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EPPO STANDARD ON PHYTOSANITARY PROCEDURES

PM 3/70 (2) Compliance procedures for consignments of potato tubers at export and import

Specific scope: This Standard describes the compliance procedures for consignments of potato tubers (intended for planting, consumption, or processing) at export and import, in EPPO member countries. It covers the risk associated with '*regulated pests*', as defined by the IPPC in ISPM No. 5 *Glossary of Phytosanitary terms* (IPPC, 2024a).

Specific approval and amendment: First approved in 2006-09. Revised in 2025-09.

Authors and contributors are given in the Acknowledgements section.

1 | INTRODUCTION

Potatoes are important crops and were cultivated on more than 5.1 million hectares in the EPPO region in 2021 (FAOSTAT, 2023). Potato tubers are considered a high risk pathway for the introduction of pests into a production area; with potato tubers intended for planting posing a higher risk for the introduction of quarantine pests than potatoes for consumption or processing. Risks from different commodities of potatoes are described in Standard PM 8/1 EPPO Commodity Standard for Potato (EPPO, 2017). Consignments of potato tubers may carry pests from the EPPO A1 or A2 Lists of pests recommended for regulation as quarantine pests (also see PM 8/1), pests recommended for regulation as regulated non-quarantine pests (RNQP) (see Picard et al., 2018 and EPPO Certification scheme for seed potatoes PM 4/28 (EPPO, 2023)), or other pests regulated as quarantine or regulated non-quarantine pests by EPPO countries. Marketing standards (e.g. certification standards) also include requirements for other pests and symptoms which should be complied with at import. These pests or symptoms, referred to as 'quality pests', are not in the scope of this Standard. Other pests possibly presenting a new risk may also be detected during inspection at import and may lead to action by the National Plant Protection Organization (NPPO) depending on the risk assessed.

A phytosanitary import regulatory system should be established '*to prevent the introduction of quarantine pests or limit the entry of regulated non-quarantine pests*'. This may include requirements for: country-, area-, place of production-, production site- or lot- freedom from specified pests; tolerances (e.g. for RNQPs); production from mother plants of specified phytosanitary status; the amount of soil in a lot and; treatments and packing. Guidance for a phytosanitary import regulatory control system is provided in ISPM No. 20 *Guidelines for a phytosanitary import regulatory system* (IPPC, 2024b).

The exporting country should fulfil all the requirements set by the importing country. This may include, where required, a tuber inspection prior to export to ensure that the consignment meets the phytosanitary requirements of the importing country at the time of inspection. An inspection at import may be used to verify compliance with these requirements and for the detection of pests for which the phytosanitary risk has not yet been determined (ISPM No. 23 *Guidelines for inspection*; IPPC, 2021d).

2 | COMMODITIES CONCERNED

This Standard applies to consignments of *Solanum tuberosum* tubers and other tuber-forming *Solanum* species and their hybrids, herein called 'potato tubers', intended for planting (i.e. seed potatoes), consumption or processing (i.e. 'ware potatoes', which also includes starch potatoes as defined in PM 8/1). Potato tubers are typically transported in jute and polypropylene bags (e.g. 10–50 kg, Figure 1a), as well as in boxes or wooden crates (Figure 1b). The use of so called 'big bags', or 'jumbo bags', which hold approximately 1000–1300 kg has also become common practice (Figure 1c). Ware potatoes may also be shipped loose in shipping containers, or in tipper lorries.

3 | DEFINITIONS

The various phytosanitary terms such as '*commodity*', '*compliance procedure*', '*consignment*', '*inspection*', '*lot*', '*pest*', '*pest status*', '*phytosanitary certificate*', '*place of production*', '*production site*', '*quarantine pest*', '*regulated non-quarantine pest*', '*testing*' etc. are used as defined in ISPM No. 5 (IPPC, 2024a).

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FIGURE 1 (a) Bags (25 kg). (b) Wooden crate (about 1250 kg). (c) 'Big' or 'jumbo' bags (1250 kg). Seed potatoes (a–c). Courtesy: C. Picard (EPPO GD, 2025).

In particular, a lot is defined as '*a number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment*'. In this Standard, the term '*unit*' is used to cover any subdivision of a lot, either a potato or a packing unit (e.g. bag, box or crate).

4 | PESTS OF POTATO TUBERS

The exporting country is required to fulfil the phytosanitary import requirements for regulated pests listed by the importing country.

Since this Standard mainly addresses the risk of introducing quarantine pests into EPPO member countries, it relates, primarily to those pests infesting potato tubers which are listed in the EPPO A1 and A2 Lists of pests recommended for regulation as quarantine pests (EPPO, 2022a). The importing country may also regulate additional quarantine pests which EPPO does not recommend for regulation, provided that a technical justification is made.

Additionally, requirements for RNQPs on seed potatoes, with associated tolerances, should be fulfilled. Standard PM 4/28 *Certification scheme for seed potatoes* (EPPO, 2023) lists RNQPs and associated tolerances for seed potatoes.

Table 1 lists EPPO A1 and A2 pests known to infest potato tubers, along with other regulated pests (including quarantine pests and RNQPs) in EPPO member countries. Appendix 1 provides descriptions of the potential symptoms observed on potato tubers, with a focus on pests for which potato is a major host.

Details on EPPO A1 and A2 pests infesting potato can be found in EPPO/CABI (1997), and in species-specific EPPO datasheets available via EPPO Global Database (EPPO, 2025).

5 | PHYTOSANITARY SYSTEM FOR POTATO TUBERS

5.1 | For certification at export

The NPPO of the exporting country should obtain the relevant phytosanitary requirements of the importing country (including import permits if required) and verify that the consignment conforms to those requirements at the time of certification, following the procedures in ISPM No. 7 *Phytosanitary certification system* (IPPC, 2021a).

To comply with the requirements of the importing country it may be necessary to conduct pest surveys, inspections and testing during the growing period of the crop, and/or post-harvest testing (e.g. for the potato cyst nematodes *Globodera rostochiensis* and *G. pallida*). The issuance of an export phytosanitary certificate can only be carried out if traceability is ensured between the crop in the field and the lot, and with phytosanitary measures taken throughout its production.

Guidance on the programme of field inspections and surveys within the EPPO region to ensure that exported potatoes satisfy the phytosanitary requirements of importing countries is provided in EPPO Standard PM 3/71 *General crop inspection procedures for potatoes* (EPPO, 2007).

The compliance check at export consists of a documentary/information check, an identity/integrity check, and a physical check. Identity and physical checks are performed depending on the requirements of the importing country.

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TABLE 1 Pests of potato tubers.

A1 pests (absent from the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	A2 pests (present in the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	Other pests regulated by specific EPPO member countries as quarantine or regulated non-quarantine pests (see EPPO global database)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]
Bacteria				**Bacteria**				**Bacteria**			
'*Candidatus* Liberibacter solanacearum'	Y	N	Y	'*Candidatus* Phytoplasma solani'[c]	Y	N	Y	'*Candidatus* Phytoplasma aurantifolia-related strains (GD32; St_JO_10, 14, 17; PPT-SA; Rus-343F; PPT-GTO29, -GTO30, -SINTV; Potato Huayao Survey 2; Potato hair sprouts)	Y	N	Y[a]
'*Candidatus* Phytoplasma americanum'	Y	N	Y	*Clavibacter michiganensis*	Y	N	Y	'*Candidatus* Phytoplasma australiense'	Y	N	Y[a]
Ralstonia syzygii	Y	N	Y	*Clavibacter sepedonicus*	Y	N	Y	'*Candidatus* Phytoplasma pruni-related strains (Clover yellow edge, Potato purple top Akpot7, MT117, Akpot6; PPT-COAHP, -GTOP)	Y	N	Y[a]
Fungi				*Ralstonia pseudosolanacearum*	Y	N	Y	'*Candidatus* Phytoplasma fragariae-related strains (YN-169, YN-10G)	Y	N	Y[a]
Phymatotrichopsis omnivora	Y	Y	Y	*Ralstonia solanacearum* sensu stricto	Y	N	Y	'*Candidatus* Phytoplasma trifolii'	Y	N	Y
Thecaphora solani	Y	N	Y	**Fungi**				*Dickeya* (wet rot, blackleg)[c]	Y	N	Y
Insecta				*Synchytrium endobioticum*	Y	Y	Y	*Pectobacterium* (wet rot, blackleg)[c]	Y	N	Y
Diabrotica speciosa	Y	Y	Y	**Insecta/Acari**				*Streptomyces* (common scab)[c]	Y	N	Y
Diabrotica undecimpunctata howardi	Y	Y	Y	*Epitrix cucumeris*	Y	Y	Y	**Chromista**			
Diabrotica undecimpunctata undecimpunctata	Y	Y	Y	*Epitrix papa*	Y	Y	Y	*Phytophthora cryptogea*[c]	Y	N	Y
Epitrix subcrinita	Y	Y	Y	*Tecia solanivora*	Y	Y	Y	*Phytophthora erythroseptica* (wet rot)[c]	Y	N	Y
Epitrix tuberis	Y	Y	Y	*Tetranychus evansi*	Y	N	Y	*Phytophthora infestans* (dry rot, wet rot)[c]	Y	N	Y
Heteronychus arator	Y	N	Y	**Nematoda**				*Pythium* (wet rot)[c]	Y	N	Y
Limonius californicus	Y	Y	Y	*Ditylenchus dipsaci*	Y	Y	Y	**Fungi/Protista**			
Melanotus communis	Y	Y	Y	*Globodera pallida*	N[d]	Y	Y	*Alternaria* (dry rot)[c]	Y	N	Y
Naupactus leucoloma	Y	Y	Y	*Globodera rostochiensis*	N[d]	Y	Y	*Athelia rolfsii* (wet rot)[c]	Y	N	Y
Premnotrypes latithorax	Y	N	Y	*Meloidogyne chitwoodi*	Y	Y	Y	*Boeremia* (dry rot)[c]	Y	N	Y
Premnotrypes suturicallus	Y	N	Y	*Meloidogyne enterolobii*	Y	Y	Y	*Fusarium* (dry rot)[c]	Y	N	Y
Premnotrypes vorax	Y	N	Y	*Meloidogyne fallax*	Y	Y	Y	*Geotrichum candidum* (wet rot)[c]	Y	N	Y
Nematoda				*Meloidogyne graminicola*	Y	Y	Y	*Helicobasidium brebissonii* (dry rot)[c]	Y	N	Y
Meloidogyne ethiopica	Y	Y	Y	*Meloidogyne luci*	Y	Y	Y	*Helminthosporium solani* (silver scurf)[c]	Y	N	Y

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TABLE 1 (Continued)

A1 pests (absent from the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	A2 pests (present in the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	Other pests regulated by specific EPPO member countries as quarantine or regulated non-quarantine pests (see EPPO global database)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]
Nacobbus aberrans s.l.	Y	Y	Y	**Viruses and viroids**				*Polyscytalum pustulans*	Y	N	Y
Viruses and viroids				*Begomovirus coheni* (tomato yellow leaf curl virus)	Y	N	N[a]	*Rhizoctonia solani*[c]	Y	N	Y
Alphanucleorhabdovirus tuberosum (potato yellow dwarf virus)	Y	N	Y	*Begomovirus solanumdelhiense* (tomato leaf curl New Delhi virus)	Y	N	N[e]	*Sclerotinia minor* (dry rot)[c]	Y	N	Y
Cheravirus avii (cherry rasp leaf virus)	Y[a]	N	N	*Crinivirus tomatichlorosis* (tomato chlorosis virus)	Y	N	N	*Sclerotinia sclerotiorum* (dry rot)[c]	Y	N	Y
Comovirus andesense (Andean potato mottle virus)	Y	N	N	*Nepovirus lycopersici* (tomato ringspot virus)	Y	N	N	*Spongospora subterranea*[c]	Y	Y	Y
Crinivirus flavisolani (potato yellow vein virus)	Y	N	Y	*Orthotospovirus impatiensnecromaculae* (impatiens necrotic spot virus)	Y	N	Y[a]	*Verticillium* spp.	Y	N	Y
Ilarvirus TSV (potato strain) (Tobacco streak virus potato strain)	Y[a]	N	N	*Orthotospovirus tomatomaculae* (tomato spotted wilt virus)[c]	Y	N	Y	*Colletotrichum coccodes*	Y	N	Y
Nepovirus solani (potato black ringspot virus)	Y	N	N	*Pospiviroid fusituberis* (potato spindle tuber viroid)[c]	Y	N	Y	**Insecta**			
Potato yellowing virus	Y	N	N	*Pospiviroid impedichrysanthemi* (Chrysanthemum stunt viroid)	Y[a]	Y	[a]	*Epitrix similaris*	Y	Y	Y
Tepovirus tafsolani (potato virus T)	Y	N	N	*Potexvirus pepini* (pepino mosaic virus)	Y	N	N	*Phthorimaea operculella*	Y	N	Y
Tymovirus latandigenum (Andean potato latent virus)	Y	N	N					*Premnotrypes sanfordi*	Y	N	Y
Tymovirus mosandigenum (Andean potato mild mosaic virus)	Y	N	N					*Premnotrypes solani*	Y	N	Y
								Phyrdenus muriceus	Y	N	Y
								Rhigopsidius tucumanus	Y	N	N
								Nematoda			
								Ditylenchus destructor	Y	Y	Y

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								Viruses and viroids			
								Alfamovirus AMV (alfalfa mosaic virus)[c]	Y	N	Y
								Alphanucleorhabdovirus melongenae (eggplant mottled dwarf virus)	Y	N	N
								Begomovirus solanumflavusvenae (tomato yellow vein streak virus)	Y	N	N[e]
								Carlavirus chisolani (potato virus H)	Y	N	N
								Carlavirus misolani (potato virus M)[c]	Y	N	N
								Carlavirus sigmasolani (potato virus S)[c]	Y	N	N
								Cheravirus arracaciae (oca strain) (arracacha virus B oca strain)	Y	N	N
								Cucumovirus CMV (cucumber mosaic virus)[c]	Y	N	N
								Curtovirus betae (beet curly top virus)	Y	N	N
								Nepovirus arabis (arabis mosaic virus)[c]	Y	N	N
								Nepovirus betae (beet ringspot virus)[c]	Y	N	Y
								Nepovirus nigranuli (tomato black ring virus)[c]	Y	N	Y
								Polerovirus PLRV (potato leafroll virus)[c]	Y	N	Y
								Pomovirus solani (potato mop-top virus)[c]	Y	Y[f]	Y
								Potexvirus ecspotati (potato virus X)[c]	Y	N	Y
								Potexvirus marmoraucuba (potato aucuba mosaic virus)[c]	Y	N	Y
								Potyvirus atuberosi (potato virus A)[c]	Y	N	N
								Potyvirus vetuberosi (potato virus V)[c]	Y	N	N
								Potyvirus yituberosi (potato virus Y)[c]	Y	N	Y
								Tobacco necrosis virus[c]	Y	N	Y

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TABLE 1 (Continued)

A1 pests (absent from the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	A2 pests (present in the EPPO region)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]	Other pests regulated by specific EPPO member countries as quarantine or regulated non-quarantine pests (see EPPO global database)	In/on tubers[a,b]	In adherent soil[a,b]	Visible[a,b]
								Tobamovirus tabaci (tobacco mosaic virus)[c]	Y	N	N
								Tobravirus capsici (pepper ringspot virus)	Y	N	Y
								Tobravirus tabaci (tobacco rattle virus)[c]	Y	Y[f]	Y

Note: Remarks on pests not included in the Table. Some pests are leaf feeders and have only very occasionally been recorded attacking tubers under high infestation rates e.g. when leaves are lacking (e.g. *Spodoptera eridania*, *S. litura* and *S. ornithogalli*; EPPO A1). Some others have an extremely low chance of association with the pathway because only pupae can be associated (e.g. *Bactrocera latifrons* and *Ceratothripoides brunneus*; EPPO A1). Some additional pests may only be present as hitchhikers (*Leptinotarsa decemlineata*, EPPO A2). Potato as a natural host remains uncertain for *Begomovirus chillicapsici* (Chilli leaf curl virus; only reported once in potato) and *Begomovirus solanumhavanaense* (tomato mosaic Havana virus; only reported in NCBI GenBank database without associated publications in peer-reviewed journals) (EFSA, 2020). There appears to be no published evidence about symptoms in potato tubers caused by *Begomovirus solanumseverugosi* (tomato severe rugose virus), *Begomovirus solanumtainoense* (tomato mottle Taino virus) and *Begomovirus tuberosi* (potato yellow mosaic virus) or of infection of potato tubers.

[a]Uncertainties. *Orthotospovirus impatiensnecromaculae* (impatiens necrotic spot virus) has only been reported infecting potato in USA, and in the field in Iran (https://gd.eppo.int/taxon/INSV00/hosts). No information available for symptoms in potato tubers caused by *Begomovirus coheni* (tomato yellow leaf curl virus). Reports for *Ilarvirus TSV* (tobacco streak virus, TSV) infecting potato tubers are old (Salazar et al., 1982). It is considered that TSV is rarely perpetuated by tubers. *Pospiviroid impedichrysanthemi* (Chrysanthemum stunt viroid) has only been reported once in potato tubers under non-experimental conditions. *Cheravirus avii* (cherry rasp leaf virus) has only been reported once in a breeding clone of *Solanum tuberosum* (Thompson et al., 2004). Although no tuber symptoms appear to have been reported for '*Candidatus* Phytoplasma aurantifolia'-related strains, '*Candidatus* Phytoplasma australiense', '*Candidatus* Phytoplasma pruni'-related strains and '*Candidatus* Phytoplasma fragariae'-related strains they are likely to be similar to stolbur, since all phytoplasmas disrupt phloem mass transport and carbohydrate transport that have the potential to increase sugars in potato tubers leading to discolouration of the tuber flesh.

[b,]In/on tubers?' means 'Relevant for inspection or testing of tubers?'. 'In adherent soil?' means 'Relevant for inspection or testing of adherent soil?'. 'Visible?' means 'May be visible/symptomatic in/on tubers or soil?'.

[c]Considered as fulfilling RNQP criteria for the EU during a 2-year project on RNQPs funded by the European Commission (Picard et al., 2018). Remarks: *Nepovirus betae* (beet ringspot virus) was not discussed during the project since it had been described as a strain of *Nepovirus nigranuli* (tomato black ring virus, TBRV). However, it is now characterized as a distinct virus species (Fowkes et al., 2021). This is probably the reason why it is not reported as regulated in any EPPO country, whereas TBRV is regulated in several countries. Concerning *Tobacco necrosis virus*, its two strains, *Tobacco necrosis virus* strain A (TNV A) and *Tobacco necrosis virus* strain D (TNV D) have been raised from the rank of strains (serotypes) of TNV to the rank of species and placed into two separate genera: TNVA – *Alphanecrovirus nicotianae*. TNV D – *Betanecrovirus nicotianae*. TNV D is the virus mentioned by EFSA in List of non-EU viruses and viroids infecting potato (*Solanum tuberosum*) and other tuber-forming *Solanum* species. Both are probably responsible for symptoms in potato.

[d]Very rarely. Symptoms on tubers caused by *Globodera pallida* and *G. rostochiensis* are very rarely found. See Appendix 1.

[e]The only symptom is that tubers may be small which will not be visible after grading.

[f]Via the vector (*Spongospora subterranea* for *Pomovirus solani* (potato mop-top virus), nematodes of the genera *Trichodorus* and *Paratrichodorus* for *Tobravirus capsici* (pepper ringspot virus)).

'*pest*'.

The scientific name of a pest is underlined when it is visible/symptomatic in/on tubers or soil; and when potato is considered as a major host. More information on these pests is provided in Appendix 1.

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Based on the requirements of the importing country and considering the results of the crop inspections and any testing, the NPPO of the exporting country should prior to export define the scope of the documentary/information and physical checks. These may include:

Documentary/information checks:
- verifying that the tubers have been grown by an officially registered producer
- verifying that the tubers have been exported by an officially registered exporter
- verifying that the seed potatoes have been grown in a certification scheme
- checking the official information on the pest status in the site of production, place of production, area or country of origin (e.g. pre-export certificate in countries of the European Union (EU))
- checking the information contained in the phytosanitary certificate of the country of origin when the lots are to be re-exported
- checking information on the treatments applied
- checking the testing results

Physical checks:
- checking that requirements are fulfilled by sampling soil and/or tubers, for both inspection and testing:
  - checking the soil tolerance in the consignment/lot (e.g. free, practically free, 1%, 2% w/w, see PM 8/1 and PM 4/28), including measures for brushing or washing potatoes
  - inspecting for freedom from quarantine pests (zero tolerance)
  - defining the quarantine pests which cannot be detected visually and taking samples for testing if necessary (e.g. for pests present or suspected to be present in the exporting country)
  - checking compliance with tolerance levels for RNQPs
- checking packing requirements

5.2 | For release at import

Inspection of potato tuber consignments in the importing country may be carried out at an authorized point of entry into the country, at point of transhipment, at point of destination, or at other places (e.g. major markets), provided that their integrity is maintained, that adequate inspection facilities are available and that the consignments remain under official control.

For the import inspection, relevant parts of ISPM No. 20 (IPPC, 2024b) and ISPM No. 23 (IPPC, 2021d) should be followed.

The compliance procedure at import consists of, in this order, documentary checks, identity/integrity checks and physical checks. Identity and physical checks are performed depending on the risk identified by the NPPO of the importing country. Physical checks consist of sampling for inspection and possibly for testing to verify if the consignment complies with the phytosanitary import requirements (or phytosanitary requirements if the consignment is in transit). The scope of the physical checks may include all the elements of the indents provided in Section 5.1 for export.

6 | INSPECTIONS

6.1 | Inspection conditions

General conditions

The NPPO should follow the general conditions for inspections as described in ISPM No. 23 (IPPC, 2021d). In particular, the facilities used should be suitable for inspection and sampling, e.g. with adequate lighting and equipment. Examples of the minimum requirements for infrastructure at points of entry to the EU are described in Article 3 and 4 or Regulation (EU) 2019/1014 (EU, 2019).

The NPPO should ensure that adequate help is provided by the exporter/importer to enable the inspector to carry out their inspection (e.g. providing information on lots, physical carrying of packages, or under certain circumstances unloading tipper lorries or 'big bags' for sampling).

Written instructions should be made available to inspectors, and appropriate training should be provided.

Equipment used

For inspection of potato tubers, equipment which can be used is described in Appendix 2. This includes equipment for visual examination, as well as for soil and tuber sampling (e.g. knife, magnifying glass, inspection table, disinfectant, disposable gloves, bags, paper sheets, weighing scales, pull tight seals, labels).

Hygiene and other precautionary measures

Appropriate precautions should be taken during inspection and sampling to prevent further spread of quarantine pests. This should involve cleaning and disinfecting material/equipment between separate lots, as well as washing hands or wearing gloves when handling/collecting potato tubers for sampling and changing them after each separate lot. This may also be necessary, depending on the risk assessed, to prevent contamination with RNQPs.

If the inspector suspects the presence of a quarantine pest, the lot or consignment should be detained

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under official control. It should be stored separately from other lots in such a way that there is no risk of spreading the pest until testing has been completed and appropriate measures taken. Specific hygiene measures may be required depending on the suspected pest.

If the inspector detects an RNQP in seed potatoes above the tolerance level, the lot or consignment should be detained under official control until appropriate measures are decided and taken (see Section 6.4 *Acceptance/rejection at import*).

Attention should be given to the safe storage and disposal (e.g. autoclaving) of suspected/infested tubers which were subjected to destructive sampling (tubers cut), which were removed during inspection, and of disposable materials/equipment used during inspection.

6.2 | Lot identification

Prior to physical examination of the consignment, its composition should be checked to confirm its identity and integrity (ISPM No. 23, IPPC, 2021d) and to determine the number of lots in the consignment. The lots, their individual sizes (in kg or tonnes) and their distinctive characteristics should be indicated on the phytosanitary certificate and on labels on the packaging.

A consignment may be considered to consist of one or more identifiable lots, each of which is then subject to inspection and/or sampling for testing.

