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Risks to plant health posed by EU import of soil or growing media

EFSA Panel on Plant Health (PLH Panel)

Abstract

Following a request from the European Commission, in this scientific opinion the EFSA Panel on Plant Health evaluates the risk of entry into the European Union of harmful organisms associated with soil or growing medium attached to plants for planting, as commodities, and as contaminants on imported consignments. The Panel compared several definitions of soil and growing media and used, in this opinion, the current definition for growing media of the International Plant Protection Convention. In Council Directive 2000/29/EC, no specific definition of soil and growing media is provided but growing media are described in two different ways. From the soil and growing media and/or components thereof identified through extensive literature searches, the Panel distinguished eight groups of soil and growing media and assessed the probability of association of these groups with harmful organisms. A total of 207 scientific publications were reviewed by the Panel in order to identify and rate the effectiveness of options that could reduce the risk of entry of pests posed by the import of soil and growing media. A detailed description and evaluation of the requirements for soil and growing media laid down in current EU legislation on plant health and in a few other regions of the world is provided. The Panel found that the 'prohibition of import' is the only phytosanitary measure with a very high effectiveness and a low uncertainty. The effectiveness of the phytosanitary measures 'pest free production site and preparation of consignment' is rated as moderate to high with an uncertainty rated as medium to high. Although several phytosanitary measures in these categories of risk reduction options could be highly effective, EU legislation does not provide clear formulation and guidance on their implementation.

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Key words: effectiveness, EU legislation, growing media, harmful organisms, risk reduction options, soil

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Summary

Following a request from the European commission, the EFSA Panel on Plant Health (PLH) was asked to deliver a scientific opinion on the risk of entry into the EU of harmful organisms associated with soil or growing medium attached to plants for planting, as commodities, and as contaminants on imported consignments.

Probability of association of harmful organisms with soil and growing media

The Panel defined eight groups of soil and growing media with contrasting ratings of probability of association with harmful organisms. For five of these groups, the uncertainty associated with the ratings is high because of multiple factors influencing the association between soil and growing media and harmful organisms, and because of the diversity of existing soil and growing media. The probability of association was rated as follows:

Groups of soil and growing media	Association of harmful organisms	Uncertainty
Media including plant materials	Very likely	High
Animal manure	Moderately likely	High
Water	Moderately likely	High
Other media composed of animal materials, different from manure	Unlikely to moderately likely	High
Other inorganic media, different from water	Moderately likely	High
Peat	Unlikely	Medium
Synthetic media	Very unlikely	Low
Media having undergone a production process eliminating the plant pests	Very unlikely	Low

Current legislation in the EU

There is no definition of soil in Council Directive 2000/29/EC. Imports of growing media as commodities, entirely without soil and organic substances, are not regulated. However, based on a literature review, the Panel found that this type of growing media could be associated with harmful organisms. The current EU legislation does not deal explicitly with soil and growing media as contaminants.

Following its evaluation, the PLH Panel found that several aspects of current EU legislation on soil and growing media increase the risk of entry of harmful organisms into the EU:

- For a given soil or growing medium, the import restrictions listed in the regulation are not applied to all non-EU countries but depend on the country of origin.
- For a given soil or growing medium and a given origin, the restrictions listed in the regulation depend on whether the soil or growing medium is imported as such or is imported attached to plants.
- The EU regulation does not provide any details on the implementation of phytosanitary measures (e.g. heat treatments or inspection of production sites and consignments) in order to maintain production sites and consignments of soil and growing media free from harmful organisms.
- Peat is regulated in two different manners:
  - in Annex IIIA (12), growing media as commodities, composed entirely of peat, are excluded from the restrictions;
  - in Annex IVAI (34), growing media attached to plants, composed entirely of peat, are included in the restrictions.

The regulations on soil and growing media implemented by non-EU countries are, in some cases, simpler and provide clearer guidance on how to reduce the risk of entry of harmful organisms into

their territories, especially with regard to the application of heat treatment to soil and growing media imported as commodities.

Effectiveness of risk reduction options and phytosanitary measures

The extensive literature search performed to assess the effectiveness of risk reduction options shows that heat, pesticide and fumigation treatments are able to reduce the presence of harmful organisms in soil and growing media, but that these treatments are not 100 % effective in all cases. Their effectiveness depends on several factors, especially soil characteristics, the harmful organisms and the application procedures.

The Panel evaluated the effectiveness of the phytosanitary measures included in the EU legislation and concludes that:

- ‘Prohibition of import’ is the only phytosanitary measure with a very high effectiveness and a low level of uncertainty.
- The effectiveness of several phytosanitary measures from the category ‘pest free production site & preparation of consignment’ is rated as moderate to high. Although several of the proposed measures from this category of risk reduction options could potentially have a high level of effectiveness, the EU legislation does not provide any clear guidance on how to ensure that the production sites are free from harmful organisms or on how to prepare the consignments in order to maintain growing media free from harmful organisms. The formulation of these phytosanitary measures is thus too vague to ensure their appropriate implementation. For this reason, the uncertainty associated with the effectiveness of these measures is rated as medium to high, depending on the formulations of the requirements in the regulation. Guidance is given in Appendix D on how to clarify the formulation of these phytosanitary measures.

In future, quantitative pathway analysis could be performed for specific commodities of soil and growing media (e.g. peat) in order to assess the risk of entry of harmful organisms more accurately.

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1. Introduction

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

The current European Union plant health regime is established by Council Directive 2000/29/EC 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).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants, plant products and other objects, and the control checks to be carried out at the place of origin on plants, plant products and other objects destined for the Union or to be moved within the Union, the list of harmful organisms whose introduction into or spread within the Union is prohibited and the control measures to be carried out at the outer border of the Union on arrival of plants, plant products and other objects.

Soil and growing medium provide a medium via which harmful organisms and other non-native species, including agricultural or invasive weeds, can be sustained and spread. The risks posed by the movement of soil and growing medium as potential pathways for the introduction of a variety of harmful organisms are universally recognised and addressed by legal acts. Council Directive 2000/29/EC sets out in Annexes III, IV and V requirements relating to the introduction and movement of soil and growing medium in the EU, but there is concern whether these requirements are appropriate to effectively prevent the introduction and spread of harmful organisms. There is also concern whether third countries apply the requirements in full and how compliance can be verified at or after import.

There are three separate scenarios for the import and movement of soil and growing medium which need to be considered when addressing the phytosanitary risks posed by these objects:

1) Soil and growing medium attached to plants for planting
2) Soil and growing medium imported as commodities, i.e. not in association with plants intended for planting
3) Soil and growing medium attached as a contaminant to imported goods (ranging from ware potatoes to agricultural machinery)

The Working Group on the Annexes of Council Directive 2000/29/EC of the Standing Committee on Plant Health has been tasked to review the existing EU requirements for soil and growing medium. The experts of the Working Group have determined there are a number of important issues on which technical input is needed to be able to carry out this review. Therefore it has been decided to request a scientific opinion of the EFSA Panel on Plant Health on the risks to plant health posed by movements of soil or growing medium attached to plants for planting, as commodities and as a contaminant on consignments. The experts of the Working Group have prepared a report highlighting the main issues on which technical input of EFSA is needed, to provide guidance to EFSA for the preparation of the scientific opinion.

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a scientific opinion on the risks to plant health posed by soil or growing medium attached to plants for planting, as commodities and as a contaminant on imported consignments. EFSA is requested to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by the introduction and movement of soil and growing medium. EFSA is also requested to carry out an evaluation of the effectiveness of the present EU requirements for soil and growing medium, which are listed in Annexes III, IV and V of Council Directive 2000/29/EC, in reducing the risk of introduction and spread of harmful organisms that could be associated with these objects. EFSA is requested to take into account the report prepared by the Working Group on the Annexes of Council Directive 2000/29/EC of the Standing Committee on Plant Health when preparing the opinion.

1.2. Scope of the opinion

Following a request from the European Commission, in this scientific opinion the Panel defines groups of soil and growing media (SGM), and evaluates the probability of entry into the EU of harmful organisms associated with these groups for the pathways of soil and growing media imported as such, attached to plants for planting as commodities, and as contaminants.

The risk assessment area is the territory of the European Union (hereinafter referred to as the EU) with 28 Member States, restricted to the area of application of Council Directive 2000/29/EC[1].

This scientific opinion provides a detailed description and evaluation of the current plant health legislation on SGM currently implemented in the EU, and in a few other regions of the world. This opinion also addresses several specific questions listed in the report of the Annex Working Group of the Standing Committee of Plant Health (Appendix A).

Internal movements within the EU, the risks of pest establishment and the natural spread of organisms harmful to plants are not considered in this opinion.

2. Data and methodology

2.1. Guidance documents

2.1.1. Risk assessment

The risk assessment has been conducted in line with the principles described in the guidance document of the EFSA Panel on Plant Health (PLH) on pest risk assessment (EFSA PLH Panel, 2010). However, the four different risk factors that should be analysed in the assessment of the probability of entry of a pest (i.e. pest association with the pathway at origin, pest survival during transport or storage, surviving existing pest management procedures and the transfer to a suitable host) were not addressed separately because of the very wide range of pests and commodities that could act as pathways. The Panel therefore focused its analysis on the probability of association of pests with different soil and growing media (SGM) groups.

2.1.2. Guidance on risk reduction options

The evaluation of risk reduction options (RROs) has been conducted in line with the principles described in the guidance on pest risk assessment (EFSA PLH Panel, 2010), as well as in the guidance on the evaluation of options to reduce the risk of introduction and spread of organisms in the EU (EFSA PLH Panel, 2012). The main categories of RROs listed in this guidance document were systematically checked and considered if applicable. However, in this opinion, the technical feasibility of the measures was not assessed, because of the very wide range of organisms and commodities that are subjected to control.

2.1.3. Rating systems

In order to follow the principle of transparency described in section 3.1 of the guidance document on a harmonised framework for risk assessment (EFSA PLH Panel, 2010), the Panel has developed rating descriptors to provide clear justification when a rating is given. The different rating systems that were used for performing the assessments in this scientific opinion are presented in Appendix B. Four different systems were used:

1) The evaluation of the probability of association of the pests with several SGM groups was performed using a scale with five levels (very unlikely, unlikely, moderately likely, likely and very likely).

[1] 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. Official Journal of the European Communities L 169/1, 10.7.2000, pp. 1–112.

2) The evaluation of the effectiveness of the phytosanitary measures at preventing the pest from entering the risk assessment area was performed using a scale with five levels (very low, low, medium, high and very high).

3) The evaluation of the effectiveness of the methods aimed at reducing the presence of pests in SGM was performed using a scale with three levels (no effect, partial effect and 100 % effect).

4) The uncertainties related to each effectiveness rating were rated using a scale with three levels (low, medium and high).

2.2. Reviews: legislation and literature

This scientific opinion was developed based on literature reviews and the analysis of different legislations as described below.

2.2.1. Inventories of soil and growing media and their associated harmful organisms

Bremmer et al. (2015)[2] presents two inventories that were developed through a project outsourced by EFSA to identify different types of SGM and their association with harmful organisms by means of extensive literature searches following the methodology described in the EFSA guidance on systematic review (EFSA, 2010).

A first inventory was developed to list (i) SGM (and when relevant components thereof) imported as commodities (i.e. not in association with plants intended for planting), (ii) SGM attached to plants for planting, and (iii) SGM attached as contaminants to imported goods (ranging from ware potatoes to agricultural machinery).

A second inventory was developed to list the harmful organisms associated with the SGM identified in the first inventory, including: the quarantine organisms listed in Council Directive 2000/29/EC[1]; the organisms addressed by emergency measures in the EU[3]; and the organisms included in European and Mediterranean Plant Protection Organization (EPPO) pest lists[4].

Considering the complexity and the very broad scope of the outsourced project, the Panel performed a quality check of the two inventories and found that some of the reported associations between harmful organisms and SGM were not relevant. The Panel also found that some associations reported in the literature were missing in the inventories. Therefore, the two inventories were considered by the Panel as indicative and not exhaustive and were used as external sources of information.

The information provided by the outsourced project was reviewed by several experts and was supplemented by the Panel by performing additional literature searches, especially on the association of pests with soil and growing media. The Panel distinguished eight groups of SGM with contrasting levels of probability of association with harmful organisms (Appendix C). Relevant examples of associations of harmful organisms with SGM were identified from the scientific literature and used by the Panel to illustrate the risk posed by the eight groups of SGM.

2.2.2. Review of the legislation on soil and growing media

The Panel reviewed the current EU regulation relevant to SGM and performed a qualitative evaluation of the effectiveness of the current measures in place.

The current legislations applied in Australia, Canada, New Zealand and the United States of America for plant quarantine, biosecurity, soil, growing media and fertilisers were also scrutinised and evaluated. These legislations were chosen because they were originally published in English, reducing the risk of errors being introduced by translation.

[2] http://www.efsa.europa.eu/en/supporting/pub/834e.htm
[3] EU emergency measures are available at http://ec.europa.eu/food/plant/organisms/emergency/index_en.htm
[4] EPPO lists: EPPO A1 and A2 lists of pests recommended for regulation as quarantine pests, list of pests recently added to the EPPO A1/A2, lists or of urgent phytosanitary concern, EPPO Alert List, EPPO lists of invasive alien plants are all available at http://www.eppo.int/QUARANTINE/quarantine.htm

2.2.3. Effectiveness of risk reduction options

Two types of assessment were carried out:

- An extensive literature search was performed to retrieve publications providing information on the effectiveness of RROs at reducing the presence of pests in SGM. Data were extracted from the selected articles in order to identify the most effective options. Further details of this assessment are provided in section 6.
- A qualitative assessment of the effectiveness of the phytosanitary measures currently applied in the EU was performed. This assessment was carried out by the Panel based on the characteristics of the phytosanitary measures described in the EU legislation and on the results of the extensive literature search mentioned above.

3. Definitions and indicative list of soil and growing media

3.1. Definitions of 'Soil and growing media'

Several definitions of SGM are presented in Table 1. In this opinion, the Panel uses the current definition of a growing medium of the International Plant Protection Convention (International Standard for Phytosanitary Measures (ISPM) No 5; FAO, 2013a) because it is the global reference and it includes a larger range of materials than other definitions.

According to ISPM No 5 (FAO, 2013a), a growing medium is 'any material in which plant roots are growing or intended for that purpose'. Soil is not defined in ISPM No 5, but a definition is given in a draft ISPM on 'Movement of growing media in association with plants for planting in international trade' (FAO, 2013b).

In the current plant health legislation, no specific definition of SGM is provided, but growing media are described in two different ways:

1) Annex IIIA (14) of Council Directive 2000/29: 'Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat';
2) Annex IVA1 (34) of Council Directive 2000/29 'Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants'.

The Panel notes that the ISPM No 5 definition of a growing medium is more general than the current descriptions of SGM used in the Annexes to Council Directive 2000/29/EC. In particular, the Annex IIIA (14) description excludes peat and all media that do not include soil or organic substances.

Various definitions have been proposed for soil, but all of them show several commonalities. In all definitions, soil is defined as a mixture of organic and mineral materials located close to the surface of the earth. Some definitions provide more details than others. For example, definition number 9 in Table 1 indicates that soil is located in, approximately, the upper two metres of the earth's surface and that it includes minerals, water, decomposed animal and plant material, and microorganisms.

In agreement with the draft ISPM (FAO, 2013b), the Panel opts for a wider definition applicable to all soils and growing media, considering, in particular, that soil is one type of growing medium: 'Soil is a growing medium that is naturally occurring, composed of the loose surface material of the earth and consisting of a mixture of minerals and organic material'.

Table 1: Examples of definitions or descriptions of soil and/or growing media

	Source	Description or definition
1.a	Annex IIIA (14) of Council Directive 2000/29/EC	Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat
1.b	Annex IVAI (34) of Council Directive 2000/29/EC	Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants
2	ISPM 5 (FAO, 2013a)	Growing medium: any material in which plant roots are growing or intended for that purpose
3	Draft ISPM (FAO, 2013b)	Soil: a growing medium that is naturally occurring, composed of the loose surface material of the earth and consisting of a mixture of minerals and organic material
4	Oxford English Dictionaries, online	Soil: the upper layer of earth in which plants grow, a black or dark brown material typically consisting of a mixture of organic remains, clay, and rock particles
5	Soil Science Society of America, online	(i) The unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (ii) The unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.
6	British Society of Soil Science (BSSS, 2011)	Soils are the dynamic skin of the Earth, formed by the interaction of minerals, organic materials, organisms, water and air
7	Code of Federal Regulations USA (CFR, 2014)	Soil: The loose surface material of the earth in which plants grow, in most cases consisting of disintegrated rock with an admixture of organic material and soluble salts
8	Canadian Food Inspection Agency (CFIA, 2012)	Soil: the loose surface of the earth in which plants grow, in most cases consisting of disintegrated rock with an admixture of organic material Soil-related matter: humus, compost, earthworm castings, muck, plant litter and debris, either individually or in combination
9	Australia Department of Agriculture (ICON Database C20162, online)	Soils are the unconsolidated materials, naturally found on the immediate surface (approximately top two meters) of the earth's surface. They are aggregates of minerals, water, decomposed animal and plant material and micro-organisms
10	Biosecurity New Zealand (Biosecurity New Zealand, 2007)	Soil: the upper layer of earth containing a mixture of organic material, sand, gravel, clay and silt.

3.2. Indicative list of soil and growing media

Following the analysis of the results of the extensive literature searches described in section 2.2.1. 880 different SGM were identified by the Panel (Appendix C). This list is not exhaustive and there is no sharp demarcation between fertilisers and growing media. Because of the very large number of products that are used to grow plants, it is not possible to list all existing SGM types. However, the Panel distinguished eight groups of SGM that are presented below.

The great majority of SGM found in the selected references are media that include plant materials; they accounted for 678 out of 880 growing media (Figure 1A). These growing media are very diverse and include compost, food waste, green manure, straw, bark, etc.

Among the growing media without plant material, the main groups were:

- inorganic media different from water (78 references), such as sand, volcanic rock and gravel;
- media having undergone a process able to eliminate plant pests or at least strongly reduce their presence (73 references), such as ash, tannery sludge, molasses and coal;

- synthetic media (27 references), such as polymers, polyethylene terephthalate (PET) bottle particles and polystyrene granules.

Other media (water, media composed of animal materials and peat) were mentioned, but in only a limited number of references (Figure 1B).

The percentages of references related to different types of SGM do not reflect the volume of each SGM type traded across countries; they describe the diversity of SGM used to grow plants.

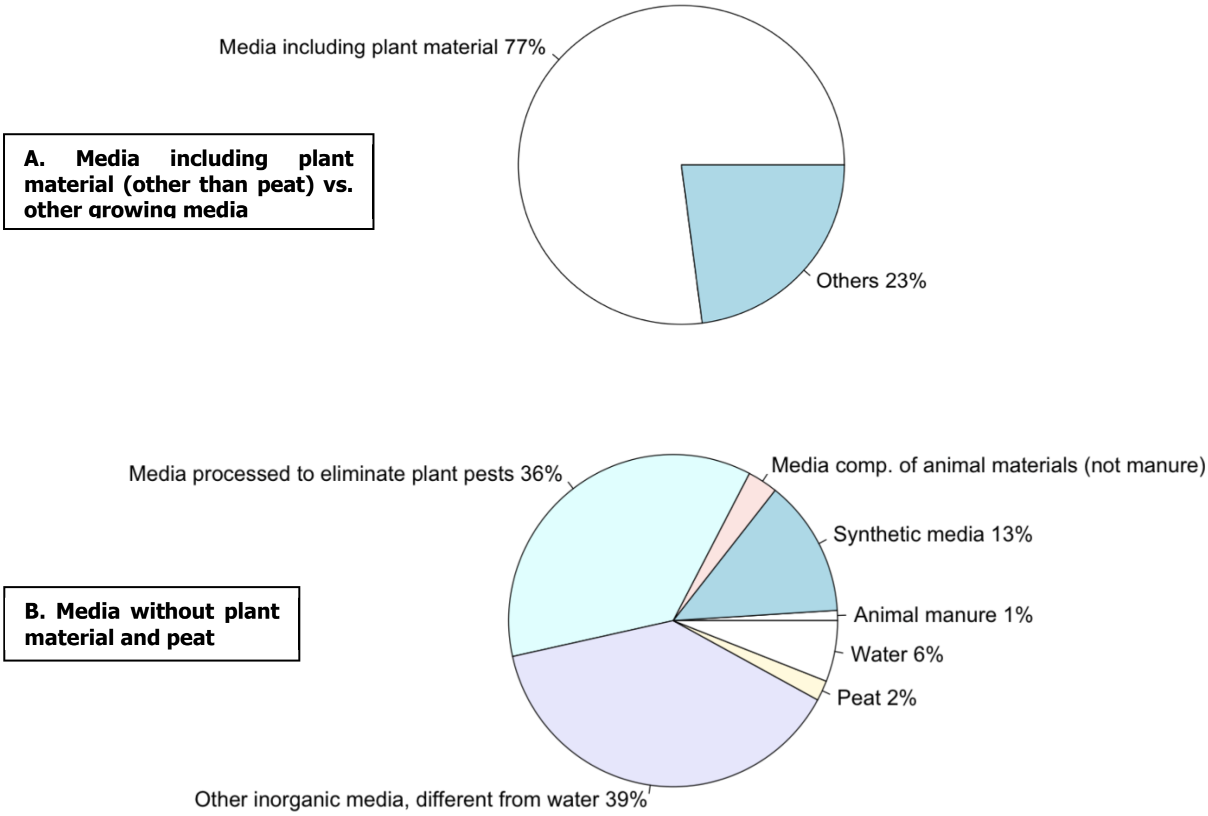

Figure 1: Percentage of references related to different media types, with and without plant material, found through an extensive literature search. Peat was treated as a separate group of soil and growing media. (A) Media including plant material (other than peat) vs. other growing media; (B) Media without plant material and peat

4. Assessment of the probability of association of harmful organisms with soil and growing media

4.1. Sources of information used to find associations of harmful organisms with soil and growing media

Following the analysis of the results of the extensive literature searches described in section 2.2.1, the Panel developed an inventory of SGM types and associated harmful organisms (section 2.2.1. and Appendix C). The results are summarised in Figure 2. They show that most of the associations between harmful organisms and SGM reported in the literature were found in media including plant materials (50 % of the associations) and in inorganic media different from water (20 % of the associations). The inventory of pests associated with the SGM is not exhaustive because of the very high numbers of SGM types (and/or components thereof) identified, and because new cultivation substrates are being continuously developed, as the overall trend is to develop new organic growing media as alternatives to peat (Bremmer et al., 2015). Therefore, the Panel has addressed this topic by using a more general approach, grouping the SGM types into broad groups for which the potential associations with pests are illustrated by relevant examples.

4.2. Rating the probability of association of harmful organisms with soil and growing media

The Panel rated the probability of association of harmful organisms with eight groups of SGM. These ratings were defined irrespective of the pathways and under the assumptions that (i) the growing media have not already been used to grow plants and that (ii) no RROs or processing to disinfect the growing media have been applied. The ratings are presented in Table 2.

4.2.1. Media including plant material

The association of plant pests with media including plant material, in particular growing media produced by composting or by anaerobic digestion of plant material, is rated as very likely because plant material may be composed partly or entirely of hosts of harmful organisms. Noble and Roberts (2004), Mikkelsen et al. (2006) and Noble et al. (2009) list a large number of pathogenic fungi, oomycetes, plasmodiophoromycetes, bacteria, viruses, pest insects, mites and nematodes associated with composts. Many of them can be eradicated during the composting process, but composting is not fully reliable because its effectiveness depends on a large number of factors (e.g. the type of organisms, the temperature, the duration and the mixing procedure of the plant materials during composting) (Noble and Roberts, 2004; Noble et al., 2009). In windrow composting, Potato cyst nematodes have been reported to survive in the superficial parts of the windrow (Goeffeng et al., 1978). Noble et al. (2009) provide a comprehensive review of detection methods for quarantine organisms associated with plant materials. Since the probability of association is influenced by factors such as plant species, plant origins, agricultural practices and processing methods, the uncertainty is high.

4.2.2. Animal manure

The association of plant pests with animal manure is rated as moderately likely by the Panel. Colleran (2000) identified various plant pathogenic fungi in organic waste used for biogas production. Potato cyst nematodes may remain infective in manure–straw mixtures for three months (Ländell, 1988). Spores of the corn smut Ustilago maydis can survive in the digestive tract of animals and germinate in the drainage from barnyard manure, and are spread with manure (Plant Disease Diagnostic Clinic, 2015). The local dispersal of the quarantine pest responsible for potato wart (*Synchytrium endobioticum*) has been shown to be possible by resting spores in contaminated manure (CABI, 2015). However, manure–straw mixtures and biogas slurry have also been found to exert an inhibitory effect on a range of fungal pathogens (McQuilken et al., 1994; Yan et al., 2011). Sewage sludge can contain quarantine organisms (Pietsch et al., in press). For example *S. endobioticum* can reach sewage sludge in waste water from households or food processing plants. This fungus is highly persistent due to the occurrence of resting sporangia with the capacity to survive unfavourable conditions. *S. endobioticum* can survive temperatures of 140 °C for two hours, and hence will not be inactivated by common heat treatments. Another organism that would present a challenge with regard to heat treatment is the weed *Abutilon theophrasti* can survive a heating to more than 100 °C for 15 min. A lower heat resistance is reported for *Clavibacter michiganensis* ssp. *Sepedonicus*, but this bacterium is still able to survive the sludge pasteurization, which is done at 70 °C for 60 minutes. Because the risk depends on several factors, such as place of origin, type of animals, animal feeds and processing method, the uncertainty is considered high.

4.2.3. Water

The association of plant pests with water is rated as moderately likely. Pure water is free from any organism, but it can easily be contaminated. Even very pristine water from snow melt, alpine streams and lakes has been found to contain pathogenic, sometimes antibiotic-resistant, strains of *Pseudomonas syringae* in France and the USA, in some cases in high quantities (up to 6 000 cells g^{-1}) (Morris et al., 2007, 2008), whilst zoospores of several oomycete pathogens (*Phytophtora alni, P. cinnamomi* and *P. lateralis*) are transmitted by running waters (reviewed by Husson et al., 2006). Soil water has been observed to transport zoospores of the potato wart fungus (*Synchytrium endobioticum*), although their lifespan is short (one to two hours) (CABI, 2015). Groundwater can be contaminated with organic material or human faecal bacteria (see, for example, a review by Jamieson et al., 2002), and thus might also be contaminated with plant pathogens. Since the probability of association is influenced by the place of origin of the water used as a growing medium and by the processing method, the uncertainty is rated as high.

4.2.4. Other media composed of animal materials, different from manure

The probability of association of plant pests with other media composed of animal materials, different from manure, is rated as moderately likely. Specific material can be associated with particular organisms. For example, wool can host weed seeds. A classic example is that of the South African invasive weed *Senecio inaequidens,* whose seeds were introduced into Europe in imported wool and dispersed from wool processing locations (Jamieson et al., 2002). Since the probability of association is influenced by several factors such as the place of origin, the breeding system and the processing method, the uncertainty is considered high.

4.2.5. Other inorganic media, different from water, especially sand

Several references report the presence of harmful organisms in other inorganic media, different from water, especially sand. Many plant-parasitic nematodes prefer sand or sandy soils as habitats. Sand with a particle size of fine to medium allows nematodes to find water films and pores of an optimal size for effective movement (Wallace, 1958). This is also the case for many quarantine species such as several *Pratylenchus* spp., *Radopholus similis* (banana and citrus race), *Xiphinema americanum* (Ponchillia, 1972), potato cyst nematodes (*Globodera* spp.) and root-knot nematodes (*Meloidogyne* spp.). Sand dries out easily and then becomes less suitable for nematode survival. However, some nematodes may enter a quiescent stage to survive dehydration for months or decades (Womersley et al., 1998). This occurs in the root lesion nematode *Pratylenchus penetrans*, cyst nematodes *Globodera* spp. and *Heterodera* spp., stem nematode *Ditylenchus dipsaci* and root-knot nematodes (*Meloidogyne* spp.). Potato cyst nematodes can endure prolonged periods of drought since the eggs are protected in the cyst. It has been demonstrated that juveniles and the eggs inside the cyst may remain infective for up to 32 years in the absence of host plants (Holgado et al., in press). Although sand from deeper soil horizons may also contain nematodes (nematode populations follow the distribution of plant roots), the risk of nematodes being present in sand collected from deep layers is lower. Since the probability of association is influenced by several factors, such as the depth of plant roots, the place of origin and the processing method, the uncertainty is considered high.

4.2.6. Peat

Peat is formed from organic matter in waterlogged environments under anaerobic conditions, and in highly acidic conditions (Whitmore, 1984; Howes, 1998). Peat is harvested from bogs and fens, i.e. habitats with a low abundance of higher plants. There are few studies on the occurrence of plant pathogens in peat. Peat is generally considered free of most plant pathogens, and is not regulated in, for example, the EU or the USA. It has been suggested that fungi are the main decomposers and have a more dominant role than bacteria in peatland ecosystems (Latter et al., 1967; Williams and Crawford, 1983). Latiffah et al. (2010) recorded a total of 27 isolates of *Fusarium* from five peat soil samples from Malaysia. *Fusarium solani*, *F. oxysporum*, *F. semitectum* and *F. proliferatum* were the most common species. The occurrence of the pathogenic fungus *Pythium ultimum* varies with locality, having a low prevalence in New Zealand (Robertson, 1973), while being more common in the peat moors of Ireland (Dooley and Dickinson, 1971). However, the overall abundance of fungi is reported to be lower in peatland compared with agricultural land (Dooley and Dickinson, 1971; Robertson 1973), and the majority of fungi recorded in peatlands are saprophytes (Thormann and Rice, 2007). Nematodes are common in peat. Most species are microbial feeders, omnivores or predators (Brzeski, 1962; Hoschitz and Kaufmann, 2004; Wasilewska, 1991), but there are also some reports of the occurrence of plant parasitic species. Brzeski (1962) reported the occurrence of *Criconemoides sphagni, C. annulifer* and *Criconema menzeli* in peat mosses in Poland. In Norway, Stoen et al. (1988) reported the presence of *Cephalenchus hexalineatus* in peat bogs and in blocks of peat prepared for use in horticulture. This species is not a quarantine pest, but may damage spruce seedlings (Stoen et al., 1988) and is also highly pathogenic to roses (Bioforsk, unpublished). Hoschitz and Kaufmann

(2004) reported *Nagelus*, *Pratylenchus* and *Rotylenchus* in a bog site. Studies in Poland report low numbers of *Tylenchorhynchus*, *Hirschmanniella*, *Pratylenchus*, *Hemicycliophora* and *Paratylenchus* in an undrained sedge moss fen site (Wasilewska, 1991). Since the probability of the association of harmful organisms with peat is influenced by factors such as the place of origin and the processing method, the uncertainty is considered high.

