Draft ISPM: International movement of seeds (2009-003)

Status box	
This is not an official part of the standard and it will be modified by the IPPC Secretariat after adoption.	
Date of this document	2016-12-01
Document category	Draft ISPM
Current document stage	*From* SC 2016-11 *to* CPM-12
Major stages	2009-11 SC introduced topic *International movement of seed* (2009-003) 2010-03 CPM-5 added topic 2010-12 SC approved draft specification for member consultation via e-decision 2011-02 Draft specification sent to member consultation 2011-05 SC revised and approved specification 54 2013-07 EWG drafted ISPM 2013-10 EWG participants reviewed draft ISPM 2013-12 Steward reviewed draft ISPM 2014-04 Steward consulted EWG and revised draft ISPM based on TPG comments on consistency (modifications in track changes) 2014-05 SC approved draft ISPM for member consultation 2014-07 Member consultation 2015-02 Steward reviewed member comments and revised draft 2015-05 SC-7 reviewed draft (not recommended for 2015 second consultation) 2016-01 Assistant Steward and Steward reviewed comments of members and SC and revised draft 2016-05 SC-7 revised draft and approved for second consultation period 2016-06 TPFQ reviewed and suggested changes to cover the issue of forest tree seeds; Steward and SC-7 slightly adjusted proposed text 2016-07 Second consultation 2016-11 SC November meeting approved to send to CPM-12
Steward history	2008-11 SC Mr Arundel SAKALA (ZM, Lead Steward) 2010-04 SC Mr David PORRITT (AU, Lead Steward) 2011-05 SC Mr Marcel BAKAK (CM, Assistant Steward) 2012-04 SC Ms Soledad CASTRO-DOROCHESSI (CL, Lead Steward) 2012-04 SC Mr David PORRITT (AU, Assistant Steward) 2012-11 SC Ms Julie ALIAGA (US, Assistant Steward) 2012-11 SC Mr Motoi SAKAMURA (JP, Assistant Steward) 2013-11 SC Ms Julie ALIAGA (US, Lead Steward) 2013-11 SC Ms Soledad CASTRO-DOROCHESSI (CL, Assistant Steward) 2014-11 SC Mr Ezequiel FERRO (AR, Assistant Steward) 2015-05 SC Mr Nico HORN (NL, Steward)
Notes	2011-11 SC added new tasks regarding implementation issues 2011-12 Secretariat applied consistency changes in line with the decision made by SC May 2009 2012-11 SC replaced task regarding implementation issues 2013-12 Edited 2014-05 Edited 2016-06 Edited

Adoption

[Insert text]

INTRODUCTION

Scope

[1] This standard provides guidance to assist national plant protection organizations (NPPOs) in identifying, assessing and managing the pest risk associated with the international movement of seeds (as a commodity class).

[2] The standard also provides guidance on procedures to establish phytosanitary import requirements to facilitate the international movement of seeds; on inspection, sampling and testing of seeds; and on the phytosanitary certification of seeds for export and re-export.

[3] Under ISPM 5 (*Glossary of phytosanitary terms*) seeds (as a commodity class) are intended for planting and not for consumption. Viable seeds, which are a sample of a seed lot, imported for laboratory testing or destructive analysis are also addressed by this standard.

[4] This standard does not apply to grain or vegetative plant parts (e.g. tubers of potatoes).

References

[5] The present standard refers to International Standards for Phytosanitary Measures (ISPMs). ISPMs are available on the International Phytosanitary Portal (IPP) at https://www.ippc.int/core-activities/standards-setting/ispms.

Definitions

[6] Definitions of phytosanitary terms used in this standard can be found in ISPM 5.

[7] In addition to the definitions in ISPM 5, in this standard the following definitions apply.

Seed-borne pest	A pest carried by seeds externally or internally that may or may not be transmitted to plants growing from these seeds and cause their infestation
Seed-transmitted pest	A seed-borne pest that is transmitted via seeds directly to plants growing from these seeds and causes their infestation

Outline of Requirements

[8] Seeds, as with other plants for planting, may present a pest risk because they may be introduced to an environment where pests associated with the seeds have a high probability of establishing and spreading.

[9] Seeds are regularly moved internationally for commercial and research purposes. Therefore, when assessing the pest risk and determining appropriate phytosanitary measures, NPPOs should consider the intended use of the seeds (research, planting under restricted conditions or planting under natural conditions).

[10] A pest risk analysis (PRA) should determine if the seeds are a pathway for the entry, establishment and spread of quarantine pests and their potential economic consequences in the PRA area, or if the seeds are a pest themselves or a pathway and the main source of infestation of regulated non-quarantine pests. The PRA should consider the purpose for which the seeds are imported (e.g. field planting, research, testing) and the potential for quarantine pests to be introduced and spread or for regulated non-quarantine pests to cause an economically unacceptable impact when present above a threshold.

[11] Specific phytosanitary measures may be used to reduce the pest risk associated with the international movement of seeds, including phytosanitary measures that may be applied before planting, during growth, at seed harvest, post-harvest, during seed processing, storage and transportation, and on arrival in the importing country. Phytosanitary measures may be used either alone or in combination to manage the pest risk. Phytosanitary import requirements may be met by applying equivalent phytosanitary measures.

