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Norwegian Scientific Committee for Food and Environment

VKM Report 2018:15

Assessment of Quarantine Pest Dispersal from Norwegian Potato and Root Vegetable Packing Plants with Evaluation of Risk Reducing Options

Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment

Report from the Norwegian Scientific Committee for Food and Environment (VKM) 2018:15
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Cover photo, left to right: Yellow potato cyst nematode, photo by Bonsak Hammeraas; Potato wart, photo by Leif R. Hansen; Bacterial ring rot, photo by Erling Fløistad, NIBIO.

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Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM), appointed a project group to answer the request from the Norwegian Food Safety Authority. The project group consisted of three VKM members from the Panel on Plant Health and one project manager from the VKM secretariat. The VKM Panel on Plant Health evaluated and approved the final opinion drafted by the project group.

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Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

The Norwegian Food Safety Authority (NFSA) has commissioned the Norwegian Scientific Committee for Food and Environment (VKM) to identify quarantine pests and potential quarantine pests that may be dispersed with organic waste, wastewater or sludge from packing plants that handle domestic and imported potatoes and vegetables. The NFSA asks VKM to identify risk reduction options and evaluate the effectiveness and feasibility of the options. The VKM Panel on Plant Health did the assessment.

The crops relevant for the assessment are potatoes, bulb, carrots, onions and other root vegetables that are susceptible to damage from quarantine pests. Norwegian potato production has decreased during recent decades, while there has been a significant increase in the production of carrots, bulb onions, and other root vegetables. The industries handling potato and vegetables from domestic production and imported potato and root vegetables are located in most agricultural regions of Norway.

The assessment deals with both quarantine pests and potential quarantine pests. In total 13 plant pathogenic viruses, five plant pathogenic bacteria and phytoplasmas, five plant pathogenic fungi, six plant parasitic nematodes and four plant parasitic insects have the potential for dispersal with waste from packing plants.

The entry of quarantine plant viruses into Norwegian packing plants is considered very unlikely. The entry of two plant pathogenic bacteria is very likely as the ring rot bacterium *Clavibacter michiganensis* ssp. *sepedonicus* is present in Norway, while there are regular outbreaks of the brown rot bacterium *Ralstonia solanacearum* in countries exporting potatoes to Norway. Entry of the potato wart fungus *Synchytrium endobioticum* with domestic potato is unlikely, but the entry of the pest with imported potato is moderately likely, due to its distribution in countries exporting potato to Norway. The entry of the onion white rot fungus *Stromatinia cepivora* into packing plants is very likely due to its domestic distribution and its distribution in countries exporting onions to Norway. The entry of the stem and bulb eelworm *Ditylenchus dipsaci* and the potato rot nematode *D. destructor* is moderately likely. The entry of yellow potato cyst nematode *Globodera rostochiensis* is very likely. The entry of the white potato cyst nematode *G. pallida* is moderately likely for

Norwegian potato and very likely for imported potato. As the two nematodes *Meloidogyne chitwoodi* and *M. fallax* are absent from Norway, the probability of entry into packing plants is unlikely for domestic crops and moderately likely for imported crops. The probability of entry of the potato tuber damaging insects in the genus *Epitrix* is likely.

There are several risk reduction options available to prevent spread of quarantine pests from packing plants. Safe deposition of damaged or rotted potato and root vegetables from the production lines reduce the risk of contamination of agricultural land. Large volumes of water are required in washing of potato and root vegetables at the packing plants. Most quarantine pests may survive in wastewater and enter rivers and lakes if the water treatment is not sufficient to kill or remove viable pest propagules.

Depositing organic and inorganic waste at a landfill site has medium effectiveness and high feasibility. Use of waste as soil improvement has medium effectiveness, but high feasibility. Passage of water through a sedimentation tank or sand filter before entering a watercourse has very low effectiveness and high feasibility. Passing the water through municipal treatment plant has high effectiveness and feasibility, while further filtration or UV-treatment has low effectiveness and low feasibility. Heat treatment of waste has high effectiveness and feasibility for most pests, but the effectiveness and feasibility are low to medium for *Synchytrium endobioticum*, *Stromatinia cepivora*, *Globodera* spp. and *Meloidogyne* spp. Waste used as animal feed has high effectiveness and feasibility for most pests, but the effectiveness is low for *Synchytrium endobioticum*, *Stromatinia cepivora*, *Globodera* spp. and *Meloidogyne* spp.

For several of the quarantine pests described in the current report there are few or no data on survival in water, soil and plant debris. The lethal temperatures of the pests are not known, and these assessments are, therefore, largely based on expert judgement

Key words: Pest Risk Assessment, risk reduction, quarantine pests, potato, root vegetables, packing plants, pest distribution, pest entry, pest survival, pest dispersal, pest establishment, risk reduction options, VKM, Norwegian Scientific Committee for Food and Environment, Norwegian Food Safety Authority.

Sammendrag på norsk

Mattilsynet har bedt Vitenskapskomiteen for mat og miljø (VKM) om å identifisere karanteneskadegjørere og potensielle karanteneskadegjørere som kan bli spredt med organisk avfall, vann eller slam fra mottaksbedrifter som håndterer norskproduserte og importerte poteter og grønnsaker. Mattilsynet har bedt VKM om å identifisere risikoreduserende tiltak og vurdere effekten av tiltakene. VKMs faggruppe for plantehelse har utført vurderingen.

Kulturene som er relevante, er potet, gulrot, kepaløk og andre rotgrønnsaker som er mottakelige for angrep av karanteneskadegjørere. Norsk potetproduksjon har gått ned de siste tiårene, mens det har vært en signifikant økning i produksjonen av gulrot, kepaløk og andre rotgrønnsaker. Mottaksbedriftene for potet og rotgrønnsaker er lokalisert i de fleste landbruksdistrikter i Norge. Utover en gjennomgang av vitenskapelig litteratur har vurderingen benyttet både ekspertvurderinger og informasjon fra bedriftenes internkontrollrutiner

Vurderingen innbefatter karanteneskadegjørere og karanteneskadegjørere. Totalt 13 plantepatogene virus, fem plantepatogene bakterier og phytoplasma, fem plantepatogene sopper, seks plantepatogene nematoder og fire parasittiske insektarter har potensiale for spredning med avfall fra mottaksbedrifter.

Det vurderes som meget usannsynlig at virus som er potensielle karanteneskadegjørere kommer inn i norske mottaksbedrifter. Inntak av ringråtebakterieartene *Clavibacter michiganense* ssp. *sepedonicus* og *Ralstonia solanacearum* vurderes som meget sannsynlig, fordi *Clavibacter michiganense* ssp. *sepedonicus* finnes i Norge og utbrudd av *Ralstonia solanacearum* er vanlig i land vi importerer poteter fra. Inntak av potetkreftsoppen *Synchytrium endobioticum* er usannsynlig med norsk potet, men moderat sannsynlig med importpotet fordi soppen finnes i land vi importerer potet fra. Inntak av løkhvitråtesoppen *Stromatinia cepivora* er meget sannsynlig, fordi soppen er utbredt både i Norge og i land vi importerer løk fra. Inntak av stengelnematoden *Ditylenchus dipsaci* og poteträtenematoden *D. destructor* er moderat sannsynlig. Inntak av gul potetcystenematode *Globodera rostochiensis* er meget sannsynlig. Inntak av hvit potetcystenematode *G. pallida* er moderat sannsynlig for norsk potet og meget sannsynlig for importert potet. De to nematodeartene *Meloidogyne chitwoodi* og *M. fallax* forekommer ikke i Norge og inntak er usannsynlig med norsk potet, mens det er moderat sannsynlig at de kommer inn i bedriftene med importert potet. Inntak av poteskadegjørere i billeslekten *Epitrix* er sannsynlig.

Det er flere risikoreduserende tiltak for å hindre spredning av karanteneskadegjørere fra mottaksbedrifter. Sikker deponering av poteter og grønnsaker som er råtne eller skadet i produksjonslinjen, reduserer risikoen for spredning til landbruksarealer. Det brukes store volum av vann til vasking av potet og rotgrønnsaker. De fleste karanteneskadegjørere overlever i avfallsvann og kan komme over i elver og vassdrag om ikke vannet renses tilfredsstillende.

Deponering av organisk og uorganisk avfall på fyllplasser har middels effekt, men er lette å gjennomføre. Bruk av avfall til jordforbedring har middels effekt, men er lette å gjennomføre. Drenering av vann fra mottaksbedriftene gjennom sedimenteringstanker eller sandfilter før det renner ut i vassdrag har liten effekt, men høy gjennomførbarhet. Drenering av vann gjennom kommunale vannbehandlingsanlegg har høy effekt og gjennomførbarhet, mens filtrering eller UV-behandling har liten effekt og gjennomførbarhet. Varmebehandling av avfall har høy effekt og gjennomførbarhet for de fleste skadegjørere, men liten til middels effekt og gjennomførbarhet for *Synchytrium endobioticum*, *Stromatinia cepivora*, *Globodera* spp. og *Meloidogyne* spp. Bruk av avfall til dyrefor har høy effekt og gjennomførbarhet for de fleste skadegjørere, men liten effekt for *Synchytrium endobioticum*, *Stromatinia cepivora*, *Globodera* spp. og *Meloidogyne* spp.

For flere av karanteneskadegjørerne beskrevet i rapporten er det lite eller ingen data på overlevelse i vann, jord eller dødt plantemateriale. Dødelig temperatur for disse er heller ikke kjent, så vurderingene knyttet til dette er, i hovedsak, basert på ekspertuttalelse.

Nøkkelord: Risikovurdering av skadegjørere, karanteneskadegjører, potet, rotgrønnsaker, mottaksbedrifter, utbredelse av skadegjører, innførsel av skadegjører, overleving av skadegjører, spredning av skadegjører, etablering av skadegjører, bekjempelsestiltak, VKM, Vitenskapskomiteen for mat og miljø, Mattilsynet

Abbreviations and glossary

Table 1. Definition and the use of the terms in the current opinion is according to the ISPM No.5 Glossary of phytosanitary terms by FAO (2015).

Abbreviations/ terms	Definition and explanation of terms
CABI	Centre for Agriculture and Biosciences International
Commodity	A type of plant, plant product, or other article being moved for trade or other purpose
Consignment	A quantity of plants, plant products and/or other regulated articles being moved from one country to another and covered by a single phytosanitary certificate
Country of origin	Country where a consignment of plants was grown
Dispersal	Movement of viable pest propagules
EFSA	European Food Safety Authority
Endangered area	An area where ecological factors favour the establishment of a pest, whose presence in the area will result in economically important loss

Entry	Movement of a pest into an area where it is not yet present, or present but not widely distributed
EPPO	European Plant Protection Organization
EPPO Global Database	EPPO Global Database is maintained and constantly updated by the Secretariat of the EPPO
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry
FAO	Food and Agriculture Organization of the United Nations
Introduction	The entry of a pest resulting in its establishment
NFSA	Norwegian Food Safety Authority
NIBIO	Norwegian Institute of Bioeconomy Research
Packing plant	An establishment for processing and packing food, to be sold at wholesale.
Pathotype	A variety of an organism, that causes disease in a particular host or range of hosts.
Pathway	Any means that allows the entry or spread of a pest

Pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products
PRA area	Pest risk analysis area: Area in relation to which a pest risk analysis is conducted
Quarantine pest	A pest of potential economic importance to the area endangered and not yet present there, or present but not widely distributed and being under official control.
Quarantine	Official confinement of plants or plant products subject to phytosanitary regulations for observation and research or for further inspection, testing and/or treatment
Sludge	A semi-solid slurry from wastewater treatment or industrial processes
Vector	An organism or vehicle that transmits a causative agent or disease-causing organism between hosts or from a reservoir to a host
VKM	Norwegian Scientific Committee for Food and Environment

Background as provided by the Norwegian Food Safety Authority

The Norwegian Food Safety Authority hereby requests an evaluation of the effect of risk reducing options to avoid the spread of quarantine pests from businesses receiving potatoes or unwashed vegetables with roots for sorting, packaging, washing or industrial processing (hereafter called receiving businesses).

Background

There are receiving businesses in most counties of Norway. As a group they are heterogeneous when size, the number of suppliers they have, their activity and the number of products they produce are concerned, but potentially they can all receive products that are infected with quarantine pests. Therefore, quarantine pests can be spread with the waste, if the waste is not treated in an appropriate way. Examples of receiving businesses or activities are potato packaging, potato sorting, chips production, potato flour production, spirit production, production of potato griddle cake, potato salads and frozen mixtures of vegetables. Some businesses handle Norwegian products only, while others also handle imported products.

Requirements of the plant health regulations

According to the Regulations relating to plants and measures against pests it is prohibited to introduce and spread pests listed in the annexes 1 and 2 of the regulations. These pests are referred to as quarantine pests. Quarantine pests in annex 1 are relevant, when waste from receiving businesses is concerned. Receiving businesses are required to notify their activity to the Norwegian Food Safety Authority, cf. § 7e) of the plant health regulation, and they are obliged to carry out internal controls, cf. § 9. Among other things the internal controls means that the receiving business shall map the risk of contravening conditions in the regulations in relation to the business' activities and initiate measures to reduce this risk of spreading quarantine pests from the business.

The Norwegian Food Safety Authority supervise the businesses by auditing their internal control systems.

§ 18 of the Act relating to food production and food safety, etc. (Food Act) states that "Any person shall exercise due care to avoid any risk of the development or spread of plant pests."

Probability of plant pests being introduced to the facility

The receiving businesses can receive potatoes (except seed potatoes) or vegetables with roots, such as carrot, swede, onion, leek, turnip-rooted celery, beetroot etc. The products can have been grown locally, originate from other parts of Norway or be imported. The potatoes can be washed or unwashed when arriving. Most of the imported potatoes are washed, whereas Norwegian potatoes will most of the time be unwashed. When it comes to vegetables with root, this request concerns unwashed products only.