4.2.7. Synthetic media, such as glass wool, polystyrene, etc.

The association of plant pathogens with synthetic media, such as glass wool, polystyrene, etc., is very unlikely if they have not previously been used for any purpose that might expose them to contamination by harmful organisms. For unused synthetic media, the uncertainty is low.

4.2.8. Media having undergone a production process resulting in the elimination of the plant pests (e.g. coal)

The association of plant pathogens with media having undergone a production process resulting in the elimination of the plant pests (e.g. coal) is very unlikely with a low uncertainty. This process should not be considered a RRO as it is not specifically applied to reduce the risk posed by the harmful organisms.

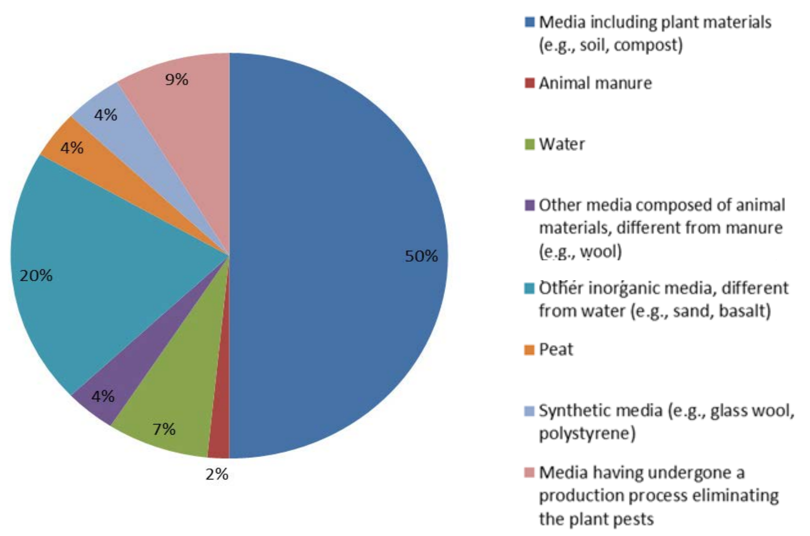

Figure 2: Percentage of associations of harmful organisms with soil and growing media groups (based on data from Appendix C)

Table 2: Ratings of probability of association between harmful organisms and groups of soil and growing media

Groups of soil and growing media	Rating	Uncertainty	Comments
Media including plant materials (e.g. soil, compost)	Very likely	High	Plant material may include plant species that are hosts of harmful organisms. The probability of association is influenced by several factors (plant types, plant origins, agricultural practices, processing method, etc.)
Animal manure	Moderately likely	High	Manure can host harmful organisms (e.g. fungi, nematodes). The probability of association depends on several factors (place of origin, type of animals, animal feeds, processing method etc.)
Water	Moderately likely	High	The probability of association depends on the place of origin and the processing method.
Other media composed of animal materials, different from manure (e.g. wool, horns etc.)	Unlikely to moderately likely	High	Wool of animals as a component of growing media may host weed seeds and soil as a contaminant. The probability of association depends on several factors (place of origin, breeding system, processing method, etc.)
Other inorganic media, different from water (e.g. sand, basalt)	Moderately likely	High	Inorganic media may have been contaminated by harmful organisms. The probability of association depends on the depth of distribution of plant roots, place of origin, processing method, etc.
Peat	Unlikely	Medium	Several nematodes have been described in association with peat although the species are not regulated in Council Directive 2000/29/EC.
Synthetic media (e.g. glass wool, polystyrene)	Very unlikely	Low	Very unlikely probability of association if the synthetic media were not already used to grow plants and were not exposed to contamination
Media having undergone a production process eliminating the plant pests (e.g. coal, paper, textiles etc.)	Very unlikely	Low	

5. Legislations on soils and growing media

5.1. EU legislations

The Panel focused its analyses on Council Directive 2000/29/EC, following the specific request formulated in the Terms of Reference (see section Terms of Reference).

As the definition of SGM adopted by the Panel also includes fertilisers, biostimulants, animal by-products and treated waste, the Panel also reviewed the following EU legislation:

1) Regulation (EU) No 142/2011, implementing Regulation (EC) No 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption, includes special requirements for import of animal by-products for use as organic fertiliser or soil improver. For example, Chapter VIII and Annex XIV, Chapter II, Section 1 of this regulation specify the requirements for import, transit and export of animal by-products and of derived products, including manure and organic fertilisers, for use outside the feed chain. The import of unprocessed manure is prohibited. The import of processed manure (conforming with (EU) 142/2011 Annex XI, Chapter 1, Section 2: heat treatment of at least 70 °C for at least 60 minutes, or equivalent measure), derived products from processed manure and guano from bats is permitted. The Panel notes a potential contradiction between the permission to import processed manure for use as an organic fertiliser or soil improver according to (EU) No 142/2011 and the prohibition to import a growing medium as such, which consists in whole or in part of [...] solid organic substances, according to Council Directive 2000/29/EC, Annex III, Part A (14).
2) Regulation (EC) No 2003/2003 (the Fertilisers regulation) aims to ensure the free circulation on the internal market of 'EC fertilisers', i.e. those inorganic fertilisers that comply with requirements regarding their nutrient content, their safety, and the absence of adverse effects on the environment. The EU 2020 Strategy (European Commission, 2010), aimed at revising the

regulation relating to fertilisers, liming materials, soil improvers, growing media and plant biostimulants and at repealing Regulation (EC) No 2003/2003, should take into account potential contradictions between these regulations and phytosanitary regulations.

3) Certification scheme: Commission Decision 2007/64/EC[5] lays down the criteria that growing media should meet to qualify for the EU Eco Label.

5.2. Soil and growing media in Council Directive 2000/29/EC

'Soil' and 'growing medium' are referred to in several articles and in several points of Annexes II, III, IV and V of Council Directive 2000/29/EC (Appendix D, Table 12), but there are no definitions provided in Article 2 of this Directive which could guide the implementation of the requirements. However, a description of 'growing medium' is given for two specific requirements: Annex III, Part A (14) and Annex IV, Part A, Section I (34) (Table 1). Since the two descriptions cover different types of materials, they appear to be relevant only in the context of the particular requirement. Soil is not described in Council Directive 2000/29/EC.

5.2.1. Soil and growing media as commodities

Council Directive 2000/29/EC includes the prohibition of the import of SGM as such, i.e. as commodities from many origins except some European and Mediterranean counties (2000/29/EC Annex III, Part A (14); Figure 2). A growing medium, as described for this requirement, consists, in whole or in part, of soil or solid organic substances, such as parts of plants, humus, including peat or bark, other than that composed entirely of peat. Consequently, there is no prohibition of import of growing media not containing soil or organic substances or those consisting entirely of peat from any country. The import of isolated bark of *Castanea*, *Quercus* (other than *Quercus suber*), *Acer saccharum* and *Populus*, which may be used as growing media, are prohibited with regard to specified countries of origin.

5.2.2. Soil and growing media attached to plants to sustain vitality

There is no import prohibition for SGM attached to or associated with plants intended to sustain the vitality of the plants. Instead, special import requirements must be met as formulated in Annex IV, Part A, Section I (34). These requirements apply to certain origins only; for example, most Mediterranean countries are exempt from this requirement.

A growing medium in this context is described as 'consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance'. This description is different from the description in the context of soil and growing media as commodities (Annex III, Part A (14)), mainly because for growing media entirely composed of peat attached to plants to sustain vitality, special import requirements apply; these requirements consist of a pre-planting component with three options and a post-planting component with two options, resulting in a total of six options, as presented in Appendix D. The same requirements also apply to the import of *in vitro* plants in growing media.

Naturally or artificially dwarfed plants must not only comply with the special requirements of Annex IV, Part A, Section I (34), but also with the additional special requirements for SGM of Annex IV, Part A, Section I (43). The requirements of Annex IVAI (43) are similar to those of Annex IVAI (34) in the sense that these requirements also consist of a pre-planting and a post-planting component. However, in Annex IVAI (43), there are three pre-planting options and three post-planting options, resulting in a total of nine additional options (Appendix D). Although the additional requirements of Annex IVAI (43) largely overlap with the general requirements for growing media to sustain the vitality of the plants of Annex IVAI (34), they are formulated in a different manner leading to possible incompatibilities of requirements and possible non-compliances. For example, according to Annex IVAI (34), (b), there is a choice between two post-planting options ('**EITHER** appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms, **OR** within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount

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[5] Commission Decision 2007/64/EC of 15 December 2006 establishing revised ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to growing media (notified under document number C(2006) 6962) version OJ L 32, 6.2.2007, p. 137–143.

necessary…'). According to Annex IVAI (43), (b), (aa), sixth indent, there is no choice between these options, but both requirements need to be fulfilled simultaneously ('have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms **AND** within two weeks prior to dispatch, have been shaken and washed with clean water to remove the original growing medium…').

Several additional requirements for SGM attached to plants to sustain their vitality, targeted to specific pests for specific groups of plants, are formulated in Annex IV, Part A, Section I (see Appendix D). These requirements range from 'pest free country' to 'pest free production site'.

5.2.3. Soil and growing media as contaminants attached to or associated with plants

There is no import prohibition for SGM attached to plants or associated with plants as contaminants (i.e. not sustaining the vitality of the plants). Special import requirements for SGM as contaminants with plants are formulated in Council Directive 2000/29/EC Annex IV, Part A, Section I, for tubers of *Solanum tuberosum*, but not for underground organs of other plant species (bulbs, corms, etc.). The requirements are targeted at specific pests and belong to various categories such as 'pest free country', 'pest free area' and 'inspection of consignments' (see Appendix D).

For the import of several plant commodities, notably tubers of *S. tuberosum* not intended for planting, into the Protected Zones of France (Brittany), Finland, Ireland, Portugal (Azores) and the UK (Northern Ireland), a tolerance level for the maximum amount of soil present in the consignment is formulated: 'the consignment or lot shall not contain more than 1 % by weight of soil'. This soil may contain harmful organisms, but there is no statement on prejudice to other provisions of the Annexes of Council Directive 2000/29/EC.

5.2.4. Soil and growing media as contaminants with other commodities

There are also no import prohibitions for soil and growing medium attached to or associated with commodities other than plants as contaminants. Special import requirements for SGM as contaminants with commodities other than plants are formulated in Council Directive 2000/29/EC Annex IV, Part B, only for the import of used agricultural machinery into the Protected Zones of France (Brittany), Finland, Ireland, Portugal (Azores) and the United Kingdom (Northern Ireland). The machinery must be cleaned and free from soil and plant debris when brought into places of production where beets are grown, or the machinery must come from an area where beet necrotic yellow vein virus (BNYVV) is known not to occur.

5.2.5. Ambiguities for soil and growing media in Council Directive 2000/29/EC

The requirements for soil or a certain growing medium are sometimes formulated in two or more sections of Council Directive 2000/29/EC and may result in different approaches for this growing medium, depending on factors such as country of origin and whether or not it is attached to plants.

1) Bark as a growing medium

Given the two descriptions of 'soil and growing media as such', isolated bark can be considered a '**growing medium consisting in whole of plant parts'**. It will not always be possible to determine whether a consignment of isolated bark is intended to be used as a growing medium or for other purposes. Council Directive 2000/29/EC includes contradicting requirements for 'soil and growing media as such' (Annex III) and 'isolated bark' (Annex III, Annex IV, Part A, Section I). For example, isolated bark of *Quercus* L. is prohibited from Russia if imported as a growing medium, but does not have to fulfil any requirements if imported as isolated bark (Annex III, Part A (6)).

2) Growing media entirely composed of peat attached to plants for planting and peat as such

The two descriptions for SGM (Annex IIIA (14) and Annex IVAI (34)) differ with respect to growing media composed entirely of peat. According to Annex IIIA (14), growing media as commodities ('as such'), *composed entirely of peat,* are exempt from the import prohibition and may be imported without restriction. When the same growing media, *composed entirely of peat*, are attached to plants for planting (in the minimum amount to sustain their vitality), import is not possible unless the special requirements of Annex IVAI (34) have been met. No explanation is provided for this difference. The

Panel notes that plant parasitic nematodes may be introduced into the EU with the unrestricted import of growing media composed entirely of peat (see section 4.2.6).

3) Interpretation of the terms 'artificial' versus 'natural' growing medium in Annex IVAI (43)

In Annex IVAI (43), an 'artificial' growing medium is distinguished from a 'natural' growing medium, without a description of these terms. It is implied that, unlike natural growing media, an artificial growing medium is free from harmful organisms. However, a growing medium created, e.g. by mixing soil with inorganic fibres, would be an artificial growing medium that might contain pests.

It would be valuable if the terminology used in these requirements was clearly explained with regard to the intended purpose of the requirements.

4) Possible overlapping requirements according to Annex IVAI (33), (34) and (43)

There is an apparent overlap of Annex IVAI (33), (34) and (43), all of which refer to plants with roots. Dwarfed plants need to comply with Annex IVAI (43), without prejudice to (33) and (34). The requirements for planting and for maintaining pest freedom after planting for dwarfed plants (43) are very similar, but not identical, to the conditions for plants that have to comply with (34). It seems inconsistent that dwarfed plants need to comply with (33), whereas for non-dwarfed plants this prejudice is not mentioned. The formulation of Annex IVAI (34) appears to cover the requirements of Annex IVAI (33). These ambiguities may lead to problems in implementing the requirements for such plants, increasing the uncertainty associated with the requirements (see section 6.3).

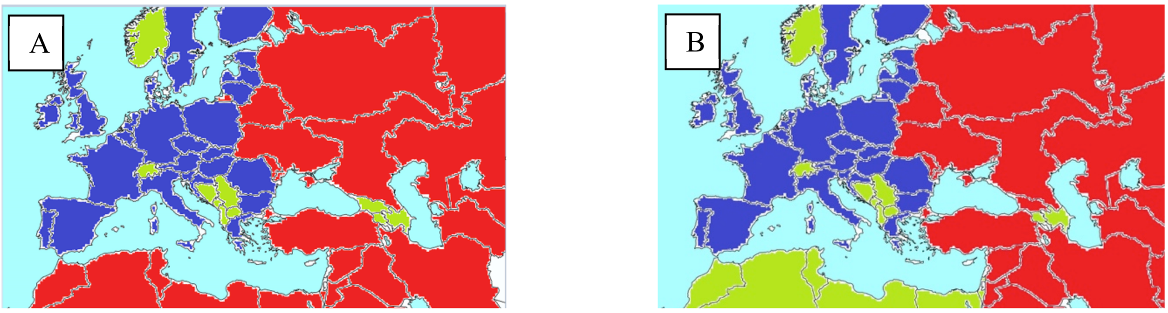
5) Diverging requirements for soil and growing media with respect to the country of origin when imported as commodities ('as such') and when attached to plants

There are several diverging requirements for the origin of SGM when imported as commodities ('as such') and when attached to plants.

One diverging requirement is where, according to Annex IV, Part A, Section I (34), special requirements exist for SGM from a specified country of origin if attached to plants, while according to Annex III, Part A (14), the import of SGM as commodities from the same country is not prohibited or restricted (i.e. no requirements are included in Annex IVA). For example, the import of SGM as commodities ('as such') is not prohibited from Georgia and no specific requirements exist. However, when SGM are attached to plants imported from Georgia the special requirements in Annex IVAI (34) should be fulfilled (see also Figure 3A and B).

Another diverging requirement is that Annex III, Part A (14), includes the prohibition of import of SGM as consignments from specified countries (e.g. Algeria), while, for these countries, there are no specific requirements in Annex IV, Part A, Section I (34), for SGM attached to plants.

Figure 3 gives a more general illustration of these divergences. Figure 3A shows the countries from which the import of SGM as commodities ('as such') is prohibited according to Annex III, Part A (14). Such prohibitions exist for Belarus, the Ukraine and Russia but not for Armenia, Azerbaijan or Georgia. The rationale for the exclusion of Armenia, Azerbaijan or Georgia from prohibition is not clear.



EU countries

Countries from which import of soil and growing media as such is prohibited

Countries from which import of soil and growing media as such is allowed with no specific requirements

EU countries

Countries for which Annex IVA1 (34) should be complied with for soil and growing media attached or associated with plants

Countries for which Annex IVA1 (34) does not need to be complied with for soil and growing media attached to plants

Figure 3: Differences in soil regulations for countries neighbouring the EU. (A) Prohibition of soil and growing media as such. (B) Soil and growing media attached to or associated with plants and special requirements laid down in Annex IVAI (34) of Council Directive 2000/29/EC

Figure 3B shows the countries for which special requirements are in place for the import of plants with soil or a growing medium attached, according to Annex IV, Part A, Section I (34). These requirements are not applicable for consignments from the following countries (although some pest-specific requirements may be applicable): Algeria, Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Egypt, Israel, Iceland, Kosovo, Libya, Macedonia, Montenegro, Morocco, Norway, Tunisia, Serbia and Switzerland (see Figure 3B).

6) Amount of soil and growing media attached

There is no restriction on the amount of SGM attached to plants. The only indication given in Council Directive 2000/29/EC is that the SGM type is 'intended to sustain the vitality of the plants'. As large plants can be imported into the EU, this can mean that a large quantity of SGM will also be imported (see Figure 4).

For SGM attached to or associated with plants as contaminants there is no restriction, except for the import of tubers of *Solanum tuberosum* other than those for planting, and of several other plants other than those for planting into the BNYVV protected zones, where a tolerance for the consignment of 1 % by weight of soil is formulated.

For soil and growing media attached to or associated with other commodities there is no restriction in Council Directive 2000/29/EC.

Figure 4: Examples of plants being moved in trade with growing media attached. (A) Plants being prepared for trade in a commercial nursery in Italy, February 2013 (picture: Jean Claude Grégoire). (B) and (C) Consignments of potted plants imported from Israel at Marseille harbour (courtesy of Border Inspection point of Fos sur mer, Marignane and Marseille)

7) Soil and growing media as packaging material

No requirements exist in Council Directive 2000/29/EC with regard to SGM when used as packaging materials for the protection of plants during transport. However, the same materials are subject to special requirements when used as growing media (e.g. coconut fibre).

8) Requirements not specific to soil and growing media that provide some phytosanitary protection

Council Directive 2000/29/EC includes a number of requirements regarding harmful organisms listed in Annexes IAI and IIAI which result in either a prohibition of imports of a specific plant genus or species from specified origins or specific requirements for soil (e.g. a limit to the amount of soil that can be present on the commodity).

As these requirements are not directed at SGM, they are not relevant to the analysis conducted here. However, they result in a reduction in the risk associated with the import of SGM.

5.3. Non-EU legislations

In this section, examples of phytosanitary measures implemented in Australia, Canada, New Zealand and the USA are provided. These countries were chosen because their phytosanitary legislation was originally written in English. The intention is not to fully evaluate the regulations of these countries but to explore approaches that are possibly different from those described in Council Directive 2000/29/EC. Further details are presented in Appendix E.

The main regulations that were considered by the Panel are for:

Australia: Australian Department of Agriculture's import conditions database ICON. Available online at http://apps.daff.gov.au/icon32/asp/ex_querycontent.asp

Canada: Canadian Food Inspection Agency- Acts and Regulations. Available online at http://www.inspection.gc.ca/about-the-cfia/acts-and-regulations/list/eng/1419029096537/1419029097256

New Zealand: New Zealand Ministry for Primary Industries 'The Biosecurity Act 1993'. Available online at http://www.mpi.govt.nz/law-and-policy/legal-overviews/biosecurity/

United States: US Government publishing Office; eCFR- Electronic Code of Federal Regulations database Available online at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title07/7cfr330_main_02.tpl

5.3.1. Soil and growing media as commodities

1) Soil

Various phytosanitary measures are implemented with respect to the import of soil as a commodity by the countries studied. These countries provide definitions of soil in the context of the legislation. The definitions differ slightly between the countries, and consequently the effectiveness of the phytosanitary measures in the countries may also vary slightly.

- Prohibition: the import of soil as a commodity is prohibited in Canada.
- Specified treatment: Official treatments (heat, irradiation) in authorised facilities at entry into the country are obligatory for all imported consignments of soil in the USA and New Zealand. The conditions of the treatments, e.g. temperature and duration, are explicit.
- Restricted end use: The import of soil for chemical or physical analysis is possible in the four countries studied. In the USA and Canada, additional end uses (research, religious, ceremonial, patriotic or similar) are formulated.
- Restricted end use combined with specific treatments: In Australia, the import of soil is possible only for uses other than in animal feeds or fertilisers or for growing purposes. Every imported consignment is still subjected to gamma irradiation treatment, with conditions as specified in the legislation, at entry into the country.

2) Growing media

- **USA**

The import of Soil Amendments and Plant Growth Enhancers (PGEs) requires an import permit and is subject to special conditions. Soil Amendments and PGEs are defined as 'materials that typically are added to soil, plants, or the plant-growth environment to enhance plant growth. These include fertilisers, compost, sludge, manure, microbes, additives, and others or combinations thereof' (USDA-APHIS, online[6]). The following categories of PGEs may be imported without restriction but are inspected at import:

- PGEs that are free of organic material; organic materials that are exempt from the United States Department of Agriculture (USDA) regulations are described in the soil circular (7CFR 300.300-1[7]). These include volcanic rock, pumice and peat (if processed to uniform consistency and free of plant parts and seeds). Sterile media is not regulated, but certification of the sterilisation process is required.
- PGEs that contain only pure cultures of organisms of known identity that are not human, animal, or plant pests or pathogens or biocontrol organisms/biopesticides.

- **Canada**

In Canada, the import of growing media is regulated by the Fertilisers Act and Regulations[8]. No person shall sell, or import into Canada, any fertiliser or supplement unless the fertiliser or supplement

[6] USDA-APHIS, online. Importation of Soil Amendments or Plant Health Enhancers, (Including Fertilisers, Compost, Sludge, and Other Materials Used to Enhance Plant Growth). United States Department of Agriculture, Animal and Plant Health Inspection Service. Available at http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth/sa_import/sa_permits/sa_plant_pests/sa_plant-growth-enhancers/!ut/p/a0/04_Sj9CPykssy0xPLMnMz0vMAfGjzOK9_D2MDJ0MjDzd3V2dDDz93HwCzL29jAx8TfULsh0VAY_1WkE!/

[7] Circular Q-330.300-1 Soil (01/2010) Revised, USDA-APHIS. Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=f7a880aa88acc1bb263c81e49c88a85e&mc=true&node=pt7.5.330&rgn=div5

[8] Fertilisers Act, R.S.C., 1985, c. F-10), Published by the Canada Minister of Justice, available online at http://laws-lois.justice.gc.ca

(i) has been registered as prescribed; (ii) conforms to prescribed standards; and (iii) is packaged and labelled as prescribed in the Fertilisers Act. The following information is relevant to the import of growing media into Canada:

- *'supplement'* means any substance or mixture of substances, other than a fertiliser, that is manufactured, sold or represented for use in the improvement of the physical condition of soils or to aid plant growth or crop yields;
- supplements must be registered prior to being imported or sold in Canada (T-4-107)[9];
- registration is allowed only after science-based evaluation of product safety information and labelling;
- compost is regulated under this act;
- potting soils must conform to the labelling requirements for supplement products.

Growing media, or components thereof, that are not considered soil or soil-related matter are not subject to the import or movement requirements (D.95.26)[10] and are listed below:

- tissue culture medium (alone, without plants);
- soil-free growing media;
- silica sand and pure minerals such as barite, greensand, kaolin, rock phosphate, rottenstone and tile clay (for industrial, cosmetic, therapeutic or environmental clean-up applications);
- sand from salt-water beaches and seashells that are free from all animal matter;
- gravel.

- **Australia**

Australia distinguishes various growing media. Import of manure is prohibited from all countries (Australian Government Department of Agriculture import condition (ICON C5246[11]). Fertilisers, soil conditioners and potting mixes of terrestrial animal and avian origin are prohibited from all countries except New Zealand (ICON C9004[12]), where an import permit and special conditions are required. Import permits and special conditions are also required for the following materials from all countries:

- fertilisers, soil conditioners and potting mixes of aquatic animal origin (ICON C5278[13]);
- fertilisers, soil conditioners and potting mixes of microbial origin (ICON C5177[14]);
- fertilisers, soil conditioners and potting mixes of plant origin (ICON C19058[15]);
- high risk (level 2 and level 3) and low risk (level 1) fertilisers including biohumate, compost accelerator, compost maker, humins, soil conditioners, etc. (ICONs C19945[16], C19946[17]);
- coir peat for end use as fertiliser (ICONs C5155, C5156)[18].

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[9] T-4-107 - Registration of Supplements Under the *Fertilizers Act.* Available at http://www.inspection.gc.ca/plants/fertilizers/trade-memoranda/t-4-107/eng/1307857765764/1307857913709

[10] D-95-26: Phytosanitary requirements for soil and soil-related matter, and for items contaminated with soil and soil-related matter. Available at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-95-26/eng/1322520617862/1322525442569

[11] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8963544&intCommodityId=1071&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[12] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8907898&intCommodityId=775&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[13] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9079228&intCommodityId=10676&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[14] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8903790&intCommodityId=27430&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[15] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8903489&intCommodityId=27425&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[16] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9028108&intCommodityId=16305&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[17] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9028126&intCommodityId=28760&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[18] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8745090&intCommodityId=539&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

- **New Zealand**

Growing media of plant origin are grouped into three risk classes: (i) fertilisers and growing media comprising plant products; (ii) manufactured fertilisers in granular, powdered and liquid form containing plant extracts; and (iii) manufactured fertilisers containing live organisms (Biosecurity New Zealand, Importation of Fertilisers and Growing Media of Plant Origin: BNZ-FERTGRO-IMPRT[19]). Depending on the risk class, a 'Permit to Import' and special import requirements are in place. Requirements for coco peat and coir fibre products include an import permit and special import requirements (according to New Zealand Import Health Standard for coco peat and coir fibre products).

3) Peat

- **USA**

No import requirements exist for peat, cosmetic mud or other mud products from fresh water estuaries or the earth's upper surface, if processed to a uniform consistency, and free of plant parts or seeds. However, such consignments are inspected at import (USDA-APHIS-Soil Circular[20]).

- **Canada**

There are no import restrictions for peat, originating from a non-agricultural area, that has not been used previously for growing plants or for other agricultural purposes (Canadian Food Inspection Agency (CFIA) Directive D-95-26[21], Appendix 1).

- **Australia**

Import requirements are in place for peat from Foot and Mouth Disease (FMD) Approved Countries (ICON C5254[22]) and from FMD Unapproved Countries (ICON C5272[23]). Biodegradable plant pots (e.g. jiffy pots) require an import permit and special requirements depending on the production process (ICON C19046[24]).

- **New Zealand**

The import of raw peat requires a Phytosanitary Certificate with special declarations and treatments, depending on the country of origin. No import restrictions apply to listed processed peat products, e.g. jiffy peat pots.

4) Sand, clay and various other materials

- **USA**

No import restrictions are in place for material that is free of organic matter, such as pure sand, clay (laterites, bentonite, china clay, attapulgite, tierrafino, etc.), talc, rocks, volcanic pumice, chalk, salt, iron ore, gravel and sediment, mud or rock from the oceans of the earth. However, such consignments are inspected at import (USDA-APHIS-Soil Circular[25]).

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[19] Biosecurity New Zealand, 2009. Import Health Standard BNZ-FERTGRO-IMPRT: Importation of Fertilisers and Growing Media of Plant Origin. Available at https://archive.org/details/nzs.bio.bnz.fertgro.imprt.2009

[20] Circular Q-330.300-1 Soil (01/2010) Revised, USDA-APHIS. Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=f7a880aa88acc1bb263c81e49c88a85e&mc=true&node=pt7.5.330&rgn=div5

[21] D-95-26: Phytosanitary requirements for soil and soil-related matter, and for items contaminated with soil and soil-related matter. Available at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-95-26/eng/1322520617862/1322525442569

[22] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9018741&intCommodityId=1271&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[23] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9018760&intCommodityId=1271&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[24] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8939095&intCommodityId=27404&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[25] Circular Q-330.300-1 Soil (01/2010) Revised, USDA-APHIS. Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=f7a880aa88acc1bb263c81e49c88a85e&mc=true&node=pt7.5.330&rgn=div5

- **Canada**

No import restrictions are in place for commodities that are not considered soil or soil-related matter and are not subject to the import or movement requirements listed elsewhere (D.95.26[26]), as listed below:

- tissue culture medium (alone, without plants);
- soil-free growing media;
- silica sand and pure minerals such as barite, greensand, kaolin, rock phosphate, rottenstone and tile clay (for industrial, cosmetic, therapeutic or environmental clean-up applications);
- sand from salt-water beaches and seashells that are free from all animal matter;
- gravel.

- **Australia**

No restrictions exist for the import of mineral and metal ores, rocks and sand (and articles containing these materials), excluding soil, for all uses other than as animal feeds, fertilisers or for growing purposes (ICON C18187[27]).

