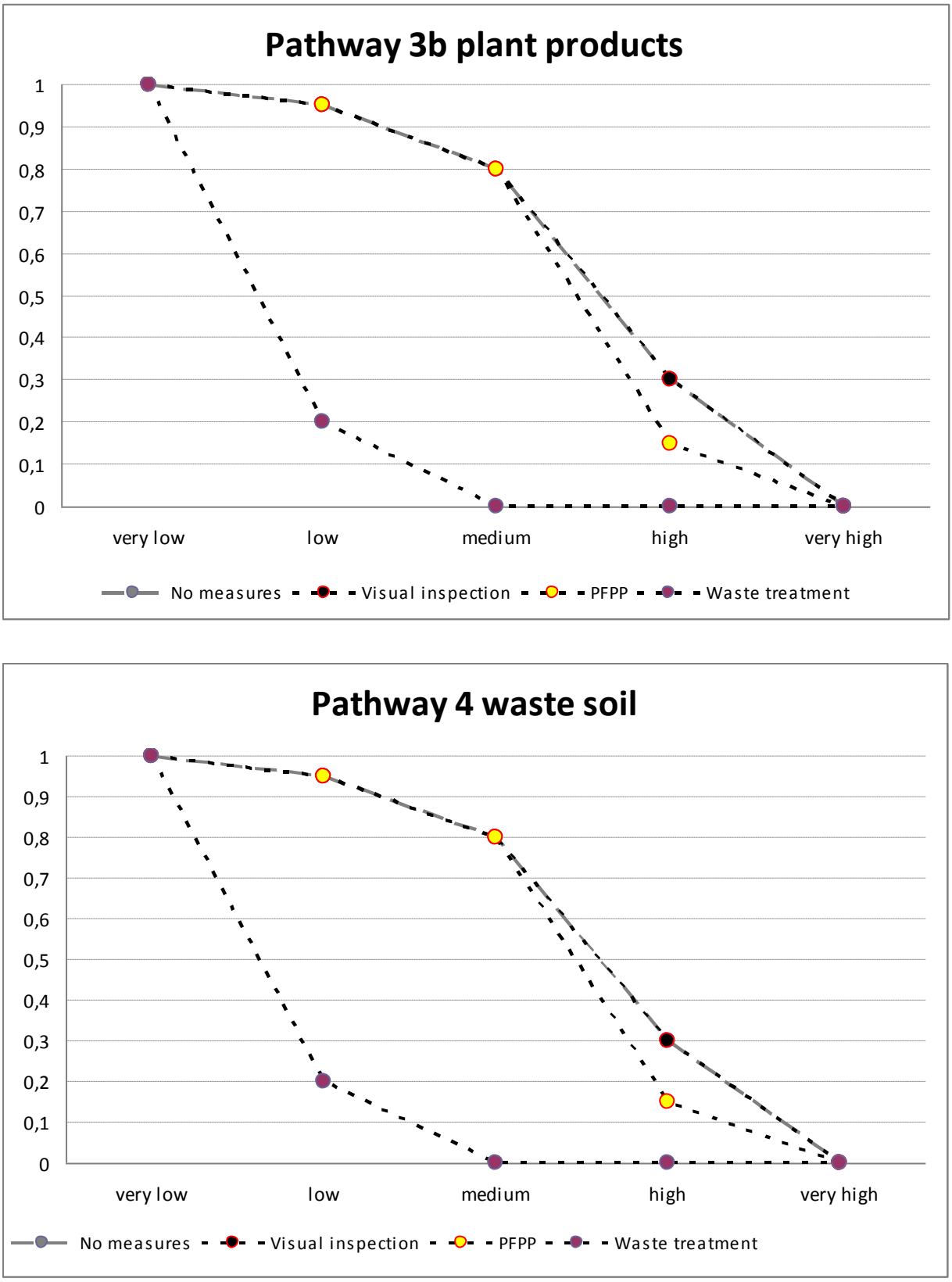


Fig. 4. Effect of waste treatment on entry risk by trade of tubers, bulbs and roots of host plants intended for consumption of processing (3b) and waste soil attached to these products (4) as calculated by method 4b. The greater the area under the curve (i.e.to the left of the line), the greater the risk (see also text).