The probability of quarantine pests being introduced to the facility will vary from business to business, but in principal the businesses should consider the probability of quarantine pests entering the business, as high, and therefore handle the waste and sewage in such a way that quarantine pests will not be spread.

In addition to currently regulated pests, also new and potential quarantine pests may be introduced to the facility.

Types of waste from packing plants

The waste from packing plants that handle domestic and imported potatoes and vegetables can be soil, processing water and organic matter.

The soil can be from sorting, sludge from interceptor for sludge or slurry basin etc. Concerning soil from sorting, the Norwegian Food Safety Authority considers that routines for appropriate handling have been established in cooperation with NIBIO, and that an assessment from the Norwegian Scientific Committee for Food Safety is not necessary.

With processing water is meant the wastewater from washing the received products and/or machinery and equipment and water that has been used for processing the products. The water can contain particles of both soil and organic matter. The processing water can leave the receiving business through the public sewage to a purification plant or be led through an interceptor for sludge, a slurry basin and sand filter or an infiltration plant before being discharged to the watercourse. The water passing through the public sewage to a sewage treatment plant is not part of this request.

Organic waste can be from peeling (mechanical peeling or steam peeling at 100°C), damaged products, leftovers, rasp and fruit water from potato flour production. Damaged products and left overs can be unwashed, whereas the other waste fractions will be washed before the relevant treatment. Rasp is the solid part remaining of the potato when the starch is removed. The fruit water is the water remaining after separation of the starch and rasp. The organic waste represents a resource, which is often used as animal feed or soil improvement. Organic matter being used for composting is not a part of this request.

Aspects of uncertainty

Both the Norwegian Food Safety Authority and the receiving businesses need more information and knowledge on what is sufficient treatment of the waste in order to prevent the spread of plant pests from the facilities.

Two reports from 2016 provide more knowledge on several of the issues:

A report from the University of Aarhus in Denmark: "Plantesundhedsmæssige risiki ved deponering af restprodukter og affald fra industriel forarbejdning og sortering af kartofler samt anbefalinger om restriksjoner for deponering, herunder karenstider for planteavl" (Nielsen et al. 2016).

A report from the Norwegian Scientific Committee for Food Safety: "Assessment of manure and digestive tract content from slaughterhouses as a pathway for weed and plant pests".

The Danish report concerns four kinds of businesses receiving potatoes for further treatment (potato peeling companies, potato packing companies, producers of potato chips and potato flour respectively) and specified quarantine pests related to potatoes. The Norwegian Food Safety Authority also wishes that other kinds of businesses are included in the assessment, for example producers of spirit, potato griddle cake, salads and frozen mixture of potatoes and/or vegetables with roots. This means that businesses not receiving potatoes, but unwashed vegetables with roots, are to be assessed.

Terms of reference as provided by the Norwegian Food Safety Authority

This request is related to waste from businesses receiving potatoes (both washed and unwashed) or unwashed vegetables with roots for sorting, packaging, washing or industrial processing.

The Norwegian Food Safety Authority (NFSA) requests the Norwegian Scientific Committee for Food Safety to:

1. Identify which host plants/products and which quarantine pests and potential quarantine pests are relevant for this assessment

2. Identify risk reducing options (heat treatment, filtration and others) in order to prevent the spread of the relevant quarantine pests with each of the specified waste from such businesses, both businesses handling imported products and businesses handling Norwegian products only.

3. Evaluate the effectiveness and feasibility of the options.

Types of waste to be considered:

- Organic waste (peel, left overs, damaged products, rasp and others) to be used as feed and soil improvement respectively

- Waste water from washing and processing the products (possible particles of soil and organic matters included) which will be led to a watercourse

- Sludge from processing to be used for soil improvement

NFSA will provide information on risk reducing options being used in selected businesses and data on import.

Assessment

1 Introduction

This document presents a scientific Opinion prepared by the VKM Panel on Plant Health (hereafter referred to as the Panel) in response to a request from the NFSA. The Opinion is an assessment of the effects of risk reducing options to avoid dispersal of quarantine pests of potato and root vegetables from businesses handling imported and/or domestic plant products, hereafter called packing plants.

NFSA considers that routines for appropriate handling of soil from sorting have been established and that an assessment of the potential risk of dispersal of quarantine pests through soil from sorting is to be excluded from the assessment. Therefore, the potential of dispersal of quarantine pests through soil from sorting processes is not part of this assessment. Likewise, the potential risk of dispersal of quarantine pests with water passing through the public sewage to a sewage treatment plant is not part of the assessment. The risk of dispersal of quarantine pests with organic matter, to be used for composting, is also not part of the request.

1.1 Identification of relevant host plants

Based on the background provided by NFSA the crops relevant for the assessment are: Potatoes (except seed potatoes) and vegetables with roots, such as carrots, swedes, bulb onions, leek, turnip-rooted celery, beetroots etc. These are major products handled by the domestic potato and vegetable packing plants.

1.1.1 Norwegian potato production

Potatoes are produced in most agricultural areas of Norway. During the Second World War and in the post-war years, potatoes were cultivated on more than 500 000 decare (daa), and in 1949 potato was planted on 582 000 daa. The area of potato cultivation decreased during the last fifty years of the twentieth century, and during the last two decades the area of domestic potato cultivation has decreased from 150 180 daa in 2000 to 115 810 daa in 2016 (Fig 1, Table 2).

Table 2. Norwegian potato production (Statistics Norway 2017).

Year	Potato (daa)	Yield (kg/daa)	Total harvest (tonnes)
2000	150 180	2 397	356 500
2010	132 056	2 517	333 200
2016	115 810	3 034	350 800

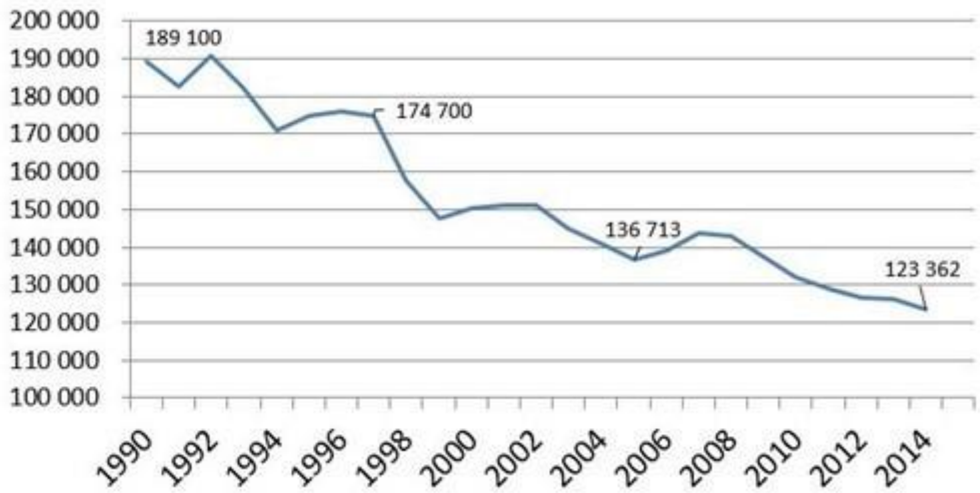

Figure 1. Potato cultivation in Norway over the last 25 years. (Norsk landbruksrådgivning)

1.1.2 Potato import to Norway

Potato import to Norway has been recorded by NFSA in their surveying system since 2007 (Tables 3 and 4). The information presented in Tables 3 and 4 is the number of imported potato consignments, not the volume of potatoes. Country names given in Table 3 are from where the potato consignments originated. However, the exporting country may not always be the country of origin since occasionally re-export may occur. Some of the commodities are ready-packed and sold by shops directly to consumers.

During the period 2007 - 2017 Denmark, France, Israel, Great Britain and Sweden each exported more than 1000 consignments of potato to Norway, while altogether 31 countries supplied the Norwegian market with potato during the same period (Table 3).

Weight data on the potato consignments listed in Tables 3 and 4 are not available.

Table 3. Total numbers of potato consignments imported to Norway in the period 2007 to 2017 (NFSA 2018). Consignments from countries not in bold did not enter via packing plants.

Country of origin	**Number of consignments**
Afghanistan	26
Belgium	616
Belize	1
Benin	1
Bosnia-Herzegovina	218
Brazil	1
Denmark	7695
Egypt	1
Estonia	7
Finland	555
France	9449
French Guinea	1
French Polynesia	1
Greece	12
Ireland	4
Iceland	8
Israel	2381
Italy	88
Croatia	1
Cyprus	497
Malta	1
Morocco	49
Portugal	3
Saudi-Arabia	216
Serbia	12
Spain	762
Great Britain	1868
Switzerland	1
Sweden	1044
Tunisia	23
Germany	636
Total	26178

Table 4. Numbers of potato consignments imported to Norway annually in the period 2013-2017 (NFSA 2018). Consignments from countries not in bold did not enter via packing plants.

Country	2013	2014	2015	2016	2017
Afghanistan	9	3	0	0	0
Belgium	91	28	0	78	23
Bosnia-Herzegovina	13	16	18	25	19
Denmark	917	800	537	728	467
Finland	54	46	50	52	26
France	1177	1229	1164	1034	1027
French Polynesia	0	0	0	1	0
Greece	0	0	0	0	2
Ireland	0	1	0	1	0
Iceland	0	2	3	0	1
Israel	301	239	221	276	223
Italy	1	0	9	18	14
Cyprus	54	63	40	31	44
Morocco	1	5	6	15	22
Portugal	0	1	1	0	0
Spain	61	101	69	36	67
Great Britain	120	206	169	156	118
Sweden	184	130	134	211	145
Tunisia	5	0	0	0	0
Germany	55	28	19	76	89

1.1.3 Norwegian carrot production

Most of the commercial carrot production in Norway is located in the counties of Vestfold, Aust-Agder and Rogaland. Norwegian carrot cultivation has increased significantly during the last two decades due to increased competitiveness of domestic growers (Table 5).

Import of carrots to Norway is limited to the spring and early summer and amounts to 15-20% of the domestic production. The Netherlands, Israel, Italy and Denmark are the major countries exporting carrots to Norway (Statistics Norway 2017).

Table 5. Norwegian production of carrots (Statistic Norway 2017).

Year	Carrots (daa)	Yield (kg/daa)	Total harvest (tonnes)
1996	11 324	3 564	40 355
2010	13 901	3 308	45 991
2016	16 083	3 237	52 057

1.1.4 Norwegian onion and leek production

Norwegian growers produce bulb onion sets from seed during the first year of cultivation, and the onion sets are planted the following year to produce onions for the market. Leek transplants are produced in greenhouses and planted in the field in early spring. The Norwegian production of onion and leek has increased during recent years due to increased competitiveness of domestic growers (Table 6). Bulb onions are imported during spring and early summer from New Zealand and European countries.

Table 6. Norwegian production of bulb onions and leek (Statistics Norway 2017)

Year	Bulb onion (daa)	Bulb onion harvest (tonnes)	Leek (daa)
1996	5 166	17 919	1 496
2010	6 237	17 630	1 344
2016	8 296	23 591	1 626

Norwegian production of bulb onion has increased by almost a third during the last 20 years (Table 6). Onion sets are produced by growers in Hedmark, Rogaland and Oppland counties on land that is free from the onion white rot fungus (*Stromatinia cepivora*). The white rot fungus is present in other onion growing areas, and the pathogen causes yield losses for some growers.

1.2 Quarantine pests and potential quarantine pests considered

Quarantine pests and potential quarantine pests of hosts listed in section 1.1, i.e. viruses, bacteria, fungi, nematodes and insects are copied from the Regulations relating to plants and measures against pests Annexes 1, 2 and 3 (NFSA 2018). EPPO A1, A2 and Alert lists were included in the assessment.

1.3 Types of businesses considered

In this assessment, packing plants in different parts of Norway that receive potatoes, bulb onions and other root vegetables for sorting, washing, packing and further industrial processing were considered. Some of the enterprises only receive potatoes and/or root vegetables grown in Norway, and others also receive commodities imported from abroad.

NFSA provided very detailed information about the handling and transport of potatoes and root vegetables, and daily routines concerning plant health from a total of 11 packing plants, situated in the counties of Nord-Trøndelag, Rogaland, Aust-Agder, Vestfold, Hedmark and Oppland. Three of the packing plants are rated as small size enterprises, four as medium size, and four as large enterprises. All of the enterprises considered handle potatoes and/or root vegetables grown in Norway, and five also handle imported commodities.

The authors of this Opinion visited one of the large potato packing plants, and a large bulb onion packing plant to study the reception, washing, grading and packing processes of the enterprises.

1.3.1 Visit to an onion-packing plant

The packing plant visited by the project group handle production waste, composed of soil, organic material and water, as though contaminated with propagules of either *Stromatinia cepivor*a*, Ditylenchus dipsaci* or *D. destructor.* Soil and organic waste from domestically produced onion is composted in ranks, 1.5 m high, 2.5 m wide and 30-40 m long, on concrete floors. The waste is mixed with straw and garden waste and the temperature in the ranks reaches 50-55°C. The ranks are turned twice weekly to ensure satisfactory fermentation.

The composted waste is used for soil improvement in parks and gardens. Waste from imported onions is not composted, but deposited at a safe site. Production water is allowed to sediment before being pumped into the municipal wastewater treatment plant and from there to the local river.

The packing plant does not handle onion sets.

1.3.2 Visit to a potato-packing plant

The potato packing plant visited by the project group receives increasing amounts of imported potato as the domestic potato production is decreasing. The packing plant handles all potato consignments as though they are contaminated with one or more of the numerous viruses, bacteria, fungi, nematodes and insects that are quarantine pests or potential quarantine pests of potato. Contract growers deliver potatoes in large, wooden boxes or as truckloads. The boxes are returned to the producer without being washed. Potatoes that have decayed, due to bacterial or fungal infections, and green potatoes are used in the production of starch and alcohol at an external plant. Some organic wastes are supplied to an external heating plant.