When the end use of minimal risk minerals, metal ores and related material (including soil) is 'stock feed', import is possible with an import permit and special import conditions apply (ICON C9790[28]). The import of material, listed as 'Minimal Risk Minerals, Ores and Related Material' sourced from at least 2 m below the earth's surface, is allowed without import permit, but a manufacturer's declaration is required.

- **New Zealand**

Sand or clay that is visually free of organic material, commercially packed and intended for manufacturing or as absorbents is permitted without restriction (e.g. kitty litter, silica sand (glass) or pottery, or for paint manufacture or drilling fluid). Sand or clay containing organic material must be treated as soil.

Rock or gravel that is inspected and found to be free of organic material is permitted without restriction. Rock or gravel containing organic material must be treated as soil.

5.3.2. Soil and growing media attached to or associated with plants

1) Soil and growing media attached for sustaining plant vitality

- **USA**

Plants for planting ('restricted article') for importation into the USA must be free of sand, soil, earth, and other growing media. The following are exceptions:

- articles from Canada;
- articles established and growing solely in agar or in other agar-like tissue culture medium;
- epiphytic plants (including orchid plants) established solely on tree fern slabs, coconut husks, coconut fibre, new clay pots or new wooden baskets;
- specifically listed plants for planting in specified growing media from specified places of origin and produced under specified growing conditions (7CFR 319.37-8[29]). These growing media must be one of the following: baked expanded clay pellets, coal cinder, coir, cork, glass wool, organic and inorganic fibres, peat, perlite, phenol formaldehyde, plastic particles, polyethylene, polymer stabilised starch, polystyrene, polyurethane, rock wool, sphagnum

[26] D-95-26: Phytosanitary requirements for soil and soil-related matter, and for items contaminated with soil and soil-related matter. Available at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-95-26/eng/1322520617862/1322525442569

[27] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8751804&intCommodityId=26555&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[28] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=7995854&intCommodityId=767&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[29] 7 CFR 319.37-8 - Growing media. Available at http://www.gpo.gov/fdsys/granule/CFR-2012-title7-vol5/CFR-2012-title7-vol5-sec319-37-8

moss, urea-formaldehyde, Stockosorb superabsorbent polymer, vermiculite, volcanic rock or zeolite, or any combination of these media.

For the import of plants for planting, certification requirements with respect to soil are formulated for specified products (7CFR 319.37-5[30]).

- **Canada**

Plants for import into Canada must be entirely free from soil, except if originating from continental USA. The maximum permitted amount of soil is a thin film of dust, that is the amount that might be left by using dirty water for washing the plants. Any thicker a film, or a patch or clump of soil constitutes non-compliance and is grounds for refusing the material.

Growing media, including soil-free growing media, are considered equivalent to soil and is prohibited unless the plants are produced under the Canadian Growing Media Program (CFIA Directive D-96-20[31]).

Plants without roots must be free from soil, soil-related matter and growing media. Plants with roots must be produced in a facility approved by both the CFIA and the exporting country's National Plant Protection Organization, and in accordance with approved plant production procedures. Approved growing media must be new and must consist of synthetic or other approved substances (other than soil and related matter) used singly or in combination. Examples of approved growing media include expanded or baked clay pellets, expanded polystyrene beads, floral foam, ground coconut husk, ground cocoa pods, ground coffee hulls, ground rice husk, peat, perlite, pumice, recycled paper, rock wool, sawdust, sphagnum, styrofoam, synthetic sponge, vermiculite, and volcanic ash or cinder. The growing media must remain free of plant pests and of sand and related matter.

- **Australia**

Only plant species listed in the ICON database can be imported into Australia. All nursery stock must be free from soil and other extraneous contamination of quarantine concern. Plants may arrive established in potting media, but media will be removed from the roots at entry and all plants will receive quarantine treatment (fumigation) bare-rooted. All plants must be subject to post-entry quarantine procedures for at least three months (ICON C7300, C7302)[32]. Seedlings may be imported established in growth plugs made of compressed peat or an inert material such as Oasis© or Rock Wool, but are also subject to fumigation and post-entry quarantine for at least three months.

- **New Zealand**

Import of plants with soil or growing media attached into New Zealand is subject to special requirements and must be declared on the Phytosanitary Certificate as follows: 'The plants were raised from seed/cuttings in soil-less rooting media in containers maintained out of contact with the soil' or 'The roots of the plants have been dipped in fenamiphos at 1.6g a.i. per litre of water for 30 minutes' (Ministry for Primary Industries (MPI) Standard 155.02.06)[33].

2) Soil and growing media associated as packaging material

- **USA**

Any restricted article for importation into the USA must not be packed in a packing material unless the plants were packed in the packing material immediately prior to shipment. Such packing material must be free from sand, soil or earth (except for sand, as designated below); must not have been used

[30] 7 CFR 319.37-5 - Special foreign inspection and certification requirements. Available at http://www.gpo.gov/fdsys/granule/CFR-2012-title7-vol5/CFR-2012-title7-vol5-sec319-37-5

[31] D-96-20: Canadian Growing Media Program, Prior Approval Process and Import Requirements for Plants Rooted in Approved Media. Available at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-96-20/eng/1323854223506/1323854343186

[32] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8993798&intCommodityId=28154&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[33] Ministry for Primary Industries Import Health Standard 155.02.06: Importation of Nursery Stock 21 January 2015. Available at https://mpi.govt.nz/document-vault/1152

previously as packing material or otherwise; and must be listed in CFR 319.37-9[34]. Examples are baked or expanded clay pellets, ground peat, rock wool, quarry gravel and sphagnum moss. The following types of soil or earth are authorised as safe for packing: peat, peat moss and osmunda fibre (CFR 319.69-5[35]).

- **Canada**

Plants for planting frequently enter Canada in association with packing material that is intended to protect them during shipping and maintain moisture (CFIA Directive D-08-04[36], paragraph 3.10). Approved packing materials are the following: coconut husk fibres (coir), cork (ground cork), wood shaving, wood wool, sawdust, excelsior (or other very fine wood shavings), paper, peat, perlite, polyacrylamide (water-absorbing polymers), rice chaff and vermiculite. Other products or materials may be approved by the CFIA on a case-by-case basis. All of the above materials must be free of pests, soil and soil-related matter. The material must be new and will not be accepted if it has been previously used for growing, rooting or packing plants or plant materials.

- **Australia**

The Department of Agriculture prefers that plants are imported bare rooted; however, packing material can be used to help decrease the risk of damage to the plant during transport to Australia (ICON C8815[37]). Accepted media include buckwheat hulls, plastic foam, wood shavings, vermiculite, peat moss and sphagnum moss. Plants should not arrive rooted in the packing material.

- **New Zealand**

Only inert/synthetic material may be used for the protection, packaging and shipping of materials of nursery stock (MPI Standard 155.02.06. [38]). Peat can be used as a packing material, but is subjected to the same conditions as consignments of raw peat (BMG-STD-SOWTR[39], paragraph 5.5).

5.3.3. Soil as a contaminant

- **USA**

No soil shall be moved into or through the USA from any place outside thereof or from any territory or possession into or through any other territory or possession or the continental USA, whether the soil is moved as such or incidentally by adhering to the means of conveyance or to other articles (7CFR 330.300[40]). When soil is found as a contaminant with a product, the consignment may be rejected (e.g. cut flowers, 7CFR 319.74-2[41]).

- **Canada**

The importation of items contaminated with soil and soil-related matter from all countries is prohibited (CFIA D-95-26[42]).

[34] 7CFR 319.37.9 Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=fdb2970893cbb5c7e6a1e999db7d5fa6&mc=true&node=se7.5.319_137_69&rgn=div8

[35] 7CFR 319.69.5 Available at http://www.ecfr.gov/cgi-bin/text-idx?SID=fdb2970893cbb5c7e6a1e999db7d5fa6&mc=true&node=se7.5.319_169_65&rgn=div8

[36] D-08-04: Plant protection import requirements for plants and plant parts for planting. Available at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-08-04/eng/1323752901318/1323753612811

[37] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8990908&intCommodityId=8563&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[38] Ministry for Primary Industries New Zealand, Import Health Standard 155.02.06: Importation of Nursery Stock 21 January 2015. Available at https://mpi.govt.nz/document-vault/1152

[39] Biosecurity New Zealand, 2007. Soil definition in Import Health Standard for soil, rock, gravel, sand, clay, peat and water from any country, BMG-STD-SOWTR. Ministry of Primary Industries, New Zealand. Available at http://www.biosecurity.govt.nz/imports/non-organic/standards/bmg-std-sowtr.htm

[40] 7CFR 330.300 Subpart—Movement of Soil, Stone, And Quarry Products. Soil from foreign countries or Territories or possessions. Available at http://www.gpo.gov/fdsys/pkg/CFR-2012-title7-vol5/xml/CFR-2012-title7-vol5-part330.xml#seqnum330.300

[41] 7CFR 319.74-2 Conditions governing the entry of cut flowers. Available at http://www.gpo.gov/fdsys/pkg/CFR-2012-title7-vol5/xml/CFR-2012-title7-vol5-sec319-74-2.xml

[42] D-95-26: Phytosanitary requirements for soil and soil-related matter, and for items contaminated with soil and soil-related matter. Available online at http://www.inspection.gc.ca/plants/plant-protection/directives/date/d-95-26/eng/1322520617862/1322525442569

- **Australia**

The import of products contaminated with soil is prohibited.

Special requirements exist for used machinery (ICON C19874[43]): each consignment must be free of soil, mud, insects, plant and animal debris and other biosecurity risk material before arrival in Australia.

Special requirements exist for soil and articles containing soil (ICON C20162[44]): import conditions require that soil and articles containing soil be subjected to gamma irradiation at 50 kGray (5 Mrad), prior to release to the importer, by a treatment provider with a compliance agreement with the Department of Agriculture.

An import prohibition exists for fireworks containing soil, sand and other plant material (ICON C5184[45]): if prohibited plant material or other quarantine risk material, such as soil, is found in fireworks, the consignment will be re-exported or destroyed at the importer's expense.

- **New Zealand**

Soil that is a contaminant on a consignment must be treated or destroyed. Treatment or destruction is to be undertaken at an approved transitional facility (BMG-STD-SOWTR[46]).

Consignments of nursery stock contaminated with soil must be treated, reshipped or destroyed (MPI Standard 155.02.06[47], Importation of Nursery Stock, paragraph 2.2.1.4).

5.4. Main differences between EU and examples of non-EU legislation

5.4.1. Clear definitions for soil and growing media

For SGM imported as a commodity, the legislation of the non-EU countries distinguishes clearly soil from other types of growing media. The legislation of the non-EU countries studied includes separate definitions for soil and for growing media, which allows for transparent identification of commodities not subjected to import requirements and commodities that need various types of requirements. In Council Directive 2000/29/EC, soil is not defined and therefore it is not clear if earth materials such as clay or sand, free from organic material, are included in the legislation. The descriptions for growing media in Council Directive 2000/29/EC Annex IV, Part A, Section I, include soil as a possible component and, since soil is not defined, it is difficult to differentiate growing media according to the level of risk of plant pests and the associated need for phytosanitary measures.

5.4.2. Phytosanitary measures

In Council Directive 2000/29/EC, the measure 'restricted end use' is used for only specified products 'intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading BNYVV' in certain Protected Zones. In the legislation of the non-EU countries, this measure is more widely implemented, in particular to distinguish import of soil and components of growing media intended to be used for non-agricultural purposes.

In the legislation of non-EU countries, the conditions for special requirements (e.g. temperature duration, treatment details and sample size) are explicitly described, whereas in Council Directive 2000/29/EC the conditions to be applied are left to the interpretation of the exporting country. This results in much higher uncertainty of the effectiveness of the special requirements given in Council Directive 2000/29/EC (see section 6.3).

[43] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9080153&intCommodityId=28579&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[44] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=9075767&intCommodityId=29199&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[45] http://apps.daff.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8120302&intCommodityId=782&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0

[46] Biosecurity New Zealand, 2007. Soil definition in Import Health Standard for soil, rock, gravel, sand, clay, peat and water from any country, BMG-STD-SOWTR. Ministry of Primary Industries, New Zealand. Available at http://www.biosecurity.govt.nz/imports/non-organic/standards/bmg-std-sowtr.htm

[47] Ministry for Primary Industries New Zealand, Import Health Standard 155.02.06: Importation of Nursery Stock 21 January 2015. Available at https://mpi.govt.nz/document-vault/1152

5.4.3. Soil and growing media attached to plants for planting

With respect to SGM attached to plants for planting, Canada and the USA specify detailed requirements for the origin, production methods and growing media to be used for plants for planting that are permitted for import. Australia and New Zealand have a strong focus on the required treatment at or before entry and on post-entry quarantine, which is obligatory for all plants for planting. In Council Directive 2000/29/EC, such detailed specific requirements are not included.

5.4.4. Soil and growing media as packing material

Council Directive 2000/29/EC does not cover SGM when used as packing material to protect plants during transport. This use of soil or growing media may pose a risk of entry of plant pests. In the legislation of non-EU countries these risks are addressed by lists of approved packing materials.

The legislation of non-EU countries is more explicit than Council Directive 2000/29/EC in the prohibition of SGM as a contaminant with plants. Non-EU countries specify the prohibition of SGM attached to machinery or other commodities, whereas such a restriction is not formulated in Council Directive 2000/29/EC, except in relation to BYNVV Protected Zones.

6. Effectiveness of risk reduction options (RROs)

6.1. Extensive literature search on the effectiveness of risk reduction options

This literature search focused on treatments intended to establish a pest-free site of production or to ensure freedom of SGM from harmful organisms. An extensive literature search was carried out in order to collect scientific papers assessing the effectiveness of RROs to reduce the risk associated with harmful organisms present in SGM. Papers were collected using the ISI Web of Knowledge database (Appendix F). The time span was 2000–2014, and the option 'All databases' was selected.

The total number of papers collected by the literature search was equal to 662. Among these references, 207 papers were found to report the results of experiments assessing the effectiveness of RROs on some harmful organisms for some SGM types. This subset of papers was retained for further analysis and was reviewed in detail. Each paper included results for one or several treatments, i.e. for combinations of RROs, harmful organisms and SGM types. The total number of treatments tested in the 207 papers was equal to 300. The data reported in the selected papers were used to score the effectiveness of the RRO considered for each treatment. An effectiveness score was derived for each of the 300 treatments using the four-level scoring system described in Table 3 below.

Table 3: Four-level scoring system for rating the effectiveness of risk reduction options used for rating the 300 treatments retrieved from the literature search

Score definition
Missing data
No effect
Partial reduction of presence of harmful organisms in SGM
Estimated 100 % reduction of presence of harmful organisms in SGM

These scores should be interpreted with caution because the experiments reported in the reviewed papers were dealing with very specific combinations of SGM types, RROs and harmful organisms. Thus, a RRO with a '100 % reduction' does not indicate that this RRO was able to eradicate a large range of harmful organisms in a large range of SGM, but rather that it was able to control one or a few species in a specific SGM in a given experimental setting.

In addition, it is important to take into account the fact that we were not able to derive confidence intervals for these scores because of the limited availability of data in the papers reviewed. Thus, the score '100 % reduction' should not be viewed as a true level of reduction of 100 %, but rather as an estimated value whose associated uncertainty might be large.

The type of RRO tested in each paper was extracted during the review process. Additional information was extracted from the papers showing '100 % reduction': the names of the harmful organisms, the description of the SGM, a detailed description of the tested RROs and the type of variable measured to evaluate the effectiveness of the tested RROs. The extracted data, the effectiveness scores and the expert comments are presented in Appendix F.

6.2. Results of the extensive literature search

Four categories of RROs were tested in the selected papers, namely biological, chemical, heat and mechanical treatments. In some cases, several types of treatments were combined, and three types of combinations of treatments were identified from the selected papers: biological and chemical treatments, biological and heat treatments, and chemical and heat treatments. Biological treatments were more frequently tested than chemical and heat treatments in the literature, and only a limited number of papers assessed combinations of treatments (Figure 5).

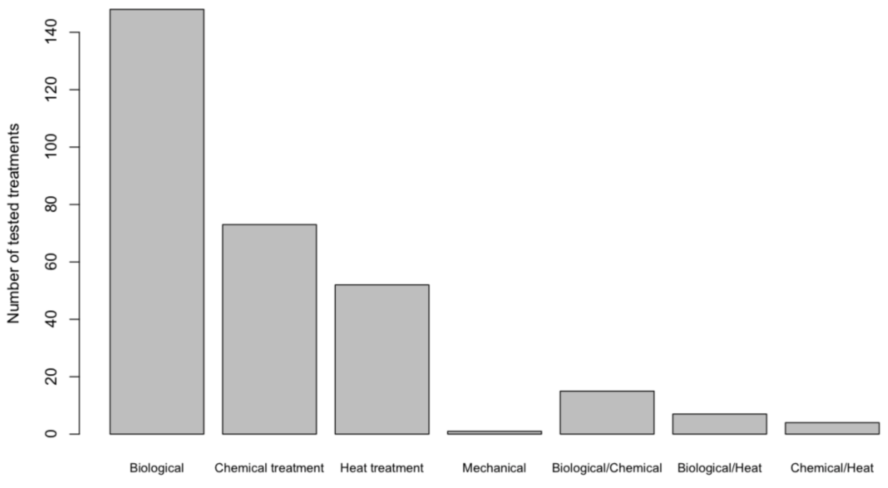

Figure 5: The principal categories of RROs evaluated in the selected papers, and the number of treatments (out of 300) tested for each category

Each category of treatments was divided into several sub-categories in order to describe the diversity of the RROs evaluated in the 207 selected papers (Figure 6). Two sub-categories of biological treatments were evaluated in the selected papers: the use of antagonists (i.e. microorganisms able to control pathogens) and the use of organic amendments with a suppressive effect on pathogens (66 % and 34 % of the tested treatments, respectively). The most frequently tested heat treatment was solarisation (72 % of the tested treatments), followed by composting (15%). Three additional heat treatments were also tested in the selected papers, namely steaming, pasteurisation and the use of microwaves. Two types of chemical treatments were considered: pesticide application (53%) and fumigation (47%). A large diversity of combinations of treatments was evaluated in the selected papers. The most frequently tested combinations were 'antagonist + pesticide' (46 % of the treatments), 'organic amendment + solarisation' (14%) and 'antagonist + solarisation' (11%). Details of the treatment characteristics (the solarisation procedure, chemical products, names of antagonists, type of organic amendments, etc.) can be found in Appendix F.

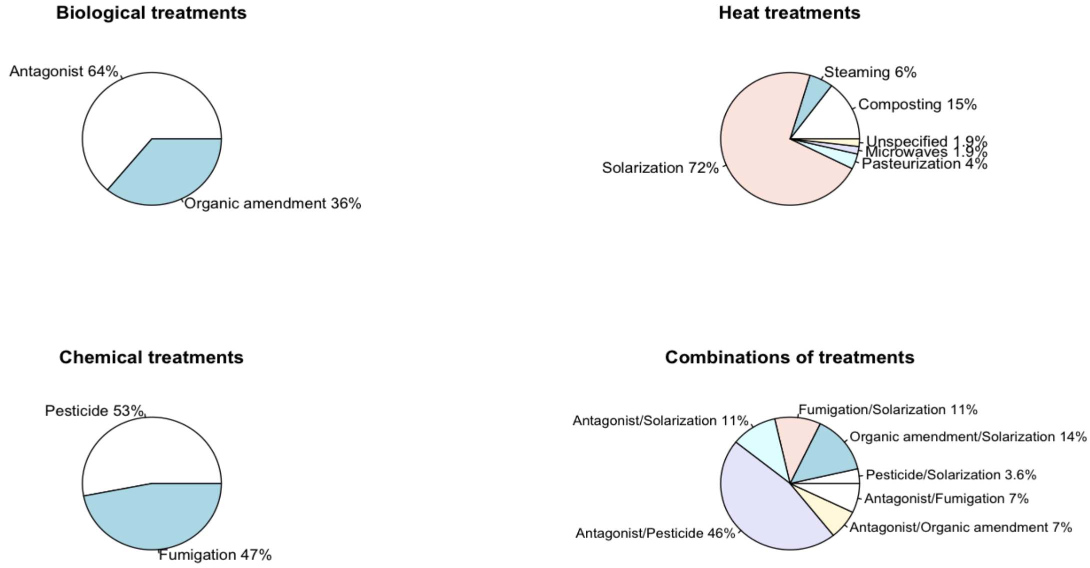

Figure 6: Sub-categories of RROs evaluated in the selected papers. (Slice sizes are proportional to the numbers of tested RROs)

In most cases, biological treatments resulted in a partial reduction in harmful organisms (Figure 7). However, in a few situations, biological treatments led to '100 % reduction' or to no reduction in harmful organism presence. The use of biological treatments alone is thus rarely very efficient for controlling harmful organisms.

Compared with biological treatments, the proportions of cases showing 100 % reduction of harmful organisms were higher for fumigation and for pesticide treatments (Figure 8). Fumigation and pesticides led to '100 % reduction' in 55 % and 89 % of the treatments considered, respectively, and these two types of RROs never had a score of 'no effect'. This result shows that chemical treatments always had some effect on harmful organisms and '100 % reduction' occurred in most of the cases considered. However, the use of chemical treatments was not fully efficient in all cases, and only a partial reduction in the presence of harmful organisms in SGM was found in several cases. In addition, several of the chemical products showing high levels of effectiveness are now banned in several countries.

Solarisation and composting always had some effect on harmful organisms in the treatments considered but, in many cases, these two types of heat treatment led to only a partial reduction in harmful organism presence (50 % and 63 % of the composting and solarisation treatments, respectively) (Figure 9). Thus, this result indicates that solarisation and composting did not lead to '100 % reduction' in all cases. The effectiveness of these heat treatments depends on the type of organisms, the SGM characteristics and the treatment procedure (Appendix F).

The effectiveness of three other types of heat treatments, i.e. steaming, pasteurisation and microwaves, was also analysed, but these were based on a very limited number of papers. Pasteurisation always showed a partial reduction of harmful organisms, steaming showed '100 % reduction' in two treatments and a partial reduction in one treatment, and microwaves showed '100 % reduction' in one treatment.

Scores obtained for two types of treatment combinations are presented in Figure 10. Treatments combining the use of antagonists and pesticides led to '100 % reduction' in 13 treatments (tested in the same paper) and were able to control several pathogens. However, all of these results were obtained using *in vitro* conditions, and greenhouse and field experiments failed to reproduce the effects. Combinations of organic amendments and solarisation led to '100 % reduction' in half of the tested treatments and a partial reduction in the other half. This combination of treatments is thus able to reduce the presence of harmful organisms, but is not 100 % effective in all cases.

In conclusion, this extensive literature search showed that heat, pesticide and fumigation treatments are able to reduce the presence of harmful organisms in SGM, but that these treatments are not 100 % effective in all cases. Their effectiveness depends on several factors, especially on SGM characteristics, the type of harmful organisms and the procedure of application. Because of the variability in their effects, the effectiveness of these measures is highly uncertain.

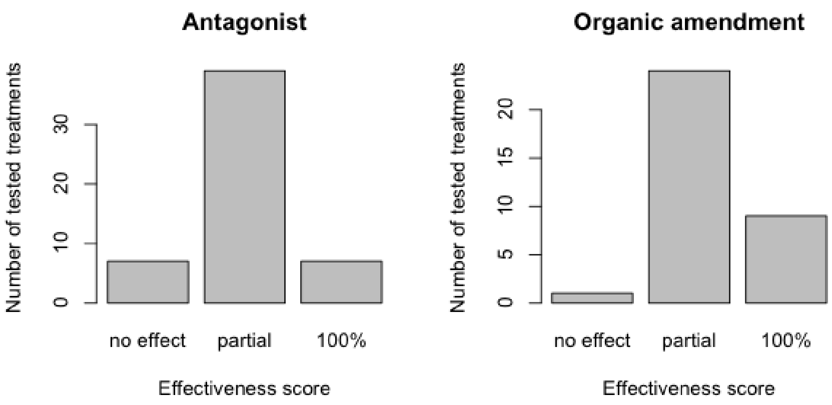

Figure 7: Scores of effectiveness for antagonist and organic amendment (no reduction, partial reduction or 100 % reduction)

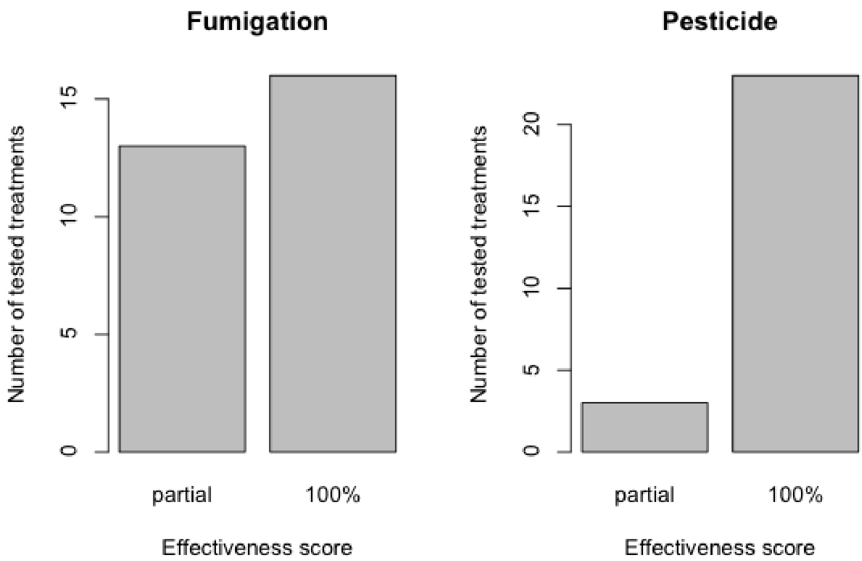

Figure 8: Scores of effectiveness for fumigation and pesticide treatment (partial reduction or 100 % reduction)

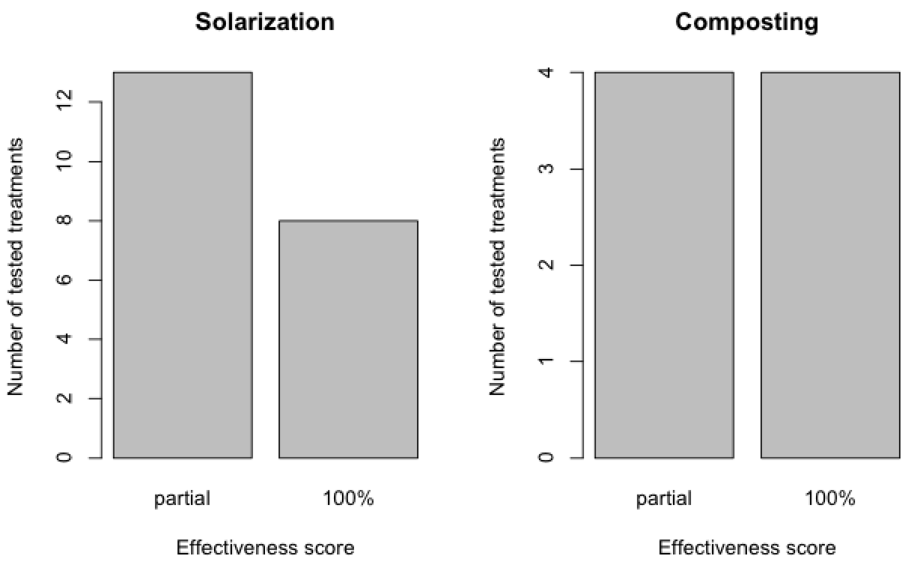

Figure 9: Scores of effectiveness for solarisation and composting (partial reduction or 100 % reduction)

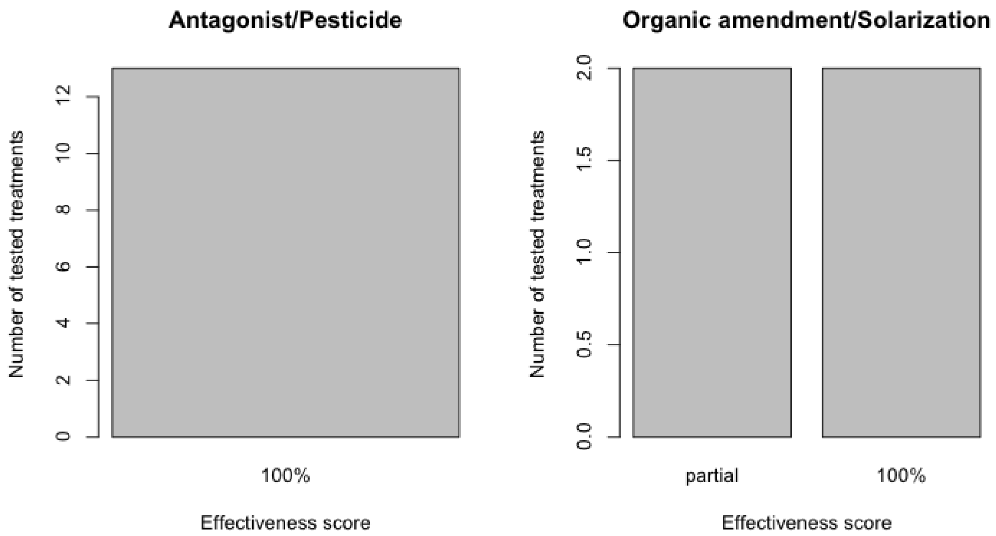

Figure 10: Scores of effectiveness for combinations of antagonist and pesticide, and organic amendment and solarisation (partial reduction, 100 % reduction). All of these results were obtained using *in vitro* conditions

6.3. Assessment of the risk reduction options applied in the EU legislation

The RROs currently implemented in the EU regulation were identified and classified according to the categories defined in the EFSA guidance document on RROs (EFSA PLH Panel, 2012). The levels of effectiveness and uncertainty were rated for each RRO using the rating system defined in Appendix B. The ratings are presented in Appendix D and the results of the Panel's assessment are summarised below.