BACKGROUND

[12] Seeds are moved internationally for many uses. They are planted for the production of food, forage, ornamental plants, biofuels and fibre as well as for forestry and for pharmacological uses. They also have pre-commercial uses (research, breeding and seed multiplication).

[13] As with other plants for planting, seeds may present a pest risk when introduced to an environment where any pests associated with the seeds have a high probability of establishing and spreading (ISPM 32 (*Categorization of commodities according to their pest risk*)).

[14] Seed companies may have breeding and multiplication programmes in several countries, and may distribute seeds from these countries to many other countries. Moreover, research and breeding are conducted internationally to develop new varieties that are adapted to a range of environments and conditions. The international movement of seeds may involve small or large quantities of seeds.

[15] Contracting parties face challenges associated with the international movement of seeds that are distinct from the international movement of other types of plants for planting. For example, seeds produced in one country and exported to a second country for processing (e.g. pelleting and coating), testing and packing may then be re-exported to numerous other destinations (including the country of origin). At the time of production of the seeds, the destination countries and their phytosanitary import requirements may not be known, especially if a number of years pass between production and export to the final destinations.

IMPACTS ON BIODIVERSITY AND THE ENVIRONMENT

[16] This standard may help manage the pest risk posed by seeds moved internationally, including the pest risk posed by invasive alien species (as defined in the Convention on Biological Diversity).

[17] Harmonized international phytosanitary measures for seeds may help preserve biodiversity by increasing the potential for exchanging healthy seeds (free from pests).

REQUIREMENTS

1. Pest Risk Analysis

[18] PRA for seeds performed in accordance with ISPM 2 (*Framework for pest risk analysis*), ISPM 11 (*Pest risk analysis for quarantine pests*) and ISPM 21 (*Pest risk analysis for regulated non-quarantine pests*) should identify the regulated pests potentially associated with seeds and seeds as pests. The PRA should consider the purpose for which seeds are imported (e.g. field planting, research, testing) and the probability of regulated pests establishing and spreading and in consequence causing economic impacts (ISPM 32).

1.1 Seeds as pests

[19] PRA for seeds as pests should follow the guidance provided in Annex 4 of ISPM 11.

1.2 Seeds as pathways

[20] In PRA for seeds as pathways, the ability of a pest to transfer to a suitable host and cause infestation needs specific consideration to identify pests that warrant regulation.

[21] Some seed-borne pests associated with a suitable host upon entry may result in infestation of the host when the seed is planted while others may not.

[22] Seed-borne pests include:

- seed-transmitted pests that are carried by the seed internally or externally and directly infest the host plant growing from the seed (category 1(a))
- non-seed-transmitted pests that are carried by the seed internally or externally and are transferred to the environment (e.g. water, soil) and then infest a host plant under natural conditions (category 1(b))
- pests carried by the seed, internally or externally, that do not transfer to a host plant under natural conditions (category 1(c)).

[23] A further category of pests may be relevant even though the pests are not seed-borne. This is the category of contaminating pests present in a seed lot (including seeds of plants as pests) (category 2).

[24] Pests in categories 1(a), 1(b) and 2 should be further assessed for establishment, spread and economic impacts. Pests in category 1(c) cannot establish because they are not transferred to a suitable host.

[25] Examples of pests in each category are provided in Appendix 1.

[26] The PRA should consider whether the transmission of pests has been observed or confirmed to occur under natural conditions or under experimental conditions (e.g. in a laboratory or a growth chamber). When the transmission of pests has been observed or confirmed under experimental conditions it is necessary to confirm that it can also occur under natural conditions.

[27] Consideration of the biological and epidemiological characteristics of specific pest groups may help in determining the probability of a pest being introduced with seeds in an area. Guidance on the likelihood of pest groups being carried and introduced with seeds is provided in Appendix 2. The pests and host seeds should be assessed at the species level unless there is technical justification for using a higher or lower taxonomic level, in accordance with the requirements in ISPM 11.

1.3 Purpose of import

[28] The production of seeds may involve several steps (e.g. breeding, multiplication, destructive analysis, restricted field planting), which may be performed in different countries. The purpose of import of seeds may impact the probability of establishment of quarantine pests and should be considered when conducting the PRA and determining phytosanitary measures (ISPM 32).

[29] The purpose of import may be broadly ranked from lowest to highest pest risk as follows.

1.3.1 Seeds for laboratory testing or destructive analysis

[30] Such seeds are not intended for planting or for release into the PRA area. PRA may not be necessary because these seeds will not be released into the environment.

[31] Seeds imported for testing may be germinated to facilitate testing, but their purpose is not for planting. Requirements for laboratory testing or similar confinement and the destruction of the seeds and plants growing from these seeds should be sufficient as a phytosanitary measure.

[32] The NPPO of the importing country may not require other phytosanitary measures for these seeds if the pest risk is considered low or negligible.

1.3.2 Seeds for planting under restricted conditions

[33] Such seeds are imported for research and are grown in protected environments (e.g. glasshouses, growth chambers) or in isolated fields. These seeds should be planted under conditions that prevent the introduction of quarantine pests into the PRA area. Examples include seeds for evaluation, germplasm and seeds as breeding material.

[34] For these seeds, NPPOs may require relevant phytosanitary measures, which should not be more stringent than needed to address the pest risk identified.

