Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

Pest risk assessment for apple proliferation phytoplasma (“*Candidatus* Phytoplasma mali”)

Opinion of the Panel on plant health of the Norwegian Scientific Committee for Food Safety

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Pest risk assessment for apple proliferation phytoplasma ("*Candidatus* Phytoplasma mali")

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VKM Panel on plant health has appointed a project group consisting of four panel members to make a draft assessment answering the request from the Norwegian Food Safety Authority. The members of the project group are acknowledged for their valuable work on this assessment.

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Assessed by

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Summary

The plant pest Apple proliferation phytoplasma (AP) on apple gives symptoms on shoot, leaf, fruit and roots. The most serious consequences are secondary shoots forming “witches’ brooms” on the trees, and reduced crop yield, the crop consisting mainly of very small, tasteless non-marketable fruits. The pathogen is spread by use of infected propagation material, by insect vectors, and by natural root bridges with other trees. The pathogen is considered as very serious for apple production in Southern Europe.

In the 2010 season the Norwegian Food Safety Authority registered a significant increase in number of AP detections. Both the number of farms with infected trees and the extent of infection on each farm were significantly higher than seen before. The Norwegian Food Safety Authority might therefore consider a possible revision of the phytosanitary measures and priorities related to AP. Thus, the Norwegian Food Safety Authority, in a letter of 22nd June 2011, requested a pest risk assessment of AP from VKM. The Authority also asked for an evaluation of the effectiveness of current phytosanitary measures to reduce risk

The current document is VKM’s answer to this request, and it was adopted by VKM’s Panel on Plant Health 23.1.2012. The draft of this document was made by a project group consisting of four members of the panel, mainly as contract work by Bioforsk.

VKM’s Panel on Plant Health gives the following main conclusions of the risk assessment: 1) The overall probability of entry is considered as very likely, with a low level of uncertainty. Plants for planting, scions, budwood and rootstocks are the main pathways for AP. Insect vectors are only of concern regarding local spread of AP. 2) The overall probability of establishment is considered as very likely, with a low level of uncertainty. Apple and some other species of *Malus* are the main hosts of the pest, and the number of host plant species is low. However, host plants are widespread and abundant in the PRA area. The vector *Cacopsylla melanoneura* occurs in parts of the PRA area. The climatic conditions are considered as suitable for AP because there have already been restricted outbreaks in Norway. Establishment is not restrained by competitors or natural enemies. Existing cultural or management practices are ineffective to prevent establishment. 3) AP may easily be spread by plants for planting, rootstocks, scions, budwood, and psyllid vectors. Plant materials are easily and rapidly spread within the whole PRA-area, and consequently represent a considerable risk for spread of the disease. Psyllid vectors and root bridges may be important for rapid local spread; 4) There is a high probability that AP may cause extensive economic damage in fruit orchards in the country. Apple is commonly grown in private gardens all over the southern part of Norway. In the central and northern part of Norway apple growing is restricted because of lower average temperatures. Commercial growing on a large scale is mainly restricted to some areas in the counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in Western Norway, and the counties of Buskerud, Telemark and Hedmark in Eastern Norway. Consequently these areas will be at most risk economically for AP to establish in Norway.

Keywords

Pest risk assessment; apple proliferation phytoplasma; “*Candidatus* Phytoplasma mali” ; economic consequences; distribution; entry; establishment; spread; pest status; Norway

Contents

Background

In Norway the plant pest Apple proliferation phytoplasma (AP), scientific name ”*Candidatus* Phytoplasma mali” was detected for the first time in 1996. It is likely that AP was introduced to Norway as early as in the 1970s.

AP infection on apple gives symptoms on shoot, leaf, fruit and roots. The most serious consequences are secondary shoots forming “witches’ brooms” on the trees, and reduced crop yield, the crop consisting mainly of very small, tasteless non-marketable fruits. The pathogen is spread by use of infected propagation material (plants for planting, scions and budwood, and rootstocks), by insect vectors, and by natural root bridges with other trees. The pathogen is considered as very serious for apple production in Southern Europe. The last few years many new research results have been published, reflecting that AP is given priority also internationally.

According to the Norwegian Regulations Relating to Plants and Measures Against Pests, AP is prohibited to spread in Norway (The Norwegian Food Safety Authority 2011a). In addition, special requirements are made saying that domestic production and trade with plants for planting of *Malus* (apple) shall be free from the pest. Corresponding requests are made concerning plants for planting of *Malus* that are imported to Norway. Furthermore, it is forbidden to import plants for planting of *Malus* from countries in which another plant pest, the fire blight-causing bacterium *Erwinia amylovora*, is present except through quarantine. Since fire blight is found in most European countries, there is almost no import of *Malus* today. However, dispensation from the import ban can be granted for material intended for experiments, research, plant breeding or propagation. AP is on the EPPO A2 list, and is regulated in EU with requirements similar to Norwegian regulations.