6.3.1. Risk reduction options applied to soil and growing media as such

SGM as such are either not regulated (e.g. peat and SGM imported from countries excluded from the regulation) or prohibited.

The Panel has rated the effectiveness of the RRO 'prohibition of import' as **very high** with **low uncertainty**. However, as mentioned in section 5.3, prohibition is not applied to all non-EU countries and to all types of SGM. Thus, peat can be imported into the EU as a commodity, and SGM as such can be imported from several countries including Armenia, Azerbaijan and Georgia. The rationale for exemption of the mentioned countries is unknown, since harmful organisms associated with SGM are known to occur in these countries. The current exclusion is questionable.

6.3.2. Risk reduction options applied to soil and growing media attached to or associated with plants

Two principal categories of RROs are listed in the regulation for this type of commodity: 'prohibition of import' of SGM attached to or associated with plants and 'pest free production site + treatment of consignment' to ensure freedom of SGM from harmful organisms.

The Panel has rated the effectiveness of the RRO 'prohibition of import' as **very high** with **low uncertainty**, as mentioned in section 6.3.

A high number of variants of RROs falling into the category 'pest free production site + treatment of consignment' are mentioned in Council Directive 2000/29/EC (Appendix D), for example 'growing medium was free from soil and organic matter, and appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms', 'growing medium was subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms', etc. Their exact formulation differs depending on the type of considered plant materials (Appendix D). These RROs could potentially be highly effective if they really ensure that the SGM are free from any harmful organisms, but the vague terminology used in the regulation makes it difficult to accurately assess the effectiveness of this category of RROs.

Because of the vagueness of the terminology used in Council Directive 2000/29/EC, the effectiveness of the RROs of the category 'pest free production site + treatment of consignment' is rated as **moderate to high.** In our assessment (Appendix D), the effectiveness is considered moderate when the formulation is 'growing media was found free from...' and is considered high when the formulation was 'growing media was free from...' (Appendix D). The effectiveness is also considered high for 'growing media subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms'. The results of the literature review presented in section 6.2 indeed show that heat treatment and fumigation can potentially be highly effective, but effectiveness depends on several factors, especially on the SGM characteristics, the type of harmful organisms and the procedure of application.

The **uncertainty** regarding the effectiveness of the category 'pest free production site + treatment of consignment' is rated as **medium to high** by the Panel for several reasons:

- the regulation does not provide any guidance on how to check for the presence of harmful organisms in SGM;
- the regulation does not explain how to maintain growing media free from harmful organisms;
- the wording is unclear in several parts of Council Directive 2000/29/EC (e.g. the requirement that draft plants should be 'planted in unused artificial growing medium' is unclear because the term 'artificial' is not defined);
- the regulation does not present any protocol for heat treatment or fumigation treatment.

The last point constitutes an important source of uncertainty because the literature review presented in section 6.2 reveals that the effectiveness of heat and fumigation is highly variable and depends on the methods of application of these treatments and on the target organisms. The use of general terms, such as 'heat treatment' or 'fumigation treatment', in Council Directive 2000/29/EC is thus not sufficient to ensure that the treated SGM are free from harmful organisms.

6.3.3. Risk reduction options applied to soil and growing media as contaminants

There is no RRO specifically dedicated to SGM attached to commodities other than plants (e.g. machinery) except in relation to BNYVV Protected Zones.

With regard to tubers of *Solanum tuberosum*, the import of soil attached to or associated with this commodity as a contaminant is subject to special requirements for specified organisms (Appendix D, Table 13). The effectiveness of these RROs for the specified organisms is rated as **high** with **medium to high uncertainty**.

There is no restriction on the amount of soil attached to or associated with plants or other commodities as contaminants, except in relation to BNYVV Protected Zones, where a tolerance of 1 % by weight of adhering soil is formulated for tubers of *Solanum tuberosum* other than those intended for planting, and for several other commodities other than those intended for planting. Pests other than those specifically addressed may be introduced; therefore, the effectiveness of these RROs is rated as **low** with **low uncertainty**.

6.3.4. Conclusions on the effectiveness of risk reduction options applied in the EU regulation

Based on this assessment, the Panel concludes that the only RRO showing a very high effectiveness with a low of uncertainty is 'prohibition of import'.

The effectiveness of several RROs of the category 'pest free production site + preparation of consignment' is rated as moderate to high. Although several of the proposed RROs from these categories could potentially show a high level of effectiveness, the EU regulation does not provide any clear guidance on how to ensure that the production sites are free from harmful organisms or on how to prepare the consignments in order to maintain the SGM free from harmful organisms. The formulation of these RROs is thus too vague to ensure their appropriate implementation. For this reason, the uncertainty associated with the effectiveness of these RROs is rated as medium to high, depending on the formulations of the requirements in the regulation. Guidance is given in Appendix D on how to clarify the formulation of these RROs.

Table 4: Ratings of risk reduction options applied in the EU regulation

Type of RROs	Rating of effectiveness	Rating of uncertainty
Prohibition of import	Very high	Low
Pest free production site + treatment of consignment	Moderate to high	Medium to high

7. Uncertainties

The following sources of uncertainties were identified by the Panel:

- the definition of soil and growing media
  - no specific definition was found in EU legislation;
- the inventory of existing soil and growing media
  - 880 SGM types were identified, but this list is indicative and cannot be considered exhaustive;
- the risk of association of harmful organisms with soil and growing media
  - the uncertainty regarding the risk of association was considered high for five out of the eight groups defined by the Panel, medium for one group, and low for only two groups;
  - the uncertainty is due to the diversity of the existing SGM types and the multiplicity of factors influencing the risk of association of harmful organisms with SGM;
- the special requirements for importing SGM into the EU
  - these special requirements are not always precisely described in EU legislation (e.g. heat treatment is mentioned in general terms without a protocol)
  - the conditions of application of the special requirements are left to the interpretation of the exporting countries;
- the effectiveness of RROs and phytosanitary measures
  - apart from prohibition, the uncertainty was rated as medium to high

- the literature review showed that the effects of RROs on pest presence were highly variable and influenced by many factors
- the uncertainty of the effectiveness of the EU phytosanitary measures is increased by the unclear guidance in EU legislation on their application.

8. Conclusions

Following a request from the European commission, the EFSA PLH Panel was asked to deliver a scientific opinion on the risk of entry into the EU of harmful organisms associated with soil or a growing medium attached to plants for planting, as commodities, and as contaminants on imported consignments.

Probability of association of harmful organisms with soil and growing media

The Panel defined eight groups of soil and growing media with contrasting ratings of probability of association with harmful organisms. For five of these groups, the uncertainty associated with the ratings is high because of multiple factors influencing the association between soil and growing media and harmful organisms, and because of the diversity of existing soil and growing media. The probability of association was rated as follows:

Table 5: Ratings of probability of association between harmful organisms and groups of soil and growing media

Groups of soil and growing media	Association of harmful organisms	Uncertainty
Media including plant materials	Very likely	High
Animal manure	Moderately likely	High
Water	Moderately likely	High
Other media composed of animal materials, different from manure	Unlikely to moderately likely	High
Other inorganic media, different from water	Moderately likely	High
Peat	Unlikely	Medium
Synthetic media	Very unlikely	Low
Media having undergone a production process eliminating the plant pests	Very unlikely	Low

Current legislation in the EU

There is no definition of soil in Council Directive 2000/29/EC. Imports of growing media as commodities, entirely without soil and organic substances, are not regulated. However, based on a literature review, the Panel found that this type of growing media could be associated with harmful organisms. The current EU legislation does not deal explicitly with soil and growing media as contaminants.

Following its evaluation, the PLH Panel found that several aspects of current EU legislation on soil and growing media increase the risk of entry of harmful organisms into the EU:

- For a given soil or growing medium, the import restrictions listed in the regulation are not applied to all non-EU countries but depend on the country of origin.
- For a given soil or growing medium and a given origin, the restrictions listed in the regulation depend on whether the soil or growing medium is imported as such or is imported attached to plants.
- The EU regulation does not provide any details on the implementation of phytosanitary measures (e.g. heat treatments or inspection of production sites and consignments) in order to maintain production sites and consignments of soil and growing media free from harmful organisms.
- Peat is regulated in two different manners:

– in Annex IIIA (12), growing media as commodities, composed entirely of peat, are excluded from the restrictions;
– in Annex IVAI (34), growing media attached to plants, composed entirely of peat, are included in the restrictions.

The regulations on soil and growing media implemented by non-EU countries are, in some cases, simpler and provide clearer guidance on how to reduce the risk of entry of harmful organisms into their territories, especially with regard to the application of heat treatment to soil and growing media imported as commodities.

Effectiveness of risk reduction options and phytosanitary measures

The extensive literature search performed to assess the effectiveness of risk reduction options shows that heat, pesticide and fumigation treatments are able to reduce the presence of harmful organisms in soil and growing media, but that these treatments are not 100 % effective in all cases. Their effectiveness depends on several factors, especially soil characteristics, the harmful organisms and the application procedures.

The Panel evaluated the effectiveness of the phytosanitary measures included in the EU legislation and concludes that:

- 'Prohibition of import' is the only phytosanitary measure with a very high effectiveness and a low level of uncertainty.
- The effectiveness of several phytosanitary measures from the category 'pest free production site & preparation of consignment' is rated as moderate to high. Although several of the proposed measures from this category of risk reduction options could potentially have a high level of effectiveness, the EU legislation does not provide any clear guidance on how to ensure that the production sites are free from harmful organisms or on how to prepare the consignments in order to maintain growing media free from harmful organisms. The formulation of these phytosanitary measures is thus too vague to ensure their appropriate implementation. For this reason, the uncertainty associated with the effectiveness of these measures is rated as medium to high, depending on the formulations of the requirements in the regulation. Guidance is given in Appendix D on how to clarify the formulation of these phytosanitary measures.

In future, quantitative pathway analysis could be performed for specific commodities of soil and growing media (e.g. peat) in order to assess the risk of entry of harmful organisms more accurately.

Documentation provided to EFSA

1. Request (see Background and Terms of Reference) to provide a scientific opinion on the risks to plant health of soil and growing medium; Ref Ares(2013)543730, 4April 2013. Submitted by the European Commission, DG SANCO E2(Directorate General for Health and Consumers).

2. Report of the experts of the Working Group on the Annexes of Council Directive 2000/29/EC of the Standing Committee on Plant Health on Terms of Reference for EFSA to consider the risks posed by soil or growing medium attached to plants for planting, as commodities and as contaminant on imported consignements. Brussels, 13 September 2012. European Commission, Health and Consumers Directorate General.

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Abbreviations

BNYVV	beet necrotic yellow vein virus
CFIA	Canadian Food Inspection Agency
CFR	United States Government Code of Federal Regulations
EPPO	European and Mediterranean Plant Protection Organization
FMD	foot and mouth disease
ICON	Australian Government Department of Agriculture import condition
ISPM	International Standard for Phytosanitary Measures
MPI	Ministry for Primary Industries
NPPO	National Plant Protection Organization
PET	polyethylene terephthalate
PGE	plant growth enhancer
PLH	Plant Health
RRO	risk reduction option
SGM	soil and growing media
USDA	United States Department of Agriculture

Appendix A – Report of the Annexes Working Group of the Standing Committee on Plant Health

EUROPEAN COMMISSION
HEALTH AND CONSUMERS DIRECTORATE-GENERAL

Safety of the Food Chain
Plant health

Brussels, 13 September 2012

Report of the Working Group on the Annexes of Council Directive 2000/29/EC of the Standing Committee on Plant Health on Terms of Reference for EFSA to consider the risks posed by soil or growing medium attached to plants for planting, as commodities and as a contaminant on imported consignments

Disclaimer: This report was prepared by the Working Group on the Annexes of Council Directive 2000/29/EC of the Standing Committee on Plant Health and represents the views of author. These views have not been adopted or in any way approved by the Commission and do not necessarily represent the view of the Commission or the Directorate General for Health and Consumer Protection. The European Commission does not guarantee the accuracy of the data included in this report, nor does it accept responsibility for any use made thereof.

Background

Soil and growing medium provide a medium via which harmful organisms and other non-native species, including agricultural or invasive weeds, can be sustained and spread. The risks posed by the movement of soils and growing medium as potential pathways for the introduction of a variety of harmful organisms are universally recognised and addressed by regulation. Council Directive 2000/29/EC sets out import requirements and prohibitions relating to the import of soil and growing medium, but there is concern whether these requirements are appropriate to effectively prevent the introduction of harmful organisms. There is also concern whether third countries apply the requirements in full and how compliance can be verified during import inspections.

The Working Group on the Annexes of Council Directive 2000/29/EC (AWG) has been tasked to review the existing EU requirements for soil and growing medium and has decided that there are a number of important issues on which technical input from EFSA should be requested. There are three separate scenarios for the import of soil into the EU which need to be considered:

1) Soil and growing medium attached to plants for planting
2) Soil and growing medium imported as commodities, i.e. not in association with plants intended for planting
3) Soil and growing medium attached as a contaminant to imported goods (ranging from ware potatoes to agricultural machinery), packaging and passengers and their luggage

The following sets out the areas upon which the AWG would like to request EFSA to comment.

Definitions

Before considering the potential risks posed by soil and growing medium it is important to define what is meant by these terms. There are no definitions in article 2 of Directive 2000/29/EC but there is a broad description in Annex IIIA (14) of Directive 2000/29, 'Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat'. There is a definition for growing medium in ISPM No. 5 which defines growing medium as 'any material in which plant roots are growing or intended for that purpose'. In addition a new ISPM on the movement of growing medium in association with plants in international trade is being prepared. The current draft indicates that soil is one type of naturally occurring growing medium and defines soil as 'a growing medium that is naturally occurring, composed of the loose surface material of the earth and consisting of a mixture of minerals and organic material'. However a wide range of materials can be components of growing media. The list of possible components of growing medium from the draft ISPM is included below; EFSA is expected to take the existing definitions of soil and growing mediums and the list of possible components of growing medium as a starting point of reference for their opinion. However it should be noted that this list is just an indicative list of materials which could be used in growing media, if other materials are identified which could be used as growing medium these should also be considered. As the ISPM is still only a draft, it is anticipated that the EFSA opinion could form part of the input from the EU for the preparation of the ISPM for growing medium associated with plants for planting as it is expected that EFSA will deliver the opinion before the ISPM is finalised.

Materials listed in the draft ISPM as possible components of growing media:

- baked clay pellets
- clay, gravel, sand, silt
- synthetic media (e.g. glass wool, rock wool, polystyrene, floral foam, plastic particles, polyethylene, polymer stabilised starch, polyurethane, water absorbing polymers)
- vermiculite, perlite, volcanic rock, zeolite, scoria
- coconut fibres (coir/coco peat)
- paper
- sawdust, wood shavings (excelsior)
- tissue culture medium (agar-like)
- water
- wood chips
- cork
- peat
- Sphagnum moss
- other plant material (e.g. rice hulls/chaff, grain hulls, coffee hulls, sugarcane refuse, grape marc, cocoa pods)
- bark
- bio waste
- compost
- humus
- soil
- tree fern slabs
- vermicompost (vermicast plus earthworms)

Soil and growing medium in general

The following questions apply to all three scenarios. Justification is required for the present prohibition on soil and growing medium and in particular whether the current geographic exclusions are appropriate and whether given these exclusions the Annex IVAI of Directive 2000/29 requirements are adequate to mitigate the risk of the soil borne organisms which are currently listed in Annexes I and II of Directive 2000/29/EC and other potential risks. The AWG believes that the Annex III of Directive 2000/29 prohibitions only relate in a limited way to the organisms listed in Annexes I and II of Directive 2000/29 and in the main provide protection against unlisted harmful organisms.

1) What are the main phytosanitary risks posed by soil and growing medium to plant health? Examples should include organisms listed in Annex I and II of Directive 2000/29 as well as non-listed organisms, whose listing may have not been considered as necessary because there was a prohibition on soil and growing medium.

PLH Panel:

Any plant pest could be present in soil, but a number of species spend all or a part of their life cycles in the soil, or in/on other organisms (animals, plant debris, seeds, etc.) in the soil. An indicative list of these organisms of interest for this opinion has been derived from the Annexes of Directive 2000/29, the A1, A2, Alert and Action lists of EPPO, as well as from an extensive literature search. This list, summarised in Appendix C, cannot be considered as an exhaustive list of all the pests that can be associated with soil and growing media.

2) Does the risk posed by soil or growing medium differ depending on the intended end use, for example by the 'final consumer', professional grower, amenity plantations etc.

PLH Panel:

The Panel considers that different destinations of the soil and growing media (SGM), as well as the nature of the uses, would strongly influence the likelihood of transfer and subsequent establishment of harmful organism after entry. The risk will vary with the end use of the SGM, but the Panel cannot rank the risk, as the associated uncertainty is high because of a lack of available information on the practices of plant growers in the EU, the diversity of cultural practices and the multiplicity of factors involved.

To assess the risk, a quantitative pathway analysis needs to be performed for each potential pathway of introduction of the pests with SGM.

3) Can any specific risks be identified which are inadequately addressed by the current Annex III of Directive 2000/29 prohibition or IVAI of Directive 2000/29 requirements?

PLH Panel:

This question is addressed in section 5.1 ('EU legislations').

4) If so, are there specific measures which could be included in Annex IVAI of Directive 2000/29 or are these risks only sufficiently mitigated by an Annex III of Directive 2000/29 prohibition of soil and growing medium? Case studies can be used, if appropriate, to answer this question.

PLH Panel:

This question is addressed in different sections:

section 5.4 includes examples of alternative measures in place in non-EU countries;

section 6.2 shows ratings of RROs based on the literature review; and

section 6.3 shows the effectiveness of RROs implemented in Council Directive 2000/29/EC.

5) Can examples be provided on how third countries regulate soil and growing media?

PLH Panel:

This question is addressed in section 5.3 ('Non-EU legislations').

6) Are the current Annex III of Directive 2000/29 prohibitions technically justified? Are they sufficiently stringent; can allowing imports of soil and growing medium from the third countries which are currently excluded from the prohibition be technically justified?

PLH Panel:

This question is addressed in section 3.2.2 ('Soil and growing media in Council Directive 2000/29/EC'). The Panel also notes that many countries around the world do not allow the import of soil. This is confirmed by the analysis of some selected regulations in section 5.3. Regarding growing media, only specific well-described types of growing media are allowed for import. Regarding Annex III, some countries are not listed in the prohibitions and the rationale for such exemptions is not clear (in particular, several pests that can be found in soil and are included in Annex IV requirements are present in these countries). In particular, several ambiguities in the existing legislation, among which prohibition (or lack of prohibition) of imports from third countries are outlined in the section 'Ambiguities for soil and growing media in Council Directive 2000/29/EC.

7) If the current exclusions from the Annex III of Directive 2000/29 prohibitions can be technically justified, are the current Annex IVAI of Directive 2000/29 requirements adequate *to mitigate the risk posed by soil-borne harmful organisms?*

PLH Panel:

This question is addressed in section 5.2 ('Soil and growing media in Council Directive 2000/29/EC').

In addition to these general questions, some more specific questions which relate to the three scenarios are listed below. These should help steer the work of EFSA and ensure that EFSA addresses the issues which are of particularly interested.

SOIL AND GROWING MEDIUM ATTACHED TO PLANTS FOR PLANTING

1a) Are the current requirements in Annex IVAI of Directive 2000/29/EC implementable in a real world situation, and are they likely to be effective in preventing the introduction of harmful organisms with plants intended for planting?

PLH Panel:

No, because shaking and washing free of soil will not remove endoparasitic or semi-endoparasitic organisms. These types of organisms are strongly associated with plant roots, and even very small amounts of growing medium remaining attached to roots may contain vital parasites. Moreover, it is very difficult to remove all the adhering soil, especially with large plants.

1b) Some countries are excluded from the Annex IVAI of Directive 2000/29 requirements (in particular for points 34 and 43). Can these exclusions be justified in terms of risks?

PLH Panel:

The requirements laid down in Annex IVAI point 34 are not applicable for consignments from the following countries: Algeria, Morocco, Egypt, Libya, Israel and Tunisia. With regard to nematodes, Libya, Malta, Tunisia and Cyprus have Globodera rostochiensis; Malta, Tunisia and Cyprus also have Globodera pallida. Egypt has Aphelenchoides besseyi. Morocco and Egypt have Radopholus similis. Ralstonia solanacearum occurs in Morocco, Libya and Egypt. Synchytrium endobioticum occurs in Tunisia. These are thus a few examples of the occurrence of quarantine organisms in countries excluded in Annex IVAI, and this illustrates that the current exclusion is questionable.

For dwarfed plants, the requirements laid down in Annex IVAI point 43 are not applicable for consignments from European countries not belonging to the EU. However, it is not specified which countries are included within this category. Several quarantine pests associated with SGM may occur in these countries; therefore, the current exclusion is questionable.

All these requirements are analysed in section 5.2.

2) What is the minimum volume of soil or growing medium necessary to sustain the vitality of plants?

PLH Panel:

The minimum volume of SGM necessary to sustain the vitality of plants is highly variable and depends on the kind of plant (e.g. tree vs. seedling to transplant, size of the plant), the status of the plant (e.g. dormancy vs. vegetation), the timeframe between uprooting and transplant (e.g. days vs. months) and the environment (e.g. controlled environment vs. open air). Consequently, no precise answer can be provided.

3a) What are the risks posed by this minimum amount of soil or growing medium, in terms of the risk of introduction of harmful organisms?

There is no minimum amount of soil defined in general terms. Any amount of SGM attached or associated to plants can contain harmful organisms.

3b) Do the risks posed by this minimum amount of soil vary depending on the intended use of the soil or growing medium attached to the plants for planting or the plants for planting themselves (e.g. growing medium used for transport of plants for planting only (such as peat for flower bulbs), with propagation material intended for professional growers or attached to plants destined for final consumer.

PLH Panel:

From a qualitative point of view, a very small amount of SGM can include harmful organisms. In quantitative terms (all else being equal), the higher the volume of soil, the higher the probability of the pest being associated with the soil, the higher the number of pest individuals, and—at least in some cases—the lower the effectiveness of the RROs. Examples are provided in section 6. However *large plants pose a higher risk in terms of quantity of SGM attached. Some of the RROs included in 2000/29 are not applicable to large plants (e.g. shake them free of SGM) (see also Figure 4).*

4) Does the volume of trade in a particular plant or just the volume of soil or growing medium associated with individual plants need to be considered when assessing the risk?

PLH Panel:

There could be a small amount of soil or growing medium per plant, but a high volume of trade would result in a large quantity of soil being imported. The volume of trade is very important even with small amounts of adhering growing medium.

All else being equal (same SGM, same pest, same origin, etc.), the probability that the pest is associated with the SGM and the number of individual pests which can enter through a SGM depend on the total volume of the SGM, irrespective of whether this volume is associated with few or many plants. In addition, the effectiveness of some RROs may change with commodity volume (see section 6, 'Effectiveness of risk reduction options (RROs)').

5) Is it possible to reliably check for compliance, at import, with the current requirements in Annex IVAI of Directive 2000/29 and any proposed new measures? If so, how?

PLH Panel:

Most of the requirements for Annex IVAI of Directive 2000/29 are based on measures to be implemented in the exporting country (e.g. IV AI 18 testing for the presence of nematodes, IVAI (34), measures at planting during the production and before dispatch). It is the responsibility of the exporting country when issuing a phytosanitary certificate to ensure compliance of these requirements. Compliance checking can, however, be performed at import by testing the growing media for the presence of plant parasitic nematodes as indicator pests. Such testing is recommended in the EPPO Standard PM 3/60 (1) (EPPO, 2014). Testing growing medium and plants in growing medium. Extract 'The testing method to ensure that the growing medium has been properly handled relies on the principle that any growing medium that contains non-disinfested soil, or that has been in contact with soil, will almost always contain plant-parasitic nematodes.'

6) Which harmful organisms are considered relevant in relation with Annex IVAI (34) of Directive 2000/29?

PLH Panel:

Annex IVAI (34) refers to soil and growing medium attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or any solid inorganic substance, intended to sustain the vitality of the plants, originating in: Turkey, Belarus, Georgia, Moldavia, Russia, Ukraine, non-European countries other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia. The harmful organisms referred to are insects and harmful nematodes and other harmful organisms. There is no specific link made between 'harmful organisms' in point 34 and the lists of harmful organisms in Annexes I and II of Council Directive 2000/29/EC. Consequently, it could potentially cover all insects and plant parasitic nematodes, as well as any other harmful organisms. The Panel considers that establishing such a list is not appropriate given the intention of this requirement to provide general protection.

SOIL AND GROWING MEDIUM AS COMMODITIES

Soil and growing medium can be imported as commodities in their own right from a restricted number of third countries, i.e. not in association with planting material.

1) Do soil and growing medium imported as commodities in their own right pose different risks to those imported in association with plants intended for planting? If so, what are the specific risks posed by soil or growing medium as a commodity?

PLH Panel:

Owing to the general character of the question, a generic answer cannot be formulated and can be provided only on a case-by-case basis.

SGM as commodities in their own right pose different risks to those imported in association with plants intended for planting for the following reasons.

The RROs applicable are not the same in the two cases; see section 6 ('Effectiveness of risk reduction options (RROs)').

If no plant residues or other organic material supporting saprophytic growth are present in SGM imported as a commodity, the number of harmful organisms that can survive is lower than in SGM attached to plants.

The nature of the SGM (e.g. organic vs. mineral), its properties (e.g. moisture) and processing (e.g. drying) play a relevant role in determining the difference between SGM as commodities and in association with plants intended for planting.

2) Which possible intended uses could be excluded and under what conditions, for instance clay for ceramic industries, landfills, road construction, ores for metal production (such as aluminium).

PLH Panel:

Some intended uses of SGM as commodities (e.g. industrial processes craftsmanship or ending up in landfill or land where plants may not be grown) may be considered to pose a lower risk of pest transfer to a susceptible host.

3) Is there a certain depth (or soil horizon) below which soil does not pose a significant phytosanitary risk?

PLH Panel:

Little information is available on specific depths below which harmful organisms are completely absent. For instance, Radopholus similis has been detected at 3 m below the surface (EPPO/CABI, 1997).

4) Are there any available treatments which can be practically implemented and are sufficiently effective to mitigate or prevent the risk of introduction of harmful organisms into the EU or the spread within, which are appropriate for treating large volumes of soil or growing medium (e.g. steaming, fermentation, drying, washing, sieving, heat treatment or irradiation)? If so, what are they and for which types of growing media could they be applied?

PLH Panel:

This question is addressed in section 6 ('Effectiveness of risk reduction options (RROs)'). The only very efficient treatment with a low uncertainty is prohibition.

5) Are there 'quality' standards available with indicators for soil or growing medium in terms of government or industry regulations or standards (EU or non-EU)? Are these useful for mitigating plant health risks?

PLH Panel:

Yes, quality standards are available and defined for commercial SGM; however, these standards do not necessarily include criteria specifying pest absence. Such standards may be expanded with these criteria and could then be useful for reducing plant health risks. In some non-EU countries, some commercial products are excluded from phytosanitary requirements (see section 4.2.6 on'Peat').

SOIL AND GROWING MEDIUM ATTACHED TO IMPORTED GOODS AND PACKAGING AS CONTAMINANTS

Imported goods and packaging are considered to include items such as ware potatoes, agricultural machinery, packaging material (e.g. wooden pallets) and shipping containers which are often contaminated with soil or growing medium. There is also a risk of movement of soil and growing medium with passengers and their luggage.

1) Do soil and growing medium as contaminants pose different risks to soil imported attached to plants intended for planting or soil as a commodity? If so in what way?

PLH Panel:

SGM as contaminants pose different risks to those imported in association with plants intended for planting and soil as a commodity for the following reasons.

- *The range of final destinations of the contaminated items is broader and the destinations are often unknown, which introduces high uncertainty in the risk assessment. The risk for soil as contaminant may vary depending on the following:*
  - *type of commodity contaminated, for instance, seeds, tubers, used agricultural machinery (see Appendices C and D);*
  - *end use of the contaminated item (e.g. agricultural use vs. non-agricultural ones);*
  - *area of origin and destination (e.g. agricultural or natural areas vs. industrial areas);*
  - *amount of the soil adhering to the contaminated item.*
- *The RROs applicable are different for the two cases (see Appendix C and D for examples).*
- *Many SGM as contaminants are not subjected to any process that can influence pest survival, apart from natural drying (e.g. soil adhering to used agricultural machinery).*
- *When delivered in agricultural areas or ending up in landfill or land where plants may be grown, SGM as contaminants can be easily detached or washed off (by cleaning or by rainfall) and become part of the natural soil of the site.*
- *It could be difficult to know where the contamination has occurred in the country of origin, which pests are associated with such contamination and the pest density. Uncertainty is higher for SGM as a contaminant than for SGM imported in association with plants intended for planting and soil as a commodity.*
- *Ware potatoes (or other plant parts or parts which can be contaminated by soil during harvesting or parts which remain on the field after harvesting for some time and are not processed for removing that soil) pose a specific risk because any SGM are likely to be infested by the specific pests of potatoes (or other plant parts) and the place of origin is known.*

See further details in Appendix C and section 3.2, 'Indicative list of soil and growing media'.

2) Can any specific risks associated with soil as a contaminant be identified which are inadequately addressed by the current Annex III of Directive 2000/29 prohibition and Annex IV of Directive 2000/29 requirements (for example, Annex IVAI (34) of Directive 2000/29, which exempts soil from certain countries, probably related to the import of ware potatoes), if so, are there additional measures which could be included in Annex IVAI of Directive 2000/29 or are these risks only sufficiently mitigated by extending the Annex III of Directive 2000/29 prohibition for soil and growing medium?

PLH Panel:

Annex III refers to prohibition for SGM as such. The Panel considers that this is referring to SGM as a commodity not as a contaminant.