1.3.3 Seeds for field planting

[35] Seeds intended for unrestricted release into the PRA area may present the highest pest risk for quarantine pests.

[36] The NPPO of the importing country may require phytosanitary measures; any such measures should be proportionate to the assessed pest risk. Specific tolerance levels for regulated non-quarantine pests may be determined and published.

1.4 Mixing, blending and bulking of seeds

[37] Mixing of seeds combines different species, varieties or cultivars into a single lot (e.g. lawn grass mixture, wildflower mixture). Blending of seeds combines different seed lots of the same variety into a single lot. Bulking combines seeds of the same variety from different fields immediately after harvest into a single lot.

[38] Seeds from various origins and different harvest years may be mixed or blended. All seeds in a mixture, a blend or a bulk lot should meet the relevant phytosanitary import requirements.

[39] In assessing the pest risk of mixed, blended or bulked seeds, all combinations of pests, hosts and origins should be considered. The impacts of the mixing, blending or bulking processes (e.g. dilution, increased handling) should also be considered in determining the overall pest risk of mixtures, blends and bulk lots of seeds.

[40] Testing and inspection may be done either on the components or on the mixture or the blend to be certified.

[41] All components of the mixture, blend or bulk lot should be traceable.

1.5 Pest management in seed production

[42] Certain practices used in seed production may alone or in combination be sufficient to meet phytosanitary import requirements. Full documentation of phytosanitary measures applied to the seeds should be maintained to facilitate trace-back, as appropriate.

[43] Phytosanitary measures may be included in integrated pest management and quality control protocols applied in seed production.

[44] In the case of tree seeds, phytosanitary measures are often applied only at the time of harvest.

[45] Production practices may vary between seed production sectors (e.g. field crops, forestry). Options that may be considered when determining pest risk management include:

Pre-planting:

- use of resistant plant varieties (section 1.5.2)use of healthy seeds (free from pests)
- seed treatment (section 1.5.3)
- crop management (e.g. rotation or mixed planting)
- field selection
- soil or growing medium treatment
- geographical or temporal isolation
- sanitation or disinfection of water

[46] Pre-harvesting:

- hygiene measures (e.g. disinfection of workers' hands and shoes, farm equipment, machinery and tools)

- field inspection and, where appropriate, testing if symptoms are observed
- field sanitation (e.g. removal of symptomatic plants, removal of weeds)
- parent plant testing
- crop treatment
- protected environments (e.g. glasshouses, growth chambers)
- sanitation or disinfection of water

[47] Harvesting and post-harvest handling:

- hygiene measures (e.g. disinfection of workers' hands and shoes, farm equipment, machinery and tools)
- timely harvest (e.g. just as seed matures, for tree seeds in mast years, from fruit at the pre-ripe stage)
- use of disinfectants during seed extraction
- seed cleaning, drying, conditioning and sorting
- seed testing
- seed storage
- seed treatment (section 1.5.3)
- sanitation (e.g. removing plant debris, soil or visibly infested plants and seeds)
- seed packaging and sealing
- mechanical treatment (e.g. separation of healthy seeds (free from pests)
- harvesting method (e.g. use of collection mats or tarpaulins for tree seeds).

1.5.1 Seed certification schemes

[48] Certain elements of a seed certification scheme (a scheme to improve the quality of seeds) may have an effect on the pest risk of the seeds being certified. Some of these elements (e.g. inspection for the presence of pests, purity analysis to detect weed seeds) may be considered in pest risk management by NPPOs and assessed on a case-by-case basis.

[49] Seed certification schemes should ensure seed traceability. Information on international seed certification schemes is provided in some of the sources in Appendix 3.

1.5.2 Resistant plant varieties

[50] Modern breeding programmes may produce plant varieties that have a level of resistance to pests, which may include resistance to regulated pests. When confirmed resistance to a regulated pest is such that a resistant variety is not infested by the pest, the NPPO of the importing country may consider this resistance as an appropriate pest risk management option.

[51] A plant variety's level of resistance to different regulated pests may vary depending on the resistance characteristics present in the plant. Resistance genes may be effective against all or some races, strains, biotypes or pathotypes of the targeted pest, but the emergence of new races, strains, biotypes or pathotypes may affect the level of resistance. The pest resistance should therefore be assessed on a case-by-case basis. The NPPO of the importing country may consider the use of resistant varieties as an appropriate phytosanitary measure in the framework of a systems approach.

[52] A suggested bibliography on the use of resistant plant varieties is provided in Appendix 3.

1.5.3 Seed treatment

[53] Seeds may be treated to eliminate an infestation by a pest; however, they may be treated even if not infested, either as a precaution by a general disinfection or to protect the seedlings growing from the seeds when exposed to pests in the environment. Seed treatments may also be unrelated to pests; for example, seeds may be treated with seedling growth enhancer.

[54] Seed treatments include, but are not limited to:

- pesticides (fungicides, insecticides, nematicides and bactericides)
- disinfectants, which are generally used against bacteria and viruses; disinfection may take place during various steps in seed processing (e.g. seed extraction, seed priming[1]) or during a dedicated disinfection process
- physical treatments (e.g. dry heat, steam, hot water, irradiation by ultraviolet light, high pressure, deep-freezing)
- biological treatments based on different modes of action (e.g. antagonism, competition, induced resistance).