- For seed potatoes, each lot should be composed of a single cultivar of the same category, class, origin (producer) and tuber size.
- For ware potatoes, each lot should be composed of tubers of a single cultivar, from the same origin (producer) and from the same packing station.

The integrity of the lot should be maintained throughout the process. For further guidance on the identification of lots, see EPPO Standard PM 3/72 on lot identification (EPPO, 2009).

6.3 | Sampling

This section contains guidance on sampling for visual examination (general and specific aspects) and testing of consignments of potato tubers, as well as sampling of any associated soil.

The NPPO should set a sample size. Sampling should be adapted depending on the pest risk (e.g. origin of the tubers, type of commodity e.g. seed potatoes vs. ware potatoes, post-harvest treatments performed), the level of protection required, the requirement of the importing country and the lot size. Guidance and statistical background are available in ISPM No. 31 '*Methodologies for sampling of consignments*' (IPPC, 2016). Sampling required for specific potato pests may also be used for inspection of the lot for the other pests. Sampling for visual examination or testing should generally be carried out at lot level. Within a lot, the NPPO inspector selects the units for sampling (generally potato tubers). When using bags of e.g. 10–50 kg, the visual examination for external symptoms on potato tubers is generally conducted using all tubers from the sampled bags. The confidence level of detecting a pest at a certain infestation level will depend on the number of tubers inspected (see calculation tools S1 and S2 provided as supplementary material).

For inspection of internal symptoms after cutting or for sending to the laboratory for analysis, for example, 200 tubers could be sampled from a lot. For large lots that are sufficiently mixed and assuming a binomial distribution, this will give approximately 87% confidence level of detecting visible pests or symptoms at a 1% infestation level. Another example would consist of sampling 400 tubers from a lot to provide approximatively 98% confidence level of detecting visible pests or symptoms at a 1% infestation level; or approximatively 87% confidence level of detecting the pest at a 0.5% infestation level (see calculation tools S1 and S2 provided as supplementary material).

To improve representativeness of the sample, tubers should be sampled from different parts of the lot (e.g. from different packing units). However, practicalities and constraints, including limited resources mean that it is often difficult to draw samples with tubers from every packing unit (e.g. bag) in a large lot. For example, drawing from practical experience when sampling tubers for the quarantine pest control in imported lots in the EPPO region, when a lot consists of 25–50 kg bags, multiple bags could be sampled from a lot ensuring both of the following conditions are met: at least from 5 bags per lot and at least one bag per 10 tonnes (Table 2).

TABLE 2 Example for tuber sampling from 25 to 50 kg bags depending on the size of a lot.

Size of lot	Minimum number of packing units from which the tubers are sampled	Sample size
≤50 tonnes	5 bags	200 or 400 tubers, depending on the desired confidence level and the level of detection to achieve
>50 tonnes	1 bag per 10 tonnes	200 or 400 tubers, depending on the desired confidence level and the level of detection to achieve

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The minimum number of packing units from which the tubers are sampled should be adjusted based on the individual size of the packing units. For example, when using 'big' or 'jumbo' bags, potato tubers from at least 2 'big' or 'jumbo' bags can be sampled per lot. For small packing units (e.g. 10 kg), a similar approach to 25–50 kg bags may be used, adjusting the number to achieve the level of confidence required for a specific level of infection.

For practical reasons (e.g. managing workload in the laboratory), small lots of potato tubers from the same consignment (e.g. <500 kg for seed potatoes or ware potatoes already packaged for retail sale) may be bulked together for testing. However, the result of the test will then apply to all the sampled lots.

As far as possible, the packing units for sampling should be selected randomly from different parts of the lot, but units showing suspicious signs/symptoms (e.g. wetness) should be targeted.

The NPPO may decide to implement a multi-stage control approach, i.e. sampling and inspections carried out in several steps and at appropriate times which will be adapted, in particular for the quantities (number of tubers and packages) to be examined, to the level of risk and to the type of pest to be controlled.

6.3.1 | Tuber sampling for visual examination

General aspects

The packaging used should be inspected to ensure that it conforms with the requirements of the importing country e.g. the type of packaging used, whether the packaging is new or re-used and the printed or written information provided on the bags. If wooden crates, boxes or pallets are used, they should fulfil the requirements of ISPM No 15 *Regulation of wood packaging material in international trade* (IPPC, 2019), if this is a requirement of the importing country.

Each packing unit chosen for inspection should:

- first be subject to an overall examination of its general appearance, to obtain any indication of adverse conditions during transport (e.g. high or low temperatures, wetness), presence of plant debris, or live or dead insects on the packaging or in the shipping container. For example, some pests such as the Colorado beetle (*Leptinotarsa decemlineata*) may be present as a contaminant of potato tubers. The physical condition of the potato tubers should be checked to ensure that there are no indications of wet/dry rot, defects or symptoms that may be caused by a regulated pest.
- then be examined for the presence of soil. If it is suspected that the amount of soil in the consignment exceeds the requirements set by the importing country, this amount should be quantified. Soil can be collected from the suspected lots and weighed following sampling methods provided in Section 6.3.3. It is also possible determine the weight of soil from the weight difference of a specified volume of potatoes weighed before and after washing.

Specific aspects

All tubers selected for inspection should be checked visually for external signs and symptoms of infestation. Tubers should be sufficiently clean to observe the surface. If this is not the case, washing or brushing may be needed. The NPPO should be aware that certain pests may not show symptoms in tubers (latent infection) or are maybe difficult to detect visually at the export or import inspection.

Tubers selected for examination of internal signs and symptoms should be cut in half, generally lengthwise (from the rose-end (apex) to the heel-end) and checked for symptoms of regulated pests. When some specific pests are suspected or when specifically required, cutting should be performed transversally e.g. close to the heel-end for *Ralstonia solanacearum*, or tubers should be peeled e.g. for *Meloidogyne* spp. or *Nacobbus aberrans*. For some pests, it may be easier to observe the symptoms a few minutes after cutting (e.g. pink colouration in tubers infected with *Phytophthora erythroseptica*).

When the presence of a quarantine pest is suspected or under some circumstances to confirm that the tolerance for a particular RNQP is respected, the tubers should be tested. Testing may also be performed when presence of a new pest presenting a risk is suspected.

Cut tubers should be removed from the consignment.

If tolerance levels in the seed certification scheme, for pests listed as RNQPs or for symptoms, are applicable (e.g. percentage of tubers with a certain area of the skin infected by the specified pest such as for black scurf [*Thanatephorus cucumeris*=*Rhizoctonia solani*], common scab [*Streptomyces* spp.] or powdery scab [*Spongospora subterranea*]), for example 200 tubers can be randomly picked and used to check whether the percentage of affected tubers exceeds the tolerance. This can be combined with sampling for visual examination or testing of quarantine pests.

Some symptoms or lesions are characteristics of certain pests or category of pest, such as:

- Dry or wet rot, typical of many fungi (*Fusarium* spp., *Boeremia* spp., *Phytophthora* spp., etc.) and bacteria (*Clavibacter sepedonicus*, *Ralstonia solanacearum*, *Pectobacterium* spp., *Dickeya* spp., etc.)
- External skin blemishes due to various pests, in the form of patches (e.g. *Colletotrichum coccodes*, *Helminthosporium solani*), corky lesions (e.g. *Streptomyces* spp.), pitted and raised structures (e.g. *Rhizoctonia solani*, *Spongospora subterranea*, *Meloidogyne* spp.), outgrowths (e.g. *Synchytrium endobioticum*).

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- Necrotic arcs and lines on the surface and/or in the flesh of tubers generally caused by viruses (*Pomovirus solani* (potato mop-top virus), *Tobravirus tabaci* (tobacco rattle virus), *Orthotospovirus tomatomaculae* (tomato spotted wilt virus), etc.)
- Holes or tunnels due to insects (wireworms, *Epitrix* spp., *Phthorimaea operculella*).
- Cracks and deformations which can be due to fungi (*Rhizoctonia solani*), viruses (*Pomovirus solani* (potato mop-top virus)) or viroids (*Pospiviroid fusituberis* (potato spindle tuber viroid)).

These symptoms should be looked for during visual examination of the tubers. A more exhaustive list of symptoms is provided in Table A1 of Appendix 3, outlining the primary symptoms of pest damage on potato tubers. This table can be used in conjunction with Appendix 1.

6.3.2 | Tuber sampling for laboratory testing

If laboratory testing of tubers is required to confirm absence of a latent quarantine pest infection or to confirm that the tolerance for a particular RNQP is respected, the number of tubers required for specific tests by the laboratory should be taken randomly (e.g. from randomly selected packing units of the lot), including any tubers suspected to be infested. The tubers should be sent directly to the laboratory or should be cooled (e.g. in a coolbox) to avoid further deterioration of the sample, until they can be dispatched. The tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. If appropriate, particularly if tubers have been cut or are rotting, tubers may be wrapped individually in dry absorbent paper.

Multiple laboratory tests can be carried out on the same tubers since specific tuber-parts may be used for the different tests. With agreement from the laboratory, multiple virus tests and tests for *Pectobacterium* spp. can be carried out on the skin of the heel end. Testing for both *Clavibacter sepedonicus* and *Ralstonia solanacearum* can be performed on vascular tissue collected from just under the heel end (see PM 7/59 (2) *Clavibacter sepedonicus* (EPPO, 2022b) and PM 7/21 (3) *Ralstonia solanacearum, R. pseudosolanacearum* and *R. syzygii* (*Ralstonia solanacearum* species complex) (EPPO, 2022c)).

Meloidogyne testing (direct laboratory examination and visual examination after incubation of the tubers) can be done by peeling the tubers. Adult females are visible just below the surface, in the cortex layer, as glistening, white, pear-shaped bodies surrounded by a brownish layer, usually indicative of the presence of egg masses (see PM 3/69 (2) *Meloidogyne chitwoodi* and *M. fallax*: sampling potato tubers for detection (EPPO, 2019)).

For identification of specific pests see EPPO Diagnostic Protocols (series PM 7). Additional references for detection and identification are provided in Appendix 1 for information.

6.3.3 | Soil sampling

Sampling of soil attached to potato tubers may be part of the import or export inspection. For example, this may be required for potato cyst nematodes (see PM 3/75 Globodera rostochiensis *and* Globodera pallida*: sampling soil attached to ware potato tubers for detection prior to export and at import* (EPPO, 2014)).

If an inspection table is available (see Appendix 2, Figure A49), soil can be collected during inspection by spreading a sheet of paper, on the floor under the table to collect soil falling from the tubers. To increase the amount of soil collected, tubers could be rubbed against each other on the table. Collected soil should be transferred to a sampling bag and the sampling bag should be sealed and labelled before transport to the laboratory. Before sampling the next lot, all remaining soil on the table should be removed and a new, clean sheet of paper placed under the table.

For export, soil sampling can also be done during bagging, by placing a sheet of paper underneath the bagging machine and collecting the loose soil from there. A new sheet of paper should be used for each new lot.

Alternative methods for the collection of soil may be used, but these are more labour intensive and time consuming. One example consists of using a steel-mesh basket or a net (polypropylene) bag. The basket or the net bag is partly filled with tubers from the lot. Filling should be done over a sheet of paper which is spread out on the floor to collect any loose soil falling from the packaging or tubers. The steel basket or net bag should be lifted and shaken to rub the tubers as much as possible against each other. In case a net bag is used, the inspector should hold the bag with one hand at the bottom end and with the other hand at the top end, holding the bag closed. The bag is then shaken to rub the tubers against each other. Soil collected from the lot is transferred to a sampling bag (see previous method). Appropriate precautions should be taken to prevent further spread of quarantine pests: Except for single-use materials (which can then be disposed of without any risk to the importing territory, if applicable), the steel basket or the mesh bag should be cleaned of any remaining residues or contamination (which should also be eliminated without risk to the importing territory, if applicable) and be disinfected before any further use, in order to eliminate any risk of cross-contamination. This may also be necessary, depending on the risk assessed, to prevent cross-contamination with RNQPs.

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6.4 | Inspection results

Acceptance/rejection for export

A phytosanitary certificate for export can be issued for lots meeting the requirements of the importing country after a compliant export check/inspection, and the laboratory tests if applicable. Requirements and guidelines for preparing and issuing phytosanitary certificates (phytosanitary certificates for export and phytosanitary certificates for re-export) are described in ISPM No. 12 *Phytosanitary certificates* (IPPC, 2022).

For each consignment (except if not required by the importing country for ware potatoes), lots should be clearly indicated on the phytosanitary certificate. Additional declarations should be made in conformity with the requirements of the importing country. If applicable, it should be demonstrated how the specific requirements of the importing country are fulfilled. Treatments applied to the lot should be indicated in the appropriate section on the phytosanitary certificate.

Lots which do not meet the requirements of the importing country are ineligible for issuance of a phytosanitary certificate. However, such lots may be exported to another country or be traded within the exporting country if they meet the requirements of that country. In the case of a detection of an RNQP for the exporting country, phytosanitary action for non-compliance can also, in addition to treatment or destruction, include downgrading or redirection for another purpose such as direct consumption or processing (ISPM 16; IPPC, 2021c).

Acceptance/rejection at import

After completion of the import inspection and any required laboratory tests, lots that meet the requirements of the importing country can be released. If an unfamiliar pest is detected, the procedures specified in EPPO Standard PM 5/2 *Pest risk analysis on detection of a pest in an imported consignment* (EPPO, 2002) should be followed to allow the NPPO to decide what phytosanitary action to take. In case of non-compliance, the action to take is described in ISPM No. 20 (IPPC, 2024b).

If a quarantine pest is suspected or found, or an RNQP infestation is over the tolerance level, the NPPO of the importing country should immediately inform the NPPO of the exporting country and take appropriate measures, following ISPM No. 13 *Guidelines for notification of non-compliance and emergency action* (IPPC, 2021b). The NPPO of the importing country should on request provide details of the import inspection, sampling and laboratory tests done on the imported lots.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of the html version of this article.

APPENDIX 1 - SPECIFIC PROCEDURES

SYMPTOMS AND SAMPLING FOR IDENTIFICATION OF PESTS OF POTATO THAT MIGHT BE PRESENT IN POTATO TUBERS AND ATTACHED SOIL

For each of the pests of concern mentioned below, basic information on host range, biology, detection, and identification can be found in EPPO/CABI (1997) and EPPO (2025).

Information on the current distribution of relevant pests and photographs of symptoms can be found in the EPPO Global Database at https://gd.eppo.int/ (EPPO, 2025). Further information can be found in UNECE (2014) and in relevant EPPO Standards and in named scientific references. Pictures of potato tuber blemishes to support understanding and diagnosis are provided at https://www.potato-tuber-blemishes.org/.

Table A1 of Appendix 3 outlines the primary symptoms of pest damage on potato tubers and can be used in conjunction with Appendix 1.

When an International or EPPO Diagnostic Standard exists, it is recommended to implement this Standard and a reference to this Standard is provided. However, if there is no International or EPPO Diagnostic Standard, examples of diagnostic tests from the scientific literature for detection and identification are provided for information.

Indications about pest regulation in the EPPO region are only provided for the pests which are not recommended for regulation by EPPO as an A1 or A2 pest and are only provided as examples (not exhaustive).

BACTERIA

'*Candidatus* Liberibacter solanacearum' (zebra chip disease) (EPPO A1)

Symptom description

The specific symptoms consist of browning of vascular tissue and medullary rays throughout the entire length of the tuber, caused by disruptions of carbohydrate flow (Figure A1). When tuber slices are fried, these symptoms can become more pronounced with very dark blotches, stripes, or streaks (see picture available for '*Candidatus* Phytoplasma americanum'). These characteristic symptoms have led to the disease being named 'zebra chip' (EPPO, 2020). Other symptoms may also be observed on tubers: smaller, deformed tubers with rough skin, slender, hairy, weak sprouts (EFSA, 2021), as well as enlarged lenticels and sunken, pinkish stolon attachment sites where this is not a known characteristic of the variety (Crosslin & Munyaneza, 2009; Harveson et al., 2012; Secor, 2020).

Note that several haplotypes of this bacterium have been described, differing in genome, host range,

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vectors (psyllids) and geographical distribution. Only some haplotypes are known to be associated with diseases of potatoes. More information is available in the EPPO Global Database (https://gd.eppo.int/taxon/LIBEPS).

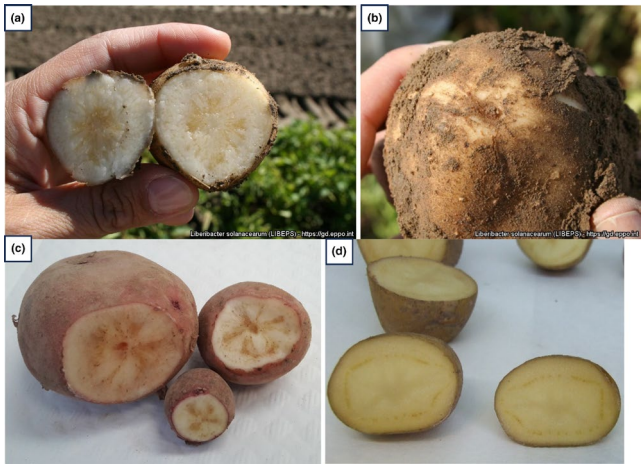

FIGURE A1 (a) Zebra chip symptoms. (b) "Pink belly", sign of severe zebra chip damage. Courtesy A&B: Oregon State University, Irrigated Agricultural Entomology Program (Rondon) (EPPO GD). (c, d) Brown discolouration and medullary rays. Haplotype E was determined. Courtesy C. Centro Regional de Diagnóstico. Junta de Castilla y León. Salamanca (ES). D. Instituto Valenciano de Investigaciones Agrarias (IVIA, ES).

Sampling, detection and identification

After cutting tubers transversally, any tubers showing symptoms should be placed in a leak proof plastic bag/box before being sent to the laboratory. Sampling, detection and identification should be performed according to EPPO Standard PM 7/143 *'Candidatus* Liberibacter solanacearum' (EPPO, 2020).

REFERENCES FOR DESCRIPTION

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'Candidatus Phytoplasma americanum' (potato purple-top wilt) (EPPO A1)

Symptom description

Symptoms may include mild vascular discoloration and brown flecking of medullary rays (see picture available for *'Candidatus* Liberibacter solanacearum') that cause caused darkening of potato chips (potato crisps) produced from infected tubers (Figure A2). Affected tubers may also produce hair sprouts (Lee et al., 2006; Secor et al., 2007; see picture available for *'Candidatus* Phytoplasma solani').

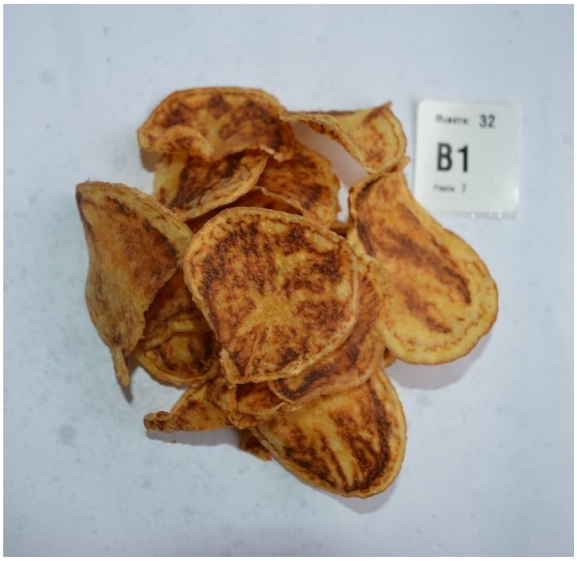

FIGURE A2 Darkening of potato crisps associated with potato purple-top wilt. Courtesy: International Potato Center (EPPO GD).

Sampling, detection and identification

After cutting tubers transversally, any tubers showing symptoms should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tuber tissue can be tested using universal phytoplasmas primers. Tests recommended for the detection and identification of *'Candidatus* Phytoplasma americanum' are described in ISPM 27 DP12 (IPPC, 2016) and EPPO Diagnostic Standard PM 7/133 (EPPO, 2018, under revision). However, false positives with bacterial species (e.g. *Paenibacillus* spp.) closely related to phytoplasmas may occur with the PCR tests recommended. For more specific detection with fewer false positives, universal real-time PCR tests using MGB modified or LNA modified probes may be used (EPPO, 2019).

REFERENCES FOR DESCRIPTION

EPPO (2018) Diagnostics. EPPO Standard. PM 7/133 Generic detection of phytoplasmas. *EPPO Bulletin* 48, 414–424.

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EPPO (2019) Phytosanitary Procedures. EPPO Standard PM 3/21(3) Post entry quarantine for potato. *EPPO Bulletin* 49, 452–479.
IPPC (2016) ISPM 27 DP12: Phytoplasmas IPPC, Rome (IT). https://openknowledge.fao.org/server/api/core/bitstreams/e9132789-5c8d-4d4d-8110-254fa5a1dad7/content
Lee I-M, Bottner KD, Secor G & Rivera-Varas V (2006) *Candidatus* Phytoplasma americanum', a phytoplasma associated with a potato purple top wilt disease complex. *International Journal of Systematic and Evolutionary Microbiology* 56, 1593–1597. https://doi.org/10.1099/ijs.0.64251-0
Secor GA, Lee IM, Bottner KD, Rivera-Varas V & Gudmestad NC (2007) First report of a defect of processing potatoes in Texas and Nebraska associated with a new phytoplasma. *Plant Disease*, 90, 377. https://apsjournals.apsnet.org/doi/10.1094/PD-90-0377B

'Candidatus Phytoplasma solani' (potato stolbur) (EPPO A2)

Symptom description

Symptomatic tubers may be flaccid and these may produce abnormal sprouts, including spindly sprouts ('hair sprouting") (Figure A3). If tuber slices are processed into fried crisps (chips) they may develop a browning like zebra chip (see *'Candidatus* Liberibacter solanacearum').

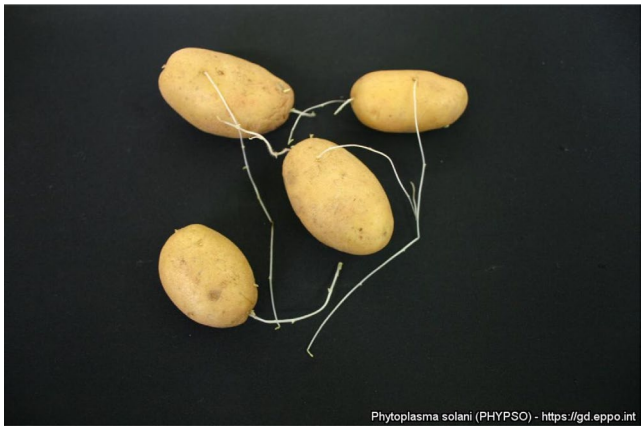

FIGURE A3 Abnormal sprouts on potato tubers. Courtesy: Uwe Preiss (EPPO GD).

Sampling, detection and identification

Affected tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tubers can be tested using universal phytoplasmas primers. Tests recommended for the detection and identification of *'Candidatus* Phytoplasma solani' are described in ISPM 27 DP12 (IPPC, 2016) and the EPPO Diagnostic Standard PM 7/133 (EPPO, 2018, under revision). For more specific detection with fewer false positives, universal real-time PCR tests using MGB modified or LNA modified probes may be used (EPPO, 2019).

Tests for the specific detection of '*Ca* Phytoplasma solani' are also described in the EPPO datasheet for '*Ca* Phytoplasma solani' (EPPO, 2024).