Annex IVAI (34) refers to 'Soil and growing medium, attached to or associated with plants, […], intended to sustain the vitality of the plants'. Soil as a contaminant does not fit in this definition (a contaminant is not intended to sustain the vitality. There are some requirements specifically targeting BNYVV for some plants for protected zones. There are no specific requirements addressing the risk of soil as a contaminant for machineries (apart from those specifically related to BNYVV for some protected zones).

The Panel consequently considers that Directive 2000/29 includes very limited requirements for soil and growing media as a contaminant.

3) Is there technical justification for requiring complete freedom from contamination with soil and growing medium in respect of these pathways? If so is it practical to achieve complete freedom prior to export?

PLH Panel:

The RROs to prevent introduction (entry + establishment) of harmful organisms with SGM in Australia, Canada, New Zealand and the USA provide examples of prohibition of import or treatment at import of SGM as contaminant to plant and plant products, and to equipment or other articles (see Appendix E); treatments at import include destruction, reconditioning to remove the soil, unspecified treatment and gamma irradiation.

RROs are available to remove SGM as contaminants; see section 6 for the effectiveness of these RROs ('Effectiveness of risk reduction options (RROs)').

Any technical justification for requiring complete freedom from contamination with SGM should account for high uncertainty about where the contamination has occurred and which pests can be associated with such a contamination. However, to fully answer the request a quantitative pathway analysis is needed and would require a specific question; therefore, the second part of the question cannot be addressed.

4) Could allowing a tolerance for adhering soil or growing medium on imported goods or plant material (other than plants for planting) be technically justified?

PLH Panel:

No specific tolerance level can be formulated as a very small amount of soil can contain harmful organisms.

5) Are there any specific risks associated with soil originally attached to the plants or which has arrived in the EU as a contaminant ending up in landfills or land where plants may be grown?

PLH Panel:

See Appendix C, 'Indicative lists of soil and growing media and associated pests'.

References

EPPO (European and Mediterranean Plant Protection Organization), 2014. Standard PM 3/60 (1) Testing growing medium and plants in growing medium. Bulletin OEPP/EPPO Bulletin 44(1), 13. doi: 10.1111/epp.12091

EPPO/CABI, 1997. Datasheets on quarantine pests: *Radopholus citrophilus* and *Radopholus similis*. In: Quarantine pests for Europe, 2nd edition. Eds Smith IM, McNamara DG, Scott PR and Holderness M. CABI, Wallingford, UK, 1425 pp.

Appendix B – Rating system for the assessments

Table 6: Probability of association with SGM and survival of the pests in SGM

Rating	Descriptors
Very unlikely	The association would be very unlikely because: • pests are not associated, or very rarely associated, with the SGM; or • pests are very unlikely to survive in the SGM
Unlikely	The association would be unlikely because: • pests are rarely associated with the SGM; or • pests are unlikely to survive in the SGM
Moderately likely	The association would be moderately likely because: • the pests are frequently associated with the SGM; or • the pests are sometimes able to survive in the SGM
Likely	The association would be likely because: • the pests are regularly associated with the pathway at the origin; or • the pests can survive in the SGM
Very likely	The association would be very likely because the pest: • the pests are usually associated with the pathway at the origin; or • the pests are very likely to survive in the SGM

Table 7: Effectiveness of the phytosanitary measures to reduce the probability of entry

Rating	Descriptors
Negligible	The probability of entry is not reduced by the measure
Low	The probability of entry is reduced to a limited extent by the measure
Moderate	The probability of entry is substantially reduced by the measure
High	The probability of entry is reduced to a major extent by the measure
Very high	The probability of entry is eliminated by the measure

Table 8: Evaluation of the methods reducing the pest presence in the SGM

Levels
Missing data
No effect
Partial reduction of presence of harmful organisms in SGM
100 % reduction of presence of harmful organisms in SGM

Table 9: Uncertainties associated with the different assessments

Rating	Descriptors
Low	Information available is complete, consistent and not conflicting. No subjective judgement is introduced
Medium	Some information is missing, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence
High	Most information is incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence

Appendix C – Indicative lists of soil and growing media and associated pests

Table 10: Indicative list of SGM

Groups of SGM	Sub-groups of SGM	Examples
Animal manure	Other municipal/industrial residues	Aquaculture pond sediments
	Unspecified	Panchagavya
Media having undergone a production process eliminating the plant pests	Bagasse	Agave bagasse; bagasse; coconut bagasse; sugar bagasse; sugar cane, bagasse; sugarcane bagasse
	Carbonised	Chestnut
	Ceramic aggregate	Ceramsite
		Expanded clay
	Chemical compound	Glue
	Combustion residue	Ash, not further specified; bottom ash; bunch ash; coal ash; fly ash; peat ash; pod husk ash; spent wash ash; volcanic ash deposit; wood ash
	Distillery by-products	Brewery sludge; condensed distiller's solubles; distillation residues; distillery spent wash; malt residue; post-methanation effluent; sweet potato shochu manure
	Fabric	Fabric spunbonded; felt; muslin cloth, covering
	Fibre	Fibre sheets, not further specified
		Fibreboard
	Foam	Glass foam
	Husks charcoal	Peanut
	Material	Glass wool, fibreglass; sheets, unspecified material; sponge; tile
	Mineral	Coal; coal cinder; coal dross; coal mine spoil; coal residue; coal rubble; coal slag; vegetable coal
	Mixture	Brick; slag
	Molasses	Sugarcane
	Mud	Cellulosic
	Other municipal/industrial residues	Medicine residues; metal chips; molasses, not further specified; residue of rubber industry
	Plant hormone	Zeatin
	Press mud	Sugar industry press mud
	Pulp	Sisal
	Residue	Charcoal, biochar
	Sludge, biosolids	Crumb rubber factory sludge; lime sludge; marble sludge; paper mill sludge; tannery sludge
	Soil conditioner	Humate
	Textile	Fabric cloth; geotextile discs/mulch; mulch blanket, not further specified
	Unspecified	Cellulose; paper; pomina; vinasse; wood sterile
	Vinegar	Wood

Groups of SGM	Sub-groups of SGM	Examples
Media including plant material	Aquatic plants	Algae (no specification required); *Azolla* (water fern*); Eleocharis dulcis* compost; manure from corral; *Posidonia* (seagrass); *Sargassum* (sea weed); water hyacinth (*Eichhornia crassipes*)
	Ash	Wood
	Bagasse	Cassava; mezcal or maguey
	Bale	Hay
	Bark	Cassava; cedar (*Cedrus*); conifer; cypress; Douglas fir; *Eucalyptus*; fermented bark; fruit trees; hardwood; humus; Japanese cedar (*Cryptomeria japonica*); Japanese cypress (*Chamaecyparis obtusa*); oak; ornamental trees; pine; red wood; *Rhododendron*; shredded; spruce; unspecified; vime's
	Bean cake	Castor
	Bean fruit husks	Castor
	Berry	Unspecified
	Biodigesters residues	Biodigested slurry; digestate of codigested cattle manure and maize-oat silage
	Biomass	Gliricidia green; residual vegetable crop
	Bioproduct	Potato
	Bran	Coffee; maize; mushroom; rice; wheat
	Brine	Olive
	Bulb	*Cyperus rotundus*
	Bunches	Empty fruit
	Bush mulch	*Lantana americana*; *Ocimum americanum*
	By-products	Date palm
	Cake	*Citrullus* (colocythin); coconut; cotton; gingelly; groundnut; kapok; mustard oil; neem (*Azadiracta indica*); olive; *Pongamia*
	Carbocalc	Sugarcane
	Catch crop	Oat; *Serradella*
	Chafes	Soybean
	Chaff	Rice
	Chip residual	Clean chip residual
	Chipped branches	Oak
	Chips	Poplar; bark; hemp; maravalha; wood
	Chopped	Bhusa (straw)
	Chopped stems	*Ilex paraguariensis*
	Cob	Corn
	Coir	Coconut
	Compost	*Aspergillus niger*-treated dry-olive-cake residues; earthworm castings/excrements; farmyard; green; mushrooms cultivation; organic; spent mushroom; sugarcane; tea; tomato tuff; unspecified; wheat gluten matrix; oil palm
	Core	Maize
	Cover crop	Logging debris

Groups of SGM	Sub-groups of SGM	Examples
	Crop residues	Barley; *Brachiaria* (signalgrass); *Brassica* spp.; canola; cereal; clover; cowpea; *Crambe*; finger millet (*Eleusine coracana*); forage radish; forage sorghum (*Sorghum bicolor* × *Sorghum sudanense*); grass or speargrass; hairy vetch (*Vicia villosa*); hybrid sorghum with sudan-grass (*Sorghum bicolor* × *Sorghum sudanense*); legume; mungbean; mustard; Pangola grass (*Digitaria eriantha* subsp. *pentzii*); peach palm (*Bactris gasipaes*); pearl millet (*Pennisetum glaucum*); phacelia; *Pueraria phaseoloides*; redtop grass; regreen (hybrid between wheat and ryegrass); rye; safflower; *Scabiosa atropurpurea*; *Sesbania*; small grains, not further specified; snail medic (*Medicago scutellata* L. Miller); Sorghum-Sudan; soybean (*Glycine max*); sunflower; tansy phacelia; triticale; unspecified; *Vigna radiata* (greengram); wheat; wheat; *Cajanus cajan*; *Mucuna deeringiana*; *Stylosanthes capitata*; *Stylosanthes macrocephala*; subclover (*Trifolium subterraneum* L.); thatch; tomato; greenhouse
	Defatted cake	Soybean
	Defibred	Xaxim; coconut; tree fern
	De-oiled	Jatropha cake
	Diced	Coconut
	Dry leaf residues	*Ipomoea fistulosa*
	Dry powder	*Eucalyptus*; leek; thyme
	Dust	Wood
	Empty fruit bunches	Oil palm
	Extract	Azadirachtin (AchookReg.); *Chromolaena odorata*; compost; *Eucalyptus* spp.; *Lantana camara*; *Ligustrum nepalensis*; *Sapium*; *Urtica parviflora*
	Farm wastewater	Mushroom
	Fibre	Cocoa; date palm; Poaceae fibre; wood
	Filter cake	Coffee; sugarcane
	Fines	Wood
	Flour	Maize
	Fluff	Tea
	Food waste	Kitchen waste, hotel waste; salad waste
	Fruit	Cranberry
	Gluten	Corn gluten
	Gluten meal	Maize
	Grain	Rice
	Grains	Wheat
	Green leaves	*Alnus nepalensis*; *Artemisia vulgaris*; *Datura* spp.; *Eupatorium odoratum*; *Schima wallichii*
	Green manure	*Cajanus cajan*; cowpea; *Crotalaria spectabilis*; milk vetch; *Mucuna deeringiana*; mungbean; scarlet starglory; *Sesbania*; *Sesbania rostrata*; *Stylosanthes capitata*; *Stylosanthes macrocephala*; sunflower
	Ground	Coffee
	Ground cover	*Arachis pintoi*
	Hay mulch	Alfalfa (lucerne)
	Hull	Corn; groundnut

Groups of SGM	Sub-groups of SGM	Examples
	Hull' solid waste	Pistachio
	Hummock	Moss
	Husk	Cacao; chickpea; coffee; cotton; *Eucalyptus* spp.; olive; pine; rice; *Sorghum*; sunflower; tung; wheat
	Husks chip	Coconut
	Industrial by-products	Fir (*Abies*); *Pinus* (pine); spruce (*Picea*); thuja industrial; sugarcane; carnauba (*Copernicia cerifera*)
	Integument	Cashew nut
	Juice	Orange; watermelon
	Juice waste	Citrus juice waste
	Kernel	Mango
	Kernel cake	Palm
	Leaf	Banana; kuppaimeni; nochi; teak; vasambu
	Leaf-based compost extract	Neem (*Azadirachta indica*)
	Leaf dust	Carnauba (*Copernicia cerifera*)
	Leaf extract	Ryegrass leaf extract; turnip
	Leaf litter	*Pueraria*
	Leaf mould	*Platanus*
	Leaf mulch	Finger millet (*Eleusine coracana*); hybrid sorghum with sudan-grass (*Sorghum bicolor* × *Sorghum sudanense*); Pearl millet (*Pennisetum glaucum*); Tithonia (*Tithonia diversifolia*)
	Leaf powder	*Eucalyptus* spp.; kassod tree (*Cassia siamea*); locust bean tree (*Parkia biglobosa*); neem (*Azadirachta indica*); swallow-wort (*Calotropis procera*)
	Leaves	*Acacia*; *Azadirachta*; *Azadirachta indica*; beech (*Fagus sylvatica* L.); bhimal (*Grewia optiva* J.R. Drumm ex Burret); carnauba (*Copernicia cerifera*); cashew tree; castor; *Casuarina*; *Cordyla*; date palm; *Faidherbia*; fleabane (*Erigeron*); *Gliricidia*; jojoba; kharik (*Celtis australis* L.); *Leucaena*; mango; *Murraya koenigii*; oak (*Quercus leucotrichophora* A. Camus.); Palas (*Butea monosperma* L.); pine; *Pongamia*; sugar beet; tea; timla (*Ficus auriculata* Lour. syn. *Ficus roxburghii* Stud.)
	Lime	Sugar beet
	Litter	*Bactris*; grassland; heath; oak; tusam
	Living mulch	Alsike clover; berseem clover; crimson clover; legume; Persian clover; subterranean clover; white clover
	Log	Wood
	Manure	*Ipomoea carnea*
	Mat	Hay
	Material	Vegetal fibre, material made of
	Meal	*Brassica napus* (rapeseed); peanut; seed; sesame; soybean
	Mesocarp fibre, decomposed	Oil palm
	Milk	Coconut
	Mill waste	Olive
	Mill wastewater	Olive
	Mould	Leaf

Groups of SGM	Sub-groups of SGM	Examples
	Mucilage	Agave
	Mud	Gyttja
	Mulch	Cameroon grass (*Pennisetum purpureum*); *Gliricidia*; Gliricidia (*Gliricidia sepium*); grass clippings; hardwood; hay; *Lantana*; local grass; meadow mix; *Medicago rugosa* (wrinkled medick); mixed clovers; mountain immortelle (*Erythrina poeppigiana*); pigeon pea; rye; *Sapium*; sesame; sugarcane; sunn hemp; tansy phacelia; triticale; ulla-grass; velvet bean (*Mucuna pruriens*); wood
	Needles	Conifer; pine
	Nuggets	Pine
	Oil	Neem (*Azadirachta indica*)
	Oil cake	*Brassica napus* (rapeseed)
		Sesame
		Sunflower
	Organic bean	Castor
	Organic residue	Energy plantation
	Other municipal/industrial residues	Agroindustrial residue from potato processing; bay oil residues; biodegradable waste; biogas spent slurry; feed mixture residue; fibre processing residues; food processing residues; food waste; herbal pharmaceutical industry waste; monosodium glutamate factory waste; municipal waste compost paste extract; sapropel; sericulture waste; slurry, spray-on-mulch; starch waste
	Palm oil mill effluent (pome)	Palm
	Parchment	Coffee
	Pea	Grass
	Peel	Banana; cassava; orange
	Pellets	Alfalfa (lucerne); *Brassica carinata*; wood
	Pith	Coconut
	Plant cover	*Agrostis stolonifera*
	Plant mulch	Bentgrass (*Agrostis palustris*); *Brachiaria* (signalgrass); *Brassica* spp.; canola; cereal; clover; *Crambe*; forage radish; forage sorghum (*Sorghum bicolor* × *Sorghum sudanense*); grass or speargrass; hairy vetch (*Vicia villosa*); legume; oat; Pangola grass (*Digitaria eriantha* subsp. *pentzii*); phacelia; rye; safflower; Serradella; snail medic (*Medicago scutellata* L. Miller); Sorghum-Sudan; soybean (*Glycine max*); subclover (*Trifolium subterraneum* L.); sunflower; wheat
	Pod husk ash	Cocoa
	Pod husks	Kola
	Pods	Bean pods
	Pomace	Olive
	Pomace compost	Olive
	Pomace or marc	Grape
	Post-harvest residues	Carnation; Chrysanthemum
	Powder	*Caragana*; ginger; sugarcane; xaxim (*Dicksonia sellowiana* hook.)
	Press mud	Press mud, unspecified; sugar mill

Groups of SGM	Sub-groups of SGM	Examples
	Press cake	Cranberry
	Priming	Apple
	Production residues	*Pochonia chlamydosporia*
	Protein	Potato
	Pruning residues	Lemon tree; olive
	Pulp	Cane; coffee; orange; potato; wood
	Receptable remains	Sunflower
	Removal wood	Apple trees
	Residues	Acai; *Brassica* spp.; broccoli; canola; cassava; coconut; coriander (*Coriandrum sativum*); *Gliricidia sepium*; glycyrrhizic; groundnut; herb; hyacinth; melon; *Miscanthus*; mungbean; municipal green; mushroom; olive; pea (seedling); pepper ; peppermint (*Mentha piperita*); ponderosa pine; reed; reed; rosemary (*Rosmarinus officinalis*); sage (*Salvia officinalis*); sunflower; tarragon (*Artemisia dracunculus*); tobacco; vinegar; wild rocket (*Diplotaxis tenuifolia*); zucchini
	Reused shells	Nutshells
	Root extract	Manipueira (cassava)
	Rootstock	Asparagus
	Sawdust	Coconut; cedar; coniferous; *Gmelina arborea*; oak; pine; wood
	Sawdust pellets	Wood
	Scrap	Mushroom
	Seed	Acai; mahoni; mango
	Seed meal	*Brassica carinata*; *Brassica napus* (rapeseed); cotton; oil palm
	Seed mixture	Palm
	Seed oil	Cotton
	Seed pomace	Castor
	Seed powder	*Azadirachta indica*; neem (*Azadirachta indica*); papaya
	Seed waste	Mustard
	Seedling	Pearl millet
	Seeds	*Terminalia catappa*
	Shells	Almond; Brazil nut; *Camellia*; hazelnut; mango; peanut; pecan; walnut
	Shives	Flax
	Shredded	Cypress
	Shredded bean	Castor
	Shredded branches	*Acacia*; *Eucalyptus gomphocephala*
	Shredded leave	Coconut
	Silage	Grass; maize
	Slash	Norway spruce stand
	Sludge, biosolids	Sewage sludge (biosolids); waste sludge from a bean curd factory; wastewater treatment plants (WWTP) sewage sludge

Groups of SGM	Sub-groups of SGM	Examples
	Slurry	Mycelial
	Sod	Couch grass (*Cynodon dactylon* L.); grass
	Soil mulch	Arachis pintoi
	Soup waste	Tomato
	Spent wash	Spent wash from sugar production
	Stalk	Corn; grape
	Stand litter	Pine
	Starch	Maize; wheat
	Stem	Buriti (*Mauritia vinifera*, Mart.)
	Stock compost	Vine
	Straw	Barley; *Brassica napus* (rapeseed); *Caragana*; carnauba (*Copernicia cerifera*); cassava; coconut; coffee; corn; finger millet (*Eleusine coracana*); flax ; forage millet (*Pennisetum americanum* (*Pennisetum glaucum*) cv. BN2); oat ; peanut; pine; rice; ryegrass straw; sesame; sorghum; soybean; Sta. Lucia grass (*Brachiaria brizantha* (*Urochloa brizantha*)); sugarcane; turnip; vetch; wax palm; wheat; wood
	Straw compost	Rice
	Substrate	*Pleurotus* spent; spent mushroom
	Tassels	Corn
	Textile	Biodegradable mulch mat
	Thiol-modified stalk powder	Corn
	Top	*Sesbania*
	Trash	Cotton
	Triturated	Acai
	Trunk tissue	Palm
	Turf	Bahia grass (*Paspalum notatum*)
	Unspecified	Acai; alfalfa (lucerne) based ; arisco; bamboo; bean; beech (*Fagus sylvatica* L.); birch (*Betula pendula*); *Brachiaria* (signalgrass); bracken (*Pteridium aquilinum*); bran; braquiaria (*Brachiaria decumbens* (*Urochloa decumbens*)); *Brassica napus* (rapeseed); *Calendula*; *Calotropis*; *Cannabis sativa*; *Carex*; cassava; celery; chaffs; cherry (*Prunus avium*); chickpea; Chinese milk vetch; *Chromolaena odorata*; citrus; coffee; compost; cork; corn; dal weed; *Dicksonia sellowiana*; English oak (*Quercus robur*); evergreen oak (*Quercus ilex*); feathermoss (*Pleurozium*); fern; giant reed (*Arundo donax* L.); grape; grass; Guinea grass (*Panicum maximum*); harvest residues; hawthorn (*Crataegus monogyna*); hay; humus; husks; Italian ryegrass (*Lolium multiflorum* Lam.); itchgrass; karanj (*Pongamia pinnata*); kenaf; lemongrass; *Lesquerella*; local mixed grasses; lupine (lupin; *Lupinus nootkatensis*); mahua (*Madhuca longifolia*); maize; Manchurian mushroom (tea); medicinal herbs; *Mikania micrantha* or mile-a-minute weed; moss, not further specified; mushroom; Napier grass (elephant grass); Napier grass (elephant grass); niger (*Guizotia abyssinica*); oak; oilcake; *Olea europaea* (olive alperujo); orange; *Parthenium*; pawpaw; pine; *Pongamia*; potato; red clover; rice; *Salvinia auriculata*; sarkanda; *Senna*; softwood; *Sorghum*; soybean; sporocarps; spring vetch (*Lathyrus vernus*); sting nettle; straw; sugarcane; sugarcane; sunflower; switchgrass (*Panicum virgatum*); tomato; turf; turf, translocated; turmeric; turves; *Ulex europaeus* (gorse); velvet bean; *Vernonia polyanthes*; weeds; wood

Groups of SGM	Sub-groups of SGM	Examples
	Vinegar	Brown rice
	Waste	Banana; *Brassica* spp.; cabbage; carrot; citrus waste; cork; forestry; fruit; garden; green; lignocellulosic; onion; orange; oyster mushroom; palm; pequi (souari nut); sort-yard; sugarcane; tea; *Thespesia populnea*; timber; vegetable; wood; yard
	Waste pellets	Leaf
	Waste powder	Yuzu (citrus junos tanaka)
	Water	Coconut
	Wheat bran compost	Bokashi
	Wild	Sunflower
	Wood	Driftwood
	Wood chips	Pine; redcedar (*Juniperus silicicola*); southern magnolia (*Magnolia grandiflora*)
	Wood fibre	Oak, Pine
	Yeast	Grape
Other inorganic media	Chemical compound	Calcium silicate; quicklime (calcium oxide)
	Dust sediment	Loess
	Material	Haydite
	Metal	Aluminium
	Mine spoil	Bauxite mine spoils; mining waste
	Mineral	Apatite; attapulgite; basalt powder; bentonite; biotite; calcined clay; clay; grit; gypsum; illite; kaolin; leonardite; perlite; pyrite; quartz; vermiculite; vivianite; volcanic clay; zeolite; soilrite
	Other municipal/industrial residues	Drilling waste; kaolin waste; penicillin production residues; phospho-gypsum; red mud (bauxite residue); slag smelter waste; tailings (pond waste from mining industry); waste concrete debris
	Residues	Limestone mine spoil
	Rock	Anthracite; basalt rock (powder); clay pellets; diatomaceous earth (diatomite); diorite; feldspar; flysch; granite; gravel; hornfels; lignite; lime; limestone; marble; mine tailings; mountain powder; phyllite; rock phosphate (PR); rock phosphate powder; slate (coarse/fine); slate rock; tuff; volcanic rock; volcanic cinder; volcanic tuff; zeolitic tuff
	Rocky soil	Sand
	Sediment	River sediment
	Sedimentary rock	Chalk; shale, expanded
	Soil	Acid granitic sandy loam; lateritic loam; loam; oxic horizon; silt; silty loam
	Soil conditioner	Turface
	Stone	Jeju scoria; pumice
	Unspecified	Pearl stone; rock
	Volcanic material	Pozzolana
	Volcanic rock	Tezontle

Groups of SGM	Sub-groups of SGM	Examples
Other media composed of animal materials, different from manure	Compost	Vermicompost/vermicast/vermiwash, not further specified
	Other municipal/industrial residues	Tannery waste
	Other municipal/industrial residues	Wool waste
	Sludge, biosolids	Dairy sludge
	Unspecified	Earthworm castings; termite mound
Peat	Peat pellets	Jiffy pellets
	Unspecified	Peat; *Sphagnum* (peat moss)
Synthetic media	Aggregate	Coke plaster; LECA (light expanded aggregates)
	Chemical compound	Polystyrene granules, beads
	Elastomer	Rubber
	Emulsion	Asphalt spray emulsions
	Fabric	Polyester fleece; row cover cloth; shade cloths, not further specified
	Fibre	Jute/gunny bag; degradable fibre
	Foam	Foam, not further specified; phenolic foam
	Material	Foil; synthetic fibre, material made of
	Mineral	Alsil; talc
	Other municipal/industrial residues	Textile industry waste
	Polymer	PET bottle particles (PBT); plastics and bioplastics (no specification required); polyacrylamide granules; polymer, (no further specification required)
	Polymer network	Hydrogel
	Rock	Rock powder; Rockwool
	Rubber	Crumb rubber
	Textile	Agro textile covering, not further specified; textile

Table 11: Associations of harmful organisms with SGM groups

The numbers of associations and organisms are derived from the results of the extensive literature search (section 2.2.1 and link to procurement). The data included in the table are not exhaustive and are considered indicative only.

No of associations of harmful organisms with groups of SGM [(a)]	No of organisms associated with SGM	Media including plant materials (e.g. soil, compost)	Animal manure	Water	Other media composed of animal materials, different from manure (e.g. wool)	Other inorganic media, different from water (e.g. sand, basalt)	Peat	Synthetic media (e.g. glass wool, polystyrene)	Media having undergone a production process eliminating the plant pests
Fungi or oomycetes	20	15	3	5	0	10	2	3	4
Bacteria	27	27	0	5	1	4	3	2	5
Insects	33	22	0	1	6	16	2	2	5
Phytoplasma	12	12	0	0	0	0	0	0	0
Virus	3	3	0	2	0	0	0	0	0
Nematodes	14	14	0	1	0	8	0	1	2
Total number of organisms	109	93	3	14	7	38	7	8	16
Total number of associations	186								

(a): For some taxa of harmful organisms categories, reports of association in literature have to be considered with caution: Nepoviruses are not included in the viruses considered in this, table however being transmitted by soilborne nematodes they can be associated with SGM; phytoplasma are found in literature associated with the SGM group containg plant material, however the Panel notes for these organisms strong limitations in survival and transfer in the entry process.