The pest status of AP in Norway is officially declared as: Present, only in some areas, subject to official control. In the 2010 season the Norwegian Food Safety Authority registered a significant increase in number of AP detections. Both the number of farms with infected trees and the extent of infection on each farm were significantly higher than seen before. Since 2009 the Norwegian Food Safety Authority has registered AP on apple in 36 properties, mostly in fruit growing districts in Western Norway, but also in some districts of Eastern Norway. It is expected that further surveys may result in more detections.

On the basis of the increased findings of AP in 2010, the Norwegian Food Safety Authority might consider a possible revision of the phytosanitary measures and priorities related to AP. Thus, the Norwegian Food Safety Authority, in a letter of 22nd June 2011, requested a pest risk assessment of AP from VKM. The current document is VKM’s answer to this request, and was adopted by VKM’s panel on plant health. The draft of this document was made by a project group consisting of four members of the panel, mainly as contract work by Bioforsk.

Be aware that the current document is a pest risk assessment, and not a Pest Risk Analysis (PRA). A PRA consists of both a risk assessment and a risk management part. VKM performs purely the risk assessment, whereas the Norwegian Food Safety Authority is responsible for the risk management. However, since this pest risk assessment is part of a PRA process, the current document refers to the PRA term in several contexts, like the identification of the PRA area and referrals to former PRAs. This is in accordance with the international standards ISPM No. 11 (FAO 2006) and PM 5/3(4) (EPPO 2009).

Terms of reference

On the basis of the increased findings of '*Candidatus* Phytoplasma mali' the previous year, the Norwegian Food Safety Authority requests VKM to carry out a pest risk assessment in accordance with the ISPM No. 11 for this pest. The following aspects should be considered specifically in the risk assessment:

1) Probability of introduction, with emphasis on the effectiveness of:
   a) The specific requirements of Annex 4A point 13.2 in regulations related to plants and measures against pests in relation to preventing the introduction of the pest with plants intended for planting of *Malus* imported to Norway from countries known to be free of fire blight.
   b) The requirements of ”karantenebestemmelser for planter og plantemateriale m.m. som er forbudt å innføre til Norge” in relation to preventing the introduction of the pest with plants intended for planting of *Malus* imported to Norway from countries where fire blight is known to occur.
2) Identification and evaluation of potential pathways for spread under Norwegian conditions, with emphasis on their importance related to domestic spread of the pathogen.
3) The effectiveness of the specific requirements of Annex 4B point 3 in regulations related to plants and measures against pests in relation to preventing the spread of the pest with plants intended for planting of *Malus* produced in Norway.
4) The probability of eradication of the pathogen from commercial apple production in Norway, following the present requirements and control measures.
5) The economic consequences for fruit production and plant production of
   a) Maintaining the present and transitional control measures as a future regime.
   b) Deregulating the pest, i.e. the pest should be considered as a quality pest.
6) Change in probability of spread and potential damage of the pest as a result of possible future climate change.

Assessment

The current pest risk assessment is made according to the EPPO Standard PM 5/3(4) Decision-support scheme for quarantine pests (EPPO 2009) by using the computer programme CAPRA that runs the EPPO decision-support scheme (downloaded from http://capra.eppo.org/index.php).

The current pest risk assessment is also in accordance with the ISPM No. 11 “Pest Risk Analyses for Quarantine Pests including analysis of environmental risks and living modified organisms" (FAO 2006) since the EPPO Standard PM 5/3(4) is based on ISPM N° 11.

The EPPO Standard PM 5/3(4) provides detailed instructions, for the following stages of pest risk analysis (PRA) for quarantine pests: initiation, pest categorization, probability of introduction, assessment of potential economic consequences and pest risk management. It provides a scheme based on a sequence of questions for deciding whether an organism has the characteristics of a quarantine pest, and if appropriate to identify potential management options. The scheme can also be used for PRAs initiated by the identification of a pathway or the review of a policy. Expert judgement may be used in answering the questions.

In the following chapters covering the initiation (Stage 1) and the pest risk assessment (Stage 2) citations from the EPPO Standard PM 5/3(4) describing the different steps are written in italic in boxes.

Stage 1: Initiation

The EPPO pest risk assessment scheme for quarantine pests assesses the potential importance of a particular pest for a defined area (the PRA area). The PRA area may be the whole EPPO member countries or any part of it.

This version of the EPPO scheme is concerned only with pest-initiated PRA. For pathway-initiated PRAs each pest should be evaluated separately in an independent session. The system does not allow an overall conclusion for a pathway-initiated analysis.

The aim of the initiation stage is to identify the pest which is of phytosanitary concern and should be considered for risk analysis in relation to the identified PRA area.

1 - Give the reason for performing the PRA

Identification of a single pest.

On the basis of the increased findings of '*Candidatus* Phytoplasma mali' the previous year, the Norwegian Food Safety Authority commissioned VKM to carry out a pest risk assessment in accordance with the ISPM No. 11 for this pest (FAO 2006).