REFERENCES FOR DESCRIPTION

EPPO (2018) EPPO Diagnostic Standard. PM 7/133 Generic detection of phytoplasmas. *EPPO Bulletin* 48, 414–424.
EPPO (2019) EPPO Phytosanitary Procedure. PM 3/21(3) Post entry quarantine for potato. *EPPO Bulletin* 49, 452–479.
EPPO (2024) *'Candidatus Phytoplasma solani'*. EPPO datasheets on pests recommended for regulation. https://gd.eppo.int/taxon/PHYPSO/datasheet (accessed 2024-10-01).
IPPC (2016) *ISPM 27 DP12: Phytoplasmas*. IPPC, Rome (IT). https://openknowledge.fao.org/server/api/core/bitstreams/e9132789-5c8d-4d4d-8110-254fa5a1dad7/content

Clavibacter sepedonicus (ring rot) (EPPO A2)

Symptom description

Tuber infection occurs through the stolon. The initial symptom is a light-yellow glassy discoloration of the vascular ring of the tuber at the stolon end ('heel-end'). This develops into a darker creamy yellow to light brown stain of the vascular ring with a crumbly to cheesy consistency, distinct from that of *Ralstonia solanacearum*. In the case of *R. solanacearum*, a creamy fluid exudate usually appears spontaneously on the vascular ring of the cut surface a few minutes after cutting. In the case of *C. sepedonicus*, when pressure is applied on the tuber, a bacterial exudate with cheesy consistency is squeezed out of the vascular area. In severe cases, the vascular ring disintegrates, forming cavities and internal hollowing. Such diseased tubers commonly show reddish brown blotches near the eyes and irregular shaped cracks on the skin. The affected tuber may then become crumbly and powdery, and is readily invaded by soft rot bacteria and secondary decay organisms. Infected tubers may mummify. Although not frequently mentioned in the literature, a distinctive feature can be the progression of the disease from the heel end to the central cortex of the tuber. Secondary rotting may develop, extending from the vascular tissues into the central cortex (Figure A4). Tuber symptoms may appear similar to brown rot caused by *R. solanacearum* in the initial stages of infection (EPPO, 2022). The rot/creamy ooze is odourless (EFSA, 2020; UNECE, 2014).

Although the symptoms of *C. sepedonicus* may be visible, it should be noted that tubers are most likely to be latently infected (non-symptomatic) (EFSA, 2020; EPPO, 2022).

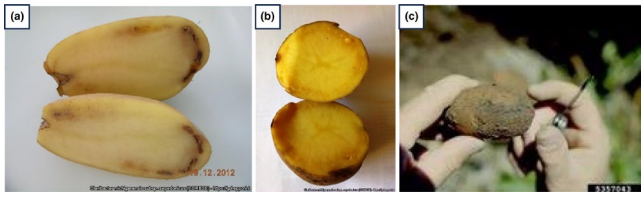

FIGURE A4 (a) Symptoms on potato tubers. Courtesy: French plant health laboratory (ANSES). (b) Initial symptom of potato ring rot infection on potato tubers (a soft cheese-like rotting of the vascular ring). Courtesy: Maria A. Kuznetsova (All-Russian Institute of Phytopathology) (EPPO GD). (c) External signs of ring rot. Courtesy: William M. Brown (Bugwood.org).

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Sampling, detection and identification

In case of suspicious symptoms, the whole tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. Tests recommended for the detection and identification of *Clavibacter sepedonicus* as well as sampling procedures are described in EPPO Diagnostic Standard PM 7/59 *Clavibacter sepedonicus* (EPPO, 2022), for symptomatic or asymptomatic tubers.

REFERENCES FOR DESCRIPTION

EPPO (2022) Diagnostics. EPPO Standard PM 7/59(2) *Clavibacter sepedonicus*. *EPPO Bulletin* 52, 262–285.

EFSA (2020) European Food Safety Authority. Pest survey card on *Clavibacter sepedonicus*. EFSA supporting publication 2020:EN-1929. Available online: https://efsa.europa.eu/plants/plant health/monitoring/surveillance/clavibacter-sepedonicus . (last updated: 2020-09-08).

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Dickeya and *Pectobacterium* (soft rot, wet rot, blackleg) (RNQP for the EU)

Symptom description

Symptoms on infected tubers caused by *Dickeya* spp. and *Pectobacterium* spp. can be very similar. These may be visible from the outside of the tuber depending on the severity of infection and soil conditions. Cutting open the symptomatic tuber will reveal macerated tissue with a cheesy or jelly like consistency which can show purple to black margins when exposed to air and can develop an unpleasant odour. However, symptomatic tubers infected by *D. dianthicola* or *D. solani* typically produce little or no odour. Tuber soft rot can be initiated at lenticels, stolon end ('heel-end') and/or in wounds under wet conditions and the rotting can spread to the whole tuber (EPPO, 2023) (Figure A5).

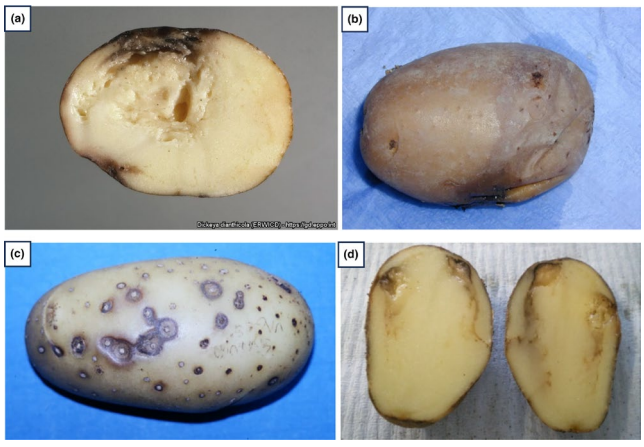

FIGURE A5 (a) Potato soft rot caused by *Dickeya dianthicola*. Courtesy: FERA crown copyright (EPPO GD). (b) Liquefaction of a naturally infected mother tuber of potato diagnosed with *Dickeya solani*. Courtesy of J. Van Vaerenbergh (ILVO, Belgium) (EPPO PM 7/155). (c, d) Lenticel or pit rot on tubers of potato diagnosed with *Pectobacterium carotovorum*. Courtesy of V. Hélias and Y. Le Hingrat (INOV3PT, France) and J. Van Vaerenbergh (ILVO, Belgium) (EPPO PM 7/155).

Sampling, detection and identification

The whole symptomatic tuber should be wrapped in dry absorbent paper and placed in a leak resistant card box before being sent to the laboratory. Tests recommended for the detection and identification of *Dickeya* spp. and *Pectobacterium* spp. are described in EPPO Diagnostic Standard PM 7/155 '*Pectobacterium* spp. and *Dickeya* spp.' (EPPO, 2023), which includes isolation and molecular tests for detection or identification of the genus or species.

Note that the use of laboratory testing is generally performed in special cases of zero tolerance (e.g. microplants, quarantine organisms) or for confirmation of a visual inspection on symptomatic tubers only, due to the worldwide presence and complex epidemiological characteristics of these bacterial genera (disease development and expression are strongly influenced by environmental conditions, unrelated to the bacterial load of mother tubers).

REFERENCES FOR DESCRIPTION

EPPO (2023) Diagnostics. EPPO Standard PM 7/155 (1) *Pectobacterium* spp. and *Dickeya* spp. *EPPO Bulletin* 53, 309–353. Available at https://onlinelibrary.wiley.com/doi/epdf/10.1111/epp.12935

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Ralstonia solanacearum species complex (bacterial wilt, brown rot): *R. pseudosolanacearum* (EPPO A2), *R. solanacearum* sensu stricto (EPPO A2), *R. syzygii* (EPPO A1)

Remark for *R. syzygii*: only subsp. *indonesiensis* is known to affect potato.

Symptom description

On tubers, external symptoms may or may not be visible, depending on the state of development of the disease. Infection eventually results in bacterial ooze emerging from the eyes and stolon end attachment of infected tubers. Soil may adhere to the tubers at the eyes. Cutting the diseased tuber will reveal a browning and eventual necrosis of the vascular ring and immediately surrounding tissues. A creamy fluid exudate usually appears spontaneously on the vascular ring of the cut surface a few minutes after cutting. This differs from ring rot infection where the tuber must be squeezed to press out a mass of yellowish macerated vascular tissue and bacterial slime. Lenticel infections have been described by Rodrigues-Neto et al. (1984) (EPPO, 2022) (Figure A6).

Sampling, detection and identification

In case of suspicious symptoms, the whole tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. Tests recommended for the detection and identification of *Ralstonia solanacearum, R. pseudosolanacearum* and *R. syzygii* are described in EPPO Diagnostic Standard PM 7/21 *Ralstonia*

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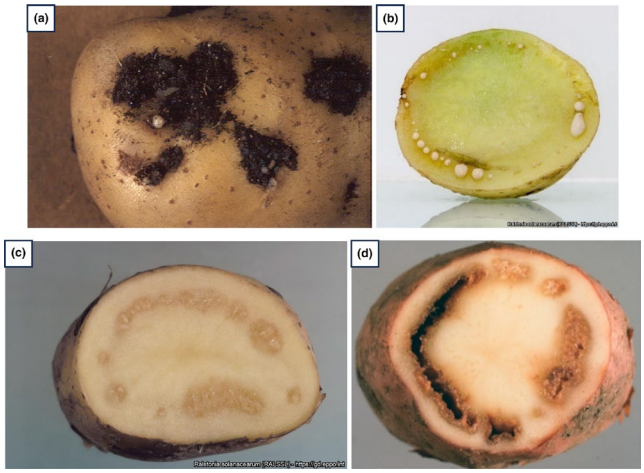

FIGURE A6 (a) Bacterial ooze from potato eye. Courtesy J. Janse, PD Wageningen (NL). (b) Potato affected by bacterial wilt and its characteristic white oozing. Courtesy: Gilles Cellier (ANSES, FR). (c) Glassiness and ooze in a tuber infected with *Ralstonia solanacearum*. (d) Advanced symptoms. Courtesy (c, d): A. Aspin (Fera Science Ltd., British Crown) (EPPO GD).

solanacearum, R. pseudosolanacearum and *R. syzygii* (*Ralstonia solanacearum* species complex) (EPPO, 2022), including tests for symptomatic or asymptomatic tubers.

REFERENCES FOR DESCRIPTION

EFSA (2020) European Food Safety Authority (EFSA). Pest survey card on *Ralstonia solanacearum*. EFSA supporting publication 2020:EN-1918. Available online: https://efsa.europa.eu/plants/planthealth/monitoring/surveillance/ralstonia-solanacearum . (last updated 2020-07-31).

EPPO (2022) Diagnostics. EPPO Standard PM 7/21 *Ralstonia solanacearum*, *R. pseudosolanacearum* and *R. syzygii* (*Ralstonia solanacearum* species complex). *EPPO Bulletin* 52, 225–261.

EPPO (2025) *Ralstonia solanacearum species complex*. EPPO datasheets on pests recommended for regulation. https://gd.eppo.int (accessed 2025-04-28).

Rodrigues-Neto J, Malavolta VA & Hamahiga I (1984) [Atypical symptoms in potato tubers infected with *Pseudomonas solanacearum* (Smith) Smith]. *Biologico* 50, 93–95.

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Streptomyces ('common scab' regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project[1])

Symptom description

Streptomyces scab diseases show some variability of symptoms, depending on the bacterial species, the ecological conditions and the cultivar. They have been separated into two main diseases:

- common scab (raised or pitted scab) caused by several *Streptomyces* species including *S. scabiei*, *S. europaeiscabiei*, *S. bottropensis*.
- netted scab caused by *Streptomyces reticuliscabiei* and some strains of *S. europaeiscabiei*.

Symptoms of common scab are characterized by corky lesions of three types: shallow scab (superficial and roughened lesions), raised scab (slightly raised lesions which may form large scabby areas) and deep or pitted-scab (roughly circular or star-shaped lesions which may form craters).

Symptoms of netted scab are superficial corky and russet spots that usually coalesce to form a network of polygonal lesions on the tuber surface (Figure A7).

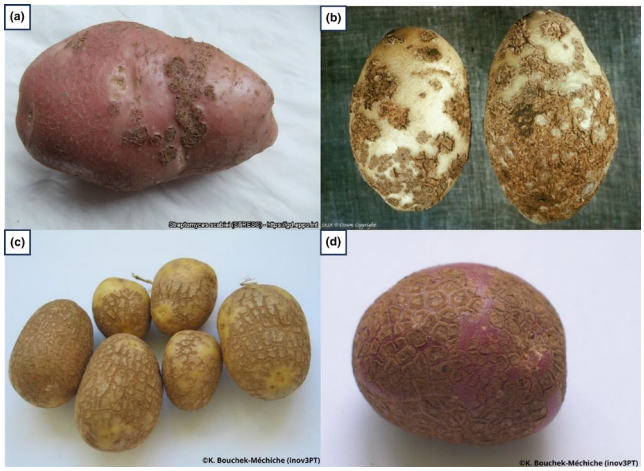

FIGURE A7 (a, b) Common scab of potato caused by *Streptomyces scabiei*. (c, d) Netted scab caused by *S. reticuliscabiei*. Courtesy: (a) Maria A. Kuznetsova (All-Russian Research Institute of Phytopathology); (b) SASA; (c, d) Karima Boucheck (INOV3PT) (EPPO GD). *Additional pictures are available in* Bugwood.org.

Sampling, detection and identification

The whole tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature (Bouchek-Mechiche et al., 2000, 2006; Lehtonen et al., 2004; Wanner, 2004, 2006). Because symptoms are readily visible on tubers, visual examination is commonly used to detect the disease. In some cases, common scab symptoms may be confused with those caused by *Spongospora subterranea* (powdery scab) which can produce surface lesions on tubers. A microscopic examination can sometimes be used to distinguish the two diseases, by revealing spore balls on the mature powdery scab lesions. The phenomenon of enlarged and suberized lenticels, which frequently occur when tubers were under conditions of excessive humidity in the field, can also be confused with common scab symptoms, although the

[1]The assessment was performed by EPPO following a 2-year project on RNQPs funded by the European Commission (Picard et al., 2018).

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brown dots formed at the lenticels are smaller and paler than the damage caused by common scab. When confirmation of the visual diagnosis or identification of the species is needed, additional tests should be performed: For example, isolation of *Streptomyces* spp. on Potato Dextrose Agar plus the addition of $CaCO_3$, amplifying the TxtAB gene for common scab or on susceptible potato varieties for netted scab and identification of the species by using species-specific primers (https://www.potato-tuber-blemishes.org/symptoms/pitted-or-raised-symptoms/common-scab).

REFERENCES FOR DESCRIPTION

Bouchek-Mechiche K., Pasco C., Andrivon D & Jouan B (2000) Differences in host range, pathogenicity to potato cultivars and response to soil temperature among Streptomyces species causing common and netted scab in France. *Plant Pathology* 49, 3–10. Available at 10.1046/j.1365-3059.2000.00419.x

Bouchek-Mechiche K, Gardan L, Andrivon D & Normand P (2006) *Streptomyces turgidiscabies* and *Streptomyces reticuliscabiei*: one genomic species, two pathogenic groups. *International Journal of Systematic and Evolutionary Microbiology* 56(Pt 12), 2771-2776. Available at 10.1099/ijs.0.63161-0

INRAE (2023) *Potato tuber blemishes*, Common scab & Netted scab. INRAE (FR). https://www.potato-tuber-blemishes.org/ (accessed 2025-02-27).

Lehtonen MJ, Rantala H, Kreuze JF, Bång H, Kuisma L, Koski P, Virtanen E, Vihlman K & Valkonen JPT (2004) Occurrence and survival of potato scab pathogens (Streptomyces species) on tuber lesions: quick diagnosis based on a PCR-based assay. *Plant Pathology* 53, 280–287. Available at 10.1111/j.0032-0862.2004.01009.x

The French seed potato (2025) Diseases and pests. Common scab and Netted scab (Streptomyces spp.). SEMAE, FN3PT (FR). https://www.plantdepommedeterre.org/en/maladie-ravageur/common-scab-and-netted-scab/ (accessed 2025-02-27).

Wanner LA (2004) Field isolates of Streptomyces differ in pathogenicity and virulence on radish. *Plant Disease* 88, 785–796. Available at 10.1094/PDIS.2004.88.8.785

Wanner LA (2006) A survey of genetic variation in Streptomyces isolates causing potato common scab in the United States. *Phytopathology* 96, 1363–1371. Available at 10.1094/PHYTO-96-1363

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Chromista

Phytophthora erythroseptica (pink rot) ('wet rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Soft or wet rot develops on the outside and inside of infected tubers: Affected tubers are rubbery in texture and have brown necrotic areas on the surface, usually at the stem end or around eyes and lenticels. The tubers may have a sweet distinctive smell e.g. resembling formaldehyde, and ooze a clear liquid if squeezed hard. When the tubers are cut transversely, the flesh has a spongy texture which, after about 20 min exposure to the air, turns pink and finally blackens over time (Figure A8). This change in flesh colour is characteristic of the disease, and distinguishes it from other types of rot, such as those caused by *Pythium* spp. or *Phytophthora infestans*. Cavities do not develop in the flesh (IRIIS phytoprotection, 2025; UNECE, 2014; Wharton & Kirk, 2007).

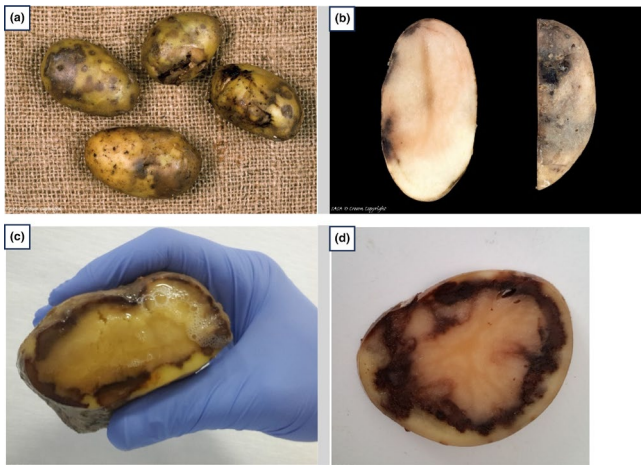

FIGURE A8 (a) External symptoms. (b) Cross section and external symptoms. (c) Squeezed potato tuber infected with *Phytophthora erythroseptica*. (d) Brown necrotic areas and flesh starting to turn pink after air exposure. Courtesy: (a, b): SASA (EPPO GD). (c, d): E. Çakir (TR) (EPPO GD). *Additional pictures are available in* Bugwood.org, https://beta.iriisphytoprotection.qc.ca/fr/node/42116 *and EPPO GD.*

Sampling, detection and identification

The whole tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Diagnosis begins with a thorough visual examination to detect the characteristic external and internal symptoms (in particular the pink discoloration of the flesh appearing after a while on the cut surface of the tubers). Isolation on agar selective medium, followed by a microscopic observation of the reproductive structures (reference to the morphological characteristics is given by Ho & Jong, 1989), may be sufficient for the identification of the species. An example of a diagnostic protocol on potato tubers is provided by Çakır et al. (2020) and includes isolation, morphological identification and if required molecular identification by amplification of ITS 4 and ITS 6, Cox and βtubulin regions from mycelial DNA, followed by sequencing and a BLAST analysis of the sequences produced.

For the detection of *Phytophthora erythroseptica* directly from potato tuber tissue, conventional PCR tests such as those of Tooley et al. (1997), used by El Hadrami et al. (2007), modified by Nanayakkara et al. (2009); and the test of Cullen et al. (2007), have been developed. Additionally, real-time PCR tests may be used (Atallah

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& Stevenson, 2006; Cullen et al., 2007). However, all these tests may also detect the closely related *P. cryptogea*, which may also cause pink rot. Therefore, if differentiation of *P. erythroseptica* and *P. cryptogea* is required, further analysis such as sequencing the PCR product from conventional PCR may be required.

REFERENCES FOR DESCRIPTION

Atallah ZK & Stevenson WR (2006) A methodology to detect and quantify five pathogens causing potato tuber decay using real-time quantitative polymerase chain reaction. *Phytopathologie* 96, 1037-1045. https://apsjournals.apsnet.org/doi/epdf/10.1094/PHYTO-96-1037

Çakır E, Ertek TS, Katırcıoğlu YZ & Maden S (2020) Occurrence of potato pink rot caused by *Phytophthora erythroseptica* in Turkey, with special reference to *Phytophthora cryptogea*. *Australasian Plant Disease Notes* 15, 14. https://doi.org/10.1007/s13314-020-0379-9

Cullen DW, Toth IK, Boonham N, Walsh K, Barker I & Lees AK (2007) Development and validation of conventional and quantitative polymerase chain reaction assays for the detection of Storage Rot potato pathogens, *Phytophthora erythroseptica*, *Pythium ultimum* and *Phoma foveata*. *Journal of Phytopathology* 155, 309–315.

El Hadrami A, Wally O, Adam LR & Daayf F (2007) PCR-based determination of colonization patterns during potato tuber infection by single and multiple pathogens. *European Journal of Plant Pathology* 117, 201–218. 5 https://link.springer.com/article/10.1007/s10658-006-9077-5

Ho HH & Jong SC (1989) Phytophthora erythroseptica. *Mycotaxon* 36(1), 73-90.

IRIIS phytoprotection (2025. Pourriture rose - Pomme de terr. CRAAQ (CA). https://www.iriisphytoprotection.qc.ca/Fiche/Champignon?imageId=8024 (accessed 2025-02-27).

Nanayakkara UN, Singh M, Al-Mughrabi KI & Peters RD (2009) Detection of *Phytophthora erythroseptica* in above-ground potato tissues, progeny tubers, stolons and crop debris using PCR techniques. *American Journal of Potato Research* 86, 239-245. https://link.springer.com/article/10.1007/s12230-009-9077-z

Tooley PW, Bunyard BA, Carras MM & Hatziloukas E (1997) Development of PCR primers from internal transcribed spacer region 2 for detection of Phytophthora species infecting potatoes. *Appl. Environ. Microbiol.* 63, 1467-1475. https://journals.asm.org/doi/pdf/10.1128/aem.63.4.1467-1475.1997

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Wharton P & Kirk W (2007) Pink rot Bulletin E2993 Michigan State University available at: https://www.canr.msu.edu/resources/potato_diseases_pink_rot_e2993

Phytophthora infestans (potato late blight) ('dry rot, wet rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Dry and soft or wet rot develops on the outside and the inside of infected tubers: Infected tubers show dark-brown or purplish-grey spots on the surface. The internal rot is reddish-brown, granular just under the epidermis and may extend to the centre of the tuber. Affected tubers generally have flesh, with brown areas, that remains firm (Figure A9). But other pathogens can then develop and cause wet rot (UNECE, 2014).



FIGURE A9 (a) Symptoms of potato late blight. Courtesy: Carlos Alberto Coutinho Conceição (EPPO GD). (b) External symptoms. Courtesy: Alessio Vitale, Caltagirone (EPPO GD).

Sampling, detection and identification

The whole symptomatic tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Diagnosis begins with a thorough visual examination to detect the characteristic external and internal symptoms. Signs of the fungus can be observed on the surface (hyphae and/or sporangia) in particular if the tuber is placed in a moist chamber for 24 h at 18°C. Isolation can be performed on agar selective medium, followed by a microscopic observation of the reproductive structures (see Sobkowiak and Śliwka (2017) for an example of a detailed procedure).

Lastly, for identification of the species, PCR tests using specific primers can be performed on the mycelial tissue from pure cultures. Ligase chain reaction (Tooley et al., 2002), conventional PCR (Hussain et al., 2005; Judelson & Tooley, 2000; Tooley et al., 1998; Trout et al., 1997) or real-time PCR (Atallah & Stevenson, 2006) tests have been developed for detection of the species in plant tissue.

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Trout CL, Ristaino JB, Madritch M & Wangsomboondee T (1997) Rapid detection of *Phytophthora infestans* in late blight-infected potato and tomato using PCR. *Plant Disease* 81, 1042-1048.
UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Pythium spp. (watery wound rot, leak rot) ('wet rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Soft or wet rot develops on the outside and the inside of infected tubers: The tuber surface shows greyish or brownish-brown surface lesions with a watery or greasy appearance. Observation of the flesh reveals the affected tissue, which is cream to brown in colour and spongy in texture, clearly separated from the healthy parts by a dark line. Rotten tissues turn dark on exposure to air and have an alcoholic to slight fishy smell. Cavities may be formed in the flesh (UNECE, 2014) (Figure A10).

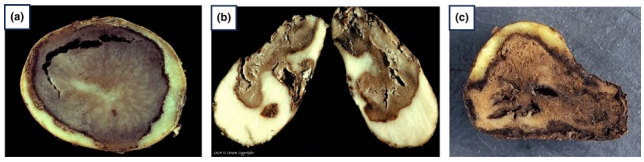

FIGURE A10 (a–c) Symptoms of watery wound rot caused by *Pythium ultimum*. Courtesy: SASA (EPPO GD).