Soil residues from the potato washing process are deposited at a site in the forest. Large volumes of water are used in the washing process as all the potatoes are washed before packing. The plant has a method for sedimentation of soil particles before reuse of the production water. Finally, the production water is pumped into a municipal wastewater treatment plant before being discharged to the local river.

The packing plant visited by the project group does not handle seed potatoes.

1.4 Data collection

Data on production statistics for relevant commodities in Norway were obtained from Statistics Norway (Statistics Norway 2017)

Data on import of relevant commodities were obtained from NFSA and Statistics Norway (Statistics Norway 2017).

1.5 Previous Pest Risk Assessment

Two relatively recent Pest Risk Assessments are relevant for the current assessment, and are outlined below.

1.5.1 Manure and digestive tract content as pathways for plant pests

A report published in 2016 from the Norwegian Scientific Committee for Food and Environment (VKM) provided an assessment of manure and digestive tract contents as a pathway for weeds and plant pests (VKM 2016). The report evaluated both quarantine pests and non-regulated plant pests. When the quarantine pests were evaluated, the assessment concluded that the potato wart fungus (*Synchytrium endobioticum*) was likely, with medium uncertainty, to survive animal digestion and manure storage. The survival of potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*) during animal digestion and manure storage was assessed to be moderately likely, with medium uncertainty. The survival of the stem and bulb eelworm (*Ditylenchus dipsaci*) and the potato rot nematode (*D. destructor*) during animal digestion and manure storage was assessed to be unlikely, with high uncertainty (VKM 2016).

Survival of plant pathogenic bacteria and viruses during animal digestion and manure storage were assessed as being unlikely, with high uncertainty. Survival of phytophagous insects during animal digestion and manure storage was assessed as being unlikely, with high uncertainty (VKM 2016).

1.5.2 Plant health risks from industrial processing of potato

An assessment of plant health risks from industrial processing and grading of potato, including recommendations on disposal of waste and waiting periods before plant production, was published by Aarhus University, Denmark (Nielsen et al. 2016).

Both domestic and exotic pests for Denmark were considered in the assessment. The risk of introduction of new pests depends on the import volume and on the frequency of pest occurrence associated with the imported commodity in the country of origin. Risk reduction measures by the company importing and processing the commodity, including safe waste treatment and disposal, were regarded as important. The assessment emphasized that exotic pests differ in their abilities to survive during transport and processing.

The assessment maintained that for some pests, pathways other than those associated with waste from packing plants should also be considered. For example, should beetles of the genus *Epitrix* be introduced, the flight ability of the beetles would be more important for their spread than dispersal from packing plants.

Treatment of waste before application onto agricultural soil was emphasized as being of importance. The temperature and treatment time required to inactivate the pest depends on the pest. Viruses can be eliminated by heat treatment of wet waste. Storage of wet waste during the winter will eliminate plant pathogenic bacteria. Dry heat treatment for 11-12 hours at 100°C or moist heat treatment for a few minutes at 100°C, were considered necessary to kill resting spores of the potato wart fungus (*Synchytrium endobioticum*).

The assessment concluded that filtration with a pore size less than 3 µm or heat treatment would eliminate nematodes. When the probability for spread of the potato rot nematode (*Ditylenchus destructor*) is considered important, untreated waste from packing plants should not be returned to the field. If the root knot nematode (*Meloidogyne hapla*) is detected, untreated waste should not be applied to the fields. Industrial waste may be applied to grassland, but the survival ability of the potato wart fungus should be considered for those fields, where potato is included in the crop rotation (Nielsen et al. 2016).

1.6 Literature search strategy

A literature search was conducted by members of the project group using the species names of the quarantine and potential quarantine pests included in the assessment.

Searches in the databases ISU, CABI and EPPO publications were carried out for the different groups of plant pests included in the assessment, namely: viruses, bacteria, fungi, nematodes and insects. The searches were conducted during the period from October 2017 to March 2018. The main focus in the literature search was the potential for survival of the different pest during entry, processing, risk reducing measures and dispersal of waste from potato and vegetable processing plants.

The reference lists of articles identified were screened for additional relevant publications. There was no restriction on age of the publications included. Additional literature was also retrieved by the members of the project group, due to their expertise on the subject.

1.7 Rating of probabilities and uncertainties

The conclusions regarding the probabilities of entry, survival and dispersal of the various pests considered are rated and presented separately, following a fixed scale: very unlikely, unlikely, moderately likely, likely, very likely. The descriptors for these qualitative ratings are shown in Appendix I (Table A1-1; Table A1-2).

The levels of uncertainty associated with the risk assessment conclusion on entry, survival and dispersal of the pests are rated separately, following a fixed scale: Low, medium and high. The descriptors for these qualitative ratings of uncertainty are given in Appendix I (Table A1-3).

2 Pest hosts, biology, distribution, regulatory status and probabilities of entry into, survival in and movement out of packing plants

2.1 Plant pathogenic viruses

The potato viruses listed in Table 7 are known to cause serious diseases. Most of them are quarantine organisms to Norway, some are only listed by Norway. The naming of viruses has changed during later years, but old names are still valid as synonyms (EPPO 2017). No viruses are quarantine pests on onion, carrot and other root vegetables.

2.1.1 Hosts

Potato is the known major host of all the viruses listed in Table 7, except for tomato ringspot virus, which has potato as an incidental host, and tomato spotted wilt virus, which has potato as a minor host. All the potato viruses listed in Table 7 also have other hosts, in particular wild-growing weeds, mainly in the genera *Solanum* and *Nicotiana*.

2.1.2 Biological information

Some of the viruses listed in Table 7 are transmitted by insect or nematode vectors, but they may also be transmitted by tubers. However, to be of phytosanitary risk the tubers would have to be used as seed potatoes. The packing plants do not handle seed potatoes. The viruses have many other hosts than potato, in particular wild-growing weeds, which make the viruses difficult to control (EPPO 2017).

Table 7. Quarantine plant viruses causing disease in potatoes, host plants, transmission, distribution, current pest categorization (EPPO 2017) and probability of entry into packing plants.

Scientific name1)	Host plants	Transmission	Distribution	Categorization	Probability of entry into packing plants
Andean potato mild mosaic virus	Potato (major)	Insect vectors/ tubers	South America	EPPO A1 (not listed by Norway)	Very unlikely, low uncertainty
Andean potato latent virus	Potato (major)	Insect vectors/ tubers	South America	EPPO A1 Quarantine pest to Norway	Very unlikely, low uncertainty
Andean potato mottle virus	Potato (major)	Insect vectors/ tubers	South America	EPPO A1 Quarantine pest to Norway	Very unlikely, low uncertainty
Arracacha virus B oca strain	Potato (major)	Tubers	South America	Quarantine pest to Norway (not listed by EPPO)	Very unlikely, low uncertainty
Potato black ringspot virus	Potato (major)	Tubers/ (vector not known)	South America	EPPO A1 Quarantine pest to Norway	Very unlikely, low uncertainty
Non-European strains of: Potato virus A, M, S, V, X, Y, potato leaf roll polerovirus	Potato (major)	Leafhoppers/ tubers	World-wide outside Europe	Quarantine pests to Norway (not listed by EPPO)	Very unlikely, low uncertainty
Potato virus T	Potato (major)	Tubers	South America	EPPO A1 Quarantine pest to Norway	Very unlikely, low uncertainty
Potato yellow dwarf virus	Potato (major)	Leafhoppers/ tubers	North America	EPPO A1 (not listed by Norway)	Very unlikely, low uncertainty
Potato yellow vein virus	Potato (major)	Leafhoppers/ tubers	South America	EPPO A1 (not listed by Norway)	Very unlikely, low uncertainty
Potato yellowing virus	Potato (major)	Aphids/tubers	South America	EPPO A1 (not listed by Norway)	Very unlikely, low uncertainty
Potato spindle tuber viroid	Potato (major)	Aphids/tubers	World-wide	EPPO A2 Quarantine pest to Norway	Very unlikely, low uncertainty
Tomato ringspot virus	Potato incidental	Root nematodes in the genus *Xiphinema*	World-wide	EPPO A2 Quarantine pest to Norway	Very unlikely, low uncertainty
Tomato spotted wilt virus	Potato (minor)	*Thripidae*/ tubers	World-wide	EPPO A2 Quarantine pest to Norway	Very unlikely, low uncertainty

1) There are no Norwegian names for these viruses

2.1.3 Distribution of the pests in Norway

Tomato spotted wilt virus was intercepted in Norwegian greenhouses on ornamentals in 1998, but the virus was quickly eradicated. Potato spindle tuber virus was intercepted in petunia in 2011 and has been eradicated (NFSA 2017). None of the other viruses listed in Table 7 have been detected in Norway.

2.1.4 Distribution of the pests in other Nordic countries

In Sweden and Finland, the tomato spotted wilt virus has been detected on a few occasions on ornamentals in greenhouses. The virus has not been detected in Denmark. None of the other viruses in Table 7 has been detected in the Nordic countries (EPPO 2017).

2.1.5 Global distribution and regulatory status of the pests

Most of the viruses in Table 7 have only been detected in South- and North America, and they are on the EPPO A1 list. Potato spindle tuber viroid, tomato ringspot virus and tomato spotted wilt virus have a worldwide distribution, and these viruses are present in some European countries. They are all on the EPPO A2 list, and they are quarantine organisms to Norway. Non-European strains of Potato virus A, M, S, V, X, Y, and Potato leaf roll polerovirus are quarantine organisms to Norway, but not to other countries in Europe (EPPO 2017, Lovdata 2018).

2.1.6 Pathways and probability of entry of the pests into packing plants

The main pathways for potato viruses in Table 7 would be seed potato tubers for planting and consumption, with soil and/or plant debris attached, coming from countries where the pests occur. Some other pathways may present a low probability with low uncertainty, such as soil and growing medium attached to rooted host and non-host plants from countries where the pests occur, soil or growing medium, and soil and plant debris attached to machinery from countries where the pests occur (EPPO 2004). Norway has regulations on potato import to Norway from both European countries and from countries outside Europe (Lovdata 2018). These measures mean that the probability for entry of any of the viruses into potato packing plants is very unlikely with low uncertainty (Table 7).

2.2 Plant pathogenic bacteria

No bacteria in the category quarantine organism are known to cause disease in carrots, onions and other root vegetables. In potato, five pathogenic species of quarantine bacteria are known (Table 8) (EPPO 2017). Three of these are phytoplasmas and depend on insects for transmission. Phytoplasmas are bacteria without a cell wall, only enclosed by a membrane. There is no conclusive evidence confirming the transmission of phytoplasmas by tubers, but they may be transmitted by complete living plants (EPPO 2017). In infected plants, phytoplasmas exclusively colonize living sieve tubes in roots and stems, and they are dependent on living plants for survival. In living insects (the specific vector), phytoplasmas colonize and survive in the gut (Kunze 1989). If stems, roots or tubers of phytoplasma-infected plants were handled in a packing plant, their dispersal in plant residues, soil and water would be of no concern. It is very unlikely that intact, living plants are dispersed from a potato processing plant. Thus, the three phytoplasmas listed in Table 8 are considered to represent a very low risk in potato packing plants in Norway, and phytoplasmas are not discussed further in this report. Only Potato stolbur phytoplasma is listed as quarantine organism to Norway (NFSA 2018). None of the plant pathogenic bacteria and phytoplasmas produce endospores (EPPO 2017).

2.2.1 *Clavibacter michiganensis* subsp. *sepedonicus* (Spieckermann & Kotthoff) Davis et al.

Taxonomic position: Bacteria: Actinobacteria

Common names: Ringråte (Norwegian), Ljus ringröta (Swedish), Ringbakteriose (Danish), Bacterial ring rot (English).

2.2.1.2 Biological information

Clavibacter michiganensis subsp. *sepedonicus* causes disease by breaking down the vascular tissues of the plant, which gradually leads to wilting of the stems and a characteristic ring-shaped rotting of the vascular tissues in the tubers. When a diseased potato tuber is planted, the bacteria multiply rapidly in the germinating plant and pass along the vascular strands into the stems and petioles. From there they further reach the roots and maturing daughter tubers. The daughter tubers will perpetuate the disease if used as seed potatoes. The bacterium may survive for a few days in soil and water, but the bacterium can survive for many months, sometimes a year or more, in plant materials, whole or parts of tubers on its own, or dry on potato bags, wood and metal surfaces, machinery and other equipment. *Clavibacter michiganensis* subsp. *sepedonicus* is mainly confined to cooler areas of the world (EPPO/CABI 1997b)

Table 8. Quarantine bacterial species causing disease in potatoes, host plants, transmission, distribution, current pest categorization (EPPO 2017) and probability of entry into packing plants.

Scientific name	English name	Norwegian name	Host plants	Transmission	Distribution	Categorization	Probability of entry into packing plants	Comments
Clavibacter michiganensis* subsp. *sepedonicus	Potato ring rot	Lys Ringråte	Potato	Tubers/ plant material/ soil/ water	World-wide	EPPO A2 Quarantine pest to Norway	Very likely low uncertainty	Present in Norway
Ralstonia solancearum	Brown rot of potato	Mørk ringråte	Potato	Tubers/ plant material/ soil/ water	World-wide	EPPO A2 Quarantine pest to Norway	Very likely low uncertainty	Absent from Norway
Candidatus Liberibacter solanacearum			Potato	*Bactericera cockerella* /plants	World-wide	EPPO A1	Very unlikely medium uncertainty	Absent from Norway
Candidatus Phytoplasma americanum			Potato	Leafhoppers/ plants	North America, Australia	EPPO A1	Very unlikely medium uncertainty	Absent from Norway
Potato stolbur phytoplasma			Potato	Leafhoppers/ plants	World-wide	EPPO A2 Quarantine pest to Norway	Very unlikely medium uncertainty	Absent from Norway

2.2.1.3 Distribution of the pest in Norway

Clavibacter michiganensis subsp. *sepedonicus* was first described in Northern Norway in 1964. Since then it has spread to many other parts of the country, but due to several comprehensive surveys and eradication campaigns, some of which are still ongoing, the disease currently has only a very restricted distribution. During the 2015 potato-growing season, a total of 178 samples were analysed for potato ring rot, and *C. michiganensis* subsp. *sepedonicus was* detected in only two samples, both originating from farms in Northern Norway (NFSA 2017).