2. Phytosanitary Measures

[55] In accordance with ISPM 11, phytosanitary measures proportionate to the assessed pest risk should be applied alone or in combination to prevent the introduction and spread of quarantine pests and to ensure that the tolerance levels of regulated non-quarantine pests are met, as identified through a PRA.

2.1 Consignment inspection and testing for pest freedom

[56] Seed sampling, including sample size (the total number of seeds tested), should be appropriate for detecting regulated pests. Guidance on sample size is provided in ISPM 31 (*Methodologies for sampling of consignments*). Harvested seeds showing visible symptoms that suggest the presence of regulated pests may need to be tested to confirm the presence of the pests.

2.2 Field inspection for the presence of pests

[57] Field inspection may be a phytosanitary measure to detect some regulated pests that produce visible symptoms.

2.3 Pest free areas, pest free places of production, pest free production sites and areas of low pest prevalence

[58] Pest free areas, pest free places of production, pest free production sites and areas of low pest prevalence should be established, recognized and maintained in accordance with ISPM 4 (*Requirements for the establishment of pest free areas*), ISPM 10 (*Requirements for the establishment of pest free places of production and pest free production sites*) and ISPM 29 (*Recognition of pest free areas and areas of low pest prevalence*).

[59] Areas of low pest prevalence in accordance with ISPM 22 (*Requirements for the establishment of areas of low pest prevalence*) may be used alone or in combination with other phytosanitary measures in a systems approach (ISPM 14 (*The use of integrated measures in a systems approach for pest risk management*)).

2.4 Treatments

2.4.1 Crop treatment

[60] Pesticide application to parent plants may be used to prevent seed infestation.

2.4.2 Seed treatment

[61] Seed treatments may be used as phytosanitary measures (section 1.5.3).

[62] Many tropical and some temperate tree species produce seeds that are sensitive to desiccation and particularly prone to latent pest development or pest infestation. Physical or chemical treatments may

[1]Seed priming is the pre-treatment of seeds by various methods in order to improve the percentage and uniformity of germination.

be applied to prevent latent pest development or pest infestation in seeds that need to be maintained at high moisture levels.

2.5 Systems approaches

[63] Systems approaches provide the opportunity to consider both pre-harvest and post-harvest procedures that may contribute to effective pest risk management. Many pest management practices to reduce pest risk throughout the seed production process, from planting to harvesting, may be integrated in a systems approach. ISPM 14 provides guidelines for the development and evaluation of integrated measures in a systems approach as an option for pest risk management.

2.6 Post-entry quarantine

[64] The NPPO of the importing country may require post-entry quarantine for seeds, including confinement in a quarantine station, in cases where a quarantine pest is difficult to detect, where symptom expression takes time, or where testing or treatment is required and no alternative phytosanitary measures are available. Guidance on post-entry quarantine stations is provided in ISPM 34 (*Design and operation of post-entry quarantine stations for plants*).

[65] As part of post-entry quarantine, a representative sample of the seed lot may be sown and the plants growing from these seeds tested (this may an option for small seed lots used for research).

[66] The NPPO of the importing country may consider, based on the findings of a PRA, that the pest risk can be adequately managed by requiring the imported seeds to be planted in a designated planting area. The planting area should be isolated from other host plants, and weed control, sanitation, and hygiene measures for people, machinery and equipment may be required.

2.7 Prohibition

[67] NPPOs may prohibit the importation of seeds of certain species or origins when a PRA determines that the seeds pose a high pest risk as a pathway for quarantine pests and no alternative phytosanitary measures are available. This includes situations where the seeds may pose a high risk of being a pathway for plants as pests (e.g. weeds, invasive alien species). Guidance on prohibition of importation can be found in ISPM 20 (*Guidelines for a phytosanitary import regulatory system*).

[68] The NPPO of the importing country may allow – for research purposes and under an import authorization that indicates specific conditions to prevent the introduction and spread of quarantine pests – the entry of seeds that are normally prohibited.

3. Equivalence of Phytosanitary Measures

[69] The equivalence of phytosanitary measures (ISPM 1 (*Phytosanitary principles for the protection of plants and the application of phytosanitary measures in international trade*)) is particularly important for the international movement of seeds as seed companies may have breeding and multiplication programmes in several countries and may export these seeds to other countries, and there may be frequent re-export from a single seed lot.

[70] Determination of the equivalence of phytosanitary measures may be initiated by the exporting country making a request for equivalence to the importing country, as described in ISPM 24 (*Guidelines for the determination and recognition of equivalence of phytosanitary measures*). It may also be initiated by the importing country. NPPOs are encouraged to provide multiple options when setting phytosanitary import requirements.

[71] Equivalent phytosanitary measures may provide NPPOs with options to achieve the required protection. An example of an equivalent phytosanitary measure is the substitution of a requirement for field inspection of the seed crop in the country of origin with appropriate seed testing or seed treatment for the regulated pest. ISPM 24 provides further guidance on the equivalence of phytosanitary measures.

[72] For seeds (including organic seeds) requiring for import a specific chemical treatment, if the chemical is not permitted for use in the country of origin, export or re-export, the NPPO of the importing country should consider an equivalent phytosanitary measure, where possible, provided that the measure is technically feasible and reduces the assessed pest risk to an acceptable level. It is recommended that phytosanitary import requirements do not specify chemical products, active ingredients or exact protocols.