2a - Enter the name of the pest

Name: Apple proliferation phytoplasma (AP)

Scientific name: '*Candidatus* Phytoplasma mali'

Common names: Apple proliferation, witches' broom

The name '*Candidatus* Phytoplasma mali' was proposed, and its taxonomic position described by Seemüller and Schneider (2004).

2d - Indicate the taxonomic position

Bacteria: Tenericutes: Mollicutes: Acholeplasmatales: Acholeplasmataceae: Phytoplasma: '*Candidatus* Phytoplasma mali'

The taxonomic position is given by EPPO (2011).

Note on the biology of the pest:

Phytoplasmas are wall-less pleiomorphic bacteria of ca. 200-800 nm in diameter. They have a single cell membrane and small genomes averaging ca. 750 kb. Phytoplasmas are self-replicating, but cannot be cultured outside their hosts in cell-free artificial culture media. They are obligate symbionts of plants and insects, and in most cases phytoplasmas need both hosts for dispersal in nature (Seemüller & Schneider 2004).
In plants AP remain mainly restricted to the phloem tissue. In insects, it must traverse the gut cells, replicate in various tissues of the insect, and traverse the salivary gland cells in order to reach the saliva for subsequent introduction into plants. Because AP are phloem-limited, only phloem feeding insects, like psyllids (*Psyllidae*), can acquire and transmit AP. The time between the initial acquisition of the phytoplasma by the insect vector from plants and the ability of the insect to introduce phytoplasmas back into plants (the latency period of the insect) is temperature-dependent and ranges from a few to 80 days. During the latency period the phytoplasma moves through and replicates in the competent vector's body. The sources of

initial inoculum of AP for infection of the aerial part of the tree during spring are infected rootstocks or vector psyllids. In winter, the phytoplasma largely degenerates simultaneously with the degeneration of the phloem tissue in the aerial part of an infected tree, but it survives in the roots where functional sieve tubes are present throughout the whole year. From the roots, the stem may be recolonized in the following spring. AP is considered non-transmissible by seed or pollen (Seemüller et al. 2011).

3 - Clearly define the PRA area

Norway.

This is in accordance with the terms of reference from the Norwegian Food Safety Authority.

4 - Does a relevant earlier PRA exist?

No.

To our knowledge it has so far not been published a PRA for AP. However, by personal communication at the EPPO Working Party on Phytosanitary Regulations in 2011 with Laurence Bouhot-Delduc, France, we were told that they are developing a PRA to be finished by the end of 2011, and Jens Unger, Germany, told us that EFSA was working with a Prima Phacie project on AP, due to be finished in the spring 2012.

6 - Specify all host plant species (for pests directly affecting plants) or suitable habitats (for non-parasitic plants). Indicate the ones which are present in the PRA area.

Cultivars and rootstocks of domestic apple *Malus* x *domestica* are naturally infected by AP, and they develop symptoms characteristic of the disease.

By PCR, using AP- group-specific primers, the pathogen has also been observed in naturally infected trees of *M.* x *adstringens*, *M. atrosanguinea*, *M. baccata*, *M.* x *dawsoniana*, *M. floribunda*, *M. fusca*, *M. halliana*, *M. hupehensis*, *M. kansuensis*, *M.* x *magdeburgensis*, *M.* x *micromalus*, *M.* x *moerlandsii*, *M. prunifolia*, *M. pumila*, *M. purpurea*, *M. sargentii*, *M. scheideckeri*, *M. sylvestris*, *M.* x *soulardii*, *M. spectabilis*, *M. toringoides*, and *M.* x *zumi*. Most of these showed specific symptoms or growth suppression (Seemüller et al. 2011).

In graft inoculation experiments, 58 ornamental and wild *Malus* species and subspecies as well as 40 hybrids of different *Malus* species, which were used as rootstocks, could be infected with AP. In addition, transmission was successful to several dodder species, and by using dodder a number of herbaceous plants were infected (Seemüller et al. 2011).

AP has also been described in the *Prunus* species Japanese plum, apricot, peach, plum and sweet cherry from different European countries (Cieslinska and Morgas 2011), and from hawthorn (*Crataegus monogyna*) in Italy (Tedeschi et al. 2009). It remains to be investigated whether the AP-type phytoplasmas identified in these hosts are pathogenic to apple (Semüller et al. 2011).

Apple is widely distributed in Norway. It is grown commercially and commonly planted in private gardens. Occasionally it may be growing in the wild due to spread from close-by fruit orchards or private gardens. Ornamental *Malus* species and hawthorn are common in private gardens in the best climatic zones of the country. In Norway hawthorn is not planted as shelter around fruit orchards which is a common practice in many other countries in Europe.

7 - Specify the pest distribution

AP is reported from the following countries in the EPPO region:

Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Moldova, the Netherlands, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine (EPPO 2011).