Appendix D – Phytosanitary measures on soil and growing media laid down in Council Directive 2000/29/EC

Table 12: Import requirements for SGM in Annexes of Council Directive 2000/29/EC

Annex IIAI	**Species**	**Subject of contamination**
Annex IIAI (a)(23)	*Radopholus citrophilus* Huettel, Dickson and Kaplan	Plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds, and plants of Araceae, Marantaceae, Musaceae, *Persea* spp., Strelitziaceae, rooted or with growing medium attached or associated
Annex IIAII	**Species**	**Subject of contamination**
Annex IIAII (a)(7)	*Radopholus similis* (Cobb) Thorne	Plants of Araceae, Marantaceae, Musaceae, *Persea* spp., Strelitziaceae, rooted or with growing medium attached or associated
Annex IIIA	**Description**	**Country of origin**
Annex IIIA (5)	Isolated bark of *Castanea* Mill.	Third countries
Annex IIIA (6)	Isolated bark of *Quercus* L., other than *Quercus suber* L.	North American countries
Annex IIIA (7)	Isolated bark of *Acer saccharum* Marsh.	North American countries
Annex IIIA (8)	Isolated bark of *Populus* L.	Countries of the American continent
Annex IIIA (14)	Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances, such as parts of plants, humus including peat or bark, other than that composed entirely of peat	Turkey, Belarus, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe, other than the following: Egypt, Israel, Libya, Morocco, Tunisia

Annex IVAI	Plants, plant products and other objects	Special requirements
Annex IVAI (18)	Plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds and plants of Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae, rooted or with growing medium attached or associated	Without prejudice to the prohibitions applicable to the plants listed in Annex III(A) (16), where appropriate, official statement that: (a) the plants originate in countries known to be free from *Radopholus citrophilus* Huettel et al. and *Radopholus similis* (Cobb) Thorne; or (b) representative samples of soil and roots from the place of production have been subjected, since the beginning of the last complete cycle of vegetation, to official nematological testing for at least *Radopholus citrophilus* Huettel et al. and *Radopholus similis* (Cobb) Thorne and have been found, in these tests, free from those harmful organisms
Annex IVAI (25.2)	Tubers of *Solanum tuberosum* L.	Without prejudice to the provisions listed in Annex III(A) (10), (11) and (12) and Annex IV(A)(I) (25.1), official statement that: (a) the tubers originate in countries known to be free from *Clavibacter michiganensis* ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al.; or (b) provisions recognised as equivalent to the Community provisions on combating *Clavibacter michiganensis* ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis *et al*. in accordance with the procedure referred to in Article 18(2), have been complied with, in the country of origin.
Annex IVAI (25.4)	Tubers of *Solanum tuberosum* L., intended for planting	Without prejudice to the provisions applicable to the tubers listed in Annex III(A) (10), (11) and (12) and Annex IV(A)(I) (25.1), (25.2) and (25.3), official statement that the tubers originate from a field known to be free from *Globodera rostochiensis* (Wollenweber) Behrens and *Globodera pallida* (Stone) Behrens and (aa) either, the tubers originate in areas in which *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* is known not to occur; or (bb) in areas where *Ralstonia solanacearum* (Smith) Yabuuchi *et al* is known to occur, the tubers originate from a place of production found free from *Ralstonia solanacearum* (Smith) Yabuuchi *et al.*, or considered to be free thereof, as a consequence of the implementation of an appropriate procedure aiming at eradicating *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* which shall be determined in accordance with the procedure referred to in Article 18(2) and (cc) either the tubers originate in areas where *Meloidogyne chitwoodi* Golden *et al*. (all populations) and *Meloidogyne fallax* Karssen are known not to occur; or (dd) in areas where *Meloidogyne chitwoodi* Golden *et al*. (all populations) and *Meloidogyne fallax* Karssen are known to occur, • — either the tubers originate from a place of production which has been found free from *Meloidogyne chitwoodi* Golden *et al*. (all populations), and *Meloidogyne fallax* Karssen 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, or

Annex IVAI	Plants, plant products and other objects	Special requirements
		• —the tubers after harvest have been randomly sampled and, either checked for the presence of symptoms after an appropriate method to induce symptoms, or laboratory tested, as well as inspected visually both externally and by *cutting* the tubers, at appropriate times and in all cases at the time of closing of the packages or containers before marketing according to the provisions on closing in Council Directive 66/ 403/EEC of 14 June 1996 on the marketing of seed potatoes and no symptoms of *Meloidogyne chitwoodi* Golden et al. (all populations) *and Meloidogyne fallax* Karssen have been found
Annex IVAI (25.4.1)	Tubers of *Solanum tuberosum* L., other than those intended for planting	Without prejudice to the provisions applicable to tubers listed in Annex III(A) (12) and Annex IV(A)(I) (25.1), (25.2) and (25.3), official statement that the tubers originate in areas in which *Ralstonia solanacearum* (Smith) Yabuuchi *et al.*is not known to occur.
Annex IVAI (25.4.2)	Tubers of *Solanum tuberosum* L.	Without prejudice to the provisions applicable to tubers listed in Annex III(A) (10), (11) and (12) and Annex IV(A)(I) (25.1), (25.2), (25.3), (25.4) and (25.4.1), official statement that: (a) the tubers originate in a country where *Scrobipalpopsis solanivora* Povolny is not known to occur; or (b) the tubers originate in an area free from *Scrobipalpopsis solanivora* Povolny, established by the national plant protection organisation in accordance with relevant International Standards for Phytosanitary Measures.
Annex IVAI (25.7)	Plants of *Capsicum annuum* L., *Solanum lycopersicum* L., *Musa* L., *Nicotiana* L. and *Solanum melongena* L., intended for planting other than seeds, originating in countries where *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* is known to occur	Without prejudice to the provisions applicable to the plants listed in Annex III(A) (11) and (13), and Annex IV(A)(I) (25.5) and (25.6), where appropriate, official statement that: (a) the plants originate in areas which have been found free from *Ralstonia solanacearum* (Smith) Yabuuchi et al.; or (b) no symptoms of *Ralstonia solanacearum* (Smith) Yabuuchi et al. have been observed on the plants at the place of production since the beginning of the last complete cycle of vegetation
Annex IVAI (26)	Plants of *Humulus lupulus* L. intended for planting, other than seeds	Official statement that no symptoms of *Verticillium albo-atrum* Reinke and Berthold and *Verticillum dahliae* Klebahn have been observed on hops at the place of production since the beginning of the last complete cycle of vegetation
Annex IVAI (31)	Plants of *Pelargonium* L'Herit. ex Ait., intended for planting, other than seeds, originating in countries where tomato ringspot virus is known to occur: (a) where *Xiphinema americanum* Cobb sensu lato (non-European populations) or other vectors of Tomato ringspot virus are not known to occur	Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(I) (27.1) and (27.2), official statement that the plants: (a) are directly derived from places of production known to be free from Tomato ringspot virus; or (b) are of no more than fourth generation stock, derived from mother plants found to be free from Tomato ringspot virus under an official approved system of virological testing

Annex IVAI	Plants, plant products and other objects	Special requirements
	(b) where *Xiphinema americanum* Cobb sensu lato (non-European populations) or other vectors of Tomato ringspot virus are known to occur	Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(I) (27.1) and (27.2), official statement that the plants: (a) are directly derived from places of production known to be free from Tomato ringspot virus in the soil or plants; or (b) are of no more than second generation stock, derived from mother plants found to be free from Tomato ringspot virus under an officially approved system of virological testing
Annex IVAI (33)	Plants with roots, planted or intended for planting, grown in the open air	Official statement that: (a) the place of production is known to be free from *Clavibacter michiganensis* ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al. and *Synchytrium endobioticum* (Schilbersky) Percival; and (b) the plants originate from a field known to be free from *Globodera pallida* (Stone) Behrens and *Globodera rostochiensis* (Wollenweber) Behrens
Annex IVAI (34)	Soil and growing medium, attached to or associated with plants, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: – Turkey, – Belarus, Georgia, Moldova, Russia, Ukraine or – non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia	Official statement that: (a) the growing medium, at the time of planting, was: • either free from soil, and organic matter, or • found free from insects and harmful nematodes and subjected to appropriate examination or heat treatment or fumigation to ensure that it was free from other harmful organisms, or • subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms, and (b) since planting: • either appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms, or • within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in (a)
Annex IVAI (43)	Naturally or artificially dwarfed plants intended for planting other than seeds, originating in non-European countries	Without prejudice to the provisions applicable to the plants listed in Annex III(A) (1), (2), (3), (9), (13), (15), (16), (17), (18), Annex III(B) (1), and Annex IV(A)(I) (8.1), (9), (10), (11.1), (11.2), (12), (13.1), (13.2), (14), (15), (17), (18), (19.1), (19.2), (20), (22.1), (22.2), (23.1), (23.2), (24), (25.5), (25.6), (26), (27.1), (27.2), (28), (32.1), (32.2), (33), (34), (36.1), (36.2), (37), (38.1), (38.2), (39), (40) and (42), where appropriate, official statement that: (a) the plants, including those collected directly from natural habitats, shall have been grown, held and trained for at least two consecutive years prior to dispatch in officially registered nurseries, which are subject to an officially supervised control regime, (b) the plants on the nurseries referred to in (a) shall: (aa) at least during the period referred to in (a):

<table>
<tr><th>Annex IVAI</th><th>Plants, plant products and other objects</th><th>Special requirements</th></tr>
<tr><td></td><td></td><td>be potted, in pots which are placed on shelves at least 50 cm above ground,
have been subjected to appropriate treatments to ensure freedom from non-European rusts: the active ingredient, concentration and date of application of these treatments shall be mentioned on the phytosanitary certificate provided for in Article 7 of this Directive under the rubric ‘disinfestation and/or disinfection treatment’,
have been officially inspected at least six times a year at appropriate intervals for the presence of harmful organisms of concern, which are those in the Annexes to the Directive. These inspections, which shall also be carried out on plants in the immediate vicinity of the nurseries referred to in (a), shall be carried out at least by visual examination of each row in the field or nursery and by visual examination of all parts of the plant above the growing medium, using a random sample of at least 300 plants from a given genus where the number of plants of that genus is not more than 3 000 plants, or 10 % of the plants if there are more than 3 000 plants from that genus,
have been found free, in these inspections, from the relevant harmful organisms of concern as specified in the previous indent. Infested plants shall be removed. The remaining plants, where appropriate, shall be effectively treated, and in addition shall be held for an appropriate period and inspected to ensure freedom from such harmful organisms of concern,
have been planted in either an unused artificial growing medium or in a natural growing medium, which has been treated by fumigation or by appropriate heat treatment and has been of any harmful organisms,
have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, have been:
shaken and washed with clean water to remove the original growing medium and kept bare rooted, or
shaken and washed with clean water to remove the original growing medium and replanted in growing medium which meets the conditions laid down in (aa) fifth indent, or
subjected to appropriate treatments to ensure that the growing medium is free from harmful organisms, the active ingredient, concentration and date of application of these treatments shall be mentioned on the phytosanitary certificate provided for in Article 7 of this Directive under the rubric ‘disinfestation and/or disinfection treatment’.
(bb) be packed in closed containers which have been officially sealed and bear the registration number of the registered nursery; this number shall also be indicated under the rubric additional declaration on the phytosanitary certificate provided for in Article 7 of this Directive, enabling the consignments to be identified</td></tr>
<tr><td>Annex IVAI (49.2)</td><td>Seeds of Medicago sativa L., originating in countries where Clavibacter michiganensis ssp. insidiosus Davis et al. is known to occur</td><td>Without prejudice to the requirements applicable to plants listed in Annex IV(A)(I) (49.1), official statement that:
(a) Clavibacter michiganensis ssp. insidiosus Davis et al. has not been known to occur on the farm or in the immediate vicinity since the beginning of the past 10 years;
(b) either
the crop belongs to a variety recognised as being highly resistant to Clavibacter michiganensis ssp. insidiosus Davis et al., or</td></tr>
</table>

		• it had not yet started its fourth complete cycle of vegetation from sowing when the seed was harvested and there was not more than one preceding seed harvest from the crop, or • the content of inert matter which has been determined in accordance with the rules applicable for the certification of seed marketed in the Community, does not exceed 0.1 % by weight. (c) no symptoms of *Clavibacter michiganensis* ssp. *insidiosus* Davis et al. have been observed at the place of production, or on any M*edicago sativa* L. crop adjacent to it, during the last complete cycle of vegetation or, where appropriate, the last two cycles of vegetation; (d) the crop has been grown on land on which no previous *Medicago sativa* L. crop has been present during the last three years prior to sowing

Annex IVB	Plants, plant products and other objects	Special requirements	Protected zones
Annex IVB (19)	Plants of *Eucalyptus* l'Herit, other than fruit and seeds	Official statement that: (a) the plants are free from soil, and have been subjected to a treatment against *Gonipterus scutellatus* Gyll.; or (b) the plants originate in areas known to be free from *Gonipterus scutellatus* Gyll.	EL, P (Azores)
Annex IV B (20.1)	Tubers of *Solanum tuberosum* L., intended for planting	Without prejudice to the provisions applicable to the plants listed in Annex III(A)(10), (11), Annex IV(A)(I) (25.1), (25.2), (25.3), (25.4), (25.5), (25.6), Annex IV(A)(II) (18.1), (18.2), (18.3), (18.4), (18.6), official statement that the tubers: (a) were grown in an area where Beet necrotic yellow vein virus (BNYVV) is known not to occur; or (b) were grown on land, or in growing media consisting of soil that is known to be free from BNYVV, or officially tested by appropriate methods and found free from BNYVV; or (c) have been washed free from soil.	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex IVB (20.2)	Tubers of *Solanum tuberosum* L., other than those mentioned in Annex IVB (20.1)	(a) The consignment or lot shall not contain more than 1 % by weight of soil, or (b) the tubers are intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading BNYVV	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex IVB (20.3)	Plants with roots, planted or intended for planting, grown in the open air	There shall be evidence that the plants originate from a field known to be free from *Globodera pallida* (Stone) Behrens	FI, LV, SI, SK
Annex IVB (22)	Plants of *Allium porrum* L., *Apium* L., *Beta* L., other than those mentioned in Annex IV(B) (25) and those intended for animal fodder, *Brassica napus* L., *Brassica rapa* L., *Daucus* L., other than plants intended for planting	(a) The consignment or lot shall not contain more than 1 % by weight of soil, or (b) the plants are intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading BNYVV	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex IVB (23)	Plants of *Beta vulgaris* L., intended for planting, other than seeds	(a) Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(I) (35.1), (35.2), Annex IV(A)(II) (25) and Annex IV(B) (22), official statement that the plants: (aa) have been officially individually tested and found free from Beet necrotic yellow vein virus (BNYVV); or (bb) have been grown from seeds complying with the requirements listed in Annex IV(B)(27.1) and (27.2), and • grown in areas where BNYVV is known not to occur, or • grown on land, or in growing media, officially tested by appropriate methods and found free from BNYVV, and • sampled, and the sample tested and found free from BNYVV;	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)

Annex IVB	Plants, plant products and other objects	Special requirements	Protected zones
		• (b) the organisation or research body holding the material shall inform their official Member State plant protection service of the material held	
Annex IVB (26)	Soil from beet and unsterilised waste from beet (*Beta vulgaris* L.)	Official statement that soil or waste: (a) has been treated to eliminate contamination with BNYVV, or (b) is intended to be transported for disposal in an officially approved manner, or (c) comes from *Beta vulgaris* plants grown in an area where BNYVV is known not to occur	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex IVB (27.2)	Vegetable seed of the species *Beta vulgaris* L.	Without prejudice to the provisions of Council Directive 70/458/EEC of 29 September 1970 on the marketing of vegetable seed, where applicable, official statement that: (a) the processed seed contains no more than 0.5 % by weight of inert matter, in the case of pelleted seed this standard shall be met prior to pelleting; or (b) in the case of non-processed seed, the seed: • shall be officially packed in such a manner as to ensure that there is no risk of spread of BNYVV, and • is intended for processing that will satisfy the conditions laid down in (a) and delivered to a processing enterprise with officially approved controlled waste disposal, to prevent the spread of Beet necrotic yellow vein virus (BNYVV); or (c) the seed has been produced from a crop grown in an area where BNYVV is known not to occur.	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex IVB (30)	Used agricultural machinery	(a) The machinery shall be cleaned and free from soil and plant debris when brought in on places of production where beets are grown, or (b) the machinery shall come from an area where BNYVV is known not to occur	F (Britanny), FI, IRL, P (Azores), UK (Northern Ireland)
Annex VB	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community**		
Annex VBI (7)	(a) Soil and growing medium as such, which consists in whole or in part of soil or solid organic substances, such as parts of plants, humus including peat or bark, other than that composed entirely of peat. (b) Soil and growing medium, attached to or associated with plants, consisting in whole or in part of material specified in (a) or consisting in part of any solid inorganic substance, intended to sustain the vitality of the plants, originating in: • Turkey, • Belarus, Georgia, Moldova, Russia, Ukraine, • non-European countries, other than Algeria, Egypt, Israel, Libya, Morocco, Tunisia		
Annex VBII	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for certain protected zones		

Table 13: Evaluation of Risk Reduction Options (RROs) implemented in Council Directive 2000/29/EC to prevent introduction (entry + establishment) of pests with soil and growing media into the territory of the EU

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
SGM as commodity ('as such')						
no RRO	All pests potentially present in or associated with		Growing medium as commodity composed entirely of peat	IIIA (14)	Not rated	
Prohibition of import	All pests potentially present in or associated with		Soil as commodity	IIIA (14)	Very high	Low
Prohibition of import	All pests potentially present in or associated with		Growing medium as commodity, consisting in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat	IIIA (14)	Very high	Low
Prohibition of import	All pests potentially present in or associated with		Isolated bark of *Castanea*	IIIA (5)	Very high	Low
Prohibition of import	All pests potentially present in or associated with		Isolated bark of *Quercus*, other than *Quercus suber*	IIIA (6)	Very high	Low
Prohibition of import	All pests potentially present in or associated with		Isolated bark of *Acer saccharum*	IIIA (7)	Very high	Low
Prohibition of import	All pests potentially present in or associated with		Isolated bark of *Populus*	IIIA (8)	Very high	Low
SGM attached to or associated with plants						
N.B. RROs of Annex IVAI (34) and Annex IVAI (43) are presented in Table 3 and Table 4, respectively						
Pest-free country	*Radopholus citrophilus*/ *Radopholus similis*	Known to be free	*Citrus*, *Fortunella*, *Poncirus*, Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae	IVAI (18)	High	Medium
Pest-free area	*Ralstonia solanacearum*	Area found free from	in countries where *Ralstonia solanacearum* is known to occur, for plants of *Capsicum annuum*, *Lycopersicon lycopersicum*, *Musa*, *Nicotiana* and *Solanum melongena* L., intended for planting other than seeds	IVAI (25.7)	High	Medium
Pest-free place of production	*Clavibacter michiganensis* ssp. *sepedonicus* and *Synchytrium endobioticum*	Known to be free	Plants with roots, planted or intended for planting, grown in the open air	IVAI (33)	High	Medium

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Pest-free production site	*Globodera pallida* and *Globodera rostochiensis*	Known to be free	Plants with roots, planted or intended for planting, grown in the open air	IVAI (33)	High	Medium
Pest-free production site	*Radopholus citrophilus*/ *Radopholus similis*	These nematodes not found in official nematological testing of representative soil and root samples during last growth cycle of specified host plants	Citrus, *Fortunella*, *Poncirus*, Araceae, Marantaceae, Musaceae, *Persea* spp. and Strelitziaceae	IVAI (18)	High	Medium
Pest-free production site	Tomato ringspot virus	Known to be free	Plants of *Pelargonium*, intended for planting, other than seeds, originating in countries where Tomato ringspot virus is known to occur AND (a) where *Xiphinema americanum* sensu lato (non-European populations) or other vectors of Tomato ringspot virus are NOT KNOWN to occur	IVAI (31)	High	Medium
Pest-free production site	Tomato ringspot virus	Known to be free from Tomato ringspot virus in the soil or plants	Plants of *Pelargonium*, intended for planting, other than seeds, originating in countries where Tomato ringspot virus is known to occur AND (a) where *Xiphinema americanum* sensu lato (non-European populations) or other vectors of Tomato ringspot virus are KNOWN to occur	IVA I (31)	High	Very high
Pest-free production site	*Verticillium albo-atrum*/ *Verticillium dahliae*	No symptoms have been on hops	*Humulus lupulus*	IVAI (26)	High	High
SGM as contaminant						
No restriction			Soil attached to used machinery			
Pest-free country	*Clavibacter michiganensis* subsp. *sepedonicus*	Known to be free	Tubers of *Solanum tuberosum*	IVAI (25.2)	High	Medium

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Pest-free country	Scrobipalpopsis solanivora	Not known to occur	Tubers of *Solanum tuberosum*	IVAI (25.4.2)	High	High
Pest-free area	*Ralstonia solanacearum*	Known not to occur	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	Medium
Pest-free area	*Ralstonia solanacearum*	Not known to occur	Tubers of *Solanum tuberosum* other than those intended for planting	IVAI (25.4.1)	High	High
Pest-free area	*Meloidogyne chitwoodi*/ *Meloidogyne fallax*	Known not to occur	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	Medium
Pest-free area	*Scrobipalpopsis solanivora*	Established by the national plant protection organisation in accordance with relevant International Standards for Phytosanitary Measures	Tubers of *Solanum tuberosum*	IVAI (25.4.2)	High	Medium
Pest-free area + no symptoms at place of production and immediate vicinity	*Synchytrium endobioticum*	Known to be free + visual inspection	Tubers of *Solanum tuberosum*	IVAI (25.1)	High	Medium
Pest-free production site	*Globodera rostochiensis*/ *Globodera pallida*	Known to be free	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	High
Pest-free production site in infested area: in infested area where an appropriate procedure aiming at eradicating *Ralstonia solanacearum* is implemented	*Ralstonia solanacearum*	Site found free from the pest	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	High

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Pest-free production site in infested area	*Meloidogyne chitwoodi*/ *Meloidogyne fallax*	Site found free from the pest, 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	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	High

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Inspection of consignment	*Meloidogyne chitwoodi*/ *Meloidogyne fallax*	The tubers after harvest have been randomly sampled and either checked for the presence of symptoms after an appropriate method to induce symptoms or laboratory tested, as well as inspected visually both externally and by cutting the tubers, at appropriate times and in all cases at the time of closing of the packages or containers before marketing according to the provisions on closing in Council Directive 66/403/EEC of 14 June 1996 on the marketing of seed potatoes (1) and no symptoms of *Meloidogyne chitwoodi* (all populations) and *Meloidogyne fallax* Karssen have been found	Tubers of *Solanum tuberosum* intended for planting	IVAI (25.4)	High	High
Provisions recognised as equivalent to the Community provisions on combating *Synchytrium endobioticum*	*Synchytrium endobioticum*		Tubers of *Solanum tuberosum*	IVAI (25.1)	Not rated	

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Provisions recognised as equivalent to the Community provisions on combating *Clavibacter michiganensis* ssp. *sepedonicus*	*Clavibacter michiganensis* ssp. *sepedonicus*		Tubers of *Solanum tuberosum*	IVAI (25.2)	Not rated	
Tolerance of amount of soil associated with the consignment	All pests potentially present in soil	The consignment or lot shall not contain more than 1 % by weight of soil	Tubers of *Solanum tuberosum*, other than those intended for planting, for the protected zones of France (Brittany), Finland, Ireland Portugal (Azores), the United Kingdom (Northern Ireland)	IVB (20.2)	Low	Low
Tolerance of amount of soil associated with the consignment	All pests potentially present in soil	The consignment or lot shall not contain more than 1 % by weight of soil	Plants of *Allium porrum* L., *Apium* L., *Beta* L., other than those mentioned in Annex IV(B) (25) and those intended for animal fodder, *Brassica napus* L., *Brassica rapa* L., *Daucus* L., other than plants intended for planting, for the protected zones of France (Brittany), Finland, Ireland Portugal (Azores), the United Kingdom (Northern Ireland)	IVB (22)	Low	Low
Restricted end use	All pests potentially present in soil	The plants are intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading BNYVV	Tubers of *Solanum tuberosum*, other than those intended for planting, for the protected zones of France (Brittany), Finland, Ireland Portugal (Azores), the United Kingdom (Northern Ireland)	IVB (20.2)	Low	Low

RRO category	Pests	Criteria according to 2000/29	Specification of commodities/circumstances	Reference to Annex of 2000/29/EC	Effectiveness	Uncertainty
Restricted end use	All pests potentially present in soil	The plants are intended for processing at premises with officially approved waste disposal facilities which ensures that there is no risk of spreading BNYVV	Plants of *Allium porrum* L., *Apium* L., *Beta* L., other than those mentioned in Annex IV(B) (25) and those intended for animal fodder, *Brassica napus* L., *Brassica rapa* L., *Daucus* L., other than plants intended for planting, for the protected zones of France (Brittany), Finland, Ireland Portugal (Azores), the UK (Northern Ireland)	IVB (22)	Low	Low

Table 14: Evaluation of the special requirements laid down in Annex IVAI (34) of Council Directive 2000/29/EC

Analysis of RROs in Annex IVAI (34) One option pre-planting + one option post-planting				
Options pre-planting	AND	**Options post-planting**	**Effectiveness**	**Uncertainty**
Growing medium was free from soil and organic matter	AND	Appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms	High	Medium
		OR		
		within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in 34(a)	Medium	High
OR				
Growing medium was 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	AND	Appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms	High	High
		OR		
		within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in 34(a)	Medium	High
OR				
Growing medium was subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms	AND	Appropriate measures have been taken to ensure that the growing medium has been maintained free from harmful organisms	High	Medium
		OR		
		within two weeks prior to dispatch, the plants were shaken free from the medium leaving the minimum amount necessary to sustain vitality during transport, and, if replanted, the growing medium used for that purpose meets the requirements laid down in 34(a)	Medium	High

Table 15: Evaluation of the special requirements laid down in Annex IVAI (43) of Council Directive 2000/29/EC

Analysis of RROs in Annex IVAI (43) **GENERAL requirements for dwarfed plants**
(a) The plants, including those collected directly from natural habitats, shall have been grown, held and trained for at least two consecutive years prior to dispatch in officially registered nurseries, which are subject to an officially supervised control regime
AND be potted, in pots which are placed on shelves at least 50 cm above ground
AND have been officially inspected at least six times a year at appropriate intervals for the presence of harmful organisms of concern, which are those in the Annexes to the Directive. These inspections, which shall also be carried out on plants in the immediate vicinity of the nurseries referred to in (a), shall be carried out at least by visual examination of each row in the field or nursery and by visual examination of all parts of the plant above the growing medium, using a random sample of at least 300 plants from a given genus where the number of plants of that genus is not more than 3 000 plants, or 10 % of the plants if there are more than 3 000 plants from that genus
AND have been found free, in these inspections, from the relevant harmful organisms of concern as specified in the previous indent. Infested plants shall be removed. The remaining plants, where appropriate, shall be effectively treated, and in addition shall be held for an appropriate period and inspected to ensure freedom from such harmful organisms of concern
AND have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms
AND be packed in closed containers which have been officially sealed and bear the registration number of the registered nursery; this number shall also be indicated under the rubric additional declaration on the phytosanitary certificate provided for in Article 7 of this Directive, enabling the consignments to be identified

AND FOR SGM: one option pre-planting + one option post-planting				
Options pre-planting	**AND**	**Options post-planting**	**Effectiveness**	**Uncertainty**
Have been planted in an unused artificial growing medium	AND	Have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, have been shaken and washed with clean water to remove the original growing medium and kept bare rooted	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, shaken and washed with clean water to remove the original growing medium and replanted in unused artificial growing medium or in a natural growing medium, which has been treated by fumigation or by appropriate heat treatment and has been examined and declared free (French and Dutch version) of any harmful organisms	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, subjected to appropriate treatments to ensure that the growing medium is free from harmful organisms, the active ingredient, concentration and date of application of these treatments shall be mentioned on the phytosanitary certificate provided for in Article 7 of this Directive under the rubric 'disinfestation and/or disinfection treatment'	High	Medium to high
OR				

AND FOR SGM: one option pre-planting + one option post-planting				
Options pre-planting	**AND**	**Options post-planting**	**Effectiveness**	**Uncertainty**
Have been planted in a natural growing medium, which has been treated by fumigation and has been examined and declared free (French version) of any harmful organisms	AND	Have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, have been shaken and washed with clean water to remove the original growing medium and kept bare rooted	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, shaken and washed with clean water to remove the original growing medium and replanted in unused artificial growing medium or in a natural growing medium, which has been treated by fumigation or by appropriate heat treatment and has been examined and declared free (French and Dutch version) of any harmful organisms	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, subjected to appropriate treatments to ensure that the growing medium is free from harmful organisms, the active ingredient, concentration and date of application of these treatments shall be mentioned on the phytosanitary certificate provided for in Article 7 of this Directive under the rubric 'disinfestation and/or disinfection treatment'	High	Medium to high
OR				
Have been planted in a natural growing medium, which has been treated by appropriate heat treatment and has been examined and declared free (French version) of any harmful organisms	AND	Have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, have been shaken and washed with clean water to remove the original growing medium and kept bare rooted	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, shaken and washed with clean water to remove the original growing medium and replanted in unused artificial growing medium or in a natural growing medium, which has been treated by fumigation or by appropriate heat treatment and has been examined and declared free (French and Dutch version) of any harmful organisms	High	Medium to high
		OR		
		have been kept under conditions which ensure that the growing medium has been maintained free from harmful organisms and within two weeks prior to dispatch, subjected to appropriate treatments to ensure that the growing medium is free from harmful organisms, the active ingredient, concentration and date of application of these treatments shall be mentioned on the phytosanitary certificate provided for in Article 7 of this Directive under the rubric 'disinfestation and/or disinfection treatment'	High	Medium to high

Appendix E – Phytosanitary measures to prevent introduction (entry + establishment) of harmful organisms with SGM in Australia, Canada, New Zealand and the USA

The main regulations that were considered by the Panel are for:

Australia: Australian Department of Agriculture's import conditions database ICON. Available online at http://apps.daff.gov.au/icon32/asp/ex_querycontent.asp

Canada: Canadian Food Inspection Agency- Acts and Regulations. Available online at http://www.inspection.gc.ca/about-the-cfia/acts-and-regulations/list/eng/1419029096537/1419029097256

New Zealand: New Zealand Ministry for Primary Industries 'The Biosecurity Act 1993'. Available online at http://www.mpi.govt.nz/law-and-policy/legal-overviews/biosecurity/

United States: U.S. Government publishing Office; eCFR- Electronic Code of Federal Regulations database Available online at http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title07/7cfr330_main_02.tpl

Table 16: Australia, Canada, New Zealand and the USA legislation on soil an growing media

Soil as a commodity	**Country**	**Details**			**Reference** (for further details see footnotes 8 to 48)
Prohibition of import	Canada	soil and 'soil-related matter'			CFIA D-95-26
Specified treatment	USA	Soil must be shipped in a securely closed, watertight or leak-proof container (primary container, test tube, vial, etc.) which must be enclosed in a second, durable watertight or leak-proof container (secondary container)	AND	At entry into the USA: Dry heat at 250 °F for at least two hours,	USDA-APHIS Circular Q-330.300-1 Soil (01/2010) Revised.
				OR	
				At entry into USA: Steam heat at 250 °F for 30 minutes at 15 lbs/p.s.i. pressure,	
				OR	
				At entry into USA: Other treatments and conditions such as: (a) destructive analysis, (b) acid washing, (c) hydroclave, and (d) incineration	
	New Zealand	Soil consignments < 10 kg		Raising the internal temperature of the soil to 100 °C for at least 25 minutes (soil must be moist) before release	BMG-STD-SOWTR

Soil as a commodity	Country	Details			Reference (for further details see footnotes 8 to 48)
		Soil consignments > 10 kg		The importer will be advised of the conditions	
Restricted end use	USA	End use: Soil for research, analytical, religious, ceremonial, patriotic or similar purposes	AND	Import permit required. Untreated soil is not authorised as a growing medium for plants unless the soil is used in controlled conditions within an inspected facility or growth chamber as authorised in the permit conditions	USDA-APHIS Circular Q-330.300-1 Soil (01/2010) Revised
	Canada	End use: Soil for scientific research, education, processing, industrial or exhibition purposes	AND	'Permit to Import' required	CFIA D-95-26
	New Zealand	End use: Soil samples imported for chemical/physical analysis (but not for culture or isolation of organisms) must be directed to a transitional facility specifically approved for analysis/destruction. The soil must be destroyed/treated after analysis according to the method approved in the transitional facility's operating procedure			BMG-STD-SOWTR
Restricted end use + specified treatment	Australia	End use: Other than animal foods, fertilisers or growing purposes	AND	Gamma irradiation at 50 kGray (5 Mrad) prior to release to the importer	ICON Condition C20162
		End use: Chemical, physical or destructive laboratory analysis AND import permit	AND	Containment in Quarantine Approved Premises Class 5.1,	ICON Condition C19453
				OR	
				Dry heat treatment at 160 °C for 2 hours as long as sample size does not exceed 500g in weight (T10026),	
				OR	
				Heat treatment in an autoclave at 121 °C, 103 kPa (15 psi) for 20 minutes (T9660),	
				OR	
				Heat treatment in an autoclave at 134 °C, 214 kPa (31 psi) for 4 minutes (T9660),	
				OR	
				Gamma irradiation at 50 kGray (T9652)	