4. Specific Requirements

[73] Specific requirements for inspection, sampling and testing of seeds for phytosanitary certification or verification are provided as follows.

4.1 Inspection

[74] Inspection may be conducted on the seed consignment or as field inspection of the growing crop, or both, as required. ISPM 23 (*Guidelines for inspection*) and ISPM 31 provide further guidance on inspection and sampling.

4.1.1 Inspection of seed consignments

[75] Seed consignments may be inspected for the presence of seeds of plants regulated as pests (i.e. weeds, invasive alien species), for signs or symptoms of regulated pests, for the presence of regulated articles (e.g. soil) or for the presence of contaminating pests. Inspection for pest symptoms may be effective where infested seeds are known to display characteristic symptoms such as discoloration or shrivelling. However, the presence of the pest should be confirmed by laboratory testing. Visual examination should be combined with testing if pest freedom or a specific tolerance level is required for asymptomatic or unreliably symptomatic regulated pests.

[76] Inspection of seeds can be done with or without the help of devices that automatically sort seeds based on visible physical characteristics. Although inspection may be effective for the detection of insects and mites, the majority of seed-borne pests (i.e. bacteria, fungi, nematodes, viroids, viruses) are not detectable by inspection with the naked eye and require a more specialized examination (e.g. with a binocular microscope) or laboratory testing. Washing, sieving or breaking seeds may be necessary before inspection.

[77] Inspection of seeds that are coated, pelleted or embedded in tape, mats or any other substrate may require removal of the covering material by washing it off the seeds or breaking it because such material may reduce the ability to see the seeds or symptoms of the pest on the seeds. In such cases, the NPPO of the importing country may require the NPPO of the exporting country to systematically sample the seeds before coating, pelleting or embedding them, and to test them. For monitoring at import, the NPPO of the importing country may request the NPPO of the exporting country to provide a sample of the seeds (of a size proportional to the seed lot) before coating, pelleting or treating them, for inspection and testing, or, alternatively, if agreed bilaterally, to collect an official sample and test the seeds without coating, pelleting or treating them and to provide the test results.

4.1.2 Field inspection

[78] Inspection of the seed crop in the field by trained staff at an appropriate time may be useful to detect regulated pests known to cause visible symptoms. A pest observed in the field on the parent plant may not necessarily be present on or in the seeds produced by these plants (section 1.2). A laboratory test may be conducted on the harvested seeds to determine if they are infested.

4.2 Sampling of lots

[79] Sampling of a seed lot may be done to inspect or test for the absence of a pest in the lot.

[80] Inspection for pests is usually based on sampling. Sampling methodologies used by NPPOs will depend on the sampling objectives (e.g. sampling for testing or inspection) and may be solely statistically based or developed noting particular operational constraints.

[81] Guidance on the sampling of consignments for inspection is given in ISPM 31.

4.2.1 Sampling of small lots

[82] Testing of samples that are taken in accordance with ISPM 31 from a small lot may result in the destruction of a large proportion of the lot. In such cases, alternative sampling methodologies (e.g. clustering small samples of different lots for testing) or equivalent phytosanitary procedures should be considered by the NPPO of the importing country, as per the guidance in ISPM 24.

[83] In cases where sampling from small lots is not possible, specific post-entry quarantine requirements may be determined by the NPPO of the importing country.

4.3 Testing

[84] Inspection may not be sufficient to determine if a regulated pest is present and other forms of examination may be needed (e.g. laboratory testing). Some bacteria, fungi, insects, nematodes, viroids and viruses may not be detectable by inspection of seed consignments or plants during growth, but they may be detectable by specific laboratory tests that follow validated diagnostic protocols for regulated pests.

[85] Molecular and serological diagnostic methods are considered indirect protocols to detect pests in seeds. These methods may give a positive result even when no viable pests are present. Consequently, when testing seeds with these methods, results should be interpreted carefully. Confirmatory tests or additional tests based on a different biological principle may be required to confirm the presence of a viable pest in a sample. NPPOs should ensure that internationally recognized or validated diagnostic protocols are used to avoid false positives or false negatives.

[86] The purpose and use of diagnostic protocols are described in ISPM 27 (*Diagnostic protocols for regulated pests*) and adopted protocols are provided as annexes to ISPM 27. Information on a range of other protocols, some of which have been validated, can be found in the sources listed in Appendix 3.

4.3.1 Testing of treated seeds

[87] Seed treatment may influence the sensitivity of testing. Ideally, a detection method that detects only viable pests should be used to determine treatment efficacy, so when the treatment has been successful the test result is negative. Examples of such detection methods are techniques for the detection of bacteria and fungi where the organism will grow on the substrate (i.e. media or blotters), and techniques for the detection of viruses where the seeds are sown and plants growing from the seeds are observed for symptoms. Most established seed testing methods have been developed and validated for use on untreated seeds. If treated seeds are to be tested, the testing method should be validated for treated seeds.