AP has been recorded from some other countries, but these are unconfirmed reports. Some countries have had outbreaks of the disease, but it has been eradicated and is no longer present (EPPO 2011). Infected *Cacopsylla picta* has been found in apple orchards in Finland, however, infected apple trees has not yet been detected (Lemmetty et al. 2011).

In Norway, AP was detected for the first time in 1996, although it is suspected that it has been present in the country since the 1970s. From 2009 to 2011, surveys were conducted on *Malus* spp. (mainly *Malus* x domestica) in commercial orchards, nurseries, and in private gardens. The pathogen was detected on 36 properties in the counties of Telemark, Hordaland, and Sogn og Fjordane. In many affected fruit orchards, high incidence of infection (up to 70-80% trees affected) and severe damage (unmarketable fruit) were observed. The disease was not detected in nurseries, but in orchards close by. Phytosanitary measures were taken, and they could include the destruction of host plants and the application of chemical control against insect vectors when there was risk of spread to nurseries (The Norwegian Food Safety Authority 2011b). Official surveys will continue in 2012 (in fruit orchards located in the vicinity of nurseries producing *Malus*) and the official production checks will be intensified in nurseries (Blystad et al. 2011).

The pest status of AP in Norway is officially declared as: Present, only in some areas, subject to official control (The Norwegian Food Safety Authority 2010).

Stage 2: Pest Risk Assessment

Section A: Pest categorization

The purpose of this section is to eliminate pests which clearly do not present a risk. If you are sure that the pest clearly presents a risk, or that in any case a full Pest Risk Assessment is required, you can omit this section and proceed directly to the main Pest Risk Assessment section.

AP is on the EPPO A2 list of pests recommended for regulation as quarantine pests (EPPO 2011). Thus, a full pest risk assessment is required. This pest categorization section is therefore omitted, and we proceed directly to the main Pest Risk Assessment section.

Section B: Probability of entry of a pest

Pathway is defined in the Glossary as "any means that allows the entry or spread of a pest" [FAO, 1990; revised FAO, 1995]. Pathways can be identified principally in relation to the geographical distribution and host range of the pest. Consignments of plants and plant products moving in international trade are the principal pathways of concern and existing patterns of such trade will, to a substantial extent, determine which pathways are relevant. Other pathways such as other types of commodities, packing materials, persons, baggage, mail, conveyances and the exchange of scientific material should be considered where appropriate. Entry by natural means should also be assessed, as natural spread is likely to reduce the effectiveness of phytosanitary measures.

Closed pathways may also be considered, as the pests identified may support existing phytosanitary measures. Furthermore, some pathways may be closed by phytosanitary measures which might be withdrawn at a future date. In such cases, the risk assessment may need to be continued. Data on detections in imported consignments may indicate the ability of a pest to be associated with a pathway. For a PRA initiated by the identification of a pathway, this is the main pathway to be considered.

1.1 – Consider all relevant pathways and list them

Relevant pathways are those with which the pest has a possibility of being associated (in a suitable life stage), on which it has the possibility of survival, and from which it has the possibility of transfer to a suitable host. Make a note of any obvious pathways that are impossible and record the reasons.

Relevant pathways:

- plants for planting
- rootstocks
- insect vectors
- scion and budwood
- root bridges (contacts)
- *in vitro* culture
- other host plants

Plants for planting (plants intended to remain planted, to be planted, or replanted (FAO 1990)) is the main pathway of concern. But also scions, budwoods and rootstocks are important pathways (EPPO1997). Plants for planting (pathway 1) and rootstocks (pathway 2) will be considered separately in detail below. Most of the points considered for these two pathways will also apply for the pathways scion and budwood.

Two psyllid species have been identified as vectors of AP (Maixner 2010). They will be considered below (pathway 3).

Transmission of AP by natural root bridges has been shown experimentally (Ciccotti et al. 2008).

AP may be maintained in micropropagated *Malus* cultivars (Jarausch et al. 1996)

It has been assumed that unknown hosts of AP may exist among orchard weeds. The pathogen is not seed or pollen transmitted (Kunze 1989).

Little is known of the importance of root bridges, micropropagated *Malus* cultivars and orchard weeds as pathways. Thus, these pathways will not be considered in more detail.

PATHWAY 1: PLANTS FOR PLANTING

1.3a – Is this pathway a commodity pathway?

Yes.

Apple trees and rootstocks, and other hosts of AP are produced and sold to fruit growers and gardeners by nurseries all over Norway. Growers may also produce trees for their own use, and may by tradition also do so to growers in the same area. However, sale or giving away for free trees must be authorized by the Norwegian Food Safety Authority. Trees may be imported from some countries when the requirements put down in "Regulations relating to plants and measures against pests" (The Norwegian Food Safety Authority 2011a) are met.

1.3b - How likely is the pest to be associated with the pathway at origin taking into account factors such as the occurrence of suitable life stages of the pest, the period of the year?