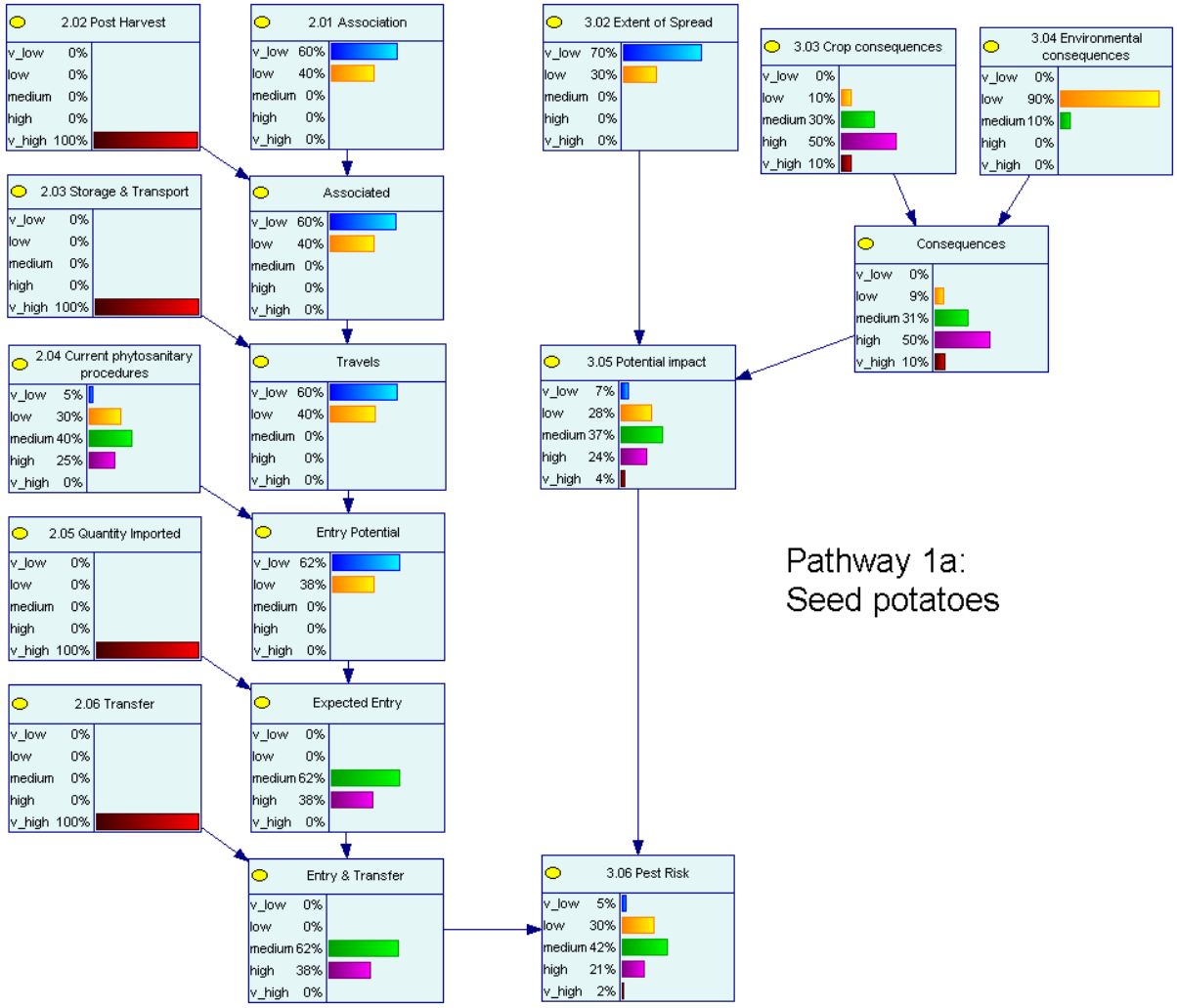


Fig. 5. Combination of ratings at the question level for pathway 1a (seed potatoes) in the presence of testing (option I) according to method 4b.