[88] The test results of treated seeds should be interpreted carefully, as the following situations may be encountered:

- The treatment inactivates the pest but the detection method detects both viable and non-viable pests. This may be the case with some serological or molecular tests or when detection is based on morphological identification of pests or pest structures that may remain even after treatment (e.g. nematodes, spores). In such cases, determination of the efficacy of the treatment is conclusive only if a test validated for treated seeds is used.
- The treatment physically or chemically inhibits the detection method; for example, some detection methods for bacteria are affected by fungicide treatments.
- The treatment adversely affects the detection method; for example, a method detects only pests present externally and any pests remaining internally after the treatment cannot be detected. In these situations, other detection methods that are able to detect internal infection should be used.

5. Phytosanitary Certification

[89] The global and temporal nature of the seed trade (i.e. re-export to many destinations, repeated re-export from the same seed lot, long-term storage) presents phytosanitary certification challenges distinct from those of the international movement of other commodities.

[90] NPPOs are encouraged to exchange additional official phytosanitary information at the time of export certification with other NPPOs to enable certification for re-export of seeds, as described in ISPM 12 (*Phytosanitary certificates*). Additional official phytosanitary information, which is not required by the first country of import, may be included on the phytosanitary certificate issued by the country of origin when so requested by the exporter in order to facilitate future re-export to other countries (ISPM 12).

[91] A country's phytosanitary import requirement for a field inspection may not be known at the time of production. Where appropriate, the NPPO of the importing country may consider equivalent phytosanitary measures (such as tests or treatments) to fulfil its phytosanitary import requirements for seeds already harvested, in accordance with ISPM 24. However, it is the responsibility of the exporting country to meet the phytosanitary import requirements.

[92] On phytosanitary certificates, "place of origin" refers primarily to places where the seeds were grown. If seeds are repacked, stored or moved, the pest risk may change as a result of their new location through possible infestation or contamination by regulated pests. The pest risk may also change if a seed treatment or disinfection removes possible infestation or contamination. In such cases, each country or place, as necessary, should be declared with the initial place of origin in brackets, in accordance with ISPM 12. If the consignment has not been exposed to infestation in the country or place of re-export, this can be indicated on the phytosanitary certificate for re-export. If different lots within a consignment originate in different countries or places, or if lots are mixed, blended or bulked, all countries or places should be indicated.

6. Record Keeping

[93] Because seeds may be stored for many years before being exported or re-exported, official phytosanitary information on the seed lot, including in the case of re-export the original phytosanitary certificate for export, when available, should be retained as long as the seeds are in storage.

This appendix is for reference purposes only and is not a prescriptive part of the standard

APPENDIX 1: Examples of seed-transmitted, seed-borne and contaminating pests

[94] This appendix provides examples of pests in the categories presented in section 1.2 (Seeds as pathways) of the standard.

Category 1(a): Seed-transmitted pests that are carried by the seed internally or externally and directly infest the host plant growing from the seed

- *Acidovorax citrulli* in seeds of *Citrullus lanatus*
- *Clavibacter michiganensis* subsp. *michiganensis* in seeds of *Solanum lycopersicum*
- *Ditylenchus dipsaci* on or in seeds of *Vicia faba* and *Medicago sativa*
- *Fusarium circinatum* on or in seeds of *Pinus* spp. and *Pseudotsuga menziessii*
- *Pea seed-borne mosaic virus* in seeds of *Pisum sativum*
- *Squash mosaic virus* in seeds of *Cucumis melo*
- *Tomato mosaic virus* in seeds of *S. lycopersicum*

Category 1(b): Non-seed transmitted pests that are carried by the seed internally or externally and are transferred to the environment (e.g. water, soil) and then infest a host plant under natural conditions

- *D. dipsaci* on or in seeds of *V. faba* and *M. sativa*
- *Fusarium oxysporum* f.sp. *lycopersici* on seeds of *S. lycopersicum*
- *Gibberella avenaceae* on seeds of *Linum usitatissimum*
- *Megastigmus* spp. in seeds of *Abies* spp.

Category 1(c): Pests carried by the seed, internally or externally, that do not transfer to a host plant under natural conditions

- *Callosobruchus chinensis* and *C. maculatus* on seeds of *Fabaceae*
- *Rice yellow mottle virus* on seeds of *Oryza sativa*

Category 2: Contaminating pests

- *Cyperus iria* in seed lots of *Oryza sativa*
- *Mycosphaerella pini* in seed lots of *Pinus* spp. contaminated with needle debris
- *Sclerotium cepivorum*, sclerotia in seed lots of *Allium cepa*

This appendix is for reference purposes only and is not a prescriptive part of the standard

APPENDIX 2: Guidance on the likelihood of pest groups being carried and introduced with seeds

[95] This appendix provides general guidance on assessing the probability of different pest groups being carried and introduced with seeds. In accordance with ISPM 11, pests and their hosts are recommended to be assessed at the species level unless there is technical justification for using a higher or lower taxonomic level. Guidance for assessing the probability of pests being associated with seeds or being present in consignments of seeds and their potential to establish and spread via this pathway is provided in section 1.2 of the standard and in ISPM 11.

[96] There is limited, and at times conflicting, information available regarding the seed transmission of pests. In addition, a pest that has been proven to be seed-transmitted in one host is not necessarily seed-transmitted in all known hosts. Seed transmission in other hosts and the level of host infestation before seed formation should be considered.

[97] NPPOs should consider in their determination of pest–host interaction that plants that may host certain pests under experimental conditions may not be hosts under natural conditions.