Likely.

Level of uncertainty: low.

AP lives in, and is dependent on functional sieve tubes in the plant. Consequently the pathogen may be present in all plant parts with sieve tubes. However, sieve tubes in the above-ground parts of the apple tree usually degenerate in late autumn and early winter, therefore, AP will usually die out in the aerial parts during winter. On the other hand it persists in the roots, where intact sieve tubes are present throughout the year (Marcone et al. 2010). Baric et al. (2011) found highest concentrations of AP in the roots from December to May.

In conclusion, rootstocks may harbour the pathogen the whole year, but scions and budwood may be free of AP during the winter.

1.4 - How likely is the concentration of the pest on the pathway at origin to be high, taking into account factors like cultivation practices, treatment of consignments?

Moderately likely.

Level of uncertainty: medium.

Little is known about the influence of cultivation practises or treatment of consignments on the concentration of AP. There are no appropriate measures for direct control of the phytoplasma. Chemical control of insect vectors may help reducing the vector populations.

1.5 - How large is the volume of the movement along the pathway?

Major.

Level of uncertainty: low.

In 2006 the number of nurseries producing fruit trees in Norway was 152, the acreage around 300 ha, and the commercial value from the producer about NOK 182 million. In 2008 the acreage of apple-production was 1 676 ha, the production around 16 701 tonnes of apples (Statistics Norway 2011). In 2010, 150 - 200 000 apple trees were produced in nurseries in Norway for commercial fruit growers and private gardens (Jan Meland, Sagaplant, personal communication). Due to the import ban of fire blight hosts from countries which have the disease, Norway has not imported *Malus* and *Pyrus* for more than 20 years, but apple breeders may have imported new varieties via the required quarantine regulations in Norway.

1.6 - How frequent is the movement along the pathway?

Often.

Level of uncertainty: low.

Usually most new trees will be planted from April to May, sometimes also in the autumn.

1.7 - How likely is the pest to survive during transport /storage?

Very likely.

Level of uncertainty: low.

AP only inhabits the sieve tubes of the tree. As long as they are functional the pathogen inside them will survive. Most likely normal transport or storage conditions will have little effect on sieve tubes.

1.8 - How likely is the pest to multiply/increase in prevalence during transport/storage?

Unlikely.

Level of uncertainty: low.

It is not known if AP will multiply in sieve tubes in trees during transport and storage. It will multiply in standing trees if the conditions otherwise are favourable. During transport and storage the pathogen is not transmitted from infected to healthy plants because vectors most likely will not be present if the plants are without leaves, such as during the winter. Hence the number of infected plants does not increase.

1.9 - How likely is the pest to survive or remain undetected during existing management procedures (including phytosanitary measures)?

Very likely.

Level of uncertainty: low.

Management procedures are not known to have an effect on the concentration of AP in the sieve tubes or the potential for survival. Trees with high concentration of phytoplasma in the aerial parts usually develop characteristic disease symptoms, but those only partially or weakly colonized develop mild or no symptoms, and thus easily may stay undetected. The insect vectors harbour the phytoplasma in a persistent way, and may consequently also be an undetected reservoir for the pathogen in the orchard (Seemüller et al. 2011).

1.10 - How widely is the commodity to be distributed throughout the PRA area?

Widely.

Level of uncertainty: low.

Apple and the other known hosts of AP are widely grown in the Southern part of Norway. They may also be grown in some parts of Northern Norway.

1.11 - Do consignments arrive at a suitable time of year for pest establishment?

Yes.

Level of uncertainty: low.

Fruit growers will usually buy and plant their trees in the spring. At this time trees will start growing, developing new sieve tube elements which the pathogen may invade from the roots. Psyllid vectors will also start their activity in the spring.

1.12 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Very likely.

Level of uncertainty: low.

The pathogen may be transmitted from infected trees to suitable hosts by psyllids, such as *Cacopsylla melanoneura*, which is known to occur in fruit orchards in Norway (Blystad et al. 2011), or by the establishment of root bridges with suitable hosts. Infected trees remain sources of infection throughout their lifespan (Seemüller et al. 2011).

1.13 - How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?

Very likely.

Level of uncertainty: low.

Planting of an infected tree in an orchard or nursery previously known to be free of the disease may bring about transfer of the pest to other hosts already present at the location by psyllids or root bridges.

<u>PATHWAY 2: ROOT STOCKS</u>

1.3a - Is this pathway a commodity pathway?

Yes.

In Norway apple rootstocks are only produced in nurseries, thus the sale to growers and gardeners who make their own trees is considerable. Due to plant health regulations apple rootstocks may only be imported from countries free from fire blight. From countries with fire blight rootstocks are only allowed imported through post entry quarantine for two years.

1.3b - How likely is the pest to be associated with the pathway at origin taking into account factors such as the occurrence of suitable life stages of the pest, the period of the year?

Likely.

Level of uncertainty: low.