2.2.1.4 Distribution of the pest in other Nordic countries

The disease was also common for many years in Denmark, Sweden and Finland, but now the disease has only a restricted distribution in Sweden and Finland. The pathogen has been eradicated in Denmark (EPPO 2017)

2.2.1.5 Global distribution of the pest

Clavibacter michiganensis subsp. *sepedonicus* has a worldwide distribution, and is present in many European countries, North America, and some countries in Asia (EPPO 2017).

2.2.1.6 Regulatory status of the pest

Clavibacter michiganensis subsp. *sepedonicus* is listed on the EPPO A2 list. It is a quarantine organism to Norway, in addition, particular requirements apply to domestic production, sale and import of potatoes concerning *C. michiganensis* subsp. *sepedonicus* (Lovdata 2018).

2.2.1.7 Pathways and probability of entry of the pests into packing plants

The main pathways for entry of *C. michiganensis* subsp. *sepedonicus*, are potato tubers for planting and consumption with soil and/or plant debris attached, coming from farms in Norway, or from countries where the pest occurs. Some other pathways may present a low probability of entry, such as soil and growing medium attached to rooted hosts and non-host plants, soil or growing medium, and soil and plant debris attached to wooden crates, potato transport bags and machinery from farms contaminated with *C. michiganensis* subsp.

sepedonicus, in Norway, or from countries where the pest occurs (EPPO/CABI 1997b). Import regulations, and regulations for potato trade within Norway, make the probability for entry very likely with low uncertainty.

2.2.2 *Ralstonia solanacearum* (Smith 1896) Yabuuchi et.al., emend. Safni et.al. 2014.

The taxonomy of *R. solanacearum* has recently been extensively revised (EPPO Reporting service 2017). The species, which was formerly a complex subdivided into races, biovars and phylotypes, has now been separated into three distinct species and three subspecies. The EPPO Global Database has not yet been updated accordingly on host range, distribution and other information about the new species. The information given below regards the former *R. solanacearum* biovar 2A, race 3, phylotype IIB.

Taxonomic position: Bacteria: Proteobacteria

Common names: Mørk ringråte (Norwegian), mörk ringröta (Swedish), brunbakteriose (Danish), brown rot of potato (English)

2.2.2.1 Host plants of *Ralstonia solanacearum*

The major host of *R. solanacearum* is potato. Minor hosts are *Nicotiana* spp, *Solanum melanogena* and *S. lycopersicum* and many other hosts in several plant families (EPPO 2017). It should also be noted that the weeds *Solanum dulcamara* and *S. nigrum,* both wild-growing in Norway, are important hosts for survival of the bacterium outside cultivation. When present on these weeds growing along waterways, the use of surface water for irrigation is an important pathway for spread of the bacterium

2.2.2.2 Biological information

Ralstonia solanacearum causes disease by breaking down the vascular tissues of the plant, which usually leads rapidly to wilting of the stems and rotting of tubers, similarly to the rot caused by *C. michiganensis* subsp. *sepedonicus*. Disease development is also similar to *C. michiganensis* subsp. *sepedonicus*, as described above. *Ralstonia solanacearum* may survive for many months in soil and water (Van Elsas, J.D *et. al*. 2005). The temperature optimum for *R. solanacearum* is 27°C, a little higher than *C. michiganensis* subsp. *sepedonicus*, and it is distributed both in cool and warm areas (EPPO/CABI 1997a).

2.2.2.3 Distribution of the pest in Norway

Ralstonia solanacearum has never been detected or intercepted in Norway (NFSA 2017).

2.2.2.4 Distribution of the pest in other Nordic countries

In Finland and Denmark *R. solanacearum* is absent, but the pest has occasionally been intercepted. In Sweden, there was an outbreak of *R. solanacearum* in the southern part of the country in 1973, which was successfully eradicated after a few years. In 2010, a new outbreak of *R. solanacearum* was detected at two production sites in Sweden. Most likely contaminated seed potatoes originating in the Netherlands had been used. Eradication is in progress (EPPO 2017).

2.2.2.5 Global distribution of the pest

Ralstonia solanacearum has a worldwide distribution. In Europe, several countries have regular outbreaks (EPPO 2017).

2.2.2.6 Regulatory status of the pest

Ralstonia solanacearum is listed on the EPPO A2 list. It is a quarantine organism to Norway, in addition, particular requirements apply to import of *Solanum* spp. concerning *Ralstonia solanacearum* (Lovdata 2018).

2.2.2.7 Pathways and probability of entry of the pests into packing plants

The main pathways of entry of *R. solanacearum* are potato tubers for planting and consumption, with soil and/or plant debris attached, coming from countries where the pest occurs. The probability is high with low uncertainty. Some other pathways may present a low risk with low uncertainty, such as soil and growing medium attached to rooted host and non-host plants from countries where the pest occurs, soil or growing medium, and soil and plant debris attached to machinery from countries where the pest occurs (EPPO/CABI 1997a).

The probability of entry of *R. solanacearum* into potato packing plants is very likely, with low uncertainty.

2.3 Plant pathogenic fungi

2.3.1 *Synchytrium endobioticum* (Schilbersky) Percival

Taxonomic position: Fungi, Chytridiomycota, Chytridiomycetes, Chytridiales

Common names: Potetkreft (Norwegian), potatiskräfta (Swedish), kartoffelbrok (Danish), potato wart (English)

2.3.1.1 Host plants of *Synchytrium endobioticum*

Potato is the only cultivated host for *S. endobioticum*, but wild *Solanum* spp. can also be infected. Tomato, and several other solanaceous plants, have been artificially inoculated with *S. endobioticum* (EPPO 2017).

2.3.1.2 Biological information

Synchytrium endobioticum is a chytrid fungus that originated in the Andean region of South-America. The fungus was introduced to Europe around 1880.

The pathogen produces thick-walled, resting sporangia, which measure 25-75 µm in diameter. The pathogen is distributed via infected seed tubers and by zoospore movement in infested soil.

In 1941, *S. endobioticum* was detected in Germany and in South Bohemia (Czech Republic) on cultivars that had previously been resistant to the pathogen (Baayen et al. 2005). New pathotypes of *S. endobioticum* have since been reported from Germany, Sweden, Denmark, The Netherlands, The Czech Republic, Ukraine and Canada (EPPO 2017).

Pathotypes of *S. endobioticum* are identified by inoculating differential potato cultivars, currently there are more than 20 known pathotypes. In Europe, pathotype 1 is the most common, but pathotypes 2, 4, 5, 6, 7, 8, and 18 have also been detected. (EPPO 2017). Development of new pathotypes of *S. endobioticum* is a challenge to potato breeders.

On tubers, the fungus develops characteristic galls up to 8 – 10 cm in diameter, which are cauliflower-like protuberances. Galls are also produced on stolons and stems, but not on the roots. The galls gradually darken, rot and disintegrate and resting spores are released into the soil. (EPPO 2017).

Resting spores survive up to 30 years in the soil, and they are resistant to temperature extremes, microbial antagonism and competition. Survival of *S. endobioticum* in water at 60°C for 2 hours has been reported (Nobel and Roberts 2004). Steinmöller et al. (2012) reported that viable, resting spores of *S. endobioticum* could be extracted after composting for 70 days at 30-45°C, composting for 21 days at 50-55°C and after composting for 12 days at 60-65°C. Furthermore, the spores survived pasteurization for 90 min at 70°C, heating in water bath at 80°C and in an oven at 90°C for 8 hrs (Steinmöller et al. 2012).

Table 9. Quarantine fungal species causing disease in potatoes, onions and leeks, host plants, transmission, distribution, current pest categorization (EPPO 2017) and probability of entry into packing plants.

Scientific name	English name	Norwegian name	Host plants	Transmission	Distribution	Categorization	Probability of entry into packing plants	Comments
Synchytrium endobioticum	Potato wart	Potetkreft	Potato	Tubers/plant materials, soil	World-wide	EPPO A2	**Domestic potato** Unlikely medium uncertainty **Import** Moderately likely medium uncertainty	Eradicated from Norway
Stromatinia cepivora	Onion white rot	Løkhvitråte	Onion, leek	Sclerotia on onion sets, soil	World-wide	EPPO A2	Very likely low uncertainty	Present in Norway
Thecaphora solani	Potato smut	Potetsot	Potato, *Solanum* spp	Tubers	South America	EPPO A1	Very unlikely low uncertainty	Absent from Norway
Stagonosporopsis andigena	Black blight of potato		Potato, *Solanum* spp.	Spores by water splash and wind	South America	EPPO A1	Very unlikely low uncertainty	Absent from Norway
Septoria lycopersici* var. *malagutii	Annular leafspot of potato		Potato, *Solanum* spp.	Spores by water splash and wind	South America	EPPO A1	Very unlikely low uncertainty	Absent from Norway

2.3.1.3 Distribution of the pest in Norway

In Norway, potato wart disease was first detected in 1914 (Jørstad 1929). During the first and second world wars, with the need for increased potato cultivation to feed the domestic population, any available potatoes were used as seed potato, and the disease became widespread. When the quarantine regulations were enforced (1919-1940 and since 1945), the number of potato wart cases declined. Potato varieties with resistance to the common pathotype 1 of the pathogen became available (Jørstad 1929, Jørstad 1939, Jørstad 1946, Jørstad and Lunden 1934).

Only pathotype 1 of *S. endobioticum* has been detected in Norway, and the last known case was in an Oslo school garden in 1994. Most potato varieties cultivated in Norway are resistant to pathotype 1. The current status of *S. endobioticum* in Norway, according to NFSA is: Eradicated (NFSA 2017).

2.3.1.4 Distribution of the pest in other Nordic countries

Denmark had eradicated *S. endobioticum* in 1989 and the country was declared free from the pathogen in 2013 (Nielsen et al. 2016). However, as the Authorities continued the surveillance of potato, *S. endobioticum* was detected with one starch potato grower in 2014, and during subsequent surveys, the same year the pathogen was found with two more potato growers in the same municipality (Nielsen et al. 2016, Wulff 2015). Continued soil surveys and tuber testing in November 2016 detected *S. endobioticum* at one more potato grower in the same area. On all relevant fields, phytosanitary measures have been applied (Nielsen et al 2016). Pathotype analyses of 7 samples revealed that 4 samples belonged to pathotype 8, and 3 samples belonged to pathotype 4 and/or 5 (Wulff 2015). The current status of *S. endobioticum* in Danmark is: Present, few occurrences (EPPO 2017).

In Finland *S. endobioticum* was first detected in 1924 (Hannukkala 2011). The pathogen became widely distributed during the second world war, but since then the number of cases has been reduced, and the last detection of *S. endobioticum* in commercial potato cultivation was in 1990. However, the pathogen is present in home and allotted gardens. In Finland, there has been no report of breakdown of resistance to pathotype 1 of *S. endobioticum*

(Hannukkala 2011). The current status of *S. endobioticum* in Finland is: Present, few occurrences (EPPO 2017).

Potato wart was first detected in Sweden in 1912, on a farm in Södermanland län. The pathogen was eradicated, but in 1928, there were new reports of the disease, and since then *S. endobioticum* has been present in the country. Up until 2010, only pathotype 1 of the pathogen was present, when pathotype 18 was then detected in a limited area of Blekinge län in southern Sweden (Knutsson 2017). The potato varieties cultivated in Sweden are resistant to pathotype 1, but they are susceptible to pathotype 18. The Swedish authorities are working to limit the spread of *S. endobioticum*, especially pathotype 18. Recently, potato wart has been detected in Blekinge län, Halland län and Värmland län in Sweden (Jordbruksverket 2016, 2017). The current status of *S. endobioticum* in Sweden is: Present, restricted distribution (EPPO 2017).

2.3.1.5 Global distribution of the pest

Dispersal with seed potato has resulted in an almost worldwide distribution of *S. endobioticum*. The pathogen is present in most EPPO member countries (Baayen et al. 2006), Newfoundland in Canada, some eastern states of USA and in most South American countries. In addition, some North African countries, South Africa and several Asian countries have reported detection of the potato wart fungus (EPPO 2017).

2.3.1.6 Regulatory status of the pest

Synchytrium endobioticum is on the EPPO A2 list. It is a quarantine organism to Norway, and particular requirements apply to domestic production and sale of potatoes (Lovdata 2018).

2.3.1.7 Pathways and probability of entry of the pests into packing plants

Plant health regulations prohibits import of potato from places of production where potato wart occurs. As potato wart has not been detected in Norway during the last 24 years, the probability of *S. endobioticum* entry into packing plants with domestically grown potatoes is unlikely with medium uncertainty. However, due to the current epidemics of potato wart in countries that export potatoes to Norway the probability for entry of *S. endobioticum* with imported consignments is moderately likely with medium uncertainty.

2.3.2 *Stromatinia cepivora* Berk. (Whetzel), syn. *Sclerotium cepivorum* Berk.

Taxonomic position: Fungi, Ascomycota, Leotiomycetes, Helotiales

Common names: Løkhvitråte (Norwegian), løghvidråd (Danish), lökvitmögel (Swedish), onion white rot (English)

2.3.2.1 Host plants of *Stromatinia cepivora*

Allium ascalonicum (shallot)*, A. cepa* (onion)*, A. fistolosum* (Welsh onion)*, A. porrum* (leek) and several other *Allium* spp. are hosts for *S. cepivora.*

2.3.2.2 Biological information

Stromatinia cepivora, is the onion white rot fungus, is commonly detected only as sterile hyphae, and previously named *Sclerotium cepivorum.* The pathogen causes one of the most serious diseases of onions, leeks, shallots, garlic and other *Allium* spp. *Stromatinia cepivora* infects susceptible *Allium* spp. throughout the growing season. Yellowing and wilting are early symptoms on the leaves. White mycelium develops at the base of the bulbs and on the roots, and a large number of sclerotia are produced in the mycelium on the bulbs.