1. Arthropods

1.1 Pre-harvest pests

[98] Arthropods in the field include pests that feed on and in seeds during the seed development period, before harvest.

[99] Arthropods in the field that have a low probability of being present in seed consignments:

- External feeders: arthropods that feed on external parts of seeds are often dislodged during harvesting and cleaning.
- Internal feeders that cause seed abortion: arthropods that feed on internal parts of seeds usually cause seeds to fall before maturity and harvest.

[100] Arthropods that are internal feeders on the mature seed in the field have a high probability of being present in seed consignments because they are usually collected with seeds during harvest. Consideration during the pest risk management stage of the PRA is needed to determine whether these arthropods (e.g. *Bruchidae*) would be visible during quality grading or inspection and whether they would survive storage conditions.

1.2 Post-harvest pests

[101] Stored product arthropods can infest seeds after harvest, particularly if the seeds are stored in poor conditions (e.g. in high moisture or with previously stored seeds). Good storage conditions, as generally applied for high value seeds, greatly decrease or remove the likelihood of arthropods feeding on stored seeds.

[102] Stored product arthropods that are external feeders have a low probability of being present in seed consignments. Arthropods that feed on but are not attached to external parts of seeds may destroy the seeds and pose a risk as contaminating pests. Secondary pests (e.g. *Mycetophagus* spp., *Acarus* spp., *Liposcelis* spp.) may also be present when sanitation is poor or extraneous matter excessive.

[103] Stored product arthropods that are internal feeders have a high probability of being present in seed consignments. Thus consideration should be given to the likelihood of infestation in poor storage conditions. Arthropods that feed on internal parts of seeds can infest seeds that are left exposed before packaging.

2. Fungi

[104] Fungal and fungal-like organisms may be associated with seeds both externally and internally without causing disease in the plants growing from these seeds; however, many species cause seed rot, necrosis, reduced germination and infestation of seedlings. Seed fungal pathogens can be grouped as field pathogens and storage pathogens. Fungi may be present on the surface of seeds or mixed with seeds as contaminating pests, and may be introduced and spread to the host crop or to other crops (e.g. by contamination of the growing medium). Fungi may also be present in the integuments or in the internal part of the seed and can be introduced and spread to the host crop in this way.

3. Bacteria

[105] Although not all bacteria are seed-transmitted, bacteria can be found on or within seeds as external or internal infections, respectively.

4. Viruses

[106] Not all viruses are seed-transmitted. Viruses as a general rule are seed-transmitted only if the seed embryo is infected, although there are exceptions in the *Tobamovirus* genus. For seed-transmitted viruses, the percentage of infected seedlings is often lower than the percentage of infested seeds.

5. Viroids

[107] Seed transmission has been demonstrated for many but not all viroids.

6. Phytoplasmas and Spiroplasmas

[108] There is no substantial evidence of seed transmission for phytoplasmas and spiroplasmas under natural conditions.

7. Nematodes

[109] The majority of plant-parasitic nematode species are recorded as internal or external root parasites; however, some species of nematodes are known to attack above-ground plant parts, including seeds (e.g. *Ditylenchus dipsaci*, *Anguina tritici* and *Anguina agrostis*). Nematodes identified as seed-transmitted pests generally are species that are known to be endoparasites (internal feeders). Some species that are ectoparasites (external feeders) have dormant stages in seeds, plant debris and soil (e.g. *Aphelenchoides besseyi*) or become endoparasitic, invading inflorescenses and developing seeds (e.g. *A. tritici*).

8. Plants as Pests

[110] Seeds of plants as pests (e.g. weeds, parasitic plants) may be introduced into a country as contaminating pests in seed lots.

This appendix is for reference purposes only and is not a prescriptive part of the standard

APPENDIX 3: Bibliography

[111] The references included in this appendix are generally recognized as authoritative. The list is neither comprehensive nor static.

1. Seeds as Pathway and Seed-borne and Seed-transmitted Diseases

Agarwal, V.K. & Sinclair, J.B. 1996. *Principles of seed pathology*, 2nd edn. Boca Raton, FL, CRC Press. 560 pp.

Bertaccini, A., Duduk, B., Paltrinieri, S. & Contaldo, N. 2014. Phytoplasmas and phytoplasma diseases: A severe threat to agriculture. *American Journal of Plant Sciences*, 5(12): 1763–1788.

Cram, M.M. & Fraedrich, S.W. 2009. Seed diseases and seedborne pathogens of North America (forest trees). *Tree Planter's Notes*, 53(2): 35–44.

ISF (International Seed Federation). n.d. ISF Regulated Pest List Database. Nyon, Switzerland, ISF. Available at http://pestlist.worldseed.org/isf/pest_lists_db.html (last accessed 23 September 2016).

Johansen, E., Edwards, M.C. & Hampton, R.O. 1994. Seed transmission of viruses: Current perspectives. *Annual Review of Phytopathology*, 32: 363–386.

Mink, G.I. 1993. Pollen- and seed-transmitted viruses and viroids. *Annual Review of Phytopathology*, 31: 375–402.

Sastry, K.S. 2013. *Seed-borne plant virus diseases.* New Delhi, Springer. 328 pp.