Sampling, detection and identification

The whole tuber should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}). Species identification can be achieved by microscopic observation of the morphology of asexual and sexual structures and using the key for *Pythium* spp. found in Van der Plaats-Niterink (1981) and in Pennsylvania State University (2024).

Molecular tests for species identification from mycelial DNA are listed in Schroeder et al. (2013). The most accurate approach for identification to species level consists in sequencing specific loci and doing a BLAST analysis (using ITS region, Cox-1 and Cox-2 genes which allow many *Pythium* spp. to be identified thanks to the large number of published reference sequences). If using primers ITS1 and ITS4, an amplicon of 828 bp is obtained (Li & Zhang, 2020). For the detection of *P. ultimum* directly from potato tuber tissue, conventional PCR tests (Cullen et al., 2007; El Hadrami et al., 2007 who used the primers of Kageyama et al., 1997) and real-time PCR tests (Atallah & Stevenson, 2006; Cullen et al., 2007) have been developed.

REFERENCES FOR DESCRIPTION

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Cullen DW, Toth IK, Boonham N, Walsh K, Barker I & Lees AK (2007) Development and validation of conventional and quantitative polymerase chain reaction assays for the detection of storage rot potato pathogens, *Phytophthora erythroseptica*, *Pythium ultimum* and *Phoma foveata*. *J Phytopathol* 155, 309–315.
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Fungi/Protista

Alternaria spp. (early potato blight) ('dry rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Although foliage can be infected by several *Alternaria* spp. (Schmey et al., 2024; Žarko et al., 2022) causing for example brown spot and early blight disease, only *A. alternata* (a small spored *Alternaria* species) and *A. solani* (a large spored *Alternaria* species) appear to have been reported infecting potato tubers. The fungus can only infect through wounds, for example those caused at harvest. Infected tubers develop a largely superficial dry rot. For *A. alternata* which has been described as black pit or black pit disease, lesions are circular in shape about 5–10 mm in diameter, dark brown to black appearing dry and slightly sunken (Droby et al. 1984; Potatoes South Africa, 2016). For *A. solani*, lesions are irregular in shape and may range from about 5 to 50 mm in diameter. They are dark brown to black, are dry and slightly sunken and have a raised purplish border (Figure A11). When tubers

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are cut through the lesions, appear as a dry, dark brown rot, which is generally much shallower (around 1.5 mm) than that of late blight (*Phytophthora infestans*). Lesions are sharply set off from healthy tissue by a corky layer (McGrath, 2021; The French seed potato, 2025). However, since it is possible that symptoms may vary between the two *Alternaria* species, tubers should be sent to the laboratory for analysis if species identification is required.

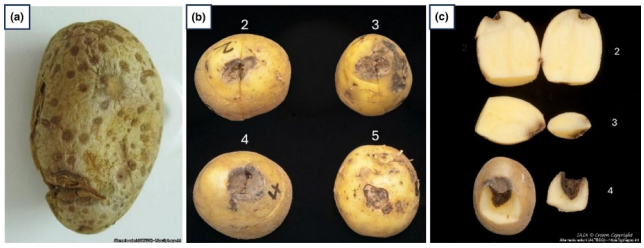

FIGURE A11 (a) Lesions caused by *Alternaria solani*. Courtesy: J. van der Waals (EPPO GD). (b) External symptoms caused by *Alternaria solani* in tubers 2–5. (c) Internal symptoms caused by *Alternaria solani* in tubers 2–4. Courtesy (b, c): SASA (EPPO GD). *Additional pictures are available in Bugwood.org.*

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}).

Culture morphological characteristics for *A solani* are described by Ellis & Gibson (1975) and Zhao et al. (2018). Those for *A alternata* are described by Zhao et al. (2018). If necessary, isolation can be confirmed using PCR to amplify the internal transcribed spacer (ITS) region of rDNA from mycelial DNA with primers ITS4/ITS6 (SASA, personal communication, 2024), and sequenced, followed by a BLAST analysis of the sequence produced. For the detection of *A. alternata* and *A. solani* direct from plant tissue, various conventional (e.g. Kokaeva et al., 2018) and real-time (e.g. Leiminger et al., 2015) PCR tests have been developed.

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Athelia rolfsii (sclerotium stem rot) (synonym: *Sclerotium rolfsii*) (wet rot symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Tubers are typically infected through the stolons. The fungus quickly grows over the tuber surface and invades, resulting in a moist cheesy decay. White hyaline septate mycelium may be observed on the surface of incubated tubers at harvest or if these are incubated at 25°C. Small spherical sclerotia (about 1–2 mm in diameter) may be seen that are white when young and brown when mature (UCIPM) (Figure A12).

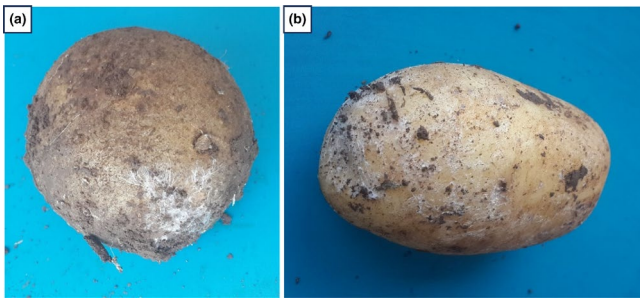

FIGURE A12 (a, b) Symptoms of *Athelia rolfsii*. Courtesy: E. Çakir (TR) (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. *Athelia rolfsii* will produce white hyaline septate mycelium on PDA followed by light to dark brown septated sclerotia

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1–2 mm in diameter (Mordue, 1974). Culture morphological characteristics are also described by Nájera (2018). If necessary, identification of the isolate can be confirmed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS5/ITS4 and sequenced, followed by a BLAST analysis of the 620-bp sequence produced (Roca et al., 2016). Various real-time PCR tests (for example Gao et al., 2015) have been developed for the specific detection of *A. rolfsii* from plant tissue, but not from potato.

REFERENCES FOR DESCRIPTION

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Roca LF, Raya MC, Luque F, Agustí-Brisach C, Romero J & Trapero A (2016) First report of *Sclerotium rolfsii* causing soft rot of potato tubers in Spain. *Plant Disease* 100, 2535-2535. https://apsjournals.apsnet.org/doi/full/10.1094/PDIS-12-15-1505-PDN

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Boeremia (potato gangrene) ('dry rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project) & *Boeremia foveata* (synonym: *Phoma exigua* var. *foveata*) (Azerbaijan and Türkiye A1 List; Israel, Morocco and Tunisia quarantine pest List)

Symptom description

Initially the lesions are round, dark and slightly depressed, often like a thumb mark. As lesions develop, they become black and sunken with an irregular wavy edge. Wrinkles tend to stretch across the lesion rather than the concentric rings expected with dry rots. Black pycnidia may form on the surface. Rotted tissue is generally brown or black with a well-defined margin between healthy and diseased tissue. Cavities are usually lined with purple, yellow or white mycelia (Figure A13). Gangrene symptoms may also be caused by less aggressive *Boeremia* spp., e.g. *B. exigua* (AHDB, 2024; UNECE, 2014).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}).

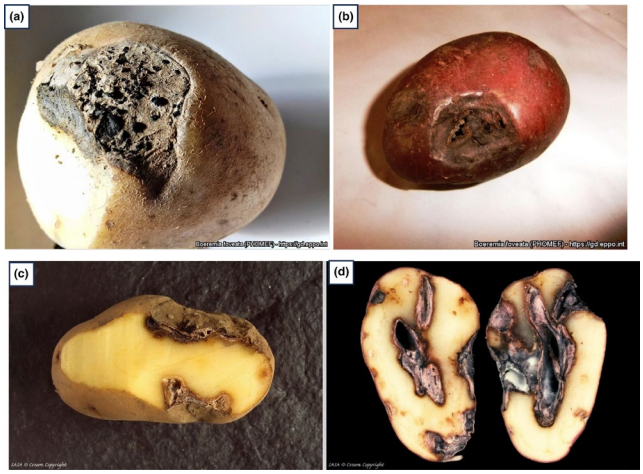

FIGURE A13 (a, b) External tuber symptoms of gangrene (close-up). Courtesy: Maria A. Kuznetsova (All-Russian Research Institute of Phytopathology) (EPPO GD). (c, d) Internal tuber symptoms of gangrene caused by *Boeremia foveata*. Courtesy: SASA (EPPO GD).

Culture morphological characteristics for *B. foveata* and *B. exigua* are described by Boerema (1967) and for *B. foveata* by CABI (2021). Morphologically *B. foveata* and *B. exigua* are similar, except that *B. foveata* usually produces a yellow brown anthraquinone pigment. A selective medium is also available for isolation (Jeffries et al., 1984). The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS1/ITS4 and sequenced, followed by a BLAST analysis of the sequence produced (Yang et al., 2012). Molecular tests such as RAPD generated PCR-RFLP (MacDonald et al., 2000) are also available for the identification of each species in culture.

For the detection of *B. foveata* and *B. exigua* direct from tuber tissue conventional and real-time PCR tests have been developed (Cullen et al., 2007). However, these do not differentiate the species and therefore if this was required further analysis would be required. The multiplex real-time PCR of A'Hara et al. (2012) enables detection and identification of each species.

REFERENCES FOR DESCRIPTION

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Cullen DW, Toth IK, Boonham N, Walsh K, Barker I & Lees AK (2007) Development and validation of conventional and quantitative polymerase chain reaction assays for the detection of Storage Rot potato pathogens, *Phytophthora erythroseptica*, *Pythium ultimum* and *Phoma foveata*. *Journal of Phytopathology* 155, 309–315. https://doi.org/10.1111/j.1439-0434.2007.01233.x

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Colletotrichum coccodes (black dot) (RNQP for Israel, Jordan)

Symptom description

Tuber skin blemish disease occurring as silvery, irregularly shaped lesions present at harvest (UNECE, 2014). Affected skin initially appears light brown to unblemished. Later unsightly dark brown patches can develop. Lesions tend to be irregularly shaped and often without a defined outline. Lesions can look silvery leading to confusion with silver scurf. Black fructifications (microsclerotia), visible with the naked eye, can develop (Figure A14). These fructifications allow to differentiate this disease from silver scurf because they are larger and produce bristles (setae) at high relative humidity which are easily seen under a hand lens (10× magnification). Deep sunken lesions, sometimes associated with dry rot of the underlying tissues, may occur after cold storage (AHDB, 2022; INRAE, 2023).

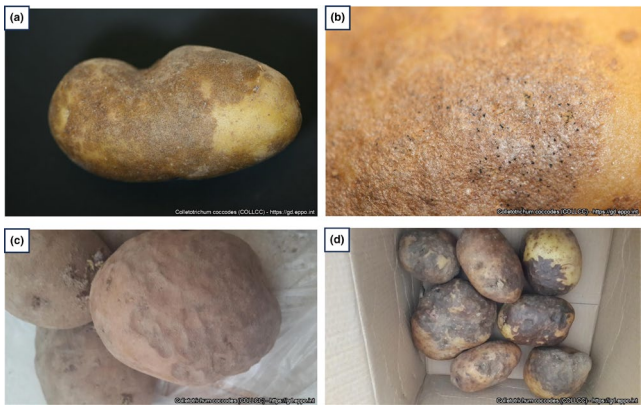

FIGURE A14 (a) External symptoms. (b) Black dot. Courtesy (a, b): Y Le Hingrat (FN3PT, FR). (c, d) Atypical symptoms of depression after cold storage. Courtesy (c, d): E Çakir (Plant Protection Central Research Institute, TR) (EPPO GD). *Additional pictures are available in EPPO GD.*

Sampling, detection and identification

Symptomatic tuber(s) should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) using pieces of affected tissue. A semi-selective medium, pectate-NPX, can also be used (Platt & Bollen, 1995). Morphological characteristics are described by Mordue (1967). If necessary, identification of the isolate can be performed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS1/ITS4.

If required molecular conventional and real time tests such as those developed by Cullen et al. (2002) and Ryazantsev et al. (2023) may be used to confirm the presence of *C. coccodes* infecting potato tubers.

REFERENCES FOR DESCRIPTION

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Ryazantsev DY, Chudinova EM, Kokaeva LY, Elansky SN, Balabko PN, Belov GL, Zavriev SK (2023) Detection of *Colletotrichum coccodes* by real-time PCR. *Biology Bulletin Reviewsv* 13, S108–S113. https://doi.org/10.1134/S2079086423070101

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Fusarium (potato dry rot) (RNQP in Switzerland and the United Kingdom; 'dry rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Symptoms depend on the infecting species. *F. caeruleum*: circular rot with concentric wrinkles on skin and white, orange or blue mycelial growth on surface. Light brown rot with a diffuse edge develops inwards from skin. *F. sambucinum*: small lesions develop at wounds and expand producing symptoms externally like gangrene, i.e. slightly depressed and irregular in shape. Internally, lesions develop cavities filled with a grey, powdery tissue. *F. avenaceum*: symptoms tend to be similar to *Fusarium caeruleum*, although rots are often smaller and affected tissue is dark brown (AHDB, 2024; UNECE, 2014). *F. culmorum*: *lesions are often dry and* dark brown, with a well-defined margin, sometimes resembling tunnels in cross-section (Figures A15–A18).

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FIGURE A15 (a–c) External and internal symptoms caused by *Fusarium caeruleum*. Courtesy: SASA (EPPO GD).



FIGURE A16 (a, b) External and internal potato tuber symptoms caused by *Fusarium sambucinum*. Courtesy: SASA (EPPO GD).

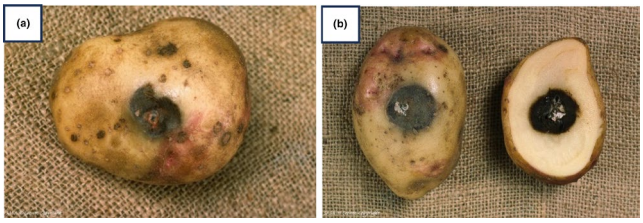

FIGURE A17 (a, b) External and internal potato tuber symptoms caused by *Fusarium avenaceum*. Courtesy: SASA (EPPO GD).

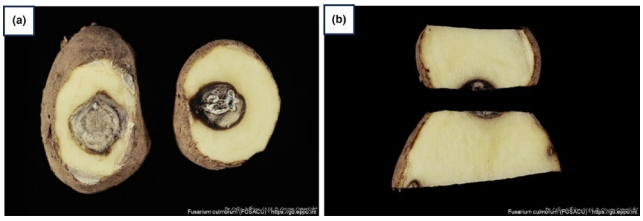

FIGURE A18 (a, b) Dry rot caused by *Fusarium culmorum*. Courtesy: C. Jeffries, SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) or with a semi-selective medium (Jeffries et al., 1984). The mycelium is coloured blue for *Fusarium caeruleum*, peachy orange for *F. sambucinum* and pink-red for *F. avenaceum* and *F culmorum*. Morphological characteristics are described by Booth & Waterson (1967a, 1967b) and Booth (1971, 1978). If necessary, identification of the isolate can be confirmed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS1/ITS4 and sequenced (Kim et al., 2024), followed by a BLAST analysis of the sequence produced.

For detection direct from potato tubers conventional and real-time PCR tests such as those developed by Cullen et al. (2005) can be used to confirm the presence of *F. avenaceum*, *F. caeruleum*, *F. culmorum* and *F. sambucinum*. An alternative real-time PCR test for *Fusarium caeruleum* has been developed by Heltoft et al. (2016).

REFERENCES FOR DESCRIPTION

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Booth C & Waterston JM (1967a) CMI Descriptions of Pathogenic Fungi and Bacteria No. 25 *Fusarium avenaceum*.

Booth C & Waterston JM (1967b) CMI Descriptions of Pathogenic Fungi and Bacteria No. 26 *Fusarium culmorum*.

Booth C (1978) CMI Descriptions of Pathogenic Fungi and Bacteria No. 574 *Fusarium sulphureum*.

Booth C (1971) Fusarium, Laboratory Guide to the Identification of the Major Species. Commonwealth Mycological Institute, Kew, Surrey, England.

Cullen DW, Toth IK, Pitkin Y, Boonham N, Walsh K, Barker I & Lees AK (2005) Use of quantitative molecular diagnostic assays to investigate Fusarium dry rot in potato stocks and soil. *Phytopathology* 95, 1462-1471. https://apsjournals.apsnet.org/doi/10.1094/PHYTO-95-1462

Heltoft P, Brurberg MB, Skogen M, Le VH, Razzaghian J & Hermansen A (2016) *Fusarium* spp. causing dry rot on potatoes in Norway and development of a real-Time PCR method for detection of *Fusarium coeruleum*. *Potato Research* 59, 67–80. https://doi.org/10.1007/s11540-015-9313-5

Jeffries CJ, Boyd AEW & Paterson LJ (1984) Evaluation of selective media for the isolation of *Fusarium solani* var. *coeruleum* and *Fusarium sulphureum* from soil and potato tuber tissue. *Annals of Applied Biology* 105, 471-481. https://doi.org/10.1111/j.1744-7348.1984.tb03073.x

Kim NS, Hong SJ, Won HS, Kim BS & Se Hwi Gwon SH (2024) Identification and pathogenicity of species isolated from stored potato tubers showing symptoms of dry rot disease. *Potato Research* 67, 1797–1808. https://doi.org/10.1007/s11540-024-09709-0

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Geotrichum candidum (watery soft rot) ('wet rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

The tuber surface is discoloured with patches of white mycelium developing on surface which feels damp (also described as rubbery rot by UNECE, 2014) (Figure A19). Internally, a grey, watery rot develops rapidly inwards from skin. When cut, the tubers exude water with a sour milk or vinegary smell (UNECE, 2014).

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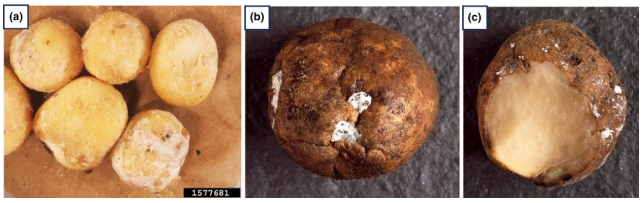

FIGURE A19 (a) White sporulation on potato tuber. Courtesy: Gerald Holmes (Strawberry Center, Cal Poly San Luis Obispo) (Bugwood.org). (b, c) External and internal symptoms. Courtesy: SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}). Colonies have a white, dense, and creamy appearance. Hyphae are hyaline, septate, dichotomously branched, and broken into chains of cylindrical to oval-shaped, single-celled arthrospores ranging in size from about 3.8 to 5.3 µm × 5.4 to 12.5 µm. If necessary, identification of the isolate can be confirmed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS1/ITS4 and sequenced, followed by a BLAST analysis of the 369 bp sequence produced (Hu, 2024). As far as is known, no molecular tests have been developed to detect *G. candidum* directly from potato tubers.

REFERENCES FOR DESCRIPTION

Hu J (2024) First Report of *Geotrichum candidum* causing rubbery rot on potato in Arizona. *Plant Disease* 108, 789. https://apsjournals.apsnet.org/doi/10.1094/PDIS-06-23-1171-PDN

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Helicobasidium brebissonii (synonym: *Rhizoctonia violacea*) (violet root rot) (RNQP in Switzerland and the United Kingdom; 'dry rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Violet root rot is mostly seen as a blemish on tubers although roots can be affected. Affected tubers can be covered in a fine network of purple mycelia that can join to form a net of thickened strands up to approximately 1 mm wide. These strands will be lost on washing but the purple-brown microsclerotia will remain in affected patches. The margins of these patches are likely to have ragged edges/cracks where the skin has been undermined (Figure A20). This skin damage may lead to a greyish dry rot or soft rotting by secondary infection (AHDB, 2024; The French seed potato, 2025).

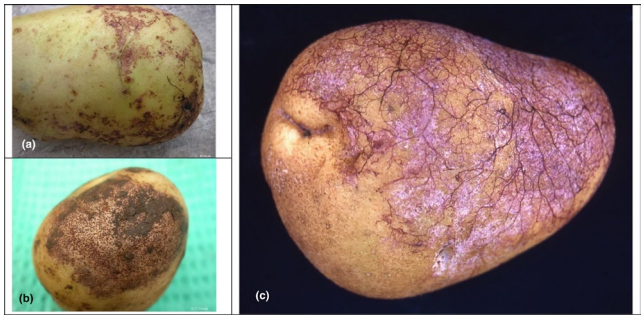

FIGURE A20 (a, c) Tuber infected by violet root rot (*Helicobasidium brebissonii*), bearing purplish mycelium hypha and evolving into rot. (b) Small black sclerotia (*H. brebissonii*) on a potato tuber. Courtesy: (a) M. Malet (MAC), (b) C. Chatot (GERMICOPA), (c) J. M. Gravoueille (ARVALIS) (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Helicobasidium brebissonii is difficult to isolate and to grow in culture. Isolation can be done from small pieces of the basidiomes placed onto unamended V-8 juice agar (Nakamura et al., 2004). Morphological characteristics are described by Nakamura et al. (2004). If necessary, identification of the isolate can be performed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primers ITS1/ITS4 and sequenced, followed by a BLAST analysis of the 503 bp sequence produced (Nakamura et al., 2004).

A conventional PCR test may be used to detect *H. brebissonii* in affected tuber tissue using primers HelicoPurp1 (TGGATCGGTTTGACTCAACG) and HelicoPurp2 (AAGTGCACTAAAGGCAAGCT) (Ellena Carroll (nee Hough) personal communication, 2025) targeting part of the internal transcribed spacer (ITS) region and generating a 101 bp amplicon (Hough et al., 2017).

REFERENCES FOR DESCRIPTION

AHDB (2024) Potato Disease Identification. Violet root rot. The Agriculture and Horticulture Development Board (GB). https://potatoes.ahdb.org.uk/knowledge-library/violet-root-rot

Hough EG, Horner MB & Horner IJ (2017) Molecular detection of *Helicobasidium purpureum* on carrots. *New Zealand Plant Protection* 70: 325-325. https://journal.nzpps.org/index.php/nzpp/article/view/94/67

Nakamura H, Ikeda K, Arakawa M, Akahira T & Matsumoto N (2004) A comparative study of the violet root rot fungi, *Helicobasidium brebissonii* and *H. mompa*, from Japan. *Mycological Research* 108, 641-648. https://doi.org/10.1017/S0953756204009785.

The French seed potato (2025) Diseases and pests. Violet root rot. SEMAE, FN3PT (FR). https://www.plantdepommedeterre.org/en/maladie-ravageur/violet-root-rot/ (accessed 2025-02-27).

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***Helminthosporium solani* ('silver scurf' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)**

Symptom description

Tuber skin blemish disease starts as small, round, silvery patches on the skin. In humid conditions, tubers may have a dark sooty appearance caused by the development of conidiophores. Large, silvery patches develop as individual lesions then expand and merge during storage (Figure A21). Tubers can become dehydrated, leading to shrivelling (AHDB, 2024; UNECE, 2014).



FIGURE A21 Circular lesions of silver scurf (a, b) with sporulation of fungus (b). (c) Close-up of lesions. Courtesy: (a, c). Y. Le Hingrat (FN3PT, FR). (b) SASA (EPPO GD). *Additional pictures are available in EPPO GD and at* https://www.plantdepommedeterre.org/en/maladie-ravageur/silver-scurf/.

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. The observation of tiny, short, black threads at a magnification of 10x can be used to confirm the presence of silver scurf. These are the distinctive conidiophores on which spores grow. Spores are easily blown or washed off, but many conidiophores are likely to remain unless scrubbed excessively.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) using small pieces of affected tissue. Morphological characteristics are described by Ellis (1968). If necessary, identification of the isolate can be confirmed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelium DNA with primers ITS5/ITS4 and sequenced, followed by a BLAST analysis of the 530 bp sequences produced (Olivier & Loria, 1998).

For detection direct on potato tubers conventional and real-time PCR tests such as those developed by Olivier and Loria (1998), Errampalli et al. (2001) and Cullen et al. (2001) can be used to confirm the presence of *H. solani*.