Growing media as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
No restriction	Canada	Commodities that are not considered soil or soil-related matter, and not subject to the import or movement requirements listed within D.95.26: • tissue culture medium (alone, without plants) • soil-free growing media imported under the Canadian Growing Media Program • silica sand and pure minerals, such as barite, greensand, kaolin, rock phosphate, rottenstone and tile clay (for industrial, cosmetic, therapeutic or environmental clean-up applications) • sand from salt-water beaches and seashells that are free from all animal matter. • gravel • peat originating from a non-agricultural area that has not been used previously for growing plants or for other agricultural purposes • moss that has been dried or treated		CFIA D-95-26
	New Zealand	Manufactured fertilisers in granular, powder and liquid form containing plant extracts, with a certificate from the manufacturer confirming the identity of the product and the processing involved		BNZ-FERTGRO-IMPRT
		Listed processed peat products, e.g. Jiffy peat pots		
Prohibition	Australia	Fertilisers, soil conditioners and potting mixes of terrestrial animal and avian origin, all origins except New Zealand		C9004
		Manure, all origins		C5246
		Coir fibre, excluding coir peat, for all uses other than as animal foods, fertiliser or for growing purposes	the restricted end use results in prohibition of import for use as growing medium	C10016
	USA	Garbage (including agricultural waste) from all foreign countries except Canada		§330.400
Import inspection	USA	Material that is free of organic matter, such as pure sand, clay (laterites, bentonite, china clay, attapulgite, tierrafino, etc.), talc, rocks, volcanic pumice, chalk, salt, iron ore and gravel. These materials must be mined or collected so they are free of organic material, such as roots, grasses, plant debris or leaf litter		USDA-APHIS Circular Q-330.300-1 Soil (01/2010) Revised
		The following material possibly containing organic matter: • peat, cosmetic mud and other mud products from fresh water estuaries or the earth's upper surface, if processed to a uniform consistency, and free of plant parts or seeds • any sediment, mud or rock from the oceans of the earth		
	New Zealand	Rock or gravel	Inspected and found to be free of organic material	BMG-STD-SOWTR
Import permit + special conditions	USA	Soil Amendments and Plant Growth Enhancers (PGEs), including Fertilisers, Compost, Sludge and Other Materials Used to Enhance Plant Growth	Special conditions are formulated on an individual basis	Plant Growth Enhancers Website
	Australia	Fertilisers, soil conditioners and potting mixes of terrestrial animal and avian origin, origin New Zealand	All terrestrial animal and avian ingredients must be sourced from	C9900

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
			animals which were born, raised and slaughtered in New Zealand. Animal manure is not permitted as an ingredient	
		Fertilisers, soil conditioners and potting mixes of aquatic animal origin: Import permit + inspection on arrival	Import permit + inspection on arrival	C9068
			AND	
			Manufacturer's declaration stating: a) the ingredients used in the manufacture of the product were not derived from terrestrial animals or avians; and b) the product contains no material derived from fish of the family Salmonidae (i.e. salmon, trout or related species); and c) all parts of the product have been heated to a minimum of either: • 85 °C for a period of not less than 15 minutes, OR • 80 °C for a period of not less than 20 minutes	
		Fertilisers, soil conditioners and potting mixes of microbial origin	Import permit + inspection on arrival	C5177
			AND	
			manufacturer's declaration relating to the ingredients and relevant processing details	
		Fertilisers, soil conditioners and potting mixes of plant origin	Import permit + inspection on arrival	C19058
			AND	
			Free of live insects, seeds, soil, mud, clay, animal faeces and undecomposed animal material and plant material prior to arrival in Australia. Any packaging used with the	

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
			consignment must be clean and new. Full container load consignments must be accompanied by a packer's declaration indicating the container/s has/have been cleaned and is/are free from material of animal and/or plant origin and soil	
		High risk (level 3) fertilisers, including compost accelerator, compost maker, humins, soil conditioners, rock phosphate, biohumate, etc.	Import permit	C19945
			AND	
			visual inspection for biosecurity contaminants at metropolitan Quarantine Approved Premise	
		Medium risk (level 2) and low risk (level 1) fertilisers, including compost accelerator, compost maker, humins, soil conditioners, etc.	Import permit	C19946
			AND	
			manufacturer's declaration stating: […] the containers identified have been inspected and no biosecurity risk material or infestation exists	
		Peat from foot and mouth disease (FMD) unapproved countries	Import permit + verification on arrival	C5272
			AND	
			phytosanitary certificate stating: 'the product was inspected prior to export and found free of live insects, overburden, seeds, soil, mud, clay, animal faeces and undecomposed animal or plant material'	
			AND	
			for consignments greater than 10 kilograms: the peat covered by the certificate comes from areas in which foot and mouth disease (FMD) has not occurred within the past 12	

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
			months OR the peat covered by the certificate was not sourced from an area within a three kilometre radius of a foot and mouth disease (FMD) affected property	
		Peat from Foot and Mouth Disease (FMD) approved countries	Import permit and tailgate verification AND packer's declaration indicating the containers have been cleaned and are free from material of animal and/or plant origin and soil AND each consignment must be free of live insects, overburden (material from the first two metres of the earth's surface including soil and plant and animal material), seeds, soil, mud, clay, animal faeces and undecomposed animal material and plant material prior to arrival in Australia	C5254
		Biodegradable plant pots for end use as fertiliser	Import permit AND depending on import permit one or more of the following: a) Mandatory treatment on arrival using: • gamma irradiation; or • heat treatment; or • ethylene oxide fumigation. b) Offshore treatment with ethylene oxide fumigation; c) Presentation of a valid manufacturer's declaration;	C19046

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
			d) Inspection at a Quarantine Approved Premises	
		Coir peat for end use as fertiliser	Import permit	C5155
			AND	
			an official international Phytosanitary certificate declaring: 'Based on inspection of representative samples, the coir peat is clean, free from soil, contaminant plant material and other extraneous matter'	
			AND	
			a certificate from a government inspection agency endorsed with the following declaration: 'No visible contamination with animal material'	
			AND	
			a certificate of analysis from a Department of Agriculture approved overseas laboratory detailing the microbiological standards according to ICON C5156 (Quality Standards for Horticultural Coir for Use as a Growing Media)	
			AND	
			free of live insects, soil, prohibited seeds, weed seeds, animal material and other quarantine risk material prior to arrival in Australia	
			AND	
			inspection on arrival in Australia	
	New Zealand	Manufactured fertilisers containing live organisms, consignments < 30 kg	Import permit + manufacturer's certificate	BNZ-FERTGRO-IMPRT
		Manufactured fertilisers containing live organisms, consignments > 30 kg	Import permit + manufacturer's certificate + inspection	

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
		Fertilisers and growing media comprising plant products	Import permit + manufacturer's certificate (specifying heat or other treatments) + phytosanitary certificate + inspection	
		Coco peat: five options are distinguished Five options are provided for entry conditions: A) Approved quality production process with grow out test in the exporting country B) Import into a glasshouse transitional facility in New Zealand from an approved quality production process C) Import with recognised treatment in the country of origin D) Import with heat treatment on arrival in New Zealand E) Approved quality production process with grow out test on arrival in New Zealand	Each option requires a different set of import conditions, that may include import permit, treatments and a phytosanitary certificate	BNZ-COFP-MPRT
		Coco fibre	Specified treatment (ethylene oxide, heat treatment or autoclaving)	
		Raw peat	Phytosanitary certificate with various special declarations and treatments, depending on the country of origin	BMG-STD-SOWTR
Restricted end use	Australia	Coir fibre, excluding coir peat	Permission only for all uses other than as animal foods, fertiliser or for growing purposes	C10016
	New Zealand	Sand or clay: visually free of organic material, commercially packed and intended for manufacturing or as absorbents (e.g. kitty litter, silica sand (glass), pottery, paint manufacture or drilling fluid)		BMG-STD-SOWTR
Import special conditions	Canada	Any fertiliser or supplement, where: • 'supplement' means any substance or mixture of substances, other than a fertiliser, that is manufactured, sold or represented for use in the improvement of the physical condition of soils or to aid plant growth or crop yields; • supplements must be registered prior to being imported or sold in Canada (T-4-107); • compost is regulated under this act; • potting soils:	Must have been registered as prescribed, only after science-based evaluation of product safety information and labelling. Must conform to prescribed standards. Must be packaged and labelled as prescribed	CFIA Fertiliser Act and Regulations

Soil as a commodity	Country	Details		Reference (for further details see footnotes 8 to 48)
		On the basis that supplements must be registered, potting soils must conform to the labelling requirements for supplement products		
	USA	Peat, cosmetic mud and other mud products from fresh water estuaries or the earth's upper surface, if processed to a uniform consistency, and free of plant parts or seeds. Any sediment, mud, or rock from the oceans of the earth. Fertilisers or other additives with the exception of those derived from composted animal and plant products that contain minerals, bone meal, and crushed grain	Inspected and found to comply with requirements	USDA-APHIS Circular Q-330.300-1 Soil (01/2010) Revised
	New Zealand	Rock or gravel	Inspected and found to be free of organic material	BMG-STD-SOWTR

SGM attached to or associated with plants TO SUSTAIN VITALITY OF THE PLANTS				
	Country	**Details**		**Reference** (for further details see footnotes 8 to 48)
Prohibition	Australia	Soil is prohibited; growing media is removed from rooted plants at import		
No restriction	USA	Plants for planting (defined as 'restricted article') growing solely in agar or in other agar-like tissue culture medium may be imported established in such growing media		Restricted article definition: 7 CFR § 319.37-1) CFR-2014-title7-vol5-sec319.37-8
		Epiphytic plants (including orchid plants) established solely on tree fern slabs, coconut husks, coconut fiber, new clay pots, or new wooden baskets may be imported on such growing media.		CFR-2014-title7-vol5-sec319.37-8
Import —special conditions	USA	Plants for planting of specified groups of plants and of specified origins (specified in 7 CFR 319.8(e))	Imported established in one of the following approved growing media: baked expanded clay pellets, coal cinder, coir, cork, glass wool, organic and inorganic fibers, peat, perlite, phenol formaldehyde, plastic particles, polyethylene, polymer stabilised starch, polystyrene, polyurethane, rock wool, sphagnum moss, urea formaldehyde, stockosorb superabsorbent polymer, vermiculite, volcanic rock, or zeolite, or any combination of these media. Growing media must not have been previously used	CFR-2014-title7-vol5-sec319.37-8(e)
			AND	
			accompanied by a phytosanitary certificate declaring that specified conditions for production, storing and packing (7 CFR 319.8(e)) are met	
		Plants for planting of *Hyacinthus* spp. (hyacinth)	Established in unused peat, *Sphagnum* moss, or vermiculite growing media, or in synthetic growing media or synthetic horticultural foams, i.e. plastic particles, glass wool, organic and inorganic fibers, polyurethane, polystyrene, polyethylene, phenol	CFR-2014-title7-vol5-sec319.37-8(f)

SGM attached to or associated with plants TO SUSTAIN VITALITY OF THE PLANTS	Country	Details		Reference (for further details see footnotes 8 to 48)
			formaldehyde, or urea formaldehyde AND a written agreement between Plant Protection and Quarantine and the plant protection service of the country where the article is grown for implementation of a specified program	
	Canada	Plants with roots	Must be rooted in approved growing media. Such media must consist of synthetic or other approved substances (other than soil and related matter) used singly or in combinations, e.g. expanded or baked clay pellets, expanded polystyrene beads, floral foam, ground coconut husk, ground cocoa pods, ground coffee hulls, ground rice husk, peat, perlite, pumice, recycled paper, rock wool, sawdust, sphagnum, Styrofoam, synthetic sponge, vermiculite, and volcanic ash or cinder AND the plants with roots must be produced in a facility approved both by Canadian Food Inspection Agency (CFIA) and the exporting country's NPPO and according to approved plant production procedures as specified (D-96-20)	D-96-20
		Plantlets *in vitro*	Must be propagated in a sterile medium under sterile conditions that preclude the possibility of infestation with any pests of quarantine concern to Canada	D-96-20

SGM attached to or associated with plants TO SUSTAIN VITALITY OF THE PLANTS				
	Country	**Details**		**Reference** (for further details see footnotes 8 to 48)
			AND	
			they must be produced and shipped in sealed, aseptic, transparent containers	
	Australia	Tissue cultures in growth media	Import permit + phytosanitary certificate	nursery stock medium risk tissue cultures: with growth media C7300 + C7301
			AND	
			visual inspection at import	
			AND	
			cultures must be established in clear, solid and sterile growth medium, free from any infection and contamination and contained in sterile and sealed containers	
	New Zealand	Tissue cultures in growing media	Phytosanitary certificate (import permit NOT required) certifying inspection at export	MINISTRY FOR PRIMARY INDUSTRIES Standard 155.02.06
			AND	
			inspection at import	
			AND	
			must have been grown in the vessel in which they are imported	
Import special conditions + post entry quarantine	Australia	Seedlings in growth plugs made of compressed peat or an inert material such as Oasis© or Rock Wool	Import permit + phytosanitary certificate	Nursery stock medium risk other than tissue cultures: Seedlings in growth plugs c7300 + c7302
			inspection	
			AND	
			fumigation (growth plug may remain)	
			AND	
			post entry quarantine at private quarantine approved premise (QAP) during > 3 months, depending on plant species and type of material	
		Rooted nursery stock (medium risk) with growth media	Import permit + phytosanitary certificate	C7300 + C7302
			inspection	

SGM attached to or associated with plants TO SUSTAIN VITALITY OF THE PLANTS				
	Country	**Details**		**Reference** (for further details see footnotes 8 to 48)
			AND	
			removal of growth medium (roots must be bare)	
			AND	
			fumigation	
			AND	
			post entry quarantine at private quarantine approved premise (QAP) during > 3 months, depending on plant species and type of material	
		Rooted nursery stock (medium risk) with stems/trunks greater than 10 cm in diameter and more than 1.5 m in length, with growing media	Same measures as for rooted nursery stock (medium risk) with growth media	C7302
			AND	
			may be subject to additional quarantine measures to ensure that the quarantine risks are addressed	
	New Zealand	Nursery stock, whole plants: all nursery stock must undergo a period of post entry quarantine in a registered transitional facility for > 3 months	Import permit + phytosanitary certificate	MINISTRY FOR PRIMARY INDUSTRIES Standard 155.02.06
			AND	
			inspection at import	
			AND	
			'The plants were raised from seed/cuttings in soil-less rooting media in containers maintained out of contact with the soil' OR: 'The roots of the plants have been dipped in fenamiphos at 1.6 g a.i. per litre of water for 30 minutes'	
			AND	
			All nursery stock must undergo a period of post entry quarantine in a registered transitional facility for > 3 months	

SGM attached to or associated with plants AS PACKING MATERIAL			
	Country	**Details**	**Reference** (for further details see footnotes 8 to 48)
Import special condition	USA	Plants for planting shall not be packed in a packing material unless the plants were packed in the packing material immediately prior to shipment; such packing material is free from sand, soil or earth (except for sand designated below); has not been used previously as packing material or otherwise; and is listed in CFR 319.37-9. Examples are: Baked or expanded clay pellets, ground peat, rock wool, quarry gravel, sphagnum moss.	CFR 319.37-9
		The following types of soil or earth are authorised as safe for packing (general use): (a) Peat, (b) peat moss and (c) Osmunda fiber (CFR 319.69-5)	CFR 319.69-5
	Canada	Approved packing materials for plants for planting are the following: Coconut husk fibres (coir), cork (ground cork), wood shaving, wood wool, sawdust, excelsior (or other very fine wood shavings), paper, peat, perlite, polyacrylamide (water-absorbing polymers), rice chaff, vermiculite. Other products or materials may be approved by the CFIA on a case-by-case basis. All of the above materials must be free of pests, soil and soil-related matter. The material must be new and will not be accepted if it has been previously used for growing, rooting or packing plants or plant materials	D-08-04, paragraph 3.10
	Australia	Plants are preferably imported bare rooted; however, packing material can be used to help decrease the risk of damage to the plant during transport to Australia. Accepted media are listed. Examples are buckwheat hulls, plastic foam, wood shavings, vermiculite, peat moss and *Sphagnum* moss. Plants should not arrive established in the packaging media	ICON C8815
	New Zealand	Only inert/synthetic material may be used for the protection, packaging and shipping materials of the nursery stock. Peat used as packing material follows the same requirements as for consignments of raw peat	Ministry For Primary Industries Standard 155.02.06. paragraph 2.2.1.4; BMG-STD-SOWTR paragraph 5.5

SGM as a contaminant – to plants or plant products			
	Country	**Details**	**Reference** (for further details see footnotes 8 to 48)
Prohibition	USA	No soil shall be moved into the United States, whether the soil is moved as such or incidentally adhering to means of conveyance or other articles. When soil is found as contaminant with a product the consignment may be rejected (e.g. with cut flowers)	CFR 330.300; CFR 319.74-2
	Canada	The importation of items contaminated with soil and soil-related matter from all countries is prohibited	CFIA D-95-26
	Australia	Consignments of plant material possibly containing soil are inspected at import; if soil is detected, the consignments must be reconditioned to remove the soil	ICON C6500
		Plant material likely to be contaminated with soil (potato tubers, sweet potato, etc.) is prohibited (ICON database)	ICON database, no import condition implemented
	New Zealand	Consignments of nursery stock contaminated with soil shall be treated, reshipped or destroyed	MPI STANDARD 155.02.06. Importation of Nursery Stock paragraph 2.2.1.4

SGM as a contaminant – to equipment or other articles			
	Country	**Details**	**Reference** (for further details see footnotes 8 to 48)
Prohibition	USA	No soil shall be moved into the United States, whether the soil is moved as such or incidentally adhering to means of conveyance or other articles. When soil is found as contaminant with a product the consignment may be rejected	CFR 330.300
	Canada	The importation of items contaminated with soil and soil-related matter from all countries is prohibited	CFIA D-95-26
	Australia	Used machinery: Each consignment must be free of soil, mud, insects, plant and animal debris and other biosecurity risk material	ICON C19874
		Fireworks containing soil, sand and other plant material: If prohibited plant material or other quarantine risk material such as soil is found in the fireworks the consignment will be re-exported or destroyed at the importer's expense	ICON C5184
	New Zealand	Soil that is a contaminant on a consignment must be treated or destroyed	BMG-STD-SOWTR
Treatment at import	Australia	Soil and articles containing soil must be subjected to gamma irradiation at 50 kGray (5 Mrad) prior to release to the importer	ICON C20162

Appendix F – Effectiveness of methods to reduce the pest presence

F1. Extensive literature search

Search strategy for effectiveness of risk reduction options.

The literature search was performed on 13/04/2014.

F1.1. Information sources

The information sources used to produce a set of relevant evidence that were consulted for performing the assessment of the effectiveness of risk reduction option (RROs) to control plant pests in soil and growing media (SGM):

ISI Web of Knowledge (Web of ScienceTM Core Collection (1975–present); BIOSIS Citation IndexSM (1926–present); CABI: CAB Abstracts® (1910–present)**;** Chinese Science Citation DatabaseSM (1989-present); Current Contents Connect® (1998–present); Data Citation IndexSM (1900–present); FSTA®—the food science resource (1969–present); MEDLINE® (1950–present); SciELO Citation Index (1997-present); Zoological Record® (1864–present)).

F1.2. Search strategy for effectiveness of risk reduction options

The search equation used to search ISI Web of Knowledge was articulated as follows:

Timespan=2000–2014
Search language=Auto

TITLE: (((growing OR pot*) AND (medi* OR mix*)) OR substrate OR soil) *AND* **TITLE:** (plant health OR disease OR pest OR pathogen OR (harmful organism)) *AND* **TITLE:** (soil) *NOT* **TITLE:** (detection) *NOT* **TITLE:** (nutrient OR nutrition OR emission OR (animal AND health) OR irrigation) *AND* **TITLE:** (Measures OR Control OR Management OR Disinfection OR Disinfestation OR Sterilization OR Eradication OR Suppression OR Elimination)

As a result, 662 hits were obtained running the search equation.

F1.3. Screening

The 662 publications were screened for relevance by their titles first and then by their abstracts. The screening process was unmasked and performed on the basis of irrelevance to the subject of this work, i.e. documents not dealing with RROs or plant pests or SGM were considered irrelevant.

As a result, 207 references were considered to produce a set of relevant evidence and the corresponding full texts were scrutinised and consulted to extract information regarding the effectiveness of the described methods to reduce the pest presence in SGM.

F2. Effectiveness of methods to reduce pest presence associated with soil and growing media

F2.1 Scoring of effectiveness of methods to reduce pest presence

Following an extensive literature search described above, the methods reducing the pest presence in the SGM identified in the literature were evaluated according to the following scale:

Score	Levels
NA	Missing data
0	No effect
1	Partial reduction of presence of harmful organisms in SGM
2	100 % reduction of presence of harmful organisms in SGM

F2.2. Results of literature screening

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Antagonist	Abd-El-Kareem et al., 2004	2	*Bacillus subtilis, Trichoderma harzianum*	*Rhizoctonia solani*	*In vitro* experiment with lupin root	No pathogen growth	No full control in greenhouse and field conditions	
Biological	Antagonist	Abd-El-Kareem et al., 2004	2	*Trichoderma harzianum*	*Sclerotium rolfsii*	*In vitro* experiment with lupin root	No pathogen growth	No full control in greenhouse and field conditions	
Biological	Antagonist	Abd-El-Kareem et al., 2004	2	*Bacillus subtilis*	*Fusarium solani*	*In vitro* experiment with lupin root	No pathogen growth	No full control in greenhouse and field conditions	
Biological	Antagonist	El-Mohamedy et al., 2010	2	Bio-enhancing bagasse (*Trichoderma harzianum*)	*Macrophomina phasealina* (Tassi) Goid	Artificially infested soil (sand:loam soil (2:1)) with seedlings of grapevine	Zero root disease severity	No full control in field conditions	
Biological	Antagonist	El-Mohamedy et al., 2010	2	Bio-enhancing bagasse (*Trichoderma harzianum*)	*Fusarium oxysporum*, Schlecht	Artificially infested soil (sand:loam soil (2:1)) with seedlings of grapevine	Zero root disease severity	No full control in field conditions	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Composting	Noble and Roberts, 2004	2	Composting of plant materials (review paper)	Temperature–time eradication conditions of 64 plant pathogen and nematode species retrieved from the literature	Different types of plant materials (bark, green waste, plant residues, etc.)	For 27 out of 32 pathogenic fungi, six oomycetes, seven bacterial pathogens, nine nematodes and three plant viruses, a peak temperature of 64–70 °C and duration of 21 days were sufficient to reduce numbers to below, or very close to, the detection limits of the tests use	Review paper. Temperature–time combinations required for eradication are highly variable and depend on the considered compost material and the pathogen species	Detection limits in most studies were quite poor, with infection levels of up to 5 % likely to be undetected. The potential survival of plant pathogens in cooler zones of compost, particularly in systems where the compost is not turned, has not been quantified
Biological	Organic amendment	Hyder et al., 2009	2	Coir (coconut (*Cocos nucifera*) mesocarp pith)	*Fusarium solani*	*In vitro* experiment (water agar)	Growth of *Fusarium solani* on water agar amended with non-autoclaved coir was completely inhibited	No complete inhibition of other plant pathogens (*Phytophthora capsici*)	No field experiments to confirm the results obtained in *in vitro* experiments
Biological	Antagonist	Cuniffe and Gilligan, 2011	2	No experimental treatment (theoretical study based on modelling)	The study does not consider any specific organism	The study does not consider any specific growing media	Simulated population of contaminated hosts	Results have no practical value but show that specific conditions have to met to ensure a highly effective biological control	
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	*Pythium ultimum*	Laboratory tests; potted cucumber seeds in inoculated compost + dimethyl disulphide	100 % prevention of seedling mortality	Full control in laboratory conditions	
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	*Pythium ultimum*	Laboratory tests; potted cucumber seeds in inoculated compost + dipropyl disulphide	20 % of plants remaining healthy	Very partial control in lab conditions	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	*Pythium ultimum*	Laboratory tests; potted cucumber seeds in inoculated compost + onion by-products (OBP)	Several doses, several length of exposure	Numbers of healthy plants not significantly different from control for some doses/exposures	
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	*Pythium ultimum*	Laboratory tests; potted cucumber seeds in inoculated compost + leek by-products (LBP)	Several doses, several length of exposure	No full control in laboratory condition	
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	Unspecified	Field tests; asparagus + *Allium* by-products vs. untreated or MB controls	Measure of yield: MB > OBP > LBP~untreated	Measure of yields, not of contamination	
Biological	Organic amendment	Arnault et al., 2013	2	Biofumigant effects of onion and leek residues (dimethyl disulphide and dipropyl disulphide)	Unspecified	Field tests; strawberry + *Allium* by-products vs. untreated on high- or low-risks soils	Low-risk: No differences; high risks: OBP > LBP~untreated	Measure of yields, not of contamination	
Biological	Organic amendment	Avilés et al., 2011	2	Different types of composts (material of origin, processing techniques)	Soil (e.g. *Fusarium*, *Pythium*, *Phytophthora*) and aerial (e.g. *Xanthomonas*, *Botrytis*, *Colletotrichum*) pathogens	Review	'Suppression' with different compost types and different organisms	Effectiveness measured as disease 'suppression'	
Biological	Antagonist	Bailey and Lazarovitis , 2003	2	*Trichoderma viride*	*Rhizoctonia solani* in radish	Laboratory tests; 'microcosms', with or without *Trichoderma viride*, planted with radish and inoculated or not with *Rhizoctonia solani*	Efficiency of control dropped from 91.7 % in first crops to 64.8 % in second crops	Parasitic amplification can cause a rapid build-up of disease and inoculum over consecutive crops	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Antagonist/ organic amendment	Siddiqui et al., 2001	2	Soil mixed with powdered stem cake or dried leaves of *Datura fastuosa* at 0.5 and 1 % (w/w). After tissue decomposition *Psuedomanas aeruginosa* and *Bacillus subtilis* were added	*Macrophomina phaseolina*, *Fusarium solani*, *Rhizoctonia solani*	Pot experiment with sandy loam soil	Complete control mentioned for *Macrophomina phaseolina*, no data shown		
Biological	Organic amendment	Abawi and Widmer, 2000	NA						
Biological	Organic amendment	Abdel-Razik et al., 2012	1						
Biological	Antagonist	Abdel-Razik et al., 2012	1						
Biological	Antagonist	Alabouvette et al., 2006	1						
Biological	Antagonist	Alvarez et al., 2013	1						
Biological	Organic amendment	Aly et al., 2003	1						
Biological	Antagonist	Bagwan, 2010	NA						
Biological	Organic amendment	Bailey and Lazarovits, 2003	NA						
Biological	Antagonist	Bisutti et al., 2010 in German	NA						
Biological	Antagonist	Bokhari et al., 2008	1						
Biological	Organic amendment	Bonneau et al., 2007	NA						
Biological		Gamliel, 2000	NA						
Biological	Organic amendment	Gamliel et al., 2000a	1						
Biological	Organic amendment	Giotis et al., 2009	1						
Biological	Antagonist	Giotis et al., 2009	0						
Biological	Organic amendment	Goswami et al., 2007	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Organic amendment	Gullino et al., 2011	NA						
Biological	Organic amendment	Klein et al., 2007	1						
Biological	Organic amendment	Klein et al., 2011	1						
Biological	Antagonist	Koberl et al., 2011	NA						
Biological	Antagonist	Koch, 1999	1						
Biological	Antagonist	Kowalchuk et al., 2003	NA						
Biological	Organic amendment	Labrada, 2007	1						
Biological	Antagonist	Labrada, 2007	1						
Biological	Antagonist	Larkin et al. 2007	1						
Biological	Organic amendment	Larkin et al., 2011	NA						
Biological	Organic amendment	Lazarovits, 2001	NA						
Biological	Organic amendment	Noble and Coventry, 2005	1						
Biological	Antagonist	Scala et al., 2011	NA						
Biological	Antagonist	Segarra et al., 2013	1						
Biological		Shen et al., 2013	1						
Biological	Antagonist	Shenoi and Sreenivas, 2007	NA						
Biological	Antagonist	Slusarski and Pietr, 2009	1						
Biological	Antagonist	Spadaro and Gullino, 2005	NA						
Biological	Composting	St Martin and Brathwaite, 2012	1						
Biological	Antagonist	Stevens et al., 2003	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Antagonist	Stiling and Cornelissen, 2005	1						
Biological	Antagonist	Sturz et al., 2004	NA						
Biological	Antagonist	Thuranira et al., 2011	1						
Biological	Antagonist	Tuao gava and Leal Menezes, 2012	1						
Biological	Organic amendment	Valenzuela et al., 2005	NA						
Biological	Antagonist	van Bruggen and Semenov, 2000	NA						
Biological	Antagonist	van Bruggen et al., 2004	NA						
Biological	Antagonist	van Bruggen et al., 2006	NA						
Biological	Organic amendment	Villegas-Pangga, 2010	NA						
Biological	Antagonist	Walgenbach et al., 2010	NA						
Biological	Organic amendment	Wang et al., 2009	1						
Biological	Organic amendment	Watanabe et al., 2011	1						
Biological	Antagonist	Williams et al., 2013	1						
Biological		Abbasi and Lazarovits, 2007	1						
Biological	Antagonist	Alabouvette et al., 2009	0						
Biological	Organic amendment	Anonymous, 2004	0						
Biological	Organic amendment	Baysal-Tustas et al., 2006	1						
Biological		Boer et al., 2006	1	*Pseudomonas fluorescens* SS101					