Stromatinia cepivora sclerotia survive in the soil between onion crops. The spherical, black sclerotia measure only 0.2-0.5 mm in diameter, and they are difficult to distinguish from soil particles. In field experiments in the United Kingdom, the sclerotia survived burial in field soil for 20 years in the absence of host plants (Coley-Smith et al. 1990).

On field experiments in California, USA, inoculum densities greater than 1.0 sclerotia per gram of soil killed most plants soon after emergence (Crowe et al. 1980). At lower inoculum densities, distinct clusters of plants became diseased, as the pathogen spread from plant to plant. Disease loci appeared later and with reduced frequency with decreasing inoculum density (Crowe et al. 1980).

There are reports on inactivation of *S. cepivora* during composting. In the Netherlands Bollen et al. (1989) incorporated samples of *S. cepivora* sclerotia between two metal sieves in compost heap layers with plant residues. Survival was assessed after 5 months composting, and none of the 36 test plants exposed to the composted samples of *S. cepivora* sclerotia became diseased (Bollen et al. 1989).

Under laboratory condition *S. cepivora* sclerotia were killed when kept at 48ºC for 3 days (Coventry et al. 2002). However, during composting of infected onions, temperatures of 57ºC for 21 days were required to kill the pathogen (Termorshuizen et al. 2003).

2.3.2.3 Distribution of the pest in Norway

The white rot fungus *S. cepivora* was introduced to Norway with imported onion sets during the 1950s (Semb 1964). The white rot fungus is widely distributed in onion growing districts of Norway. The current status of *S. cepivora* in Norway is: Present (NFSA 2017).

2.3.2.4 Presence of the pest in other Nordic countries

The white rot fungus is commonly detected on onion fields in Denmark. Most of the Danish production is for the home market, but there are some exports to Germany and other European countries, including Norway. The current status of *S. cepivora* in Denmark is: Present (EPPO 2017).

In Sweden, onion production is concentrated on the island of Öland and southern parts of the country, where onions have been grown for generations, and the white rot fungus is widespread in these areas. The current status of *S. cepivora* in Sweden is: Present (EPPO 2017).

In most of Finland onions sets are produced from seed during the first year, and onions for the market are produced during the second year. The current status of *S. cepivora* in Finland is: Present, restricted distribution (EPPO 2017).

2.3.2.5 Global distribution of the pest

In Central and Southern European countries, onions are produced from seed in one growing season. Onion white rot is a serious disease in most European countries.

The onion white rot fungus is widely distributed in the Western Hemisphere. Pères-Moreno et al. (2002) found considerable genetic diversity among different *S. cepivora* isolates collected in Spain and Mexico. Woodhall et al (2012) developed a real-time PCR assay for detection of *S. cepivora* in soil.

2.3.2.6 Regulatory status of the pest

Stromatinia cepivora is not on the EPPO A1/A2 lists. It is a quarantine organism to Norway, (Lovdata 2018).

2.3.2.7 Pathways and probability of entry of the pests into packing plants

Stromatinia cepivora is not seed-borne. Since both imported and domestic onions are potential pathways for entry of the pest into packing plants, it is very likely with low uncertainty, that the pest is introduced into packing plants.

2.3.3 *Thecaphora solani* (Thirumulachar & O'Brien) Mordue.

Taxonomic position: Fungi, Basidiomycota, Ustilaginomycetes, Urocystidales

Common name: Potato smut (English), potetsot (Norwegian)

2.3.3.1 Host plants of *Thecaphora solani*

The main host is potato, but some other tuber-bearing *Solanum* spp. are also attacked. The fungus damages tomato in South America. The weed *Datura stramonium,* which is present in Norway and widely distributed in most of Europe, is susceptible (EPPO 1979, EPPO 2017).

2.3.3.2 Biological information

The fungus infects tubers and underground stems of potato and some other tuber-forming *Solanum* spp. in the Andean region of South America. *Thecaphora solani* is not restricted to the higher, cooler elevations, and the fungus has been a problem in coastal regions of Peru.

The smut is transported in infected tubers and propagation material, and as the fungus survives in soil, it is difficult to eradicate. (EPPO 1979, EPPO 2017).

Thecaphora solani causes losses of up to 80% of potential potato yield in South America (EPPO 1979).

2.3.3.3 Global distribution of the pest

The fungus is causing disease of potato in Bolivia, Chile, Columbia, Ecuador, Mexico, Panama, Peru, Uruguay and Venezuela. The pest is absent from Europe (EPPO 2017).

2.3.3.4 Regulatory status of the pest

Thecaphora solani is on the EPPO A1 list. It is a quarantine organism to Norway (Lovdata 2018).

2.3.3.5 Pathways and probability of entry of the pests into packing plants

The probability of *T. solani* entering potato packing plants is very unlikely with low uncertainty.

2.3.4 *Stagonosporopsis andigena* (Turkenst.) Aveskamp, Gruyter & Verklay. (syn. *Phoma andina* Turkenst.).

Taxonomic position: Fungi, Ascomycota, Dothideomycetes, Pleosporales

Common names: Black blight of potato, leaf spot of potato.

2.3.4.1 Host plants of *Stagonosporopsis andigena*

Solanum lycopersicon, S. medians, S. phureja, S. stenotomum ssp*. geniocalyx* and *S. tuberosum*.

2.3.4.2 Biological information

The disease occurs at high altitudes throughout Bolivia, Columbia and Peru. On infected leaves, spores develop, and they are disseminated by water splash and wind. Leaf spots appear first on lower leaves, later leaf spots cover the whole plant. (EPPO 1984b, EPPO 2017).

The pest causes losses of up to 80% of potential potato yield in South America (EPPO 1984b).

2.3.4.3 Global distribution of the pest

Stagonosporopsis andigena is present in Bolivia, Columbia, Peru. The pest is absent from Europe (EPPO 2017).

2.3.4.4 Regulatory status of the pest

Stagonosporopsis andigena is on the EPPO A1 list. It is a quarantine organism to Norway (Lovdata 2018).

2.3.4.5 Pathways and probability of entry of the pests into packing plants

The probability of *S. andigena* entering potato packing plants is very unlikely with low uncertainty.

2.3.5 *Septoria lycopersici* var. *malagutii* Cicear. & Boerma

Taxonomic position: Fungi, Ascomycota, Dothideomycetes, Mycosphaerellales

Common name: Annular leafspot of potato.

2.3.5.1 Host plants of *Septoria lycopersici* var. *malagutii*

Solanum acaule, S. curtilobum, S. juzepczukii, S. tuberosum and S. wittimackii.

2.3.5.2 Biological information

The fungus survives in soil and plant debris. Leaves of potato and other hosts are infected by spores that are dispersed by rain splash. Small leaf spots develop into circular spots with concentric ridges on the upper side of infected leaves (EPPO 1984a, EPPO 2017).

The pest is causing up to 60 % yield losses in Bolivia, Ecuador, Peru and Venezuela (Cline and Rossman 2006).

2.3.5.3 Global distribution of the pest

In South America *S. lycopersici* var. *malagutii* is a widespread, serious pest of potato. The pest is absent from Europe (EPPO 2017).

2.3.5.4 Regulatory status of the pest

Septoria lycopersici var. *malagutii* is on the EPPO A1 list. It is a quarantine organism to Norway (Lovdata 2018).

2.3.5.5 Pathways and probability of entry of the pests into packing plants

The probability of *S. lycopersici* var. *malagutii* entering Norwegian potato packing plants is very unlikely with low uncertainty.

2.4 Plant parasitic nematodes

The transmission of plant parasitic nematodes occurs in infected plant tissue, adhering soil and debris. Although *Ditylenchus dipsaci, D. destructor, Meloidogyne chitwoodi* and *M. fallax* are protected inside the plant tissue, and hence are difficult to detect, the probability of these pests to enter packing plants is still rated as moderately likely due to their moderate abundance and often clear symptoms on the host. This is connected with a high uncertainty due to the unknown frequency of latent infections. *Globodera rostochiensis* is very likely to enter packing plants with a low uncertainty. The ratings relate to the abundance of the nematode at origin of most pathways and its high survival rate in soil and debris. In domestic crops *G. pallida* is moderately likely to enter packing plants with a high uncertainty. These ratings relate to its relatively low abundance at origin of domestic pathways. In imported crops, this nematode is very likely to enter packing plants with a high uncertainty. The ratings relate to the abundance of this nematode at the origin of many European pathways and its high capability to survive in transport. This has a low uncertainty

For domestic crops, *M. chitwoodi* and *M. fallax* are unlikely to enter packing plants with a low uncertainty. The ratings relate to the absence of the nematodes from Norway. For imported crops, both species are moderately likely to enter packing plants with a high uncertainty. The ratings relate to the low occurrence of the nematodes at the origin of pathways and the unclear distribution of the pests (Table 10).

2.4.1 *Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936.

Taxonomic position: Nematoda, Tylenchida, Anguinidae, *Ditylenchus*

Common names: Stengelnematode (Norwegian), stjälknematod (Swedish), stængelnematod (Danish), stem and bulb eelworm (English)

2.4.1.1 Host plants of *Ditylenchus dipsaci*

The nematode has a wide host range of about 500 species of plants, including onion (*Allium cepa*), garlic (*A. sativum)*, leek (*A. porrum*), shallot (*A. ascalonicum*), carrot (*Daucus carota* ssp. *sativus*), pea (*Pisum sativum*), potato (*Solanum tuberosum* ssp. *tuberosum*), sugar beet (*Beta vulgaris* ssp. *vulgaris*), turnip (*Beta rapa* ssp. *rapa*), swede (*Beta napus* v. *napobrassica*), rye (*Secale cereale*), oat (*Avena sativa*), maize (*Zea mays)*, lucerne (*Medicago sativa)*, broad/field bean (*Vicia faba*), red clover (*Trifolium pratense*), white clover (*T. repens*) and alsike clover (*T. hybridum*), daffodil and narcissus (*Narsissus pseudonarcissus*), tulip (*Tulipa gesneriana*) and hyacinth (*Hyacinthus* spp.) (CABI 1972) (Bingefors et al. 1971).

2.4.1.2 Biological information

The stem and bulb nematode *Ditylenchus dipsaci* is a very important plant-parasitic nematode from a global perspective. *Ditylenchus dipsaci* is a complex of about 30 races. This nematode can be a devastating parasite of clover, alfalfa, oats, rye, onion, leek, narcissus, daffodil, tulip, carnation and phlox (Bingefors *et al.* 1971). Major damage occurs on garlic, onion, carrot, broad beans, lucerne, red and white clover, and bulbous ornamentals like tulip, hyacinth, crocus and daffodil. In the spring and under humid conditions fourth stage juveniles (J_4) invade plants directly through the epidermis or through the stomata. Under unfavourable conditions the nematodes can aggregate in swarms in plant debris containing many thousand individuals forming so called «eelworm wool». Nematodes in the «eelworm wool» may remain in a cryptobiotic stage for many years (Duncan & Moens 2013). In cool and dry conditions, a population from onion did survive desiccation for 26 years (Sturhan & Brzeski 1991).

2.4.1.3 Distribution of the pest in Norway

Ditylenchus dipsaci is present in Norway (NFSA 2017).

2.4.1.4 Distribution of the pest in other Nordic countries

Ditylenchus dipsaci is also present in the other Nordic countries. It has few occurrences in Denmark and Iceland, and a restricted distribution in Finland, but is widespread in Sweden (EPPO 2017).

2.4.1.5 Global distribution of the pest

Ditylenchus dipsaci is widely distributed and occurs in all continents. It is widespread in Chile, Mexico, Uruguay, Israel, Austria, Czech Republic, Germany, Switzerland, United Kingdom (England and Scotland) and New Zealand. The nematode is also present in Algeria, Kenya, Marocco, Reunion, South Africa, Tunisia, Argentina, Bolivia, Brazil, Canada, Colombia, Costa Rica, Dominican Republic, Ecuador, Haiti, Paraguay, Peru, Venezuela, USA, China, Taiwan, Japan, Korea Republic, Pakistan, Kazakhstan, Kyrgyzstan, Uzbekistan, Syria, Jordan, Oman, Iran, Iraq, Yemen, Albania, Armenia, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Estonia, France, Georgia, Greece, Hungary, Irland, Italy, Latvia, Lithuania, Macedonia, Malta, Moldovia, Netherlands, Poland, Portugal (mainland), Romania, Russia, Serbia, Slovakia, Slovenia, Spain (mainland), Turkey and Ukraine (EPPO 2017).

2.4.1.6 Regulatory status of the pest

Ditylenchus dipsaci is on the EPPO A2 list (EPPO 2017). It is a quarantine organism to Norway (Lovdata 2018). It is prohibited to introduce and spread *D. dipsaci* if it occurs on seed and bulbs of *Allium cepa*, and bulbs of various ornamental plants.

Table 10. Quarantine nematode species, host plants, transmission, distribution, current pest categorization (EPPO 2017) and probability of entry into packing plants.