2. Seed Testing and Sampling Protocols

Agarwal, P.C., Mortensen, C.N. & Mathur, S.B. 1989. *Seed-borne diseases and seed health testing of rice.* Copenhagen, Danish Government Institute of Seed Pathology for Developing Countries and Kew, UK, CAB International Mycological Institute.

Albrechtsen, S.E. 2006. *Testing methods for seed-transmitted viruses: Principles and protocols.* Wallingford, UK, CABI Publishing. 268 pp.

Chahal, S.S., Thakur, R.P. & Mathur, S.B. 1994. *Seed-borne diseases and seed health testing of pearl millet.* Copenhagen, Danish Government Institute of Seed Pathology for Developing Countries.

EPPO (European and Mediterranean Plant Protection Organization). n.d. *Diagnostic protocols for regulated pests.* Paris, EPPO. Available at http://archives.eppo.int/EPPOStandards/diagnostics.htm (last accessed 23 November 2016).

ISHI-Veg (International Seed Health Initiative for Vegetable Crops). n.d. *The ISHI-Veg Manual.* Nyon, Switzerland, International Seed Federation (ISF). Available at http://www.worldseed.org/isf/ishi_vegetable.html (last accessed 23 November 2016).

ISTA (International Seed Testing Association). 2016. International rules for seed testing: ISTA Rules 2016 Introduction and Chapters 1, 2 and 7, and information on how to access other chapters. Bassersdorf, Switzerland, ISTA. Available at http://seedtest.org/en/ista-rules-for-2016-_content---1--1449--956.html (last accessed 23 November 2016).

ISTA (International Seed Testing Association). 2016. *International rules for seed testing 2016.* Chapter 7: Seed health testing. Bassersdorf, Switzerland, ISTA. Available at http://www.seedtest.org/upload/cms/user/ISTA_Rules_2016_07_seed_health.pdf (last accessed 23 November 2016).

Mathur, S.B. & Cunfer, B.M., eds. 1993. *Seed-borne diseases and seed health testing of wheat.* Copenhagen, Danish Government Institute of Seed Pathology for Developing Countries.

NSHS (National Seed Health System). n.d. Web page with links to information on diagnostic protocols for seed health testing. Ames, IA, USDA-APHIS and Iowa State University Seed Science Center. Available at http://www.seedhealth.org/methods-procedures (last accessed 23 November 2016).

Palacio-Bielsa, A., Cambra, M.A. & López, M.M. 2009. PCR detection and identification of plant-pathogenic bacteria: Updated review of protocols (1989–2007). *Journal of Plant Pathology*, 91(2): 249–297.

3. Tree Seeds

Burgess, T. & Wingfield, M.J. 2002. Quarantine is important in restricting the spread of exotic seed-borne tree pathogens in the southern hemisphere. *International Forestry Review*, 4(1): 56–65.

Mittal, R.K., Anderson, R.L. & Mathur, S.B. 1990. *Microorganisms associated with tree seeds: World Checklist 1990*. Information Report PI-X-96. Chalk River, Ontario, Petawawa National Forestry Institute, Forestry Canada. 70 pp (in French). Available at http://cfs.nrcan.gc.ca/publications?id=10573 (last accessed 23 November 2016).

Motta, E., Annesi, T. & Balmas, V. 1996. Seedborne fungi in Norway spruce: Testing methods and pathogen control by seed dressing. *European Journal of Forest Pathology*, 26(6): 307–314.

Neergard, P. 1977. *Seed pathology*, vol. I and vol. II. London, Macmillan. 1187 pp.

Rees, A.A. & Phillips, D.H. 1986. *Detection, presence and control of seed-borne pests and diseases of trees with special reference to seeds of tropical and sub-tropical pines.* Technical Note No. 28. Humlebaek, Denmark, Danida Forest Seed Centre.

Richardson, M.J. 1990. *An annotated list of seed-borne diseases*, 4th edn. Bassersdorf, Switzerland, International Seed Testing Association.

Schmidt, L. 2000. *Guide to handling of tropical and subtropical forest seed*. Humlebaek, Denmark, Danida Forest Seed Centre.

Sutherland, J.R., Diekmann, M. & Berjak, P., eds. 2002. *Forest tree seed health for germplasm conservation.* IPGRI Technical Bulletin No. 6. Rome, International Plant Genetic Resources Institute (IPGRI). 85 pp. Available at http://www.bioversityinternational.org/e-library/publications/detail/forest-tree-seed-health-for-germplasm-conservation/ (last accessed 18 November 2016).

Willan, R.L. 1987. *A guide to forest seed handling.* FAO Forestry Paper 20/2. Rome, Food and Agriculture Organization of the United Nations.

4. Resistant Plant Varieties

ISF (International Seed Federation). n.d. *Diseases and resistance*. Nyon, Switzerland, ISF. Available at http://www.worldseed.org/our-work/plant-health/overview/ (last accessed 23 November 2016).

5. Other

NSHS (National Seed Health System). n.d. Home page. Ames, IA, USDA-APHIS and Iowa State University Seed Science Center. Available at https://www.seeds.iastate.edu/national-seed-health-system (last accessed 23 November 2016).

OECD (Organisation for Economic Co-operation and Development). OECD seed schemes: rules and regulations. Paris, OECD. Available at http://www.oecd.org/tad/code/oecdseedschemesrulesandregulations.htm (last accessed 23 November 2016).