REFERENCES FOR DESCRIPTION

AHDB (2024) Potato Disease Identification. Silver scurf. The **Agriculture and Horticulture Development Board (UK)**. https://potatoes.ahdb.org.uk/knowledge-library/silver-scurf (accessed 2024-10-01).

Cullen DW, Lees AK, Toth IK & Duncan JM (2001) Conventional PCR and real-time quantitative PCR detection of *Helminthosporium solani* in soil and on potato tubers. *European Journal of Plant Pathology* 107, 387–398. https://doi.org/10.1023/A:1011247826231

Ellis MB (1968) C.M.I. Descriptions of Pathogenic Fungi and Bacteria No. 166 *Helminthosporium solani*.

Errampalli D, Saunders J & Cullen DW (2001) A PCR-based method for detection of potato pathogen, *Helminthosporium solani*, in silver scurf infected tuber tissue and soils. *Journal of Microbiological Methods* 44, 59–68. https://doi.org/10.1016/S0167-7012(00)00240-2

Olivier C & Loria R (1998) Detection of *Helminthosporium solani* from soil and plant tissue with species-specific PCR primers, *FEMS Microbiology Letters* 168, 235–241. https://doi.org/10.1111/j.1574-6968.1998.tb13279.x

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

***Polyscytalum pustulans* (skin spot) (Israel quarantine pest List)**

Symptom description

Skin blemish disease of small (1–2 mm), brown-black pimples occurring either singly or in groups on the tuber surface, distributed at random or aggregated around eyes (Figure A22). The mature fungal lesion frequently forms a sunken ring around a raised centre. Cutting through a skin spot shows a dark thickening, which may extend up to 2 mm into the tuber. Skin spot may be confused with immature powdery scab before they erupt. Lenticel discolouration is sometimes mistaken for the disease, but skin spot rarely has such a regular distribution (AHDB, 2024; UNECE, 2014).

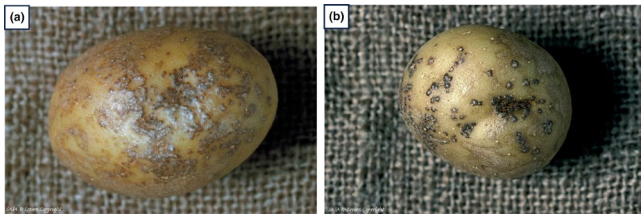

FIGURE A22 (a, b) External symptoms of potato skin spot. Courtesy: SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory.

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There is no international Standard available but tests for detection and identification are described in the scientific literature. Potato tubers or eyeplugs can be incubated in a moist container for 3 or more days at room temperature (15°C or more). If developing sporulating mycelia, these can be examined microscopically.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) by taking a tissue sample from small pieces of affected tissue. Morphological characteristics of *P. pustulans* are described by CABI (2020). A semi-selective medium has also been described (Carnegie & Cameron, 1990). If necessary, identification of the isolate can be confirmed by PCR. The internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primer pair ITS5/ITS4 and sequenced, followed by BLAST analysis the 1100 bp sequence produced (Budge et al., 2007).

For detection direct on potato tubers, PCR tests such as the real-time PCR test developed by Budge et al. (2007) and Lees et al. (2009) can be used to confirm the presence of *P. pustulans*.

REFERENCES FOR DESCRIPTION

AHDB (2024) *Potato Disease Identification*. Skin spot. The Agriculture and Horticulture Development Board (UK). https://potatoes.ahdb.org.uk/knowledge-library/skin-spot (accessed 2024-10-01).

Budge G, Boonham N, Peters J, & Kayley Coughlan K: (2007) Development and initial validation of primers for the detection and quantification of *Polyscytalum pustulans*. Project Report 2007/6. British Potato Council (UK). https://projectbluearchive.blob.core.windows.net/media/Default/Research%20Papers/Potatoes/20076%20Skin%20spot%20QPCR%20Final%20Report%20R285-1.pdf

CABI (2020) CABI Compendium datasheet 42226 Polyscytalum pustulans (skin spot of potato). https://doi.org/10.1079/cabicompendium.42226 (accessed 2024-10-01).

Carnegie S F & Cameron AM (1990). Occurrence of *Polyscytalum pustulans*, *Phoma foveata* and *Fusarium solani* var. *coeruleum* in field soils in Scotland. *Plant Pathology* 39, 517-523.

Lees AK, Sullivan L & Cullen DW (2009) A quantitative polymerase chain reaction assay for the detection of *Polyscytalum pustulans*, the cause of skin spot disease of potato. *Journal of Phytopathology*, 157, 154–158. https://doi.org/10.1111/j.1439-0434.2008.01459.x

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Rhizoctonia solani (black scurf) (RNQP in the EU, Switzerland and United Kingdom)

Symptom description

Blemishes caused by dark-brown or black sclerotia forming on tuber surface can be extensive but are easily scratched off. Long, fine, black strands (mycelia) may be associated with the sclerotia, and are easily visible with magnification (10×). Affected areas may show retarded growth in association with thickened brown skin patches that are often referred to as netting or elephant hide. Other distortions include dimples and trumpet shaped holes penetrating the tuber (AHDB, 2024; UNECE, 2014) (Figure A23).

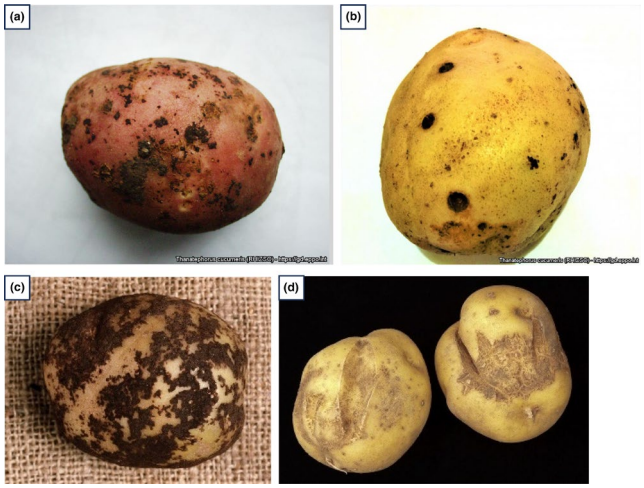

FIGURE A23 (a, c) Black scurf symptoms. (b) Surface pitting associated with *Rhizoctonia solani*. (d) Elephant hide associated with infection by *R. solani*. Courtesy: (a, b) Maria A. Kuznetsova (All-Russian Research Institute of Phytopathology) (EPPO GD). (c, d) SASA (EPPO GD). *Additional pictures are available in Bugwood.org.*

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) using small pieces of affected tissue (sclerotia or tuber periderm with symptoms). Morphological characteristics are described by Mordue (1974). If identification of the species is required, the internal transcribed spacer (ITS) region of rDNA can be amplified from mycelial DNA with primer pair ITS5/ITS4 and sequenced, followed by a BLAST analysis of the 700 bp sequence produced (Yang et al., 2022). *R. solani* is a species complex composed of several anastomosis groups (AGs) assigned on the basis of hyphal interaction. Additionally, AGs may be differentiated into subgroups and AG3-PT is generally acknowledged as the main cause of black scurf in potato. Tests (cultural and molecular) to characterize AGs are described by, for example Woodhall et al. (2007). Real-time PCR tests to detect specific AG subgroups in vivo are described by, for example, Budge et al. (2009) and Woodhall et al. (2013).

REFERENCES FOR DESCRIPTION

AHDB (2024) Potato Disease Identification. Black scurf and stem canker The Agriculture and Horticulture Development Board (UK). https://potatoes.ahdb.org.uk/knowledge-library/black-scurf-and-stem-canker (accessed 2024-10-01).

Budge GE, Shaw MW, Colyer A, Pietravalle S & Boonham N (2009) Molecular tools to investigate *Rhizoctonia solani* distribution in soil. *Plant Pathology* 58, 1071-1080. https://doi.org/10.1111/j.1365-3059.2009.02139.x

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Mordue JEM (1974) CMI Descriptions of Pathogenic Fungi and Bacteria No. 406 *Thanatephorus cucumeris*.
UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards
Woodhall JW, Lees AK, Edwards SG & Jenkinson P (2007) Characterization of *Rhizoctonia solani* from potato in Great Britain. *Plant Pathology* 56, 286- 95. https://doi.org/10.1111/j.1365-3059.2006.01545.
Woodhall JW, Adams IP, Peters JC, Harper G & Boonham N (2013) A new quantitative real-time PCR assay for *Rhizoctonia solani* AG3-PT and the detection of AGs of *Rhizoctonia solani* associated with potato in soil and tuber samples in Great Britain. *European Journal of Plant Pathology* 136, 273–280.
Yang S, Kong Y, Guo M, Dong X, Min F, Wei Q, Wang W, Mao Y, Gu X & Wang L (2022) First report of black scurf caused by *Rhizoctonia solani* AG 2-2IV on potato tubers in Heilongjiang Province, China, *Plant Disease* 106, 2996. https://apsjournals.apsnet.org/doi/epdf/10.1094/PDIS-12-21-2801-PDN

Sclerotinia minor and *S. sclerotiorum* ('dry rot' symptoms regulated under the EU Marketing Directive 2002/56/EC, considered as fulfilling the RNQP criteria during the EU Quality pest Project)

Symptom description

Tubers may develop a heel-end rot, but this is rare. Internally, the rot is pale brown with fluffy white mycelia and black sclerotia developing in cavities (UNECE, 2014) (Figure A24).



FIGURE A24 Heel-end rot caused by *Sclerotinia sclerotiorum*. Courtesy: SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}). Morphological characteristics for *Sclerotinia sclerotiorum* are described by Mordue and Holliday (1976). No differences in the structure of hyphae have been reported between *S. sclerotiorum* and *S. minor and* the general assumption is that *S. sclerotiorum* produces large smooth sclerotia, while *S. minor* produces smaller rough sclerotia. However, sclerotia morphology is particularly unreliable for species identification due to overlap in sclerotia size and shape under some circumstances. Therefore, if identification of the species is required, the internal transcribed spacer (ITS) region of rDNA can be amplified from mycelium DNA with primers ITS1/ITS4 or ITS5/ITS4 and sequenced, followed by a BLAST analysis, respectively of the 540 or 560 bp sequence produced (Baturo-Ciesniewska et al., 2017).

For the detection of *S. sclerotiorum* and *S. minor* in plant tissue a multiplex real-time PCR test has been developed (Lee et al., 2022).

REFERENCES FOR DESCRIPTION

Baturo-Ciesniewska A, Groves CL, Albrecht KA, Grau CR, Willis DK & Smith DL (2017) Molecular identification of *Sclerotinia trifoliorum* and *Sclerotinia sclerotiorum* isolates from the United States and Poland. *Plant Disease* 101,192-199. https://apsjournals.apsnet.org/doi/10.1094/PDIS-06-16-0896-RE?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed
Mordue JEM & Holliday P (1976) C.M.I. Descriptions of Pathogenic Fungi and Bacteria No. 166 *Sclerotinia sclerotiorum*.
Lee DJ, Lee JA, Chae DH, Jang HS, Choi YJ & Kim D (2022) Multiplex taqMan qPCR Assay for detection, identification, and quantification of three *Sclerotinia* species. *Mycobiology* 50, 382–388. https://doi.org/10.1080/12298093.2022.2131999
UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Spongospora subterranea[2] (powdery scab) (RNQP in the EU, Switzerland, the United-Kingdom)

Symptom description

Round, individual, raised scabs present on tubers at harvest; lesions erupt exposing brown powdery tissue (spore balls) with tattered fragments of skin along edge of lesion. Infection at the time of eye development can result in outgrowths (cankers) of varying sizes developing at the rose-end of tubers (UNECE, 2014) (Figure A25).

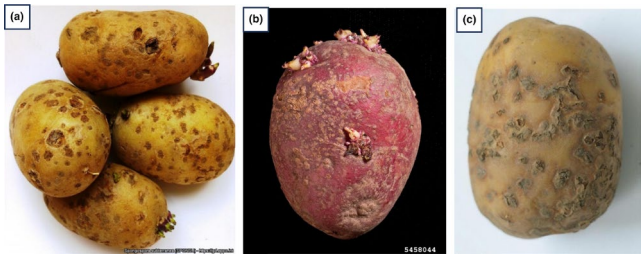

FIGURE A25 Tubers exhibiting powdery scab (*Spongospora subterranea*) lesions. Courtesy: (a) Maria A. Kuznetsova (All-Russian Research Institute of Phytopathology) (EPPO GD). (b) Sandra Jensen (Cornell University) (Bugwood.org). (c) Karima Boucheck (INOV3PT) (EPPO GD).

[2]Protista

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Sampling, detection and identification

Symptom tolerances set under certification schemes for seed potato are normally based on assessment of surface area coverage although care should be taken to ensure that scabs do not obscure the eyes which can prevent germination of the tuber. Cankers should be counted. Sampling should be conducted in a representative manner across the lot to be assessed. Under normal circumstances washing tubers is unnecessary.

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There is no international Standard available but tests for detection and identification are described in the scientific literature. Powdery scab is normally identifiable with the naked eye, but symptoms could be confused with common scab (*Streptomyces scabiei*). Diagnosis of powdery scab can be confirmed by the presence of spore balls using microscopy (20× magnification) and if further confirmation of the presence of spore balls is required by use of a lateral flow immunochromatographic test.

Spongospora subterranea is an obligate biotroph and does not grow in culture media. Thus, it is not possible to isolate the pathogen. Various ELISA and molecular tests have been developed for the detection and identification of *S. subterranea* and are described by Balendres et al. (2024).

REFERENCES FOR DESCRIPTION

Balendres MA, Woodhall J, Jonathan L, Whitworth JL & Cumagun CJR (2024)Powdery Scab of Potato: A Diagnostic Guide. *Plant Health Progress* 25, 334-339.

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Synchytrium endobioticum (potato wart disease) (EPPO A2)

Symptom description

Typical symptoms of *S. endobioticum* are proliferating warts produced on tubers. Warts vary markedly in shape but are primarily spherical to irregular, with their diameter ranging from <1 cm to more than 8 cm. They also vary from <1 g to more than 50 g fresh weight. Infection of tubers originates in eye tissue, but the warts may expand to engulf the whole tuber. Early infection of young developing tubers results in distortions and sponginess and makes them unrecognizable. In older tubers, the infected eyes develop into characteristic, warty, cauliflower-like protuberances (Figure A26). Warts are initially whitish or green if exposed to light, but gradually darken and eventually rot and disintegrate (EFSA, 2020; EPPO, 2017, 2024; UNECE, 2014).

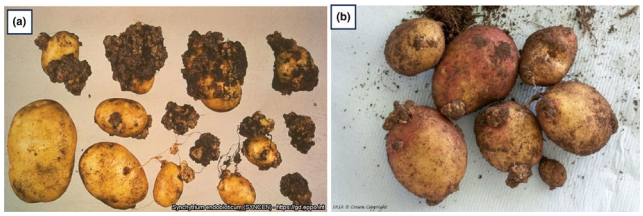

FIGURE A26 (a) Newly harvested, potato tubers of cv. Duke of York with warts; note that some warts are already starting to rot. Courtesy: Central Science Laboratory, York (GB) – British Crown (EPPO GD). (b) External symptoms. Courtesy: SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Laboratory testing should be performed according EPPO Standard PM 7/28 (2) *Synchytrium endobioticum* (EPPO, 2017, under revision), which describes tests for the detection and identification of *S. endobioticum* in soil and plant material with warts.

REFERENCES FOR DESCRIPTION

EFSA (2020) EFSA Pest Survey Card. *Synchytrium endobioticum*. https://storymaps.arcgis.com/stories/4fe5d65f57924944bb70d0e4b6f4fd79 (accessed 2024-10-01).

EPPO (2017) Diagnostics. EPPO Standard PM 7/28(2) *Synchytrium endobioticum*. *EPPO Bulletin* 47, 420-440.

EPPO (2024) *Synchytrium endobioticum*. EPPO datasheets on pests recommended for regulation. https://gd.eppo.int/taxon/SYNCEN/datasheet (accessed 2024-10-01).

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Thecaphora solani (potato smut) (EPPO A1)

Symptom description

Infected tubers are misshapen, or have galls/swellings on the surface, and are hard (Figure A27). All or part of the tuber may be infected. Galls vary in size from <1 mm to 4 cm or more in diameter. Two types of symptoms are observed on tubers, namely (1) small galls that are formed mostly at the apical end, and which appear as secondary growths, and (2) slight protuberances on the surface that may, in some cases, appear similar to symptoms caused by root-knot nematodes. Within the galls, oval to irregular brown-black specks, interspersed with lighter brown specks, occur in the flesh. The specks (spore sori) are variable size. These sori contain a reddish-dark, granular powdery mass of teliospores. The symptoms caused by *T. solani* are similar to those caused by other fungal pathogens that are known to be present in the EPPO region, namely *Spongospora subterranea* f. sp. *subterranea* (powdery scab), *Actinomyces scabies*

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(common scab) and *Synchytrium endobioticum* (potato wart disease) (EFSA, 2024).

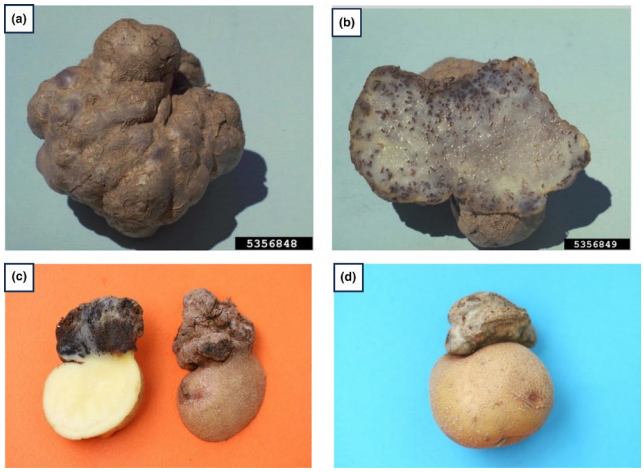

FIGURE A27 (a, b) Potato tuber in Bolivia showing symptoms of potato smut (*Thecaphora solani*), (a) external symptoms of deformation, (b) cut open. (c, d) Gall on a potato tuber. Courtesy: (a, b) William M. Brown Jr. (Bugwood.org). (c, d) International Potato Center.

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. There are no official diagnostic protocols for the detection and identification of *T. solani*. When galls are formed, the fungus can be identified based on morphology of the teliospore (EFSA, 2024). Culturing the pathogen is possible but is hampered by the very low germination rate of teliospores. The only available molecular test to identify the pathogen in cultures is based on DNA fingerprinting and partial sequencing of the LSU rDNA region (Andrade et al., 2004; EFSA, 2024).

REFERENCES FOR DESCRIPTION

Andrade O, Muñoz G, Galdames R, Durán P & Honorato R (2004) Characterization, in vitro culture, and molecular analysis of *Thecaphora solani*, the causal agent of potato smut. *Phytopathology* 94, 875-882.

EFSA (2024) EFSA Pest Survey Card. *Thecaphora solani*. https://storymaps.arcgis.com/stories/4380c293089c48aea9c479f09ee5f96d (accessed 2024-10-01).

Verticillium spp. (verticillium wilt) (RNQP for Israël and Jordan)

Symptom description

The infected tubers display brown spots on the vascular ring, more pronounced at the stolon-end ('heel-end'). Tubers may be of a smaller size. Pinkish-brown necrosis of the eyes may also be observed (The French seed potato, 2025). More extensive vascular discolouration may be present. Symptoms may differ among cultivars and geographical area. For *V. tricorpus*, symptoms of discoloured and flaking epidermis, sunken surface lesions, and sculptured/depressed reticulations have been found in minitubers (SASA, personal communication, 2025) (Figure A28).

The main *Verticillium* species known to infect potato are: *Verticillium alboatrum* sensu lato (which has been split after a taxonomic revision into three different species, *V. alboatrum* sensu stricto, *V. nonalfalfae* and *V. alfalfa* (Inderbitzin et al., 2011)), *V. dahliae* and *V. tricorpus*.



FIGURE A28 (a) Browning of the vascular ring caused by *Verticillium* wilt. Courtesy: Cornell University (USA). (b) Longitudinal section of a potato tuber showing symptoms of *Verticillium* spp. Courtesy: B. Jouan (INRAE, FR). (c, d) Minitubers infected with *Verticillium tricorpus* showing (c) sunken lesions and (d) severe sculptured/depressed reticulation. Courtesy: (c, d) SASA (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory.

Isolation can be performed on potato dextrose agar (PDA) supplemented with streptomycin (200 mg L^{-1}) using small pieces of affected tissue. After incubation, *V. dahliae* produces dark microsclerotia while *V. alboatrum* can be differentiated by the absence of microsclerotia and presence of dark resting mycelium. They are unlikely to be confused with other fungi except possibly *V. tricorpus* which produces both microsclerotia and chlamydospores, as well as a copious yellow orange pigment. Identification of *Verticillium* by this test takes up to 2 weeks. Full descriptions for morphological identification are available in Inderbitzin et al. (2011). See also EPPO Diagnostic Standard PM 7/78 *Verticillium nonalfalfae* and *V. dahlia* (EPPO, 2020).

For confirmation or in the absence of clearly defined resting structures, molecular identification can be performed with generic or specific primers. DNA can be extracted from the mycelia and the internal transcribed spacer (ITS) region, amplified with primers ITS1/ITS4, and sequenced, followed by a BLAST analysis of the sequence produced. The amplicon for *V. tricorpus* is 478-bp (Nair et al., 2015).

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Molecular tests for detection and identification of *Verticillium nonalfalfae* and *V. dahlia* from plant tissue are described in Diagnostic Standard PM 7/78 (EPPO, 2020).

REFERENCES FOR DESCRIPTION

EPPO (2020) EPPO Diagnostic Standard PM 7/78 (2) *Verticillium nonalfalfae* and *V. dahlia*. *EPPO Bulletin* 50, 462–476. https://gd.eppo.int/download/standard/202/pm7-078-2-en.pdf

Inderbitzin P, Bostock RM, Davis RM, Usami T, Platt HW & Subbarao KV (2011) Phylogenetics and taxonomy of the fungal vascular wilt pathogen *Verticillium*, with the descriptions of five new species. *PLOS ONE* 6, e28341. https://doi.org/10.1371/journal.pone.0028341

Nair PVR, Wiechel TJ, Crump NS & Taylor PWJ (2015) First report of *Verticillium tricorpus* causing Verticillium wilt in potatoes in Australia. *Plant Disease* 99, 731-731. https://apsjournals.apsnet.org/doi/10.1094/PDIS-10-14-1014-PDN

The French seed potato (2025) Diseases and pests. Verticillium wilt. SEMAE, FN3PT (FR). https://www.plantdepommedeterre.org/en/maladie-ravageur/verticillium-wilt/ (accessed 2024-10-01).

Insects/Acari

Remark: It is most likely that insects/acari are observed in potato tuber via symptomatic damage. It is very unusual to find larvae or adults free living in the consignment. Therefore samples would normally take the form of symptomatic tubers.

Diabrotica speciosa (cucurbit beetle) (EPPO A1)

Symptom description

Larvae create holes and feeding tunnels in tubers. The holes typically resemble 'pinpricks' (Figure A29).

Examination of adhering soil can be performed to look for eggs, larvae and pupae but the effectiveness of this methodology is uncertain: Eggs are laid in the soil near the base of a host plant in clusters, lightly agglutinated by a colourless secretion. Consequently, eggs could be present in adhering soil although they would be difficult to see in most circumstances. Pupae form cells in soil although they are probably too large to be carried in adhering soil.