Scientific name	English name	Norwegian name	Hosts plants	Transmission	Distribution	Categorisation	Probability of entry into packing plants	Comments
Ditylenchus dipsaci	Stem and bulb eelworm	Stengel-nematode	Onion, leek, shallot, garlic, carrot, turnip, swede, potato	Tissue, soil and debris	World- wide	EPPO A2	Moderately likely High uncertainty	Present in Norway
Ditylenchus destructor	Potato rot nematode	Potetråte-nematode	Potato, onion, carrot	Tissue, soil and debris	World-wide	EPPO (not listed)	Moderately likely High uncertainty	Present in Norway
***Globodera rostochiensi*s**	Yellow potato cyst nematode	Gul potet-cystenematode	Potato	Soil and debris	South America, Europe and New Zealand	EPPO A2	Very likely Low uncertainty	Present in Norway
Globodera pallida	White potato cyst nematode	Hvit potetcyste-nematode	Potato	Soil and debris	South America, Europe, parts of Africa and, Asia, and New Zealand	EPPO A2	**Domestic crops:** Moderately likely Low uncertainty **Imported crops**: Very likely High uncertainty	Restricted distribution in Norway
Meloidogyne chitwoodi	Columbia root-knot nematode	Columbia rotgallnematode	Potato, carrot	Tissue soil and debris	Parts of South and North America, South-east Africa and some countries in Europe	EPPO A2	**Domestic crops:** Unlikely Low uncertainty **Imported crops:** Moderately likely High uncertainty	Absent from Norway
Meloidogyne fallax	False Columbia root-knot nematode.	Falsk Columbia rotgallnematode	Potato, carrot, radish	Tissue, soil and debris	Some countries in Europe and New Zealand	EPPO A2	**Domestic crops:** Unlikely Low uncertainty **Imported crops:** Moderately likely High uncertainty	Absent from Norway

2.4.1.7 Pathways and probability of entry of the pests into packing plants

The pathways for entry are consignments of bulbs of onion, leek, shallot, garlic, carrot, turnip, swede and potato, including leaf scales, debris and attached soil. The probability of *D. dipsaci* entering packing plants is considered moderately likely with high uncertainty. The probability of dispersal from packing plants is rated as likely, with a median uncertainty due to survival in organic waste.

2.4.2 *Ditylenchus destructor* Thorne, 1945.

Taxonomic position: Nematoda, Tylenchida, Anguinidae, *Ditylenchus*

Common names: Potetråtenematode (Norwegian), potatisrötnematod (Swedish), kartoffelrådnematod (Danish), Potato rot nematode (English)

2.4.2.1 Host plants of *Ditylenchus destructor*

Potato (*Solanum tuberosum*), onion (*Allium cepa*), carrot (*Daucus carota* spp. *sativus*), mangolds (*Beta vulgaris*), bulbs of flowering plants, many weeds and fungi (EFSA 2014)

2.4.2.2 Biological information

The most important host economically is potato. The nematode enters tubers through the lenticels causing a dry rot. It multiplies just below the skin leading to the development of soft white spots in the tuber tissue surrounded by white rings. The tuber skin becomes papery and cracked. The nematode reproduces in storage, where it may invade new tubers (Sturhan & Brzeski 1991, EFSA 2014). The occurrence of *D. destructor* in fields depends on weed plants and fungi acting as hosts. Continuous cropping with potato decreases rather than increases the degree of attack (Andersson 1967).

2.4.2.3 Distribution of the pest in Norway

Ditylenchus destructor is present in Norway (NFSA 2017).

2.4.2.4 Distribution of the pest in other Nordic countries

There are few occurrences of *D. destructor* in Sweden. The pest is considered absent in Finland, and there is no information from Denmark and Iceland (EPPO 2017).

2.4.2.5 Global distribution of the pest

Ditylenchus destructor is present in South Africa, Canada, USA, Mexico, China, Japan, Korea Republic, Pakistan, Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, Iran, Saudi Arabia, Albania, Austria, Belarus, Belgium, Bulgaria, Czech Republic, Estonia, France, Germany, Greece, Hungary, Ireland, Jersey, Latvia, Luxembourg, Moldova, Netherlands, Poland, Romania, Russia, Slovakia, Switzerland, Turkey, Ukraine, United Kingdom and New Zealand. Often the distribution frequently is reported as "few occurrences" or "restricted distribution".

2.4.2.6 Regulatory status of the pest

Ditylenchus destructor is a quarantine organism to Norway (Lovdata 2018). It is prohibited to introduce and spread *D. destructor* if it occurs on seed potato and certain flower bulbs.

2.4.2.7 Pathways and probability of entry of the pests into packing plants

The pathways are consignments of infested potato tubers, onion, carrots and mangolds. The probability of *D. destructor* entering packing plants is considered moderately likely with a high uncertainty. The probability of dispersal from packing plants is rated likely, with a median uncertainty due to survival in organic waste.

2.4.3 *Globodera rostochiensis* (Wollenweber, 1923) Skarbilovich, 1959.

Taxonomic position: Nematoda, Tylenchida, Heteroderidae, *Globodera*

Common names: Gul potetcystenematode (Norwegian), gul potatiscystnematod (Swedish), gul kartoffelcystenematod (Danish), yellow potato cyst nematode (English)

2.4.3.1 Host plants of *Globodera rostochiensis*

The host plants of PCN occur in the family Solanaceae: potato (*Solanum tuberosum*), tomato (*Lycopersicon lycopersicum*) and aubergine (*Solanum melongena*), and a large variety of other solanacecus plants like black nightshade *Solanum nigrum* and bittersweet nightshade *S. dulcamara* (EFSA 2012).

2.4.3.2 Biological information

The most important host economically is potato. *Globodera rostochiensis* is amphimictic with sedentary globose females and veriform males. Hatching of the infective J_2 juveniles occurs in response to hatching factor(s) in the root exudate of potato. The nematode hatches and multiplies well in the temperature range 18-24°C (Van Riel & Mulder 1998). The hatching process of *G. rostochiensis* is rapid, which makes control with nematicides reliable (Whitehead & Turner 1998). The juveniles infect roots behind the root tip, and after migration through the cortex a nutritive tissue, the syncytium is initiated in connection with the vascular tissues. The syncytium consists of coalescent cells and is multinucleate. After three moults, nematodes become adults. Females develop from large syncytia, while males develop from smaller syncytia. The development of the gonads makes the females swell up and rupture the root epidermis. The adult males become vermiform and are attracted to the females for mating. Many males can mate with each female (CABI 1973, EFSA 2012). Multiple mating of each female may lead to genetic variability in juveniles from the same cyst. Hybridization between species (Miller 1983) may add to variability of the off-spring in mixed populations. *Globodera rostochiensis* shows a remarkable persistence in absence of host plants. In Norway, viable and infective juveniles still were present in cysts after 32 years in the field without host plants (Holgado *et al.* 2015).

2.4.3.3 Distribution of the pest in Norway

Globodera rostochiensis is present in Norway from Agder to Nord-Trøndelag (NFSA 2017).

2.4.3.4 Distribution of the pest in other Nordic countries

Globodera rostochiensis is present in Sweden, Denmark, Finland and Iceland (EPPO 2017).

2.4.3.5 Global distribution of the pest

The pest is widespread in Austria, Liechtenstein and New Zealand (EPPO 2017). In Europe, the nematode occurs in 41 countries. In 27 countries, it is reported to have a "restricted distribution" (EPPO 2017). There is a considerable challenge in detecting PCN the field soil. For detection of one cyst in 250 mL soil, the field infection need to be 60 000 000 cysts per ha (Southey 1974). This indicates a considerable probability of latent infections also where the distribution is considered to be "restricted".

2.4.3.6 Regulatory status of the pest

Globodera rostochiensis is on the EPPO A2 list (EPPO 2017). It is a quarantine organism to Norway, in addition, particular requirements apply to import, domestic production and sale of potatoes concerning *G. rostochiensis* (Lovdata 2018).

2.4.3.7 Pathways and probability of entry of the pests into packing plants

Globodera rostochiensis can be introduced via potato with attached soil, soil from infested fields and contaminated machinery. Early studies in Scotland revealed more than 20 000 cysts adhering to the wheels of a tractor, which had been driven over a field with moist soil (Lindhardt 1959). The probability of *G. rostochiensis* entering packing plants is considered very likely with low uncertainty. Dispersal of the pest from packing plants is moderately likely, with a low uncertainty.

2.4.4 *Globodera pallida* Stone, 1973

Taxonomic position: Nematoda, Tylenchida, Heteroderidae, *Globodera*

Common names: Hvit potetcystenematode (Norwegian), vit potatiscystnematod (Swedish), hvid kartoffelcystenematod (Danish), white potato cyst nematode (English)

2.4.4.1 Host plants of Globodera pallida

The host plants of *G. pallida* occur in the family Solanaceae: potato (*Solanum tuberosum*), tomato (*Lycopersicon lycopersicum* and aubergine (*Solanum melogena*), and a large variety of other solanaceous plants, like black nightshade *Solanum nigrum* and bittersweet nightshade *S. dulcamara* (EFSA 2012).

2.4.4.2 Biological information

The most important host economically is potato. *G. pallida* is amphimictic with sedentary globose females and vermiform males. Hatching of the infective J_2 juveniles occurs in response to hatching factor(s) in the root exudate of potato. *Globodera pallida* hatches and multiplies well in the temperature range 12-21°C (van Riel & Mulder 1998). Hatching is slow and late hatching juveniles escape the lethal effects of nematicides (Whitehead & Turner 1998). The juveniles infect roots behind the root tip, and after migration through the cortex a nutritive tissue, the syncytium is initiated in connection with the vascular tissues. The syncytium consists of coalescent cells and is multinucleate. After three moults in the plant, the juvenile nematodes become adults. Females develop from large syncytia, while males develop from smaller syncytia. The development of the gonads results in the females swell up and rupturing the root epidermis. The adult males become vermiform and are attracted to the females for mating. Many males can mate with each female (CABI 1973, EFSA 2012). Multiple mating of each female may lead to a high variability in juveniles from the same cyst. Hybridization between species (Miller 1983) may add to variability of the offspring in mixed populations. The intensive cropping of the potato cultivar 'Maris Piper', which is resistant to the yellow PCN, has resulted in an epidemic outbreak of the white PCN in UK (Trudgill et al. 2003). *Globodera pallida* shows a remarkable persistence in absence of host plants. In Norway, viable and infective juveniles were still present in cysts after 12 years in the field without host plants (Holgado *et al*. 2015).

2.4.4.3 Distribution of the pest in Norway

In Norway *G. pallida* has a restricted distribution occurring in Agder to Nord-Trøndelag (Holgado et al. 2017, NFSA 2017).

2.4.4.4 Distribution of the pest in other Nordic countries

Globodera pallida has a restricted distribution in Sweden, Denmark, Faroe Islands, Finland and Iceland (EPPO 2017).

2.4.4.5 Global distribution of the pest

Globodera pallida is reported to occur in Algeria, Tunisia, Argentina, Bolivia, Canada, Chile, Colombia, Costa Rica, Ecuador, Falkland Islands, Panama, USA, Venezuela, India, Japan, Pakistan, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Ireland, Italy, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Switzerland, Turkey and United Kingdom. The species is reported to be widespread in Peru and New Zealand (EPPO 2017).

2.4.4.6 Regulatory status of the pest

Globodera pallida is on the EPPO A2 list (EPPO 2027). It is a quarantine organism to Norway, in addition, particular requirements apply to import, domestic production and sale of potatoes concerning *G. pallida* (Lovdata 2018).

2.4.4.7 Pathways and probability of entry of the pests into packing plants

Globodera pallida can be introduced via potato with attached soil, soil from infested fields and contaminated machinery. The probability of *G. pallida* entering packing plants is considered moderately likely for domestic crops with a low uncertainty, and very likely for imported crops with a high uncertainty. The rating of probability for domestic crops relate to the restricted occurrence of the nematode in Norway, while the rating of probability for imported crops relates to the higher abundance at the origin of many pathways. The probability of dispersal of *G. pallida* from packing plants is considered moderately likely, with a low uncertainty.

2.4.5 *Meloidogyne chitwoodi* Golden, O`Bannon, Santo & Finley, 1980

Taxonomic position: Nematoda, Tylenchida, Meloidogynidae, *Meloidogyne*

Common name: Columbia root-knot nematode (English).

2.4.5.1 Host plants

Meloidogyne chitwoodi has a wide host range within several plant families, including crop plants and common weed species (O'Bannon *et al.*, 1982; Mojtahedi *et al.*, 1988). Potato is a good host, as are sugar beet, maize, wheat, oat, barley, carrot, bean, peas, and several grasses and graminaceous weeds. Races of *M. chitwoodi* differ in their host ranges (Janssen *et al.*, 1995; Karssen, 1995).

2.4.5.2 Biological information

Meloidogyne chitwoodi overwinters primarily as eggs. The second juvenile stage (J_2) is the infective stage, which migrates through the soil and enters the roots of a host plant where it induces the formation of special nurse cells (giant cells). The juvenile stages J_3 and J_4 do not feed. The adult female resumes feeding, and the reproductive system develop producing eggs, which are deposited into a gelatinous matrix surrounding the vulva opening. The reproduction is by facultative meiotic parthenogenesis (Eisenback & Triantaphyllou, 1991; van der Beek & Karssen, 1997) and males are not required. The nematode may have several generations a year. In potato, the first generation develops on the roots, while the second generation attacks the tubers. The nematodes live just under the peel where they cause the formation of numerous necrotic spots (EPPO 2016). Griffin (1985) reported that a temperature sum of 1428 and 1522 degree days resulted in the development of two nematode generations and some tuber galling. These temperature sums are also relevant for Norway and tuber galling would be expected in the Oslo Fjord area and in Rogaland. Since the nematode attacks a large number of plant species, including many grasses, the population can be maintained well on weeds and volunteer plants. The tolerance for low temperatures combined with active migration to greater depths will ensure the persistence of *M. chitwoodi* throughout the winter (Mojtahedi *et al.*, 1991). Griffin & Thomson (1988) found differences in virulence on potato between three populations of *M. chitwoodi*. The most virulent population came from an area with a shorter growing season and cooler weather conditions.

2.4.5.3 Presence in Norway

Meloidogyne chitwoodi is absent from Norway (NFSA 2017).