AP lives in, and is dependent on functional sieve tubes in the plant. It persists throughout the year in the roots, where intact sieve tubes are present throughout the year (Marcone 2010).

1.4 - How likely is the concentration of the pest on the pathway at origin to be high, taking into account factors like cultivation practices, treatment of consignments?

Moderately likely.

Level of uncertainty: medium.

Little is known about the influence of cultivation practises or treatment of consignments on the concentration of the pathogen.

1.5 - How large is the volume of the movement along the pathway?

Major.

Level of uncertainty: low.

In 2006 the number of nurseries producing fruit trees in Norway was 152, the acreage around 300 ha, and the commercial value from the producer about NOK 182 million. In 2008 the acreage of apple-production was 1 676 ha, the production around 16 701 tonnes of apples (Statistics Norway 2011). In 2010 between 150 - 200 000 apple trees were produced in nurseries in Norway for commercial fruit growers and private gardens. In addition, a substantial number of trees are produced by fruit growers themselves, when they graft rootstocks purchased from nurseries (Jan Meland, Sagaplant, personal communication). Due to the import ban of fire blight hosts from countries which have the disease, Norway has not imported *Malus* and *Pyrus* in more than 20 years.

1.6 - How frequent is the movement along the pathway?

Often.

Level of uncertainty: low.

Usually most new trees will be planted from April to May, sometimes also in the autumn.

1.7 - How likely is the pest to survive during transport /storage?

Very likely.

Level of uncertainty: low.

As long as the sieve tubes are functional the pathogen inside them will survive. Most likely normal transport or storage conditions will have little effect on sieve tubes.

1.8 - How likely is the pest to multiply/increase in prevalence during transport /storage?

Unlikely.

Level of uncertainty: low.

It is not known if AP will multiply in sieve tubes in trees during transport and storage. It will multiply in standing trees if the conditions otherwise are favourable.

1.9 - How likely is the pest to survive or remain undetected during existing management procedures (including phytosanitary measures)?

Very likely.

Level of uncertainty: low.

Management procedures are not known to affect the survival or the possibilities to detect AP. Disease symptoms on roots are difficult to detect and may be easily overlooked.

1.10 - How widely is the commodity to be distributed throughout the PRA area?

Widely.

Level of uncertainty: low.

Apple and the other known hosts of AP are widely grown in the Southern part of Norway. They may also be grown in areas with adequate climatic conditions in some parts of Central and Northern Norway.

1.11 - Do consignments arrive at a suitable time of year for pest establishment?

Yes.

Level of uncertainty: low.

Fruit growers will usually buy their trees in the spring. At this time trees will start growing, developing new sieve tube elements which the pathogen may invade from its presence in the roots. Psyllid vectors will also start their activity in the spring.

1.12 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Very likely.

Level of uncertainty: low.

The pathogen may be transmitted by psyllids present in the orchard, by the establishment of root contacts, or by other host plants already growing in the orchard.

1.13 - How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?

Very likely.

Level of uncertainty: low.

Planting of an infected tree in an orchard previously known to be free of the disease may bring about transfer of the pest to other hosts already present in the orchard by psyllids or root contacts.

<u>PATHWAY 3: INSECT VECTORS</u>

1.3a - Is this pathway a commodity pathway?

No.

So far only three insect vectors of AP have been described:

1) *Cacopsylla* (*Thamnopsylla*) *picta* (Foerster, 1848). This species has several synonyms, e.g. *Cacopsylla costalis* (Flor 1861), which is used by Ossiannilsson (1992), (Lauterer & Burckhardt 1997). According to Ossiannilsson (1992) *Cacopsylla* (*Thamnopsylla*) *costalis* (Flor, 1861) is distributed in eastern Sweden (Östergötland and Uppland), so far not found in Denmark or in Norway. It has been detected in South-Western Finland (Lemmetty et al. 2011).

2) *Cacopsylla* (*Thamnopsylla*) *melanoneura* (Foerster, 1848). This species is common and widespread in Denmark and in southern Sweden. In Norway it is recorded in the counties of Akershus, Buskerud, Telemark, Hordaland, and Nordland (Ossiannilsson 1992). Host plants are *Crataegus* spp., *Malus* spp. and *Pyrus* spp. (Ossiannilsson 1992). In Norway *C. melanoneura* is reported as a pest on cultivated apple trees. At the end of 1980 serious attacks of the species started in apple orchards in Sauherad in the county of Telemark. However, little damage was recorded on the fruits. After a few years with strong attacks, especially on young trees, the species more or less disappeared (Edland 2004). The species overwinters as adults usually on conifers. Early in spring they migrate to other host plants, e.g. apple, where they lay their eggs on young leaves from the middle of May until the end of June. The first eggs hatch in the end of May. The nymphs gather in large colonies on the upper surface of the leaves, usually at the top of sprouts. Great amounts of honeydew are produced. Adults of the new generation appear in July, and after a short period on the apple trees they migrate to conifers again already in July (Mayer et al. 2009, Pizzinat et al. 2011). In Norway only one generation per year has been recorded (Edland 2004).