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Antagonist	Brewer and Larkin, 2003	1	*Laetisaria arvalis, Trichoderma virens, Bacillus subtilis*					
Biological	Antagonist	Iriarte et al., 2012	1						
Biological	Antagonist	Jackson et al., 2000	0						
Biological	Antagonist	Jackson, 2009	0						
Biological	Antagonist	Janvier et al., 2007	0						
Biological	Grafting	King et al., 2008	0						
Biological	Antagonist	Labanowska and Olszak, 2003	1						
Biological	Antagonist	Labrada, 2008	0						
Biological	Antagonist	Williams et al., 2013	1						
Biological	Organic amendment	Watanabe et al., 2011	1						
Biological	Organic amendment	Wang et al., 2009	1						
Biological	Antagonist	Walgenbach et al., 2010	NA						
Biological	Organic amendment	Villegas-Pangga, 2010	NA						
Biological	Antagonist	van Bruggen et al., 2006	NA						
Biological	Antagonist	van Bruggen et al., 2004	NA						
Biological	Antagonist	van Bruggen and Semenov 2006	NA						
Biological	Organic amendment	Valenzuela et al., 2005	NA						
Biological	Antagonist	Tuao Gava and Leal Menezes, 2012	1						
Biological	Antagonist	Thuranira et al., 2011	1						
Biological	Antagonist	Sturz et al., 2004	NA						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Antagonist	Stiling and Cornelissen, 2005	1						
Biological	Antagonist	Stevens et al., 2003	1						
Biological	Antagonist	Slusarski and Pietr, 2009	1						
Biological	Antagonist	Shenoi and Sreenivas, 2007	NA						
Biological		Shen et al., 2013	1						
Biological	Antagonist	Segarra et al., 2013	1						
Biological	Antagonist	Scala et al., 2011	NA						
Biological	Antagonist	Alabouvette et al., 2009	NA						
Biological	Organic amendment	Anonymous, 2004	NA						
Biological	Antagonist	Haas and Defago, 2005	NA						
Biological	Antagonist	Hanitzsch et al., 2012	NA						
Biological	Antagonist	Hanitzsch et al., 2013	NA						
Biological	Antagonist	Hauschild et al., 2000	NA						
Biological	Antagonist	Hazir et al., 2003	NA						
Biological	Antagonist	Hermanto et al., 2013	1						
Biological	Antagonist	Vukomanovic, 2005	NA						
Biological	Antagonist	Baysal et al., 2013	NA						
Biological	Antagonist	Labanowska and Olszak, 2003	1						
Biological	Antagonist	Labrada, 2008	0						
Biological	Organic amendment	Candole and Evans, 2004	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Organic amendment	Fukui, 2002 Japanese	1						
Biological	Antagonist	Jackson et al., 2000	1						
Biological	Organic amendment	Sharma and Sharma, 2005	1						
Biological	Organic amendment	Warnock and Baumgartner, 2004	1						
Biological	Antagonist	Yuan et al., 2011	NA						
Biological	Organic amendment	Oka, 2010	1						
Biological	Antagonist	Oka, 2010	1						
Biological	Organic amendment	Peters et al., 2004	1						
Biological	Antagonist	Porras et al., 2007	1						
Biological	Antagonist	Xu et al., 2007	1						
Biological	Antagonist/Organic amendment	Hooks et al., 2010	1						
Biological	Antagonist	Hoagland et al., 2012	1						
Biological	Antagonist	Hiltpold and Turlings, 2012	1						
Biological	Antagonist	Highland, 2010a	1						
Biological	Antagonist	Highland, 2010b	1						
Biological	Organic amendment	Khabbaz and Abbasi, 2013	1						
Biological	Antagonist	Khabbaz and. Abbasi, 2013	1						
Biological	Organic amendment	Koberl et al., 2011	1						
Biological	Antagonist	Koberl et al., 2011	1						
Biological	Organic amendment	Kowalchuk et al., 2003	1						
Biological	Antagonist	Kowalchuk et al., 2003	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological	Organic amendment	Krebs, 2000	NA						
Biological	Antagonist	Krebs, 2000	NA						
Biological	Organic amendment	Kritzman and Gamliel, 2001	1						
Biological	Antagonist	Kritzman and Gamliel, 2001	1						
Biological	Organic amendment	Gilardi et al., 2012	2	*Brassica juncea* + grafting + mulching	*Verticillium dahliae*	Soil (unspecified)	100 % efficacy in one combination out of several	Not original data, lack of details	
Biological	Organic amendment	Abbasi and Lazarovits, 2007	NA						
Biological	Organic amendment	Aldebis et al., 2010	NA						
Biological	Antagonist	Boer et al., 2006	1						
Biological	Antagonist	Brewer and Larkin, 2003	NA						
Biological	Antagonist	Carretero et al., 2013	NA						
Biological	Organic amendment	Cattivello et al., 2007	NA						
Biological	Antagonist	Azcon-Aguilar et al., 2002	NA						
Biological	Antagonist	Bhatia et al., 2005	NA						
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	Propionic acid 5 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Growth reduction (%) of pathogenic and antagonistic fungi in response to imbibed *Vicia faba* seeds. Greenhouse and field experiments failed to produce the *in vitro* effects	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	Propionic acid 5 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Growth reduction (%) of pathogenic and antagonistic fungi in response to imbibed *Vicia faba* seeds. Greenhouse and field experiments failed to produce the *in vitro* effects	
Biological/chem ical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	Acetic acid 1 % (1 ml/100 g seeds)	*Fusarium solani*	Potato dextrose agar	100 % effective	Soaked seeds of *Vicia faba*. Greenhouse and field experiments failed to produce the *in vitro* effects	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	Propionic acid 1 % (1 ml/100 g seeds)	*Fusarium solani*	Potato dextrose agar	100 % effective	Soaked seeds of *Vicia faba*. Greenhouse and field experiments failed to produce the *in vitro* effects	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + furfura l 3 ml/l	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + furfura l 3 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + furfural 3 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + acetic acid 3 ml/l	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of acetic acid	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + acetic acid 3 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of acetic acid	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + acetic acid 3 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of acetic acid	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + propio nic acid 3 ml/l	Rhizoctonia solani	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of propionic acid	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + propio nic acid 3 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of propionic acid	
Biological/ chemical	Antagonist/ pesticide	El-Mougy and Abdel-Kader, 2009	2	*Trichoderma harzianum* + propio nic acid 3 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Combination treatment; antagonistic capacity. Greenhouse and field experiments failed to produce the *in vitro* effects. Effect at lower concentration of propionic acid	
Biological/ chemical	Antagonist/ fumigation	Slusarski and Pietr, 2009	1						
Biological/ chemical	Antagonist/ fumigation	Slusarski and Pietr, 2009	1						
Biological/heat	Organic amendment/ solarisation	Klein et al., 2011	2	Solarisation (60 days) + thyme or sage	*Fusarium oxysporum* f. sp. *radicis-lycopersici*, *Meloidogyne javanica*	Soil, irrigated (Jordan valley)	No colony-forming unit (CFU) and zero severity (root-knot nematode galling)	Two soil depths were checked (20 and 40 cm)	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Biological/heat	Organic amendment/ solarisation	Klein et al., 2011	2	Solarisation (55 days) + wild rocket	*Meloidogyne javanica*	Soil in experimental farm (76 % sand, 17 % silt, 7 % clay, 0.2 % organic matter, pH 7.8)	Zero severity (root-knot nematode galling)	Two soil depths were checked (20 and 40 cm)	
Biological/heat	Antagonist/ solarisation	Stevens et al., 2003	2	Plots were irrigated to field capacity for five days using drip irrigation tubing. Thermofilm infrared low density polyethylene row cover film applied for different time periods + *Trichoderma virens* applied at 0.1 to 1 g per transplant in 1991 and 1 g per transplant	*Sclerotium rolfsii*	Field experiment with sandy loam soil	100 % mortality of sclerotia buried in soil	100 % efficacy at 0–10 cm depth only after 17, 48 and 75 days of solarisation; lower effect on disease incidence on tomato	
Biological/heat	Organic amendment/ solarisation	Gamliel et al., 2000a	1						
Biological/heat	Organic amendment/ solarisation	Klein et al., 2007	1						
Biological/heat	Antagonist/ solarisation	Yucel et al., 2000	1						
Biological/heat	Antagonist/ solarisation	Yucel et al., 2000	1						
Chemical treatment	Pesticide	di Primo et al., 2003	2	Metam sodium 60 µg/g soil	*Verticillium dahliae*, sclerotia in potato stem	Field soil in fumigation chamber	100 % effective	Sandy soil (Xeric Torripsamment)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	di Primo et al., 2003	2	Metam sodium 60 µg/g soil	*Fusarium oxysporum f.* sp. *radicis-lycopersici*, Clamydospores sclerotia	Field soil in fumigation chamber	100 % effective	Sandy soil (Xeric Torripsamment)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years
Chemical treatment	Pesticide	di Primo et al., 2003	2	Metam sodium 60 µg/g soil	*Verticillium dahliae*, sclerotia in potato stem	Field soil in fumigation chamber	100 % effective	Clay loam (Xerollic Paleorthid)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years
Chemical treatment	Pesticide	di Primo et al., 2003	2	Metam sodium 60 µg/g soil	*Fusarium oxysporum* f. sp. *radicis-lycopersici*, *Clamydospores sclerotia*	Field soil in fumigation chamber	100 % effective	Clay loam (Xerollic Paleorthid)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	di Primo et al., 2003	2	Dazomet 30 µg/g soil	*Verticillium dahliae*, sclerotia in potato stem	Field soil in fumigation chamber	100 % effective	Clay loam (Xerollic Paleorthid)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years
Chemical treatment	Pesticide	di Primo et al., 2003	2	Dazomet 30 µg/g soil	*Verticillium dahliae*, sclerotia in potato stem	Field soil in fumigation chamber	100 % effective	Sandy loam (Xeric Torriorthent)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years
Chemical treatment	Pesticide	di Primo et al., 2003	2	Dazomet 30 µg/g soil	*Verticillium dahliae*, sclerotia in potato stem	Field soil in fumigation chamber	100 % effective	Clay	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	di Primo et al., 2003	2	Dazomet 30 µg/g soil	*Fusarium oxysporum* f. sp. *radicis-lycopersici, Clamydospores sclerotia*	Field soil in fumigation chamber	100 % effective	Sandy loam (Xeric Torriorthent)	Soil inoculated, watered, not treated previously. In this paper effectiveness was lower in some soil types and if the soil had been treated previous years
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Furfural 3 ml/l	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Furfural 3 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Furfural 3 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Acetic acid 5 ml/l	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Acetic acid 5 ml/l	*Fusarium solani*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Acetic acid 5 ml/l	*Sclerotium rolfsii*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	
Chemical treatment	Pesticide	El-Mougy and Abdel-Kader, 2009	2	Propionic acid 5 ml/l	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Greenhouse and field experiments failed to produce the *in vitro* effects	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	El-Mougy et al., 2012	2	Furfural 5 000 and 6 000 ppm	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Rizolex-T (Tolclofos-methyl + tiram WP 50 %) 200 ppm	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Rizolex-T (Tolclofos-methyl + tiram WP 50%) 200 ppm	*Macrophomina phaseolina*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Rizolex-T (Tolclofos-methyl + tiram WP 50%) 400 ppm	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Rizolex-T (Tolclofos-methyl + tiram WP 50%) 400 ppm	*Fusarium solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Rizolex-T (Tolclofos-methyl + tiram WP 50%) 400 ppm	*Macrophomina phaseolina*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5%) 200 ppm	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5%) 400 ppm	*Rhizoctonia solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5%) 400 ppm	*Fusarium solani*	Potato dextrose agar	100 % effective	Field experiments with furfural at 6 000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 400 ppm	*Macrophomina phaseolina*	Potato dextrose agar	100 % effective	Field experiments with Furfural at 6000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Mancerin (Pencycuron 25 %) 400 ppm	*Fusarium solani*	Potato dextrose agar	100 % effective	Field experiments with Furfural at 6000 ppm resulted in 85 % reduction of black scurf in potato	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Fusarium solani*	Pot experiment greenhouse	100 % effective	Pre-emergence + post -emergence damping-off, 100 % plant survival at 30 days and 0 % root rot at 45 days	
Chemical treatment	Pesticide	El-Sayed et al., 2009	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Macrophomina phaseolina*	Pot experiment greenhouse	100 % effective	Pre-emergence damping-off root rot severity 45 days	
Chemical treatment	Pesticide	Stevens et al., 2003	2	Plots treated with PCNB (pentachloronitrobe nzene) at 1.65 g/l at a volume of 0.25 l per transplant	*Sclerotium rolfsii*	Field experiment with sandy loam soil	100 % mortality of sclerotia buried in soil	100 % efficacy on sclerotia and disease incidence on tomato (in one out of two years)	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Fumigation	Triky-Dotan et al., 2009	2	Metam sodium at 60 µl/g of soil	*Fusarium oxysporum* f. sp. *radicis-lycopersici*	Field experiment with sandy loam and loam soils	100 % mortality not different from 96 % (but also from 0 %); lower effect on disease incidence	No effect on Pythium and Verticillium wilt	
Chemical treatment		Uematsu et al., 2007	2	Ethyl alcohol at different rates added to 10 kg soil in plastic bags	*Meloidogyne incognita*	Soil (unspecified)	No recovery of the pest at highest rates		
Chemical treatment		Uematsu et al., 2007	2	Ethyl alcohol at different rates added to 2 kg soil in plastic bags	*Fusarium oxysporum* f. sp. *cucumerinum*	Soil (unspecified)	No recovery of the pest at highest rates		
Chemical treatment		Uematsu et al., 2007	2	Ethyl alcohol at different rates added to 2 kg soil in plastic bags	*Ralstonia solanacearum*	Granular pearlite	No recovery of the pest at highest rates		
Chemical treatment		Uematsu et al., 2007	2	Ethyl alcohol at different rates added to natural soil	*Meloidogyne incognita* + *Fusarium oxysporum* f. sp. *spinaciae*	Soil (unspecified)	100 % efficacy in reducing root-knot severity when applied at highest rate		
Chemical treatment	Pesticide	Cannelongo, 2001	2	Terbufos (various formulations) added to 1 l of soil which had been placed into 4 ml polyethylene bags	*Diabrotica undecimpunctata howardi*	Silt loam soil	100 % mortality of third instars in some treatments	Patent of safened extrudable pesticidal resin composition, extruded pesticidal resin compositions and pelletised pesticidal resin comprising active ingredients	
Chemical treatment	Pesticide	Muzela, 2008	1						
Chemical treatment	Fumigation	Qiao et al., 2012	1						
Chemical treatment	Fumigation	Slusarski and Pietr, 2009	1						
Chemical treatment	Pesticide	Templeton et al., 2008	NA						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Pesticide	Van Timmeren et al., 2012	NA						
Chemical treatment	Fumigation	Walker and Uchanski, 2010	1						
Chemical treatment	Fumigation	Walker and Uchanski, 2010	1						
Chemical treatment	Pesticide	Van Timmeren et al., 2012	NA						
Chemical treatment	Pesticide	Templeton et al., 2008	NA						
Chemical treatment	Fumigation	Slusarski and Pietr, 2009	1						
Chemical treatment	Fumigation	Browne et al., 2008	NA						
Chemical treatment	Fumigation	Hamill and Dickson, 2005	1						
Chemical treatment	Fumigation	Hamill and Dickson, 2005	1						
Chemical treatment	Pesticide	Herman and Scherer, 2003	NA						
Chemical treatment	Pesticide	Herman and Scherer, 2006	NA						
Chemical treatment	Pesticide	Tenu et al., 2013	NA						
Chemical treatment	Pesticide	Triolo and Luvisi, 2006	NA						
Chemical treatment	Pesticide	Labanowska and Olszak, 2003	1						
Chemical treatment		Labrada, 2008	0						
Chemical treatment	Pesticide	Vukomanovic, 2005	NA						
Chemical treatment	Fumigation	Hutchinson et al., 2000	1						
Chemical treatment	Fumigation	Highland, 2010a	1						
Chemical treatment	Fumigation	Highland, 2010b	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Fumigation	Kowalchuk et al., 2003	1						
Chemical treatment	Fumigation	Gilreath et al., 2004	2	Methyl bromide + chloropic rin	*Fusarium oxysporum*, root nematodes (*Meloidogyne incognita*, *Belonolaimus* spp., *Tylenchorhynchus* spp.)	Soil (tomato field soil, Alfic Haplaquods, sandy, siliceous, hyperthermic 1 % of organic matter, pH = 7.3)	Zero disease severity (galling index)	No full control of *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis and Shoemake	
Chemical treatment	Fumigation	Gilreath et al., 2004	2	Dazomet	*Fusarium oxysporum*, root nematodes (*Meloidogyne incognita*, *Belonolaimus* spp., *Tylenchorhynchus* spp.)	Soil (tomato field soil, Alfic Haplaquods, sandy, siliceous, hyperthermic 1 % of organic matter, pH = 7.3)	Zero disease severity (galling index)	No full control of *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis and Shoemake	
Chemical treatment	Fumigation	Gilreath et al., 2004	2	1,3-dichloropropene + c hloropicrine + pebul ate	*Fusarium oxysporum*, root nematodes (*Meloidogyne incognita*, *Belonolaimus* spp., *Tylenchorhynchus* spp.)	Soil (tomato field soil, Alfic Haplaquods, sandy, siliceous, hyperthermic 1 % of organic matter, pH = 7.3)	Zero disease severity (galling index)	No full control of *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis and Shoemake	
Chemical treatment	Fumigation	Gilreath et al., 2004	2	Fosthiazate + meta m sodium + pebulate	*Fusarium oxysporum*, root nematodes (*Meloidogyne incognita*, *Belonolaimus* spp., *Tylenchorhynchus* spp.)	Soil (tomato field soil, Alfic Haplaquods, sandy, siliceous, hyperthermic 1 % of organic matter, pH = 7.3)	Zero disease severity (galling index)	No full control of *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis and Shoemake	
Chemical treatment	Fumigation	Hanson et al., 2010	2	Fumigation (methyl bromide:chloropicrin) + plastic film cover	Several weed species, *Pythium*, *Fusarium oxysporum*, *Verticillium dahliae*, *Tylenchulus semipenetrans* Cobb	Soil in perennial crop nurseries (California)	Zero weed seed viability and zero *Pythium* propagules in some treatments	No full control for some weed species. Effectiveness depends on the fumigant dose	Results not clearly reported for all pathogens

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical treatment	Fumigation	Browne et al., 2006	2	Methyl bromide, chloropicrin (CP), 1,3-dichloropropene (1,3-D), 1,3-D + CP, iodomethane, and iodomethane + CP all prevented severe symptoms	'Almond replant disease' (a combination of various agents)	Field tests (orchards and microplots)	The replants in non-fumigated soil developed severe symptoms (stunting, wilting, chlorosis, defoliation) by the following summer, while those in most fumigated treatments remained healthy	Effectiveness measured as disease 'suppression', but no direct measurement of pathogens in soil	
Chemical treatment	Fumigation	Browning et al., 2006	2	Butyric acid	Fungal and nematode endoparasites of strawberries: *Verticillium dahliae*, *Rhizoctonia fragariae*, *Rhizoctonia solani*, *Phytophthora fragariae*, *Pythium* sp., *Meloidogyne hapla*, *Meloidogyne incognita*, *Pratylenchus penetrans*	Laboratory tests: exposure to butyric acid vapours; incubation in butyric acid-treated sand; rinsing in diluted butyric acid	*Verticillium dahliae*, *Rhizoctonia fragariae*, *Rhizoctonia solani*, *Phytophthora fragariae* and a *Pythium* sp. killed after a two-day incubation in butryic acid-treated sand (0.88 and 8.8 mg/g). No fungal growth occurred in the presence of vapours from 0.1 and 1 M butyric acid solutions. Gall formation on tomato roots by *Meloidogyne hapla*, and *Meloidogyne incognita* was reduced by 73–100 % relative to controls when egg masses were incubated in butyric acid solution (0.1, 1 M) or treated sand (0.88 and 8.8 mg/g). Drenching	Very artificial laboratory tests, quite far from field conditions	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
							strawberry plants infested with *Pratylenchus penetrans* with butyric acid (0.1 and 1 M) reduced nematode densities by 98–100 %		
Chemical treatment	Pesticide	Cannelongo, 2001	2	Pelletised pesticidal resin compositions comprising diverse possible active ingredient, e.g. 0.0-diethy1 S-[[1,1 dimethylethyl)thio]-methyl]phosphorodithioate, 0.0 diethyl S-(ethylthiomethyl)phosphorodithioate	*Diabrotica undecimpunctata howardi*	25 ml of treated soil into 30 ml wide-mouth screw top glass jars	100 % effectiveness	Very small scale (25 ml of treated soil)	
Chemical treatment	Fumigation	Benlioglu et al., 2004	1						
Chemical treatment	Pesticide	Brooker, 2010	1						
Chemical treatment	Fumigation	Chen et al., 2012	NA						
Chemical treatment	Fumigation	Gamliel et al., 2000b	1						
Chemical/heat	Fumigation/ solarisation	Stevens et al., 2003	2	Plots were irrigated to field capacity for 5 days using drip irrigation tubing. Thermofilm IR low density polyethylene (LDPE) row cover film applied for different time periods + PCNB fungicide at 5 g/l at a volume of 0.25 l per transplant	*Sclerotium rolfsii*	Field experiment with sandy loam soil	100 % mortality of sclerotia buried in soil	100 % efficacy at 0–10 cm depth only after 17, 48 and 75 days of solarisation; 100 % efficacy also on disease incidence on tomato	
Chemical/heat	Fumigation/solarisation	Gamliel et al., 2000b	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Chemical/heat	Pesticides/solarisation	Ananos Bedrinana et al., 2009	1						
Chemical/heat	Fumigation/solarisation	Ananos-Bedrinana et al., 2009	1	Metam potassium, metam sodium, chloropicrin/1,3 dichloropricin					
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica*	Soil depth 20 cm	100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica*	Soil depth 40 cm	Less than 100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica* + *Diplotaxis tenuifolia* (wild rocket)	Soil depth 20 cm	100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica* + *Diplotaxis tenuifolia* (wild rocket)	Soil depth 40 cm	Less than 100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica* + *Thymus vulgaris* (thyme)	Soil depth 20 cm	100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Klein et al., 2007	2	Vitavax-T (Carboxin 19.5 % + tiram 19.5 %) 4 g/kg seeds	*Meloidogyne javanica* + *Thymus vulgaris* (thyme)	Soil depth 40 cm	100 % effective	Root galling on tomato in pots after 30 days	
Heat treatment	Solarisation	Stevens et al., 2003	2	Plots were irrigated to field capacity for 5 days using drip irrigation tubing. Thermofilm IR low density polyethylene (LDPE) row cover film applied for different time periods	*Sclerotium rolfsii*	Field experiment with sandy loam soil	100 % mortality of sclerotia buried in soil	100 % efficacy at 0–10 cm depth only after 17, 48 and 75 days of solarisation; lower effect on disease incidence	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Heat treatment	Heat treatment	Asjes and Blom-Barnhoorn, 2002	2	Regimes were applied in storage cells in which temperatures were maintained at the same level from July till October	Tobacco necrosis virus	Virus/fungus-infested field soil, soil in wooden trays in which tulip bulbs were planted to produce cut flowers under greenhouse conditions in winter, was used as well as residual soil, soil debris, small bulbs, roots and tunics obtained by cleaning tulip bulbs after harvest	No disease after 3- to 9-week treatment at 53 °C, after 8- to 13-week treatment at 40 °C, after 2- to 13-week treatment at 50 °C. Composting recommended to make temperature uniform in the mass	Spread by the soil-borne fungus *Olpidium brassicae*; spread of the disease complex to other fields may be caused by the distribution of residual waste	
Heat treatment	Microwaves	Ferris, 1984	2	Treatment of 1 kg soil at 7–37 % water content in plastic bags exposed to full power microwave oven	*Pythium*, *Fusarium*, nematodes	Silt and loam sand soils	100 % efficacy in reducing fungal population as CFUs in plates	Effectiveness increased with increasing time, decreased with increasing amount of soil and increasing soil water content. Lower effect on *Heterodera glycines*, *Rhizoctonia*	
Heat treatment	Solarisation	Abd-El-Kareem et al., 2004	1						
Heat treatment	Solarisation	Almasoum, 2006	NA						
Heat treatment	Solarisation	Arora and Jyotsana, 2007	1						
Heat treatment	Solarisation	Ashrafi et al., 2010	1						
Heat treatment	Solarisation	Benlioglu et al., 2004	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Heat treatment	Solarisation	Benlioglu et al., 2005	1						
Heat treatment	Solarisation	Butler et al., 2012	1						
Heat treatment	Solarisation	Farrag and Fotouh, 2010	1						
Heat treatment	Solarisation	Gamliel et al., 2000c	1						
Heat treatment	Solarisation	Gamliel et al., 2000b	1						
Heat treatment	Composting	Raviv, 2009	1						
Heat treatment	Solarisation	Saremi et al., 2010	1						
Heat treatment	Solarisation	Satish, 2010	NA						
Heat treatment	Pasteurisation	Watanabe et al., 2002	1						
Heat treatment	Solarisation	Candido et al., 2008	1						
Heat treatment	Solarisation	Ioannou, 2001	1						
Heat treatment	Solarisation	Ioannou, 2001	1						
Heat treatment	Solarisation	Ioannou and Ioannou, 2002	1						
Heat treatment	Pasteurisation	Watanabe et al., 2002	1						
Heat treatment	Composting	St Martin and Brathwaite, 2012	1						
Heat treatment	Solarisation	Satish, 2010	NA						
Heat treatment	Solarisation	Saremi et al., 2010	1						
Heat treatment	Composting	Raviv, 2009	1						
Heat treatment	Solarisation	Farrag and Fotouh, 2010	1						
Heat treatment	Solarisation	Candido et al., 2008	1						
Heat treatment	Solarisation	Hagan and Gazaway, 1992	NA						
Heat treatment	Steaming	Triolo et al., 2004	1						

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Heat treatment	Solarisation	Chaube and Dhananjay, 2003	1						
Heat treatment	Solarisation	Janvier et al., 2007	1						
Heat treatment	Solarisation	Yates et al., 2007	1						
Heat treatment	Solarisation	Porras et al., 2006	1						
Heat treatment	Steaming	Lu et al., 2010	2	Steaming (sheet, pan, injection steaming)	*Fusarium oxysporum* (f. sp. *basilici*)	Sandy-loam soil (box of 15 × 15 × 12cm)	Zero CFU in some of the samples collected in the box	Effectiveness level depends on the position in the treated box of soil (lower effectiveness deeper in the box)	Effectiveness depends on organisms, steaming method and position in the box
Heat treatment	Steaming	Lu et al., 2010	2	Steaming (sheet, pan, injection steaming)	*Fusarium oxysporum* (f sp. *basilici*, f. sp. *raphani*, f. sp. *conglutinans*), *Rhizoctonia solani, Phytophthora capsici*	Sandy soil (box of 44 × 44 × 36 cm)	Zero CFU in some of the samples collected in the box	Effectiveness level depends on the position in the treated box of soil (lower effectiveness deeper in the box)	Effectiveness depends on organisms, steaming method and position in the box
Heat treatment	Composting	Asjes and Blom-Barnhoorn, 2002	2	Composting at different temperature regimes (20, 30 and 53 °C)	Tobacco necrosis virus in tulip	Infected soils from previous cultures, in heated storage cells	100 % effectiveness at 53°C for three to nine weeks	Effectiveness measured by planting a very susceptible tulip cultivar (cv. Angelique)	
Heat treatment	Composting	Asjes and Blom-Barnhoorn, 2002	2	Composting different types of soil in compost heap (> 50 °C)	Tobacco necrosis virus in tulip	Infected soils from previous cultures, in compost heaps	100 % effectiveness after 50 days	Effectiveness measured by planting a very susceptible tulip cultivar (cv. Angelique)	
Heat treatment	Composting	Asjes and Blom-Barnhoorn, 2002	2	Composting different types of soil in compost heap (> 50 °C)	Tobacco necrosis virus in tulip	Infected soils from previous cultures, in heated storage cells	100 % effectiveness with 40 °C-temperature treatment during 8–10 weeks	Effectiveness measured by planting a very susceptible tulip cultivar (cv. Angelique)	

RRO name	RRO subcategory	Reference	Effectiveness rating	Specific treatment	Harmful organism	SGM	Effectiveness measure	Comment	Uncertainty
Heat treatment	Solarisation	Candido et al., 2008	2	Effect of a single solarisation treatment	Root-knot nematode *Meloidogyne javanica* and many annual and perennial weed species	Low-density polyethylene greenhouse tests, with soils heavily colonised by *Meloidogyne javanica*. 16 plots (6 × 4 m). Melon and tomatoes cultivated after treatment	Strong reduction of the proportion of nematode-infested plants: 99 % of infested plants and 98 % of the root gall index in the following melon crop. In addition, suppressed annual weed emergence three years later	The scale of the experiment (6 × 4 m plots) is mid-way between laboratory trials and field tests	
Heat treatment	Solarisation	Candido et al., 2008	2	Effect of two or three solarisation cycles	Root-knot nematode *Meloidogyne javanica* and many annual and perennial weed species	Low-density polyethylene greenhouse tests, with soils heavily colonised by *Meloidogyne javanica*. 16 plots (6 × 4 m). Mellon and tomatoes cultivated after treatment	Two- or three-year treatment: Almost complete suppression of the infestation of the *Meloidogyne javanica* nematode in tomato, and reduction of the nematode effect in melon by 86 % and 79%, respectively. Repeated solarisation treatments also resulted in a high reduction of emergence of most weed species in all crop cycles	The scale of the experiment (6 × 4 m plots) is mid-way between laboratory trials and field tests	
Heat treatment	Solarisation	Gamliel et al., 2000c	1						
Heat treatment	Solarisation	Katan, 2000	NA						
Heat treatment	Solarisation	Klein et al., 2007	1						
Heat treatment	Solarisation	Klein et al., 2011	1						
Heat treatment	Solarisation	Satour, 2000	1						
Mechanical	Flooding	Kowalchuk et al., 2003	1						

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