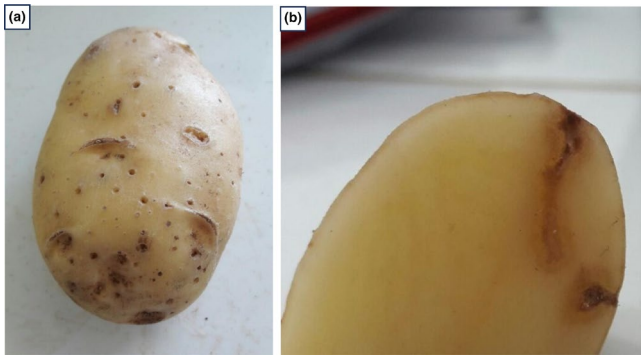

FIGURE A29 (a) Holes caused by *Diabrotica speciosa* larvae in potato tuber. (b) Gallery caused by *D. speciosa* larvae. Courtesy: (a, b) Marcos B. Barboza (EPPO GD).

Similar signs and symptoms can be observed for *D. undecimpunctata undecimpunctata* (southern corn root worm, EPPO A1) and *D. undecimpunctata howardi* (spotted cucumber beetle, EPPO A1). Although reported as supporting larval feeding (OSU, 2025), potato is not reported as a major host for these species.

Sampling, detection and identification

Symptomatic tubers should *be* placed in a leak proof plastic bag/box before being sent to the laboratory. Eggs: ovoid, about 0.74 ×0.36 mm, clear white to pale yellow. They exhibit fine reticulation which under the microscope appears like a pattern of polygonal ridges that enclose a variable number (12–30) of pits (CERIS, 2022).

Larvae: First instars are about 1.2 mm long, and mature third instars are about 8.5 mm long. They are subcylindrical; chalky white; head capsule dirty yellow to light brown, epicraneal and frontal sutures lighter, with long light brown setae; mandibles reddish dark brown; antennae and palpi pale yellow. Body covered by sparse, short, dark setae; light brown irregular prothoracic plate; dark brown anal plate on the ninth segment, with a pair of small urogomphi. A pygopod is formed by the tenth segment, which serves as a locomotion and adherence organ (CERIS, 2022).

Pupae: 5.8–7.1 mm long and white. Females have a pair of tubercles near the apex. Mature third instars build an 8 ×4 mm oval cell in the soil in which they pupate, and tenerals remain for about 3 days (CERIS, 2022).

Adults are highly unlikely to be present at tuber inspection.

Morphological identification for earlier stages (including larvae) can be confirmed to species level by molecular analysis.

REFERENCES FOR DESCRIPTION

CERIS, 2022. *Diabrotica speciosa*. West Lafayette, IN: Center for Environmental and Regulatory Information Systems, Entomology Dept, University of Purdue. 10 pp. http://download.ceris.purdue.edu/file/3141

OSU (2025) Oregon State University. Pacific Northwest: pest management handbooks. Potato, Irish-cucumber beetle. Available at https://pnwhandbooks.org/insect/vegetable/irish-potato/potato-irish-cucumber-beetle (accessed 2024-10-01).

Epitrix cucumeris (potato flea beetle) (EPPO A2), *E. papa* (EPPO A2), *E. subcrinita* (western potato flea beetle) (EPPO A1) and *E. tuberis* (tuber flea beetle) (EPPO A1)[3]

Symptom description

Larvae most commonly produce shallow tunnels or furrows in the surface of the tuber. These are unsightly

[3]Remark: although regulated by a number of EPPO countries, it should be noted that the species initially identified in Portugal as *E. similaris*, was later described as a new species, named *Epitrix papa*. The EPPO Working Partyon Phytosanitary Regulations in June 2016 agreed that *Epitrix similaris* should no longer be recommended for regulation as a quarantine pest.

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but can be removed by deep peeling. A larva may also feed outside, penetrating only partially into the potato, almost at a right angle to the surface (Hoerner & Gillette, 1928), forming a pit which usually penetrates up to 3 mm but may reach 6–9 mm, and later becomes filled with dark corky material, described as 'slivers' (Boavida et al., 2013; Gentner, 1944; Morrison et al., 1967; Wallis, 1957). 'Slivers' may show on the tuber's surface as a black point, or a raised rugose elevation in the skin ('pimples'). The 'worm-track' type of injury is the most easily recognizable. Rough skin, deep cracks and scab-like lesions are sometimes associated with the larval attack (Figure A30). The 'slivers' are best detected if the potato tubers are peeled superficially with a knife.

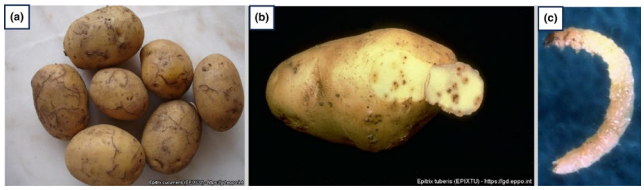

FIGURE A30 (a) *Epitrix cucumeris* damage on potatoes. Courtesy: Carlos Alberto Coutinho Conceição (EPPO GD). (b) Potato tuber showing a section with mines of *Epitrix tuberis* due to summer generation larvae. Courtesy: Agriculture, Canada Ottawa (CA) (EPPO GD). (c) *Epitrix* larvae. Courtesy: Agriculture, Canada Ottawa (CA) (EPPO GD).

Sampling, detection and identification

The larvae are very difficult to detect and collect because of their small size and translucence, and because of their feeding behaviour. When present at potato harvest, the larvae may be hidden inside the 'worm tracks', or the terminal part of the abdomen may protrude outside the tuber, while feeding. Larvae are unlikely to survive if the tubers are cleaned e.g. brushed.

The newly hatched larva is white, threadlike, and approximately 1 mm long. The full-grown larva is white, with the head and thoracic shield brown, averaging 5 mm in length and 0.8 mm in width. The pupa is pearly white and approximately 2.5 mm long and 1.5 mm wide.

Symptomatic tubers should *be* placed in a leak proof plastic bag/box (EFSA, 2020), before being sent to the laboratory. Keys for the morphological identification of adults and molecular tests are described in EPPO (2017). Published sequences and validated PCR tests are available if life stage is unsuitable for visual morphological diagnosis.

REFERENCES FOR DESCRIPTION

Boavida C, Giltrap N, Cuthbertson A & Northing P (2013) *Epitrix similaris* and *Epitrix cucumeris* in Portugal: damage patterns in potato and suitability of potential host plants for reproduction. *EPPO Bulletin* 43,323-333.

EFSA (2020) Pest survey card *Epitrix cucumeris, E. papa, E. subcrinita* and *E. tuberis*. EFSA supporting publication 2020:EN-1928. Available online: https://efsa.europa.eu/plants/planthealth/monitoring/surveillance/epitrix-cucumeris-papa-subcrinita-tuberis. Last updated: 08 September 2020.

EPPO (2017) Diagnostics. EPPO Standard PM 7/109(2) *Epitrix cucumeris*, *Epitrix papa*, *Epitrix subcrinita*, *Epitrix tuberis*. *EPPO Bulletin* 47(1), 10-17.

Gentner LG (1944) The black flea beetles of the genus Epitrix commonly identified as cucumeris (Harris) (Coleoptera: Chrysmoleidae). *Proceedings of the Entomological Society of Washington* 46, 137–149.

Hoerner JL & Gillette CP (1928) The potato flea beetle. Colorado Experiment Station. *Entomology Section Bulletin* **337**. 20 p.

Morrison H, Gentner L, Koontz R & Every R (1967) The changing role of soil pests attacking potato tubers. *American Potato Journal* 44, 137–144.

Wallis RL (1957) Seasonal abundance and host plants of the tuber flea beetle in the Rocky Mountain region. *Journal of Economic Entomology* 50, 435-437.

Heteronychus arator (African black beetle) (EPPO A1)

Symptom description

Adults burrow into the tubers and make holes of approximately 10 mm in diameter with frayed edges. The depth of the holes varies depending on the length of time the beetles feed on the tubers. Larvae may also feed in the cavities made by the adults (Figure A31).

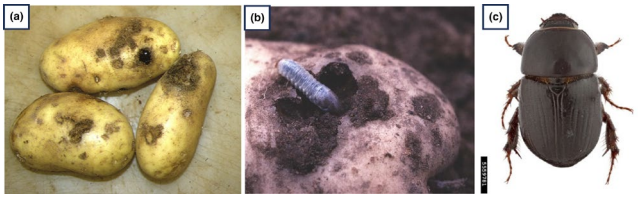

FIGURE A31 Damage to potato tubers by African black beetle adults (a) and larvae (b). Courtesy: (a, b) State of Western Australia (Department of Primary Industries and Regional Development, WA). (c) Adult of *Heteronychus arator*. Courtesy: Hanna Royals (Bugwood.org).

Sampling, detection and identification

There are three larval instars. Larvae are creamy-white except for the brown head capsule and hind segments, which appear dark where the contents of the gut show through the body wall. The head capsule is smooth textured, measuring approximatively 1.5 mm (1/16 in), 2.4 mm (1/8 in), and 4.0 mm (3/16 in) respectively for each larval instar. The third instar is approximately 25 mm (1 in) long when fully developed. Larvae are soil-dwelling and resemble white 'curl grubs.' Adults are 12–15 mm long; shiny black dorsally and reddish-brown ventrally (CABI, 2020; CPHST, 2014; Walker, 2023). Symptomatic tubers should *be* placed in a leak proof plastic bag/box before being sent to the laboratory. Morphological identification of adults can be performed with a binocular microscope.

REFERENCES FOR DESCRIPTION

CABI (2020) CABI Compendium datasheet 27067: *Heteronychus arator*. Available at https://www.cabidigitallibrary.org/doi/full/10.1079/cabicompendium.27067 (accessed 2024-10-01).

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CPHST (2014) Center for Plant Health Science and Technology (CPHST) Pest Datasheet for Heteronychus arator: http://download.ceris.purdue.edu/file/3069 (accessed 2024-10-01).
Walker (2023) PaDIL datasheet. Available at https://www.padil.gov.au/pests-and-diseases/pest/135883. (accessed 2024-12-18).

Limonius californicus (synonym *Pheletes californicus*) (sugarbeet wireworm) (EPPO A1)

Symptom description

Wireworms. Tubers are damaged by larval feeding which result in holes. These can be up to 15 mm deep, either perpendicular or at angle to the surface. Soil can contains eggs and larvae (Figure A32).

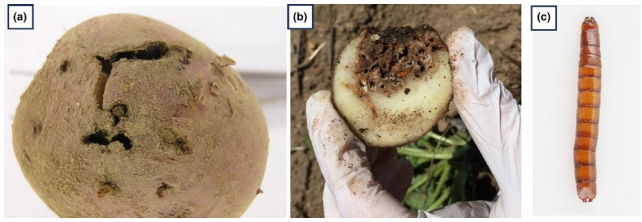

FIGURE A32 (a, b) Damage on potato tubers by *Limonius* sp. (a) and *Limonius agonus* (b), causing similar damage as *L. californicus*. (c) *Limonius* sp. larvae. Courtesy: (a) Laboratoire d'expertise et de diagnostic en phytoprotection (MAPAQ, Canada), (b) Brigitte Duval (MAPAQ, Canada), (c) Joseph Moisan-De Serres (MAPAQ, Canada) (http://www.iriisphytoprotection.qc.ca/, EPPO GD).

Sampling, detection and identification

Larvae are white when they first hatch, but change to shiny yellow and then to brown as they mature. They are slender, cylindrical, jointed and hard-bodied (hence 'wireworms'), up to 25 mm long. They have three pairs of legs behind the head. The last abdominal segment is flattened and elongated with short, stout appendages on the end (EPPO, 2005). Symptomatic tubers should *be* placed in a sealed leak proof plastic bag/box before being sent to the laboratory.

The key provided by Hathal and Al Dhafer (2009) can be used for identification of adults.

REFERENCES FOR DESCRIPTION

EPPO (2005) EPPO Data sheets on quarantine pests: *Limonius californicus*. *EPPO Bulletin* 35, 377-379.
Hathal M & Al Dhafer (2009) Revision of the North American Species of *Limonius* (Coleoptera: Elateridae). *Transactions of the American Entomological Society* 135(3), 209-352. https://doi.org/10.3157/061.135.0301

Melanotus communis (common wireworm) (EPPO A1)

Symptom description

On tubers, third-instar larvae make very narrow holes 1 mm deep, while older instars make deeper holes up to 3 mm in diameter and 2 mm deep. They may tunnel extensively within the tuber (Figure A33).

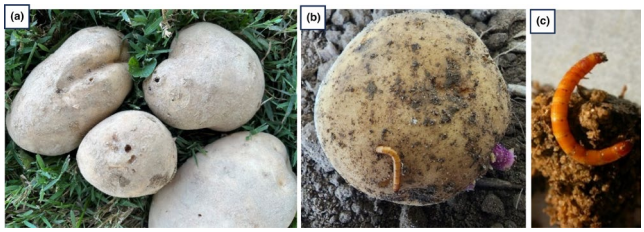

FIGURE A33 (a) Damage in potato tubers caused by *Melanotus communis*. (b) Wireworm (*M. communis*) in potato. (c) Wireworm (*M. communis*). Courtesy: (a–c) H. Doughty (VIRGINIA TECH) (EPPO GD). *Additional pictures are available in* gd.eppo.int.

Sampling, detection and identification

The main body of the larvae is pale yellow to reddish brown while the head is brown. The body is slender, cylindrical, hard-bodied and jointed, 21–25 mm long. Symptomatic tubers should *be* placed in a leak proof plastic bag/box before being sent to the laboratory. Riley et al. (1974) provide a key to larvae for nine *Melanotus* species from the northern central USA.

REFERENCES FOR DESCRIPTION

Riley TJ, Keaster AJ & Enns WR (1974) Species of wireworms of the genus Melanotus associated with corn in Missouri. *Journal of Economic Entomology* 67, 793.

Phthorimaea operculella (potato tuber worm) (Kazakhstan and Uzbekistan A1 List, EurAsian Economic Union (EAEU), Georgia, Russia, Türkiye and Ukraine A2 List, Belarus and Moldova quarantine pest list, Azerbaijan RNQP list)

Symptom description

Typical damage results from larvae boring tunnels in tubers (Chandel et al., 2005). Larvae enter potato tubers via the eyes and continue to bore or tunnel irregular galleries either through the tuber or just below the skin. Potato tuber eyes become pink due to deposition of silk and excrement by potato tuber worm infestation. Larval excreta are pushed out through the holes forming characteristic piles of faeces.

Tuber infestation caused by first instar larvae can be hard to detect, such that even with precautionary measures infested tubers are transferred to potato stores.

Shipments of potatoes infested with *P. operculella* generally show certain signs that clearly confirm the presence of the pest (e.g., adult moths flying around in a ship's hold, or silk-cocoons visible on the tuber surface that may or may not include developing pupae) (Figures A34 and A35).

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FIGURE A34 Damage of tubers potato. Courtesy: Denis Kasatkin (EPPO GD). *Additional pictures are available in Bugwood.org.*



FIGURE A35 Adult, larva and pupa of *Phthorimaea operculella*. Courtesy: Denis Kasatkin (EPPO GD).

Sampling, detection and identification

The tuber moth eggs (0.5 × 0.35 mm) and neonate larvae are nearly invisible to the naked eye (Gavara et al., 2021).

Larvae are usually cream to light brown reddish reddish-brown with a characteristic brown head. Mature larvae (0.9 cm long) may be pink or greenish and the thorax has small black points and bristles on each segment (CABI, 2021; Gill et al., 2014).

Adult moths are approximately 0.9 cm long with a wingspan of approximately 1.3 cm. Forewings have two to three dark dots on males, while females show an "X"-shaped dark pattern. Both pairs of wings have characteristic fringed edges (CABI, 2021; Rondon, 2010; Rondon & Xue, 2010).

Symptomatic tubers should *be* placed in a leak proof plastic bag/box before being sent to the laboratory.

Morphological identification can be performed with a binocular microscope. *P. operculella* larvae and pupae obtained from potatoes should be preserved in 70% alcohol. Key characters to differentiate *P. operculella* from *Symmetrischema tangolias* and *Tecia solanivora* are provided in EPPO Standard PM 7/72 Diagnostic protocol for *Tecia solanivora* (EPPO, 2006).

REFERENCES FOR DESCRIPTION

CABI (2021) Compendium datasheet 40686: *Phthorimaea operculella*. Available at https://www.cabidigitallibrary.org/doi/full/10.1079/cabicompendium.40686(accessed 2024-10-01).

EPPO (2006) Diagnostics. EPPO Standard PM 7/72 *Tecia solanivora*. *EPPO Bulletin* 36, 175-178.

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***Premnotrypes* spp. (Andean potato weevil): *Premnotrypes latithorax* (EPPO A1), *P. sanfordi* (Russia A1 List), *P. solani* (EPPO A1), *P. suturicallus* (EPPO A1) and *P. vorax* (EPPO A1)**

[Correction added on 25 February 2026, after first online publication: the above appendix title has been corrected in this version.]

The Andean potato weevil (Coleoptera: Curculionidae) is a complex of 14 species, 12 belong to the genus *Premnotrypes* (*P. clivosus, P. fractirostris, P. latithorax, P. piercei, P. pusillus, P. sanfordi, P. solani, P. solaniperda, P. solanivorax, P. suturicallus, P. vorax* and *P. zischkai*) plus *Rhigopsidius tucumanus* and *Phyrdenus muriceus*.

Symptom description

Larvae cause tunnels in tubers, these are usually filled with excreta with little externally visible damage but deep galleries. In light-skinned tubers, the damage is indicated by the presence of irregular blackish spots, and in dark-skinned tubers there may be small pustules indicating the place where the larvae have entered (Yábar Landa, 1988). Emerging larvae produce characteristic circular holes (Figure A36).



FIGURE A36 (a, b) Tuber damage and larvae of Andean potato weevil. Courtesy: Whitney Cranshaw, Colorado State University (Bugwood.org). (c) Andean potato weevil *Premnotrypes vorax* Adult. Courtesy: Natasha Wright, Braman Termite & Pest Elimination (Bugwood.org).

Sampling, detection and identification

The larvae (legless) and pupae are typical of the Curculionidae. 6.2–10 mm in length. The larva is comma-shaped, creamy-white except the ochreous head, with antennal sensorium cushion-like as characteristic of Entiminae (Marvaldi, 2003). Larval characters diagnostic of the genus are given by van Emden (1952).

Premnotrypes spp. are dark-coloured stout weevils about 4–8 mm long. The rostrum is short with the length only about twice the width and significantly shorter than the pronotum. Morphological identification of adults can be performed with a binocular microscope: The 12 species within the genus *Premnotrypes* are distinguished based on different adult morphological features, including the male aedeagus.

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory.

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P. vorax can be distinguished from other species of *Premnotrypes* by the following combination of characters: epistome (at apical dorsal part of rostrum) elevated; without superciliary arches or swellings above each eye; rostrum with strong dorsal curvature; pronotum with pointed lateral swelling; elytra flat up to the fifth interstria and then almost vertical to the side (Alcázar & Cisneros, 1999; Kuschel, 1956; Yabar Landa, 2014).

REFERENCES FOR DESCRIPTION

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Tecia solanivora (Central American potato tuber worm, Guatemalan potato moth) (EPPO A2)

Symptom description

Inspection of tubers should be performed, looking for holes and galleries with or without larvae (EPPO, 2006). To detect larvae, it is necessary to cut open suspected tubers, or to check them carefully to find signs of damage or exit holes made by larvae before pupating. Damage is like that of other potato tuber moths. Larvae bore superficial galleries containing residues of food, frass and larval exuviae (Figure A37). The entry hole may remain inconspicuous but 2–3 mm circular exit holes are visible after the larvae leave tubers. Secondary rotting may occur (EPPO, 2006; Rivera Martinez et al., 2018). Larvae leave the tubers to pupate. The pupal stage may take place on the ground, on the walls of storerooms, in bags or, occasionally, within the tuber. In storage, eggs are laid on tubers (EFSA, 2020).



FIGURE A37 (a–c) *Tecia solanivora*: Adults, external and internal damage on a potato tuber. Courtesy: Consellería do Medio Rural de la Xunta de Galicia (EPPO GD).

Sampling, detection and identification

Eggs are laid in groups and are oval shaped and 0.5 × 0.4 mm in size. Eggs turn from pale white to yellow within a few days. Before hatching, eggs appear black as the dark head capsule of the larva becomes visible.

Larvae are eruciform, with three pairs of true legs (thoracic) and five pairs of pseudolegs (four abdominal and one anal pair). The insect has 4 larval instars, measuring 1.2–14.2 mm long. After hatching, larvae are transparent white, second-instar larvae are cream with darker coffee-coloured spots, third-instar larvae are yellow-green with the spots along the body being more visible, the last larval instar body coloration is bright red-scarlet with pale to whitish pleurae and body underside. The head and prothoracic shield are dark brown (CABI, 2020; EPPO, 2006).

Adults are rather stout moths with lanceolate front wings and larger rear wings with many fringes. The female is bright brown, the first pair of wings having three marks and bright brown longitudinal lines. The male is dark brown, with two marks on the first pair of wings and scarcely visible longitudinal lines. The female is larger than the male, measuring approximately 13 × 3.4 mm, whereas the male measures approximately 9.7 × 2.9 mm (Barroso, 1974; Sotelo, 1996; Torres, 1989).

Symptomatic tubers should *be* placed in a leak proof plastic bag/box before being sent to the laboratory.

To confirm that the infestation is *T. solanivora* and not another potato moth species such as *Phthorimaea operculella* and *Symmetrischema tangolias*, larvae and adults should be identified using the morphological or molecular tests described in EPPO Diagnostic Standard PM 7/72(1) Diagnostic protocol for *Tecia solanivora* (EPPO, 2006).

REFERENCES FOR DESCRIPTION

Barroso PV (1974) Biological cycle of the Guatemalan potato tuber moth, *Scrobipalpopsis solanivora* (Povolny) (Lepidoptera: Gelechiidae). The new serious pest of *Solanum tuberosum*. Thesis. San José, Costa Rica: University of Costa Rica.

CABI (2020) *Tecia solanivora* (potato tuber moth). Available at https://www.cabi.org/isc/datasheet/52956 (accessed: 2020-11-18).

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EPPO (2006) EPPO Standard PM 7/72 *Tecia solanivora*. *EPPO Bulletin* 36, 175-178. Available at https://gd.eppo.int/taxon/TECASO/documents

Rivera Martinez A, Alija Martínez A, Galdo Pena JC, González Domínguez J, López López, Vázquez Pita M, Collar Urquijo J, Rodríquez Vázquez M & Novo Vázquez V (2018) *Tecia solanivora*. Situación da praga en Galicia. Evolución da praga en almacén [*Tecia solanivora*. Situation of the pest in Galicia. Pest data evolution in store]. *Cooperación Galega* **138** (mai 2018). (in Galician).

Sotelo G (1996) The Guatemalan potato moth, *Tecia solanivora* (Povolny) Lepidoptera: Gelechiidae. Course in Integrated Potato Pest Management. Paipa, Colombia, June 1996.

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(Lepidoptera: Gelechiidae) in the State of Tachira, Venezuela. MSc. Thesis. Maracay, Venezuela: Central University of Venezuela.

Tetranychus evansi (red spider mite) (EPPO A2)

Symptom description

Mites, white exuviae and webbing can be observed on the tuber surface, especially on/covering the sprouts (Figure A38). Due to their minute size (about 0.5–0.6 mm in length), spider mites usually remain undetected when occurring at low densities (EPPO, 2022).

Remark: Pictures of *Tetranychus* spp. with webbings on potato tubers are available in Tilahun GW & Gure TN (2023): https://doi.org/10.3329/ijarit.v13i2.70857.



FIGURE A38 *Tetranychus evansi*. Courtesy: A. Migeon (INRAE Montpellier, France) (EPPO GD).

Sampling, detection and identification

An external examination of the tuber under a stereomicroscope will confirm (or not) the presence of spider mites. Symptomatic tubers should be sent for laboratory testing for confirmation. The EPPO Diagnostic Standard PM 7/116 *T. evansi* provides recommendations on how identify the adult pest based on morphological characters. Molecular identification can also be performed.

REFERENCES FOR DESCRIPTION

EPPO (2022) Diagnostics. EPPO Standard PM 7/116(2) Tetranychus evansi. *EPPO Bulletin* 52, 362-370.