2.4.5.4 Distribution of the pest in other Nordic countries

There are reports of recent outbreaks of the pest in southern Sweden. The first in 2017 in Blekinge (EPPO 2018b) and recently in Scania (Jordbruksverket press release June 2018). *Meloidogyne chitwoodi* is considered absent in Finland, Denmark and Iceland (EPPO 2017, 2018b).

2.4.5.5 Global distribution of the pest

Meloidogyne chitwoodi occurs in temperate areas. It is reported present in Mozambique, South Africa, Argentina, Mexico, USA, Belgium, France, Germany, Netherlands, Portugal and Turkey (EPPO 2017).

2.4.5.6 Regulatory status of the pest

Meloidogyne chitwoodi is on the EPPO A2 list (EPPO 2017). It is a quarantine organism to Norway (Lovdata 2018).

2.4.5.7 Pathways and probability of entry of the pests into packing plants

Meloidogyne chitwoodi can be introduced with potato tubers including attached soil, and infested soil on machinery. The probability of *M. chitwoodi* entering packing plants is considered unlikely for domestic crops with a low uncertainty, and moderately likely for imported crops with a high uncertainty. The rating for domestic crops relates to the absence of this nematode in Norway, while the rating for imported crops relates to the higher frequency of the nematode in Europe and some other countries. The high uncertainty for imported crops relates to the unclear distribution of the pest. The probability of dispersal of *M. chitwoodi* from packing plants is considered moderately likely, with a high uncertainty.

2.4.6 *Meloidogyne fallax* Karssen, 1996

Taxonomic position: Nematoda, Tylenchida, Meloidogynidae, *Meloidogyne*

Common name: False Columbia root-knot nematode (English).

2.4.6.1 Host plants of *Meloidogyne fallax*

Studies on the range of *M. fallax* have demonstrated that its host range overlaps with that of *M. chitwoodi* (Brinkman *et al*. 1996). The major host is potato, but carrot, *Asparagus officinalis*, and strawberry have also been registered as hosts (EPPO 2017). Cereals, sugar beet, grasses, white mustard, radish and ryegrass also have been demonstrated as hosts (Heijbroek *et al.* 1998).

2.4.6.2 Biological information

Meloidogyne fallax overwinters primarily as eggs. The second juvenile stage (J_2) is the infective stage, which migrates through the soil and enters the roots of a host plant where it induces the formation of special nurse cells (giant cells). The juvenile stages J_3 and J_4 do not feed. The adult female resumes feeding, and the reproductive system develop producing eggs, which are deposited into a gelatinous matrix surrounding the vulva opening. The nematode reproduces by facultative meiotic parthenogenesis (van der Beek & Karssen, 1997) and, therefore, males are not required. The nematode may have several generations a year. In potato, the first generation develops on the roots, while the second generation attacks the tubers. The nematodes live just under the peel where they cause the formation of numerous necrotic spots (EPPO 2016). The temperature requirements of *M. fallax* is similar to those of *M. chitwoodi*, so in Norway tuber galling would be expected in the Oslo fjord area and in Rogaland. Since the nematode attacks a large number of plant species, including grasses, the population can be maintained well on weeds and volunteer plants (Unpublished results).

2.4.6.3 Presence in Norway

Meloidogyne fallax is absent from Norway (NFSA 2017).

2.4.6.4 Presence in other Nordic countries

Meloidogyne fallax is absent from other Nordic countries (EPPO 2017).

2.4.6.5 Global distribution of the pest

Meloidogyne fallax is present in Belgium, Netherlands, France, Germany, Switzerland, United Kingdom, Australia and New Zealand (EPPO 2017).

2.4.6.6 Regulatory status of the pest

Meloidogyne fallax is on the EPPO A2 list (EPPO 2017). It is a quarantine organism to Norway (Lovdata 2018).

2.4.6.7 Pathways and probability of entry of the pests into packing plants

Meloidogyne fallax can be introduced via consignments of potato tubers including attached soil, and infested soil on machinery. The probability of *M. fallax* entering packing plants is considered unlikely for domestic crops with a low uncertainty, and moderately likely for imported crops with a high uncertainty. The ratings relate to its absence in Norway and presence of the nematode in some countries exporting potato to Norway. The high uncertainty for imported crops relates to the sparse information of the distribution of the pest in countries exporting potato to Norway. The probability of dispersal of *M. fallax* from packing plants is considered moderately likely, with a high uncertainty.

2.5 Plant parasitic insects

2.5.1 Potato tuber damaging *Epitrix* species. Identity of the species and taxonomic position

Taxonomic position: Coleoptera: Chrysomelidae: Alticinae.

Common names: Tuber flea beetle (English), jordlopper på potet (Norwegian)

The great morphological similarity of several of the *Epitrix* species makes identification in the field very difficult, even by specialists. The insects may feed on a wide range of different host plants, but those that have potato as the major host may have high economic impact on potato, and the pests are of regulatory concern (EPPO 2010). The pests are listed in Table 11 (EPPO 2017).

2.5.1.1 Biological information

Adults of *Epitrix* species may be found on all above ground parts of the plant as well as in soil and on the soil surface. They mainly feed on the upper surface of leaves, and less often on the lower surfaces. Adult beetles cut characteristic "shot-like" holes in the leaves. The larvae inhabit the soil around potato roots; occasionally they may enter the tubers, leaving roughened trails or tiny tunnels filled with corky tissue. Some species are more injurious, affecting potato tubers, which then show long sinuous corky lesions and small holes. These lesions are caused by larvae, feeding under the epidermis, and digging galleries that usually remain superficial and do not affect the flesh of the tuber. (EPPO 2010).

2.5.1.2 Distribution of the pests in Norway

None of the *Epitrix*- species damaging potato have been detected in Norway (NFSA 2017).

2.5.1.3 Distribution of the pests in other Nordic countries

None of the *Epitrix*-species damaging potato are known to occur in the Nordic countries (EPPO 2017).

2.5.1.4 Global distribution of the pests

Epitrix cucumeris is present in both North- and South America, and the species has in recent years been detected in Portugal and Spain. *Epitrix papa* is present only in Portugal and Spain. *Epitrix subcrinita* and *E. tuberis* have only been detected in North- and South America (EPPO 2017).

2.5.1.5 Regulatory status

Epitrix subcrinita and *E. tuberis* are on the EPPO A1 list, *E. papa* and *E. cucumeris* are on the EPPO A2 list (EPPO 2017). None of the *Epitrix* species is regulated in Norway (Lovdata 2018).

2.5.1.6 Pathways of entry into potato packing plants

The main pathways for *Epitrix*-species are potato tubers for planting and for consumption, with soil and/or plant debris attached and coming from countries where the pests occur. Some other pathways may present a low probability, such as soil and growing medium attached to rooted host and non-host plants from countries where the pests occur, soil or growing medium, and soil and plant debris attached to machinery from countries where the pests occur. (EPPO 2010).

2.5.1.7 Pathways and probability of entry of the pests into packing plants

With no current import restrictions for *Epitrix* spp. to Norway, there is a high likelihood for contaminated tubers to be imported and enter potato packing plants, as well as survive and be moved out from the premises, with low uncertainty.

Table 11. *Epitrix*-species of quarantine status, their host plants, transmission, distribution, current pest categorization (EPPO 2017), phytosanitary risks and probability of entry into packing plants.

Scientific name	English name	Norwegian name	Host plants (major)	Transmission	Distribution	Categorization	Probability of entry into packing plants	Comments
***Epitrix cucumeris* Harris**	Potato flea beetle	NA	Potato	Insects in soil/plant debris attached to tubers	Portugal, Spain, Georgia, North and South America	EPPO A 2 (not listed by Norway)	Likely, high uncertainty	Absent from Norway
***Epitrix papa* Orlova-Bienkowskaja**		NA	Potato	Insects in soil/ plant debris attached to tubers	Portugal, Spain, North and South America	EPPO A 2 (not listed by Norway)	Likely, high uncertainty	Absent from Norway
***Epitrix subcrinita* LeConte**		NA	Potato	Insects in soil/plant debris attached to tubers	North and South America	EPPO A 1 (not listed by Norway)	Likely, high uncertainty	Absent from Norway
***Epitrix tuberis* Gentner**	Tuber flea beetle	NA	Potato	Insects in soil/plant debris attached to tubers	North and South America	EPPO A 1 (not listed by Norway)	Likely, high uncertainty	Absent from Norway

2.6 Probability of pest survival in packing plants

Table 12 list the plant pest organisms identified to follow potatoes and vegetables entering packing plants, i.e. inputs, and Table 13 evaluates if the pest in terms of viable pest propagules may be associated with output process water and/or organic waste from packing plants.

Pest survival will vary among and within pest species and whether the organism follow in soil, in water, in plant waste or as contaminants on solid surfaces. There exist differences in lethal temperature-time combinations (Table 12). Organisms lacking structures for physical protection are more vulnerable to treatments than organisms forming spores, cysts and egg sacs (Bingefors et al. 1972, Evans 1991, Herrmann *et al*. 1994, Lindhardt 1959, Stone & Webely 1975). The survival probability, or vulnerability of pest propagules, to risk reduction treatments depends both on their physical state and the environmental conditions. In the case of the nematode *G. rostochiensis* eggs and juveniles, they are more vulnerable than dry cysts (Lindhardt 1959, Stone & Webely 1975) to heat treatment.

The viruses listed in Table 12 are transmitted by insect or nematode vectors, but the viruses may also follow in potato tubers. However, to be of phytosanitary risk the tubers would have to be used as seed potatoes.

Clavibacter michiganensis subsp. *sepedonicus* is known to survive for months in whole tubers, parts of tubers, stems and roots. The bacteria may also survive for many months in a dried-up state on surfaces of wood, metal, machinery, equipment and potato storage bags (EPPO/CABI 1997b). *Clavibacter michiganensis* subsp. *sepedonicus* survives only for few days in water, soil and sludge (Steinmöller *et al.* 2013).

Ralstonia solanacearum is very difficult to eradicate once it has been introduced to an area. Entry of *R. solanacearum* into domestic packing plants handling potato import is likely.

Ralstonia solanacearum is known to survive for months in whole tubers, parts of tubers, stems and roots. It may also survive for many months in a dried-up state on the surfaces of wood, metal, machinery, equipment and potato storage bags (Bisceglie di *et. al.* 2005), (EPPO/CABI 1997a). *Ralstonia solanacearum* may also survive for many months in water, soil and sludge (Elsas van *et.al*. 2000).

Except from the potato viruses and the *Epitrix* species, which all are short lived in wastewater and organic waste, most of the organisms evaluated may be present in the output process water or organic waste from packing plants (Table 13).

Table 12. Survival of the pest in different environments of the packing plants. *)

Scientific name	In soil	In water	In plant waste	On solid surfaces	Lethal temperature *)	Proba-bility	Uncer-tainty	Comments
Potato viruses	Not known	Not known	Not known	Not known	Less than 50˚ C	Unlikely	Low	Depend on vector for spread
Clavibacter michiganensis* subsp. *sepedonicus	Few days	Few days	Many months, up to a year	Many months, up to a year	70˚ C	Very likely	Low	The bacterium survives for a short time in water, and for a long time in soil, plant debris and on solid surfaces
Ralstonia solanacearum	Many months	Many months	Many months	Many months	70˚ C	Very likely	Low	The bacterium survives for a long time in water, soil, plant debris and on solid surfaces
Synchytrium endobioticum	30 years	Long time	Several years	Several years	100˚ C	Very likely	Low	The resting spores survive for many years in soil
Stromatinia cepivora	20 years	Long time	Several years	Several years	60˚ C	Very likely	Low	The sclerotia survive for many years in soil
Ditylenchus dipsaci	1 year	6 months	Several years	Few days	46˚C x 7 h	Likely	High	The nematode survives for a long time in eelworm wool
D. destructor	1 year (weed free)	6 months	1 year	1 h	43.5˚ C x 3 h	Likely	High	The nematode survives in potato peel
***Meloidogyne* spp.**	Several years	6 months	Several years	1 year	>70˚C x 4 days (eggs in egg-sacs)	Very likely	low	The nematode survives in egg-sacs
***Globodera* spp.**	40 years	6 months	Not applicable	40 years	60˚C x 30 min (wet cysts), 90˚C x 30 min (dry cysts), 65-70˚C x 24 h (dry cysts)	Very likely	Low	The nematode survives in soil
***Epitrix* spp.**	Few days	Not known	Few days	Not known	Less than 50˚	Unlikely	Low	The pests are short-lived in water, soil, waste and plant debris

*) There are uncertainties concerning these estimated lethal temperature of the pests in packing plants. The lethal temperatures are approximate and could be higher if the pests are protected in plant debris or soil, particularly if the environments are dry. The values are considered a minimum to have an effect. To the best of the authors knowledge few if any references in scientific journals are found but may appear in more general recommendations to kill virus, bacteria, fungi, nematodes and insects.

Table 13. Probability of pest presence in process water or organic waste from packing plants

Scientific name	Probability	Uncertainty	Comments
Potato viruses in Table 7	Very unlikely	Low	The viruses are short-lived in water and organic waste
Clavibacter michiganensis* ssp. *sepedonicus	Likely	Low	The bacteria survive for short time in water, for long time in organic waste
Ralstonia solanacearum	Likely (for import)	Low	The bacteria survive for very long time in water and long time in organic waste
Synchytrium endobioticum	Moderately likely (for import)	Medium	Resting spores are thermotolerant and survive in water and organic waste.
Stromatinia cepivora	Moderately likely	Medium	Sclerotia of the pest are thermotolerant and survive in water and organic waste.
Ditylenchus dipsaci	Likely	Medium	Nematodes survive in organic waste
Ditylenchus destructor	Likely	Medium	Nematodes survive in organic waste
Globodera rostochiensis	Moderately likely	Low	Nematodes occur in soil
Globodera pallida	Moderately likely	Low	Nematodes occur in soil
Meloidogyne chitwoodi	Moderately likely	High	Nematodes survive in organic waste
Meloidogyne fallax	Moderately likely	High	Nematodes survive in organic waste
***Epitrix* spp**	Unlikely	Low	The insects are short-lived in water and organic waste

3. Identification of risk reduction options to prevent dispersal of quarantine pests from packing plants

In the previous chapters, details of the pest biology, hosts, pathways for entry into the packing plant, and the probability for entry into and movement out of from potato and vegetable packing plants are described. Here we identify risk reducing options that may prevent the presence of viable pest propagules in each of the specified wastes from businesses handling imported products as well as businesses handling Norwegian products only. Table 14 presents an overview on the assessed effectiveness and uncertainty, as well as the technical feasibility of the risk reduction options. Furthermore, in Table AII-1 an extensive overview of the effectiveness, uncertainty and technical feasibility of the identified risk reduction options for the most important pests are presented.