3) The leafhopper *Fieberiella florii* (Stål, 1864) has in Germany and Italy been shown to transmit AP. However, it is present on apple trees usually in low numbers at the end of the growing season, and its role as a vector remains to be further investigated (Seemüller et al. 2010). According to Fauna Europaea (2011) this species is distributed in the following European countries: Austria, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Italy, Kosovo, Montenegro, Serbia, Slovenia and Switzerland. In Europe *F. florii* has never been recorded north of Germany.

The *Cacopsylla*-vectors transmit the pathogen in a persistent manner, and overwinters as adults usually on conifers. It is unlikely that the vectors may be "hitchhikers" on apple trees when they are traded, which normally will take place in the autumn. Trade with conifers which harbour the vectors is very unlikely. Conifers for sale will be produced in nurseries usually situated far from fruit orchards. Consequently insect vectors are not a commodity pathway.

1.3b - How likely is the pest to be associated with the pathway at origin taking into account factors such as the occurrence of suitable life stages of the pest, the period of the year?

Likely.

Level of uncertainty: medium.

Plants infected with AP will remain sources of infection throughout their lifetime. In orchards and nurseries the psyllid vectors are important for the local spread of the pathogen in the spring and summer. The vectors may transmit AP from these sources to suitable host trees in the neighbourhood. In areas where the pathogen and the vectors are present the above scenario is likely to occur both with and without specific vector control.

1.4 - How likely is the concentration of the pest on the pathway at origin to be high, taking into account factors like cultivation practices, treatment of consignments?

Likely.

Level of uncertainty: medium.

Tedeschi et al. (2003) showed that the overwintered population of *Cacopsylla melanoneura* was higher, spends a longer period in apple orchards, and contains higher phytoplasma-titres than the offspring generation, suggesting the crucial role of the overwintered adults in vectoring the pathogen. Phytoplasma-titre in the insect body increases with time (possibly following replication processes), and, shortly after acquisition, phytoplasma are present at a low titre.

Pedrazzoli et al. (2007) has shown that both *Cacopsylla* spp. acquired AP at the same rate, but phytoplasma replication was far higher in *C. picta* than in *C. melanoneura*, indicating that *C. picta* would be a more efficient vector.

In Germany 9 % of overwintered *C. picta* harboured AP (Seemüller et al. 2011).

1.5 - How large is the volume of the movement along the pathway?

Moderate.

Level of uncertainty: high.

The vector population will vary in size during the year, and between years, influenced by factors like temperature and availability of plants to feed on.

1.6 - How frequent is the movement along the pathway?

Often.

Level of uncertainty: high.

The vectors have one generation per year. They overwinter as adults, usually on conifers. Early in spring they migrate to other host plants, e.g. apple, where they lay their eggs on young leaves from the middle of May until the end of June. The first eggs hatch in the end of May. The nymphs gather in large colonies on the upper surface of the leaves, usually at the top of the sprouts. Great amounts of honeydew are produced. Adults of the new generation appear in July, and after a short period on the apple trees they migrate to conifers again already in July. Consequently the population size of the vectors usually will be low in the spring, and increases considerably until July.

1.7 - How likely is the pest to survive during transport/storage?

Very likely.

Level of uncertainty: low.

Once infected with AP the vector is infected for its lifetime.

1.8 - How likely is the pest to multiply/increase in prevalence during transport/storage?

Likely.

Level of uncertainty: medium.

Phytoplasma-titre in the insect body increases with time (possibly following replication processes). Shortly after acquisition, phytoplasma are present at a low titre (Tedeschi et al. 2003).

1.9 - How likely is the pest to survive or remain undetected during existing management procedures (including phytosanitary measures)?

Very likely.

Level of uncertainty: low.

Infection of AP in vectors can only be detected by sampling the insects and analyse them with PCR, which is a very time-consuming process. Consequently infected insects will normally remain undetected.

Available plant protection products may control the vectors.

1.12 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Very likely.

Level of uncertainty: low.

The psyllids *Cacopsylla picta* and *C. melanoneura* are recognized vectors of AP (Seemüller et al. 2010). Both transmit the phytoplasma in a persistent manner, which implies that re-migrants that acquired the phytoplasma in the previous season may still be infective when returning to apple orchards after winter. In addition, the offspring of infected adults can also transmit the phytoplasma (Tedeschi et al. 2003).

1.13 - How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?

Not relevant.

Level of uncertainty: low.

<u>CONCLUSION ON THE PROBABILITY OF ENTRY</u>

1.14c - The overall probability of entry should be described and risks presented by different pathways should be identified

Very likely.

Level of uncertainty: low.

Plants for planting, scions, budwood and rootstocks are the main pathways for AP, and if contaminated with the pathogen they constitute a great risk for introduction of the disease. This concerns both trade with these commodities nationally and by import.