Nematodes

Meloidogyne chitwoodi (EPPO A2), *M. enterolobii* (EPPO A2), *M.* ethiopica (EPPO A1), *M. fallax* (EPPO A2), *M. luci* (EPPO A2)

Symptom description

On potato tubers, *Meloidogyne chitwoodi*, *M. ethiopica*, *M. enterolobii*, *M. fallax* and *M. luci* can cause numerous small pimple-like raised areas on the surface. Adult females may be visible just below the surface as glistening, white, pear-shaped bodies surrounded by a brownish layer of necrotic host tissue. Galling can be concentrated on one area of the tuber or single galls may be scattered near eyes or lesions. Symptoms are more apparent in some cultivars than in others; tubers may, in some cases, be heavily infected without visible external symptoms (Figure A39).

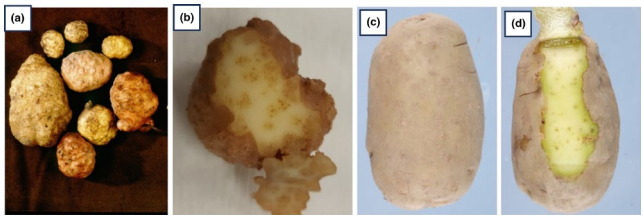

FIGURE A39 (a) Potato tubers infested with *Meloidogyne chitwoodi*. (b) Potato tuber infested by *M. enterolobii*. (c, d) A potato tuber infested with *M. chitwoodi* without distinct external symptoms but with internal symptoms. Courtesy: (a, c, d) NPPO of the Netherlands (EPPO GD), (b) Wageningen University (WUR) 'Field crops'(EPPO GD). *Additional pictures are available in EPPO GD.*

Sampling, detection and identification

Specific guidance on the sampling of potato tubers is given in the EPPO Standard PM 3/69(2) *Meloidogyne chitwoodi* and *M. fallax:* sampling potato tubers for detection (EPPO, 2019). After harvest, a sample of 200 tubers taken at random are examined visually for the presence of *Meloidogyne*, preferably after incubation of at least 2150 day-degrees as not all potato cultivars will express clear external symptoms on tubers. If symptoms are seen, nematodes should be extracted. Since visual observation of tuber galls may not always be reliable, in absence of symptoms, testing of asymptomatic tubers should be performed. It should be noted that storage of lightly infested tubers may lead to the development of obvious external symptoms. This Standard can also be used for sampling potato tubers for *M. enterolobii, M. ethiopica* and *M. luci.*

Extraction of nematodes should be carried out according to EPPO Standards PM 7/119 (EPPO, 2013).

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The Diagnostic Standards PM 7/41 *Meloidogyne chitwoodi* and *M. fallax* (EPPO, 2016a, under revision) and PM 7/103 *M. enterolobii* (EPPO, 2016b, under revision) describe morphological, and molecular and isozyme tests available for an accurate detection and identification. Given that species identification within the genus *Meloidogyne* is very difficult based solely on morphological characters, it is strongly recommended to use isozymes and/or DNA tests to confirm the identity of the *Meloidogyne* species. For *M. ethiopica* and *M. luci* there is not yet an international Standard available. Recently Žibrat et al. (2021) described a method using hyperspectral remote sensing and real-time-PCR to detect *M. ethiopica* and *M. luci* in potato tubers, but distinguishing the two species with this test is not possible. Maleita et al. (2021) developed species-specific SCAR marker for detection of *M. luci* by PCR. A species-specific SCAR marker was also developed for *M. ethiopica* (Correa et al., 2014), however this diagnostic test was not shown to be reliable and reproducible (Santos et al., 2019).

REFERENCES FOR DESCRIPTION

Correa VR, Mattos VS, Almeida MRA, Santos MFA, Tigano MS, Castagnone-Sereno P & Carneiro RMDG (2014) Genetic diversity of the root-knot nematode *Meloidogyne ethiopica* and development of a species-specific SCAR marker for its diagnosis. *Plant Pathology* 63, 476–483.

EPPO (2013) Diagnostics. EPPO Standard PM 7/119 Nematode extraction. *EPPO Bulletin* 43, 471-495.

EPPO (2016a, under revision) Diagnostics. EPPO Standard PM7/41 Diagnostic protocol for *Meloidogyne chitwoodi* and *M. fallax*. *EPPO Bulletin* 46, 171-189.

EPPO (2016b, under revision) Diagnostics. EPPO Standard PM7/103 Diagnostics *Meloidogyne enterolobii*. *EPPO Bulletin* 46, 190-201.

EPPO (2019) PM 3/69 (2) *Meloidogyne chitwoodi* and *M. fallax*: sampling potato tubers for detection. *EPPO Bulletin* 49: 486-487.

Maleita C, Cardoso JMS, Rusinque L, Esteves I & Abrantes I (2021) Species-specific molecular detection of the root knot nematode *Meloidogyne luci*. *Biology* 10, 775. https://doi.org/10.3390/biology10080775

Santos MFA, Mattos VS, Monteiro JMS, Almeida MRA, Jorge AS, Cares JE, Castagnone-Sereno P, Coyne D, Carneiro RMDG (2019) Diversity of *Meloidogyne* spp. from peri-urban areas of sub-Saharan Africa and their genetic similarity with populations from the Latin America. *Physiological and Molecular Plant Pathology* 105, 110–118.

Žibrat U, Gerič Stare B, Knapič M, Susič N, Lapajne J & Širca S (2021) Detection of Root-knot nematode *Meloidogyne luci* infestation of potato tubers using hyperspectral remote sensing and Real-Time PCR molecular methods. *Remote Sensing* 13, 1996. https://doi.org/10.3390/rs13101996

Ditylenchus dipsaci (stem and bulb nematode) (EPPO A2) and *D. destructor* (potato rot nematode) (Azerbaijan A1 List; Jordan and Türkiye A2 List; Israel, Morocco, Norway and Tunisia quarantine pest list, RNQP in the EU and for Russia, Switzerland and Ukraine)

Symptom description

Infestation by *Ditylenchus destructor* (potato rot nematode) is initially a superficial rot that resembles late blight. Later the skin takes on a paper-like appearance and often exhibits simple to star-shaped cracks. Affected tissue can show white chalky spots which contain large numbers of active nematodes (Figure A40). In heavy infestations, the tissue turns dark brown to black and can exhibit rot both dry and wet.

Tuber infestation by *Ditylenchus dipsaci* (stem and bulb nematode) manifests as grey-brown sunken spots with a paper-like skin, similar to those of *D. destructor*. The main differences in *D. dipsaci* are that the rot more often penetrates deeper into the tuber and the typical white chalky spots are absent, as are the cracks in the skin. Eventually, a brown-grained dry rot develops, which may turn into wet rot due to secondary infections.

Ditylenchus is usually not detected until harvest or after storage (Mulder & Turkensteen, 2005).

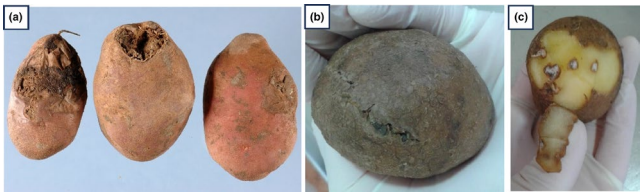

FIGURE A40 (a) Potato rot symptoms caused by *Ditylenchus dipsaci*. Courtesy: NPPO of the Netherlands (EPPO GD). (b) External damage (cracks) caused by *Ditylenchus destructor*. (c) White chalky spots caused by *D. destructor*. Courtesy: (b, c) Khomenko Iryna Olehivna (EPPO GD). *Additional pictures are available in EPPO GD.*

Sampling, detection and identification

It is difficult to detect the presence of *Ditylenchus* from external tuber appearance alone. Tubers should be cut or peeled to look for the characteristic whitish spots, in case of *D. destructor*, or the more general rot symptoms of both *Ditylenchus* species. Symptomatic tubers should placed in a leak proof plastic bag/box before being sent to the laboratory to extract the nematodes.

More details on the detection and identification of *D. destructor* and *D. dipsaci* can be found in the EPPO Diagnostic Standards PM 7/119 Nematode extraction (EPPO, 2013) and PM 7/87 Diagnostics *Ditylenchus destructor* and *Ditylenchus dipsaci* (EPPO, 2017).

REFERENCES FOR DESCRIPTION

EPPO (2013) Diagnostics. EPPO Standard PM 7/119 Nematode extraction. *EPPO Bulletin* 43, 471-495.

EPPO (2017) Diagnostics. EPPO Standard PM 7/87 *Ditylenchus destructor* and *Ditylenchus dipsaci*. *EPPO Bulletin* 47, 401-419.

Mulder A & Turkensteen LJ (2005) *Potato diseases: Diseases, pests and defects*. Aardappelwereld & NIVAP, Den Haag, Netherlands.

Globodera pallida (EPPO A2) and *G. rostochiensis* (EPPO A2) (potato cyst nematodes)

Symptom description

Symptoms on tubers caused by *G. pallida* and *G. rostochiensis* are very rarely found. Only during a short

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period of the growing season young white (*G. pallida*) or yellow (*G. rostochiensis*) females can be detected on the root system, and occasionally under heavily infestations on the tubers (Figure A41). As the females mature, their cuticles harden into brown cysts (EPPO, 2021; Turner & Evans, 1998).

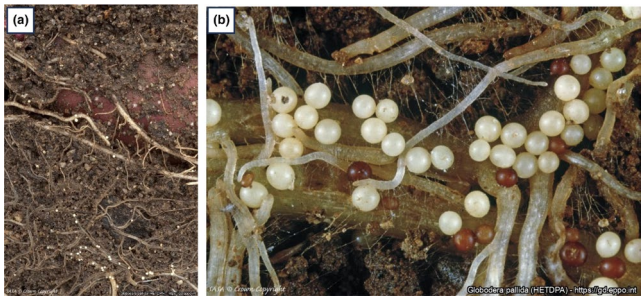

FIGURE A41 (a) Cysts of *Globodera pallida* on 6-week old potato roots. (b) Close up of *Globodera pallida* cysts on potato roots. Courtesy A&B: SASA (EPPO GD). Remark: Although root systems are typically absent from traded potato tubers, these images provide a useful reference for recognizing the appearance of cysts.

Sampling, detection and identification

Tubers with adhering soil should require extra attention. Specific guidance on the sampling of (adhering) soil and potato tubers is given in the EPPO Standards PM 3/75 *Globodera rostochiensis* and *Globodera pallida*: sampling soil attached to ware potato tubers for detection prior to export and at import (EPPO, 2014), PM 9/26 National regulatory control system for *Globodera pallida* and *Globodera rostochiensis* (EPPO, 2018) and PM 3/71 General crop inspection procedure for potatoes (EPPO, 2007).

Detection and identification should be carried out according to EPPO Diagnostic Standards PM 7/119 Nematode extraction (EPPO, 2013) and PM 7/40 *Globodera rostochiensis* and *G. pallida* (EPPO, 2021) which describe relevant procedure for the extraction of cysts and morphological and molecular tests for an accurate detection and identification. Combining morphological and molecular methods is highly recommended, especially when new introductions are suspected.

REFERENCES FOR DESCRIPTION

EPPO (2007) Phytosanitary procedures. EPPO Standard PM 3/71 General crop inspection procedure for potatoes. *EPPO Bulletin* 37, 592-597.

EPPO (2013) Diagnostics. EPPO Standard PM 7/119 Nematode extraction. *EPPO Bulletin* 43, 471-495.

EPPO (2014) Phytosanitary Procedures. EPPO Standard PM 3/75 *Globodera rostochiensis* and *Globodera pallida*: sampling soil attached to ware potato tubers for detection prior to export and at import. *EPPO Bulletin* 44, 316-317.

EPPO (2018) National regulatory control systems. EPPO Standard PM 9/26 *Globodera pallida* and *Globodera rostochiensis*. *EPPO Bulletin* 48, 516-532.

EPPO (2021) Diagnostics. EPPO Standard PM 7/40 *Globodera rostochiensis* and *G. pallida*. *EPPO Bulletin* 52, 286-313.

Turner SJ & Evans K (1998) The origins, global distribution and biology of potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*). In R. J. Marks & B. B. Brodie (Eds.), *Potato Cyst Nematodes: Biology, Distribution and Control* (pp. 7–26). CAB International.

Nacobbus aberrans sensu lato (false root-knot nematode) (EPPO A1)

Symptom description

All developmental stages of *N. aberrans* s.l. are very small (about 1 mm) and not visible to the naked eye (EFSA, 2024). Potato tubers may or may not show external symptoms (EPPO, 2009, under revision), they can also be found in the adhering soil of (imported) tubers. Infested potato tubers do not show symptoms that are easy to recognize, but they can have spongy tissue in the lenticels (Lax et al., 2022; Manzanilla-López et al., 2002; Niere and Karuri, 2018). Although a recent experiment with inoculation of potato under greenhouse conditions resulted in newly formed tubers with galls, it is not clear whether these symptoms are formed under field conditions (EFSA, 2024). The induced galls resemble to those caused by *Meloidogyne* species, but they are typically more rounded and on the roots like beads on a string (Figure A42).

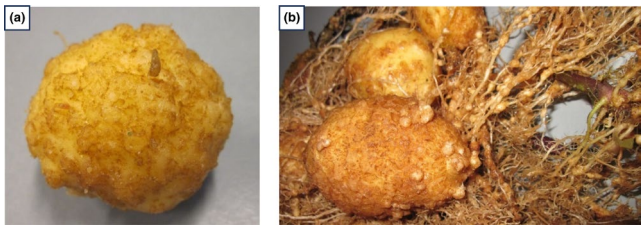

FIGURE A42 (a, b) Galls on potato tubers and roots artificially infested with *Nacobbus aberrans* s.l. Courtesy: NIVIP, Wageningen, Netherlands (EPPO GD).

Sampling, detection and identification

Symptomatic roots and tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory to extract the nematodes. Several methods for the extraction of nematodes are described in PM 7/119 (EPPO, 2013).

Detection and identification should be carried out according to EPPO Diagnostic Standard PM 7/5 Diagnostic protocol *Nacobbus aberrans* s.l. (EPPO, 2009, under revision), which provides relevant information on recommended morphological and molecular tests. To date, two PCR tests have been developed (Anthoine & Mugniéry, 2005; Atkins et al., 2005). However, Atkins et al. (2005) has shown high limit of detection and possible cross-reaction with other plant parasitic nematodes (ANSES, personal communication, 2024).

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Anthoine G & Mugniery D (2005) Variability of the ITS rDNA and identification of *Nacobbus aberrans* (Thorne, 1935) Thorne & Allen, 1944 (Nematoda: Pratylenchidae) by rDNA amplification. *Nematology* 7, 503-516.

Atkins SD, Manzanilla-López RH, Franco J, Peteira B & Kerry BP (2005) A molecular diagnostic method for detecting *Nacobbus* in soil and in potato tubers. *Nematology* 7, 193-202.

EFSA (2024) Pest survey card on *Nacobbus aberrans* s.l.. EFSA supporting publication 2024:EN-8825. doi:https://doi.org/10.2903/sp.efsa.2024.EN-8825. Available online: https://efsa.europa.eu/plants/planthealth/monitoring/surveillance/nacobbus-aberrans. (last updated 2024-05-31).

EPPO (2009, under revision) Diagnostics. EPPO Standard PM7/5 *Nacobbus aberrans* sl. *EPPO Bulletin* 39, 376-381.

EPPO (2013) Diagnostics. EPPO Standard PM 7/119 Nematode extraction. *EPPO Bulletin* 43, 471-495.

Lax P, Passone MA, Becerra AG, Sosa AL, Ciancio A, Finetti-Sialer MM and Rosso LC, 2022. Sustainable strategies for management of the 'false root-knot nematode' *Nacobbus* spp. *Frontiers in Plant Science* 13, 1046315. doi: https://doi.org/10.3389/fpls.2022.1046315

Manzanilla-López RH, Costilla MA, Doucet M, Inserra RN, Lehman PS, del Prado-Vera IC, Souza RM & Evans K (2002) The genus *Nacobbus* Thorne & Allen, 1944 (Nematoda: Pratylenchidae): Systematics, distribution, biology and management. *Nematropica* 32, 149–227.

Niere B & Karuri HW (2018) Nematode parasites of potato and sweet potato. In: Sikora RA, Coyne D, Hallmann J and Timper P (eds.). *Plant parasitic nematodes in subtropical and tropical agriculture*. CABI, Wallingford UK. pp. 222–251.

Viruses and Viroids

Crinivirus flavisolani (potato yellow vein virus, PYVV) (EPPO A1)

Symptom description

Tubers may be deformed, with large protruding eyes (CABI/EPPO, 1990).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Tuber sap from the heel-end / eyes of symptomatic tubers can be tested using the tests listed in EPPO Standard PM 3/21 (EPPO, 2019) and PM 4/28 (EPPO, 2023).

REFERENCES FOR DESCRIPTION

CABI/EPPO (1990) Datasheet on Potato yellow vein disease. Quarantine pests for Europe (second edition). Prepared by CABI and EPPO for the EU under Contract 90/399003. Available at https://gd.eppo.int/download/doc/221_datasheet_PYVV00.pdf

EPPO (2019) Phytosanitary procedures. EPPO Standards PM 3/21 Post-entry quarantine for potato. *EPPO Bulletin* 49(3), 452–479.

EPPO (2023) Production of healthy plants for planting. EPPO Standards PM 4/228 Certification scheme for seed potatoes. *EPPO Bulletin* 53, 460-475.

Orthotospovirus tomatomaculae (tomato spotted wilt virus, TSWV) (EPPO A2)

Symptom description

Affected tubers may be small and distorted and show sunken, black necrotic spots (Agriculture Australia, 2021). The tubers may also develop internal symptoms ranging from small, dark, necrotic spotting to more extensive dark internal necrosis (Jeffries, 1998; UNECE, 2014) Internal necrosis may appear as concentric rings and be visible through the skin (Agriculture Australia, 2021) (Figure A43).

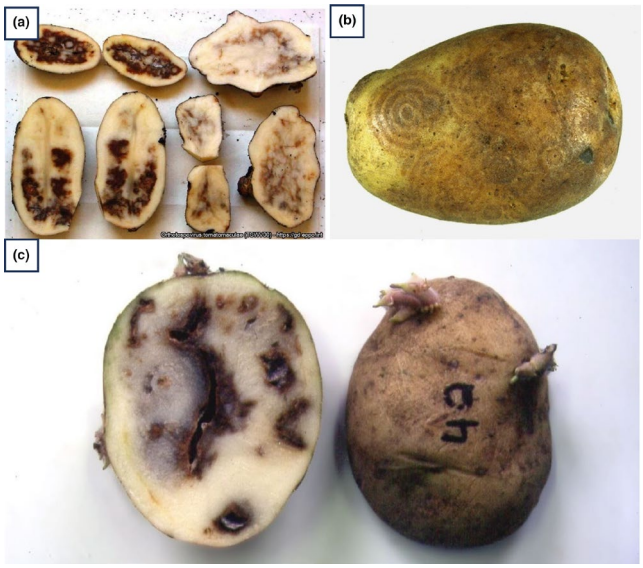

FIGURE A43 (a) Internal necrosis caused by tomato spotted wilt virus. Courtesy: C Wilson. (b) Concentric rings. Courtesy: The Plant Virology Group at Agriculture Western Australia (EPPO GD). (c) Necrotic tuber symptoms in *Solanum tuberosum* cv Shepody. Courtesy: C. Wilson.

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory.

The tests recommended for the detection and identification of TSWV are described in EPPO Standard PM 7/139 (EPPO, 2020).

REFERENCES FOR DESCRIPTION

Agriculture Australia (2021) Tomato spotted wilt virus in potatoes. https://agriculture.vic.gov.au/biosecurity/plant-diseases/vegetable-diseases/tomato-spotted-wilt-virus-in-potatoes (accessed 2024-10-01)

EPPO (2020) Diagnostics. EPPO Standard PM 7/139(1) Tospoviruses (Genus *Orthotospovirus*). *EPPO Bulletin* 50, 217-240).

EPPO (2024) *Orthotospovirus tomatomaculae*. EPPO datasheets on pests recommended for regulation at https://gd.eppo.int/taxon/TSWV00/datasheet (accessed 2024-10-01).

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Jeffries C (1998) FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No.19. Potato. FAO/IPGRI, Rome (IT). https://alliancebioversityciat.org/publications-data/potato
UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Polerovirus PLRV (potato leafroll virus, PLRV) (Azerbaijan and the United Kingdom A1 List; Türkiye A2 List; EU,[4] Moldova and Norway quarantine pest list, RNQP in the EU and for Jordan and Switzerland)

Symptom description

For some cultivars, many brown necrotic spots near the surface of the tuber or around the vascular ring (net necrosis) are occasionally observed (Jeffries, 1998) (Figure A44).



FIGURE A44 Net necrosis caused by potato leafroll virus. Courtesy: SA Slack (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tissue (peel or tuber flesh) should be sampled. DAS ELISA (EPPO, 2015) using PLRV specific polyclonal or monoclonal antibodies (antibodies were commercially available in 2024) can be performed on the extracted sap to detect and identify PLRV. Alternatively, molecular tests such as those listed in EPPO Standards PM 3/21 (EPPO, 2019) and PM 4/28 (EPPO, 2023) can be used.

REFERENCES FOR DESCRIPTION

EPPO (2015) Diagnostics. EPPO Standard PM 7/125(1) ELISA tests for viruses. *EPPO Bulletin* 45, 445–449.
EPPO (2023) Production of healthy plants for planting. EPPO Standard PM 4/28(2) Certification scheme for seed potatoes. *EPPO Bulletin* 53, 460–475.
EPPO (2019) Phytosanitary procedures. EPPO Standards PM 3/21 Post-entry quarantine for potato. *EPPO Bulletin* 49(3), 452– 479.
Jeffries C (1998) FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No.19. Potato. FAO/IPGRI, Rome (IT). https://alliancebioversityciat.org/publications-data/potato

[4]Non-EU isolates.

***Pomovirus solani* (potato mop-top virus, PMTV) (Morocco quarantine pest List, Türkiye A1 List)**

Symptom description

Primary infection of sensitive cultivars causes slightly raised lines and rings and/or brown arcs on the tuber surface and lines (spraing) in the tuber flesh (Jeffries, 1998). Powdery scab pustules may be present (Jeffries, 1998). Secondarily infected tubers may be cracked and distorted and have blotchy surface markings or reticulate surface cracking (Jeffries, 1998) and 'elephant hide' (UNECE, 2014) (Figure A45).



FIGURE A45 (a) Elephant hide and cracking on potato tubers. (b) Necrotic rings. Courtesy A&B: SASA (UK). (c) Symptoms caused by infection with potato mop-top virus. Credit: Anne Rahkonen, Luke, CC-BY-NC-SA-4.0 (https://laji.fi/). (d) Symptoms of spraing. Credit: H Barker (SCRI, UK).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tissue (peel or tuber flesh) should be sampled. DAS ELISA (EPPO, 2015) using PMTV specific polyclonal or monoclonal antibodies (antibodies were commercially available in 2024) can be performed on extracted sap to detect and identify PMTV. Alternatively, molecular tests such as those listed in EPPO Standard PM 3/21 (EPPO, 2019) and PM 4/28 (EPPO, 2023) can be used.

REFERENCES FOR DESCRIPTION

EPPO (2015) Diagnostics. EPPO Standard PM 7/125(1) ELISA tests for viruses. *EPPO Bulletin* 45, 445–449.
EPPO (2019) Phytosanitary procedures. EPPO Standards PM 3/21 Post-entry quarantine for potato. *EPPO Bulletin* 49(3), 452–479.
EPPO (2023) Production of healthy plants for planting. EPPO Standard PM 4/28(2) Certification scheme for seed potatoes. *EPPO Bulletin* 53, 460–475.
Jeffries C (1998) FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No.19. Potato. FAO/IPGRI, Rome (IT). https://alliancebioversityciat.org/publications-data/potato
UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

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Pospiviroid fusituberis (potato spindle tuber viroid, PSTVd) (EPPO A2)

Symptom description

Symptoms may differ according to cultivar and PSTVd strain: spindle-shaped appearance i.e. small, narrow and elongated tubers or presence of knobs and swelling of tissue around the eyes. In serious other cases, tubers may be deformed with deep growth cracks (Jeffries, 1998; UNECE, 2014) (Figure A46).