Deposition at landfill sites without previous treatment: Organic waste like soil, sludge, rasp and other plant material may be deposited at a landfill site, where it must be regularly covered, composted or incinerated.

Waste as soil improvement on land that is not used for potato or vegetable production. There is a high uncertainty with this method if the waste is not treated at sufficiently high temperature to kill pest potentially present in the waste.

Sand and/or UV-filter: Water used at the packing plant may be channelled to a nearby watercourse after it has passed a sedimentation tank or sand filter. The sediment in the tank and the sand from the sand filter should regularly be deposited at a landfill site. Filtering or UV treatment of process water will not exclude small size organisms like viruses, bacteria, fungi and nematodes effectively. In the case of *Meloidogyne chitwoodi* and *M. fallax*, treatments with heat and UV have proven not effective in killing eggs in egg sacs (Wesemael et al. 2015). Filters may also be easily clogged, and the effect of UV radiation may be lowered if small soil particles are present (Unpublished results).

Heat treatment of waste at 74°C for at least 4 hours, preferably by wet heat is an option. For the heat treatment to be effective, the particle size of the waste should preferably not be larger than 1.2 mm, which could be achieved by homogenization. During heat treatment, the moisture of the waste should be sufficient to guarantee heat transfer between and inside the particles (EPPO 2008). However, this will not kill eggs of *Meloidogyne* spp., which survived > 70°C for 4 days in vegetable waste during composting (Herrmann *et al.* 1994). Resting spores of the potato wart fungus *Synchytrium endobioticum* will also survive heat treatment at 74°C for at least 4 hours, and 100°C is required to inactivate the resting spores of the potato wart fungus.

Municipal water treatment: Water from the packing plant may be channelled through a municipal water treatment plant. This way of handling waste and water may be sufficient if it is known not to contain quarantine organisms that may survive for a long time. However, the presence of *Clavibacter michiganensis* subsp. *sepedonicus*, *Ralstonia solanaceraum, Synchytrium endobioticum, Stromatinia cepivora, Ditylenchus dipsaci, Ditylenchus destructor, Globodera rostochiensis, Globodera pallida, Meloidogyne chitwoodi* and *Meloidogyne fallax*, which all could survive for a considerable time in waste and water, would represent a high risk for dispersal from packing plants if appropriate actions are not taken to prevent this.

Waste used as animal feed: In a recent PRA it was discussed how pests could survive in the digestive tract of the animals, and subsequently survive in manure (VKM 2016). The probability of spread by manure was found to be unlikely for plant pathogenic viruses, bacteria and most plant pathogenic fungi. The probability for spread by manure was considered likely for the fungus *Synchytrium endobioticum*, and moderately likely for the nematodes *Globodera rostochiensis* and *G. pallida*. For other nematodes treated in the assessment, the probability for spread was considered unlikely. *Meloidogyne chitwoodi* and *M. fallax* were not included in the PRA (VKM 2016).

4. The effectiveness and feasibility of risk reduction options

The different risk reduction options, presented in chapter 3, to handle organic waste and wastewater are sufficient for elimination of most quarantine virus and organisms. However, the presence of *Clavibacter michiganensis* subsp. *sepedonicus*, *Ralstonia solanaceraum*, *Synchytrium endobioticum*, *Stromatinia cepivora*, *Ditylenchus dipsaci*, *Ditylenchus destructor*, *Globodera rostochiensis*, *Globodera pallida*, *Meloidogyne chitwoodi* and *Meloidogyne fallax*, which all could survive for a considerable time in waste and water, represent high risks for dispersal from packing plants if appropriate measures are not taken to prevent this. In Table 14 and Table AII-1 the effectiveness, feasibility and uncertainty of risk reduction options for the most important pests are described.

Organic waste like soil, sludge, rasp and other plant material and inorganic waste may be deposited at a landfill site, where it must be regularly covered, composted or incinerated. Depositing untreated organic and inorganic waste at landfill sites is a current practice at several packing plants. It is important that the sites are at safe distance from potato and vegetable farms. The option has medium effectiveness, is highly feasible and with high uncertainty.

Organic and inorganic waste can be used as soil improvement on land that is not used for potato and vegetable production. This is highly relevant for soil that has low organic matter content. The option has medium effectiveness, high feasibility and high uncertainty due to possible changes in future land use.

The use of waste water that has passed through a sedimentation tank or sand filter before being channelled directly to a water course means low effectiveness. This option is highly feasible with low uncertainty.

If the wastewater is passed through a sedimentation tank or sand filter before being channelled to a municipal water treatment plant, the effectiveness is high, and the feasibility is high with medium uncertainty.

If the wastewater is passed through a sedimentation tank or sand filter before being further filtered or UV-treated, the effectiveness and the feasibility are low with high uncertainty.

Heat treatment of the organic waste is highly effective for many viruses, bacteria, fungi, insects and some nematodes, but the effectivity is low to medium for *Synchytrium endobioticum*, *Stromatinia cepivora, Globodera* spp. and *Meloidogyne* spp. The feasibility of heat treatment is low to medium and the uncertainty is high.

The use of organic waste as feed for animals is highly effective for elimination of most pests, but the effectiveness is low for the quarantine pests *Synchytrium endobioticum*, *Stromatinia cepivora* and *Globodera* spp. The feasibility of using waste as animal feed is high and the uncertainty is medium.

Table 14. Overview of the effectiveness and feasibility of the risk reduction options

Option	Effectiveness	Uncertainty	Feasibility
Depositing organic and inorganic waste at landfill site without previous treatment	Medium	High	High
Waste used as soil improvement on land that is not used for potato and vegetable production	Medium	High	High
Waste water from the packing plant and having passed through a sedimentation tank or sand filter **1. Before being channelled directly to a water course** **2. Before being channelled to a municipal water treatment plant** **3. Further filtered or UV-treated**	Low High Low	Low Medium High	High High Low
Heat treatment of waste	High for many viruses, bacteria, fungi, insects and some nematodes Low to medium for *Synchytrium endobioticum, Stromatinia cepivora, Globodera* spp. and *Meloidogyne* spp.	High High	High Low to medium
Waste used as animal feed	High for most pests Low for *Synchytrium endobioticum, Stromatinia cepivora, Globodera* spp. and *Meloidogyne* spp.	Medium Medium	High High

5 Conclusions with answers to the Terms of reference

The NFSA requested VKM to do an assessment of the risk reduction options to prevent movement of quarantine pests out of potato and vegetable packing plants handling domestic and imported products. The answers to the terms of reference provided by the NFSA (p.24) are described below.

5.1 Identify which host plants/products and which quarantine pests and potential quarantine pests are relevant for this assessment

The crops relevant for the assessment are potato, carrot, onions, and other root vegetables, which are susceptible to quarantine pests and potential quarantine pests.

A rather large number of quarantine pests and potential quarantine pests are relevant for Norway. Chapter 2.1 includes 13 plant pathogenic viruses, chapter 2.2 includes five plant pathogenic bacteria and phytoplasmas, chapter 2.3 includes five plant pathogenic fungi, chapter 2.4 includes six plant parasitic nematodes, and chapter 2.5 includes four plant parasitic insects. The biology of these viruses and organisms is described in sufficient detail in chapter 2 to understand the mechanism of the risk reduction options identified in the assessment. On this background information, the risk reduction options are elaborated in chapter 3 of the assessment, and their effectiveness and feasibility are discussed in chapter 4.

5.2 Identify risk reduction options

Chapter 3 presents risk reduction options (heat treatment, filtration and others) in order to prevent the spread of the relevant quarantine pests with each of the specified waste from such businesses, both businesses handling imported products and businesses handling Norwegian products only. Measures to prevent movement of viable pest propagules in waste, sludge, rasp, packing materials and water from the packing plants to the environment are discussed in chapter 3.

5.3 Evaluation of the effectiveness and feasibility of the risk reduction options identified.

Depositing organic and inorganic waste at landfill sites is a current practice at several packing plants. It is important that the sites are located at safe distance from potato and vegetable farms to reduce the risk of contamination of agricultural land. This option is assessed to have a medium effectiveness with high uncertainty, but being highly feasible.

Organic and inorganic waste may be applied as soil improvement on land that is not used for potato and vegetable production. This is highly relevant for soils having low organic matter content. Although being highly feasible, this option is assessed to have medium effectiveness with high uncertainty due to possible changes in future land use.

The use of water that has passed through a sedimentation tank or sand filter before being channelled directly to a watercourse is assessed to have a very low effectiveness and low uncertainty in stopping viable pest propagules to pass through the sedimentation tank or filter. This option is highly feasible.

If the water is passed through a sedimentation tank or sand filter before being channelled to a municipal water treatment plant, the effectiveness is high with medium uncertainty, and the feasibility is assessed to high.

If the water is passed through a sedimentation tank or sand filter before being further filtered or UV-treated the effectiveness is low with high uncertainty, and the technical feasibility are also assessed to be low.

Heat treatment of the waste has high effectiveness with high uncertainty, and assessed as highly feasible for many viruses, bacteria, fungi, insects and some nematodes. The effectiveness is low to medium for *Synchytrium endobioticum, Stromatinia cepivora, Globodera* spp. and *Meloidogyne* spp. due to the thermo-tolerance of these pests. The feasibility of heat treatment is low to medium with high uncertainty for the heat tolerant pests.

Using waste as animal feed has high effectiveness and the feasibility is also high for most pests, but the effectiveness is low for *Synchytrium endobioticum, Stromatinia cepivora, Globodera* spp, and *Meloidogyne* spp., as these pests are able to survive the passage of the animal intestine. The uncertainty is medium.

6 Data gaps

For several of the quarantine pests described in the current report there are few or no data on survival in water, soil and plant debris. The lethal temperatures of the pests are not well known, in particular when pest propagules are protected by soil or plant debris. Such assessments are, therefore, largely based on expert judgement.

Furthermore, there are insufficient information available on the actual management of organic waste, wastewater and soil at the different Norwegian packing plants handling potatoes, onion and leek.

The import statistics provided by NFSA give only information on the number of consignments of potato relevant for this assessment. Data on weight of each consignment are not available. Therefore, the import statistics for countries exporting potato to Norway are not comparable.

There is a need to improve the system of tariff codes for imported commodities and data exchange between customs authorities and NFSA.

The domestic distribution of *Stromatinia cepivora* and some other quarantine pests are not well mapped. More systematic surveys for quarantine pests in Norwegian agricultural areas are needed.

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Appendices

Appendix I

Title Rating and descriptions are based on Appendix 2 in VKMs Risk Assessment of cockspur grass (*Echinochloa crus-galli).*

Table A1-1; Rating of probability of entry.

Rating	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: • is not, or is only very rarely, associated with the pathway at the origin • no import volume, • may not survive during transport or storage • cannot survive the current pest management procedures existing in the risk assessment area • may not transfer to a suitable habitat in the risk assessment area
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin, • very low import volume, • survives at a very low rate during transport or storage, • is strongly limited by the current pest management procedures existing in the risk assessment area,

	• has considerable limitations for transfer to a suitable habitat/crop in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin, • moderate import volume, • survives at a low rate during transport or storage, • is affected by the current pest management procedures existing in the risk assessment area, • has some limitations for transfer to a suitable habitat/crop in the risk assessment area.
Likely	The likelihood of entry would be high because the pest: • is regularly associated with the pathway at the origin, • high import volume, • mostly survives during transport or storage; • is partially affected by the current pest management procedures existing in the risk assessment area, • has very few limitations for transfer to a suitable habitat/crop in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin, • very high import volume,

	• survives during transport or storage; • is not affected by the current pest management procedures existing in the risk assessment area, • has no limitations for transfer to a suitable habitat/crop in the risk assessment area.

Table A1-3: Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	No or little information is missing or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	Some information is missing or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.

Appendix II

Table AII-1. General overview of the effectiveness, feasibility and uncertainty of risk reduction options for the most important pests presented in this report.

Types of waste	Risk reduction option	Usage	Effective-ness	Feasibility	Uncertainty on effectiveness
Organic waste	Untreated	feed	Low	High	Medium
	Heat treatment	feed	Low	Low	High
	Untreated	soil improvement	Medium	High	High
	Heat treatment	soil improvement	Medium	Low	High
	Untreated	landfill	Medium	High	High
	Heat treatment	landfill	Medium	Low	High
Waste water	Untreated	led to watercourse	Low	High	Low
	Sand filtered	led to watercourse	Low	High	Low
	UV-filtering	led to watercourse	Low	Low	High
	Sedimentation tank	led to watercourse	Low	High	Low
	Untreated	municipal treatment (not included in PRA)	High	High	Medium
	Sedimentation tank or sand filter	municipal treatment (not included in PRA)	High	High	Medium
	Sedimentation tank or sand filter and UV-filter	municipal treatment (not included in PRA)	High	Low	Medium
Sludge	Untreated	soil improvement	Medium	High	Medium
	Heat treatment	soil improvement	Medium	Low	Medium
	Untreated	landfill	Medium	High	Medium
	Heat treatment	landfill	Medium	Low	Medium