FIGURE A46 (a) Potato spindle tuber viroid (PSTVd): Healthy and diseased tubers, cv. Nicola. Spindle shape appearance. Courtesy: Plant Protection Service, Wageningen (NL) (EPPO GD); (b) Symptoms of PSTVd: Elongation and cracks. Courtesy: Biologische Bundesanstalt, Braunschweig (DE) (EPPO GD). (c) Deformed tubers with deep growth cracks. Courtesy: NPPO of the Netherlands (EPPO GD).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Tests recommended for the detection and identification of PSTVd are described in ISPM 27 DP 07 (IPPC, 2016) and EPPO Diagnostic Standard PM 7/138 *Pospiviroïds* (EPPO, 2021).

REFERENCES FOR DESCRIPTION

EPPO (2021) Diagnostics. EPPO Standard PM 7/138(1) Pospiviroids (genus *Pospiviroid*). *EPPO Bulletin* 51, 144-177. https://doi.org/10.1111/epp.12717

IPPC (2016) Diagnostic protocols for regulated pests. ISPM 27 DP 7: Potato spindle tuber viroid. https://www.ippc.int/en/publications/8073/

Jeffries C (1998) FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No.19. Potato. FAO/IPGRI, Rome (IT). https://alliancebioversityciat.org/publications-data/potato

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Potexvirus ecspotati (potato virus X, PVX) (United Kingdom and Switzerland A1 List; Jordan and Türkiye A2 List; EU [only for non-EU isolates], Moldova and Norway quarantine pest list; mosaic symptoms caused by PVX [EU isolates] are listed under RNQP regulation in the EU)

Symptom description

Symptomatic tubers are rarely observed. Tuber necrosis may occur in some cultivars (Awasthi & Verma, 2017; Jeffries, 1998).

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tissue (peel or tuber flesh) should be sampled. DAS ELISA (EPPO, 2015) using PVX specific polyclonal or monoclonal antibodies (antibodies were commercially available in 2024) can be performed on the extracted sap to detect and identify PVX. Alternatively, molecular tests such as those listed in EPPO Standards PM 3/21 (EPPO, 2019) and PM 4/28 (EPPO, 2023) or potexvirus genus specific primers such as those described in EPPO Standard PM 3/21 (EPPO, 2019), followed by sequencing of the amplicon produced can be used.

REFERENCES FOR DESCRIPTION

Awasthi LP & Verma HN (2017) Current status of viral diseases of potato and their ecofriendly management -A critical review. Virology: Research & Reviews. ISSN: 2514-4138. DOI: https://doi.org/10.15761/VRR.1000122

EPPO (2015) Diagnostics. EPPO Standard PM 7/125(1) ELISA tests for viruses. *EPPO Bulletin* 45, 445–449.

EPPO (2019) Phytosanitary procedures. EPPO Standards PM 3/21 Post-entry quarantine for potato. *EPPO Bulletin* 49 (3), 452–479.

EPPO (2023) Production of healthy plants for planting. EPPO Standard PM 4/28 (2) Certification scheme for seed potatoes. *EPPO Bulletin* 53, 460–475.

Jeffries C (1998) FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No.19. Potato. FAO/IPGRI, Rome (IT). https://alliancebioversityciat.org/publications-data/potato

Potyvirus yituberosi (potato virus Y, PVY) (United Kingdom and Switzerland A1 List; Jordan and Türkiye A2 List; Moldova and Norway (non-European isolates) quarantine pest list; mosaic symptoms caused by PVY are listed under RNQP regulation in the EU)

Symptom description

All PVY strains may cause tuber necrosis/potato tuber necrotic ringspot disease (PTNRD) (Whitworth et al., 2021), with the risk of disease development and severity depending on the PVY strain, the potato cultivar and the environment (Le Romancer & Nedellec, 1997). Risk of PTNRD increases from PVY^{O} to PVY^{N} to recombinants such as $PVY^{N\text{-}Wilga}$ and PVY^{NTN} and as the temperature increases from 10 to 20°C and above during the growing season and after harvest (Dolnicar et al., 2011; Le Romancer & Nedellec, 1997).

On susceptible cultivars brown blisters in the form of arcs, rings or lines, necrotic arcs and rings are produced (The French seed potato, 2025). Symptoms progress in the store from a smooth pink to reddish-brown necrotic ring or arc on the tuber surface to become raised before finally resulting in an unsightly sunken crater which may turn a darker brown (UNECE, 2014). The lesions remain superficial and there are no necrotic arcs within the tuber flesh, which distinguishes this disease from spraing caused by PMTV or TRV (UNECE, 2014).

Cracking is also a tuber symptom of PVY but may also be caused by *Potyvirus atuberosi* (Potato virus A, PVA), and *Potyvirus vetuberosi* (potato virus V, PVV) (Carnegie & McCreath, 2010) (Figure A47).

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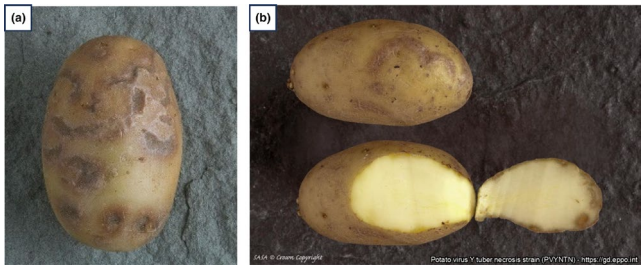

FIGURE A47 (a, b) External symptoms of potato tuber necrosis ring disease (PTNRD) caused by PVY infection. (b) Internal symptoms. Courtesy: (a, b) SASA (EPPO GD). *Additional pictures are available in* Bugwood.org.

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tissue (peel or tuber flesh) should be sampled. DAS ELISA (EPPO, 2015) using PVY^{O+C} and PVY^{N+NTN} specific monoclonal antibodies (antibodies were commercially available in 2024) can be performed on the extracted sap to determine whether infection is caused by PVY^{O} /PVY^{C} or PVY^{N}/ PVY^{NTN} (Davie et al., 2017)

To distinguish PVY^{N} from the recombinant PVY^{NTN} molecular tests such as those described in Lorenzen et al. (2006), Kogovšek et al. (2008) or Chikh-Ali et al. (2010) can be used.

REFERENCES FOR DESCRIPTION

Carnegie SF & McCreath M (2010) Mosaic virus symptoms on potato crops and the occurrence of growth cracking in tubers. *Potato Research* 53, 17-24.

Chikh-Ali M, Maoka T, Natsuaki KT & Natsuaki T (2010) The simultaneous differentiation of Potato virus Y strains including the newly described strain PVYNTN-NW by multiplex PCR assay. *Journal of Virological Methods* 165, 15-20.

Davie K, Holmes R, Pickup J & Lacomme C (2017) Dynamics of PVY strains in field grown potato: Impact of strain competition and ability to overcome host resistance mechanisms. *Virus Research* 241, 95-104.

Dolnicar P, Mavric Plesko I & Meglic V (2011) Long-term cold storage suppress the development of tuber necrosis caused by PVY^{NTN}. *American Journal of Potato Research* 88, 318–323.

EPPO (2015) Diagnostics. EPPO Standard PM 7/125(1) ELISA tests for viruses. *EPPO Bulletin* 45, 445–449.

Kogovšek P, Gow L, Pompe-Novak M, Gruden K, Foster GD, Boonham N & Ravnikar M (2008) Single-step RT real-time PCR for sensitive detection and discrimination of Potato virus Y isolates. *Journal of Virological Methods* 149, 1-11.

Le Romancer M & Nedellec M (1997) Effect of plant genotype, virus isolate and temperature on the expression of the potato tuber necrotic ringspot disease (PTNRD). *Plant Pathology*, 46, 104-111. https://bsppjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-3059.1997.d01-212.x

Lorenzen J H, Piche LM, Gudmestad NC, Meacham T & Shiel P (2006) A multiplex PCR assay to characterize Potato virus Y isolates and identify strain mixtures. *Plant Disease* 90, 935-940. https://apsjournals.apsnet.org/doi/10.1094/PD-90-0935

The French seed potato (2025) Diseases and pests. Necrosis Potato virus Y^{NTN}. SEMAE, FN3PT (FR). https://www.plantdepommedeterre.org/en/maladie-ravageur/necrosis-potato-virus-yntn-pvyntn/ (accessed 2025-02-27).

UNECE (2014) Guide to Seed Potato Diseases, Pests and Defects, available at https://unece.org/trade/wp7/SeedPotatoes-Standards

Whitworth JL, Grey SM, Ingram JT & Hall DG (2021) Foliar and tuber symptoms of U.S. potato varieties to multiple strains and isolates of *Potato virus Y. American Journal of P Research* 98, 93–103.

Tobravirus tabaci (tobacco rattle virus, TRV) (Israel quarantine pest, Jordan A2 List, Türkiye A1 List)

Symptom description

Tubers may develop spraing (see PMTV), also known as corky ringspot disease, i.e. brown, corky arcs and spots in the tuber flesh, which are sometimes visible on the skin surface (UNECE, 2014). Superficial necrosis can sometimes be seen (The French seed potato, 2025).

Infected tubers can be asymptomatic (Figure A48).

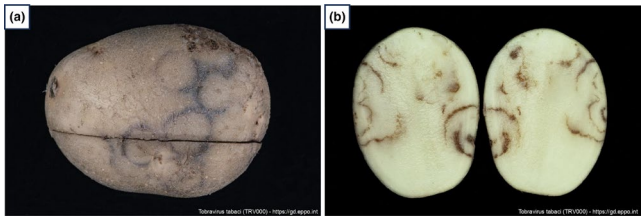

FIGURE A48 (a) Necrotic rings. Courtesy: SASA (UK). (b) Symptoms of spraing. Courtesy: Hugh Barker, SCRI (UK) (EPPO GD). *Additional pictures are available in EPPO GD.*

Sampling, detection and identification

Symptomatic tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. Symptomatic tissue (peel or tuber flesh) should be sampled. Although TRV antibodies are commercially available for use in ELISA, serological detection may be unreliable because of considerable diversity or even lack of the coat protein in TRV NM isolates (Dale et al., 2004; Sahi et al., 2016).

RT-PCR using TRV virus-specific primers such as those listed in EPPO Standards PM 3/21 (EPPO, 2019) and PM 4/28 (EPPO, 2023) can be used.

REFERENCES FOR DESCRIPTION

Dale MFB, Robinson DJ & Todd D (2004) Effects of systemic infections with Tobacco rattle virus on agronomic and quality traits of a range of potato cultivars. *Plant Pathology* 53, 788–793. https://bsppjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1365-3059.2004.01093.x

EPPO (2019) Phytosanitary procedures. EPPO Standards PM 3/21 Post-entry quarantine for potato. *EPPO Bulletin* 49(3), 452–479.

EPPO (2023) Production of healthy plants for planting. EPPO Standard PM 4/28 (2) Certification scheme for seed potatoes. *EPPO Bulletin* 53, 460–475.

Sahi G, Hedley PE, Morris J, Loake GJ & MacFarlane SA (2016) Molecular and biochemical examination of spraing disease in potato tuber in response to tobacco rattle virus Infection. *Molecular Plant Microbe Interactions.* 29, 822-828. https://pubmed.ncbi.nlm.nih.gov/27681277/

The French seed potato (2025) Diseases and pests. Tobacco rattle virus TRV. SEMAE, FN3PT (FR). https://www.plantdepommedeterre.org/en/maladie-ravageur/tobacco-rattle-virus-trv/ (accessed 2025-02-27).

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APPENDIX 2 - EXAMPLE OF EQUIPMENT USED FOR POTATO TUBER INSPECTION AT EXPORT AND IMPORT

To facilitate inspection, it is recommended that the inspection area is large enough to perform the visual examination of a packing unit (e.g. hessian bag max. 50 kg), with good lighting above. All materials/equipment should be cleaned and disinfected between each separate lot.

Equipment for visual examination

- (sharp) knife suitable for cutting tubers.
- magnifying glass.
- disinfectant for knife (e.g. alcohol, quaternary ammonium salts, benzoic acid).
- disposable gloves.
- inspection table (see Figure A49): an inspection table constructed with a slope of 10 – 15° from the rear to the front, constructed with parallel bars allows soil to fall through and facilitates soil collection for laboratory testing. If soil is not required for collection, the bars can be covered for example with a hardboard plate. At the lower end of table, tubers can be collected in the original packing unit (e.g. bag).
- large table (see Figure A50), with smooth washable surface easy to clean and disinfect, to spread out the cut tubers.

Equipment for soil sampling:

- Paper sheets for collection of soil. Preferably A2 or A1 size.
- Disposable gloves.
- Inspection table, net (polypropylene) bags, or steel basket for the collection of soil from tubers.
- New sample bags / sealable bags for collecting and identifying soil samples for laboratory testing e.g. for potato cyst nematodes.
- Weighing scales.



FIGURE A49 Example of specific inspection table used to potato tuber inspection in the Netherlands (Courtesy: M. J. Van Sabben).



FIGURE A50 Large table to spread out the cut tubers for inspection (Courtesy: C. Segovia. Phytosanitary inspector at the BCP of Cartagena, Murcia Region, Spain).

Equipment for tuber sampling:

- New polypropylene or paper bags (size: able to hold 200 tubers).
- Disposable gloves.
- Pull tight seals for closing bags and identifying the sample, thief resistant bags.
- Indelible marker and labels (Figures A51 and A52).

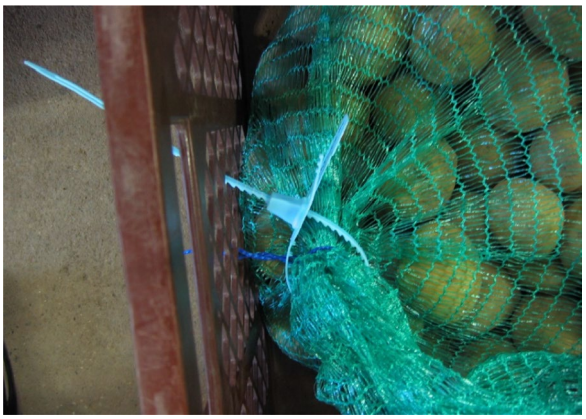

FIGURE A51 Seal for closing bags and identifying the samples, to be pulled tight (Courtesy: A. Ritter).

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FIGURE A52 Example of specific burglar-proof bags (Courtesy: V. Cappa).

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APPENDIX 3 - SHORT PROCEDURE FOR INSPECTORS

GENERAL

For visual examination of potato tuber consignments, plant health inspectors should be equipped with a knife, a magnifying glass, disinfectant, disposable gloves, bags, paper sheets, weighing scales, pull tight seals and labels. The place where the inspection is conducted should be well lit, equipped with an inspection table and a large table to spread out the cut tubers. The visual examination should begin with an overall examination of the consignment. Visual examination of the shipping container, packaging and means of conveyance can provide indications of adverse conditions during transport (e.g. high or low temperatures, wetness), presence of plant debris, or live or dead insects on the packaging or in the shipping container. The packaging used should be inspected to ensure that it conforms with the requirements of the importing country.

HYGIENE MEASURES

Inspections and sampling can themselves be a pathway for spreading pests or contaminating other lots, therefore inspectors should take appropriate precautions against quarantine pests during inspection and sampling, such as wearing gloves and disinfecting of hands and tools. Good hygiene procedures when collecting samples for the laboratory should be followed by decontaminating tools and hands. Applicable rules relating to food hygiene should be followed. This may also be necessary, depending on the risk assessed, to prevent contamination with RNQPs.

SAMPLE SIZE

The units commonly used for sampling are generally the potato tubers. However, it should be noted that when using bags of e.g. 10–50 kg, the visual examination for external symptoms on potato tubers is generally conducted using all tubers from the sampled bags. It is up to the NPPO to set sample size taking into account the statistical background provided in ISPM No. 31 *Methodologies for sampling of consignment* (IPPC, 2016).

For inspection of internal symptoms after cutting or for sending to the laboratory for analysis, for example, 200 tubers could be sampled from a lot. For large lots that are sufficiently mixed and assuming a binomial distribution, this will give approximatively 87% confidence level of detecting visible pests or symptoms at a 1% infestation level. Another example would consist of sampling 400 tubers from a lot to provide approximatively 98% confidence level of detecting visible pests or symptoms at a 1% infestation level; or approximatively 87% confidence level of detecting the pest at a 0.5% infestation level.

To improve representativeness of the sample, tubers should be sampled from different parts of the lot (e.g. from different packing units). However, practicalities and constraints, including limited resources mean that it is often difficult to draw samples with tubers from every packing unit (e.g. bag) in a large lot. For example, drawing from practical experience when sampling tubers for the quarantine pest control in imported lots in the EPPO region, when a lot consists of 25–50 kg bags, multiple bags could be sampled from a lot ensuring both of the following conditions are met: at least from 5 bags per lot and at least one bag per 10 tonnes. When using 'big' or 'jumbo' bags, potato tubers from at least 2 'big' or 'jumbo' bags can be sampled per lot. For small packing units (e.g. 10 kg), a similar approach to 25–50 kg bags may be used, adjusting the number to achieve the level of confidence required for a specific level of infection.

As far as possible, the packing units for sampling should be selected randomly from different parts of the lot, but units showing suspicious signs/symptoms (e.g. wetness) should be targeted.

Facilities and equipment should allow that packing units, such as bags to be sampled, are emptied in such a way that all tubers in this package can be checked, for example on a specific inspection table (Figures A49 and A50 of Appendix 2).

TUBER SAMPLING FOR VISUAL EXAMINATION

Each packing unit chosen for inspection should be examined for the presence of soil. If it is suspected that the amount of soil in the consignment exceeds the requirements set by the country of import, soil should be collected from the suspected lots and weighed (see soil sampling).

All tubers selected for inspection should be checked visually for external signs and symptoms of infestation. Tubers should be sufficiently clean to observe the surface. If this is not the case, washing or brushing may be needed.

Tubers selected for examination of internal signs and symptoms should be cut in half, generally lengthwise (from the rose-end (apex) to the heel-end) and checked for symptoms of regulated pests. When some specific pests are suspected or when specifically required, cutting should be performed crosswise e.g. close to the heel-end for *Ralstonia solanacearum*, or tubers should be peeled e.g. for *Meloidogyne* spp. or *Nacobbus aberrans*. For some pests, it may also be easier to observe symptoms a few minutes after cutting (e.g. pink colouration

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TABLE A1 Examples of symptoms on potato tubers.

Holes or tunnels
Diabrotica speciosa (cucurbit beetle)
Epitrix cucumeris, *E. papa*, *E. subcrinita, E. tuberis* (flea beetles)
Heteronychus arator (African black beetle)
Limonius californicus (sugarbeet wireworm)
Melanotus communis (common wireworm)
Phthorimaea operculella (potato tuber worm)
Premnotrypes spp. (Andean potato weevil)
Tecia solanivora (Central American potato tuber worm/ Guatemalan potato moth)
Flaccid tubers, spongy tissue
'*Candidatus* Phytoplasma solani' (potato stolbur)
Nacobbus aberrans sensu lato (false root-knot nematode)
Necrotic arcs and lines on the surface and/or in the flesh of tubers
Orthotospovirus tomatomaculae (tomato spotted wilt virus)
Potyvirus yituberosi (potato virus Y)
Pomovirus solani (potato mop-top virus)
Tobravirus tabaci (tobacco rattle virus)
Presence of cysts or webbing
Globodera pallida and *G. rostochiensis* (potato cyst nematode)
Tetranychus evansi (red spider mite)
Cracks and deformations
Crinivirus flavisolani (potato yellow vein virus)
Pomovirus solani (potato mop-top virus)
Pospiviroid fusituberis (potato spindle tuber viroid)
Rhizoctonia solani (black scurf)
External skin blemishes: Patches
Colletotrichum coccodes (black dot)
Helicobasidium brebissonii (violet root rot)
Helminthosporium solani (silver scurf)
External skin blemishes: Corky lesions
Streptomyces spp. (common scab, netted scab)
External skin blemishes: Pitted and raised structures
Colletotrichum coccodes (black dot)
Rhizoctonia solani (black scurf)
Spongospora subterranea (powdery scab)
Streptomyces spp. (common scab, netted scab)
Meloidogyne spp. (root knot nematode)
External skin blemishes: Outgrowths
Spongospora subterranea (powdery scab)
Synchytrium endobioticum (wart disease)
Thecaphora solani (potato smut)
Dry rot
Alternaria spp. (early potato blight)
Boeremia spp. (potato gangrene)
Ditylenchus destructor (potato rot nematode) and *D. dipsaci* (stem and bulb nematode)
Fusarium spp. (potato dry rot)
Phytophthora infestans (potato late blight)
Sclerotinia minor and *S. sclerotiorum* (dry rot)
Soft rot /wet rot
Athelia rolfsii (synonym: *Sclerotium rolfsii*) (sclerotium stem rot)
Dickeya spp. (soft rot)
Clavibacter sepedonicus (ring rot)
Geotrichum candidum (watery soft rot)
Pectobacterium spp. (soft rot)
Phytophthora erythroseptica (pink rot)
Phytophthora infestans (potato blight)
Pythium spp.(watery wound rot, leak rot)
Ralstonia solanacearum (brown rot)
Internal discoloration or discolouration of vascular ring
'*Candidatus* Liberibacter solanacearum' (zebra chip disease)
'*Candidatus* Phytoplasma americanum' (potato purple-top wilt)
Clavibacter sepedonicus (ring rot)
Polerovirus PLRV (potato leafroll virus)
Potexvirus ecspotati (potato virus X)
Verticillium spp. (verticillium wilt)

related to infection with *Phytophthora erythroseptica*). When the presence of a quarantine pest is suspected, or under some circumstances to confirm that the tolerance for a particular RNQP is respected, the tubers should be tested. Testing may also be performed when presence of a new pest presenting risk is suspected. Cut tubers should be removed from the consignment.

If tolerance levels for pests listed as RNQPs or for symptoms in the seed certification scheme are applicable (e.g. percentage of tubers with a certain area of the skin infected by the specified pest such as for black scurf [*Thanatephorus cucumeris*=*Rhizoctonia solani*], common scab [*Streptomyces* spp.] or powdery scab [*Spongospora subterranea*]), for example 200 tubers can be randomly picked and used to check whether the percentage of affected tubers exceeds the tolerance. This can be combined with sampling for visual examination or testing of quarantine pests.

Some symptoms or lesions are characteristics of certain pests or category of pest. These symptoms should be looked for during visual examination of the tubers, such as:

Other symptoms are described in Appendix 1.

TUBER SAMPLING FOR LABORATORY TESTING

If laboratory testing of tubers is required to confirm absence of a quarantine latent infection or to confirm that the tolerance for a particular RNQP is respected, the number of tubers required for specific tests by the laboratory should be taken randomly (e.g. from randomly

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selected packing units of the lot), including any suspected tubers.

The tubers should be placed in a leak proof plastic bag/box before being sent to the laboratory. If appropriate, particularly if tubers have been cut or are rotting, tubers may be wrapped individually in dry absorbent paper. Live larvae shall be packed with a section of fruit. If not sent directly, the potato tubers should be cooled (e.g. in a coolbox) to avoid further deterioration of the sample.

SOIL SAMPLING

Sampling of soil attached to potato tubers may be part of the import or export inspection (e.g. for potato cyst nematodes *Globodera rostochiensis* and *G. pallida*). If an inspection table is available (Figures A49 and A50 of Appendix 2), soil can be collected during inspection by spreading a sheet of paper, on the floor under the table to collect soil falling from the tubers. To increase the amount of soil collected, tubers could be rubbed against each other on the table. Collected soil should be transferred to a sampling bag and the sampling bag should be sealed and labelled before transport to the laboratory. Before sampling the next lot, all remaining soil on the table should be removed and a new, clean sheet of paper placed under the table. For export, soil sampling can also be done during bagging by placing a sheet of paper underneath the bagging machine and collecting the loose soil from there. Alternative methods for collection of soil are provided in Section 6.3.3.

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