Insect vectors are only of concern regarding local spread of AP. However, when conditions are favourable for the insects to propagate the spread can be epidemic.

Section B: Probability of establishment

1.15 - Estimate the number of host plant species or suitable habitats in the PRA area.

Few.

Level of uncertainty: high.

Apple and some other species of *Malus* are the main hosts, and they may develop disease symptoms. The pathogen has been detected by PCR in a number of other plants species not showing known disease symptoms. It remains to be investigated if the pathogen is pathogenic to these species. (Seemüller et al. 2011).

1.16 - How widespread are the host plants or suitable habitats in the PRA area? (specify)

Widely.

Level of uncertainty: low.

Apple and the other potential hosts are widely grown in Southern Norway. In the central and northern part of the country suitable habitats are more restricted.

1.17 - If an alternate host or another species is needed to complete the life cycle or for a critical stage of the life cycle such as transmission (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers), how likely is the pest to come in contact with such species?

N/A.

Level of uncertainty: low.

The pathogen may be transmitted by grafting and root bridges, and thus it is not dependent on vectors to be spread.

1.18a - Specify the area where host plants (for pests directly affecting plants) or suitable habitats (for non-parasitic plants) are present (cf. QQ 1.15-1.17).

This is the area for which the environment is to be assessed in this section. If this area is much smaller than the PRA area, this fact will be used in defining the endangered area.

Suitable habitats are common in Southern Norway, and somewhat restricted in Central and Northern Norway.

Apple is commonly grown in private gardens in the southern part of Norway. Commercial growing on a large scale is mainly restricted to some areas in the counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in Western Norway, and the counties of Buskerud, Telemark and Hedmark in South Eastern Norway.

1.18b - How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the current area of distribution?

Largely similar.

Level of uncertainty: low.

Most of the apple cultivars known to be affected by AP in other countries in Europe can also be grown in Norway. AP is present in some areas in Southern Norway.

1.19 - How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the current area of distribution?

Not relevant.

Level of uncertainty: low.

Other abiotic factors than climate which could affect establishment of AP is not known.

1.20 - If protected cultivation is important in the PRA area, how often has the pest been recorded on crops in protected cultivation elsewhere?

Rarely.

Level of uncertainty: medium.

For economic reasons it is usually only during propagation that apple trees and rootstocks are cultivated in the greenhouse in Norway. According to Seemüller et al. (2010), AP-infected greenhouse-grown trees may be affected by the higher temperatures in the greenhouse. They developed disease symptoms in contrast to comparable trees that were grown simultaneously the field.

1.21 - How likely is it that establishment will occur despite competition from existing species in the PRA area, and/or despite natural enemies already present in the PRA area?

Very likely.

Level of uncertainty: medium.

Competitors and natural enemies to AP are not known.

1.22 - To what extent is the managed environment in the PRA area favourable for establishment?

Moderately favourable.

Level of uncertainty: medium.

From the literature little is known about the effect of managed environment for the development of AP. However, it is likely that a dense population of host plants in an apple orchard or nursery could be favourable for the establishment of the disease if psyllid vectors are present.

1.23 - How likely is it that existing pest management practice will fail to prevent establishment of the pest?

Likely.

Level of uncertainty: low.

Available plant protection products may control the vectors, but the pathogen may nevertheless be transmitted by grafting and root bridges.

1.24 - Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the PRA area?

Very likely.

Level of uncertainty: low.

The infection of AP is for life once it is established. In the winter the pathogen may not survive in the above ground parts of the tree, but it will inhabit the roots, well protected from eradication programmes. Even if all infected trees are removed there will be a risk that the pathogen may remain in other hosts in the orchard or nursery. On this background the current measures to control outbreaks of AP in Norway most likely will not guarantee the elimination of the disease from the orchard or nursery (The Norwegian Food Safety Authority 2011b).

1.25 - How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

Likely.

Level of uncertainty: low.

AP has, as far as is known, only asexual reproduction, and no resting stages. Consequently it may start to multiply as soon as an infection has taken place.

1.26 - How likely are relatively small populations to become established?

Very likely.

Level of uncertainty: medium.

Little is known about which size of population is necessary for an infection to become established. However, it is well known that severe symptoms only develop when the phytoplasma concentration in the stem is high. Due to the colonization pattern between summer and winter the pathogen normally dies out in the above-ground part of the tree, but it survives for the whole life of the tree, often in low concentrations in the roots. From the roots re-infection of the rest of the plant may take place in the spring (Seemüller & Harris 2011).

1.27 - How adaptable is the pest?

Moderate adaptability.

Level of uncertainty: medium.

Considerable variability in virulence and genomic traits for strains of AP has been reported by Seemüller & Schneider (2007). Based on symptomatology, the phytoplasma strains were defined as being avirulent to mildly, moderately, or highly virulent. Differences have also been observed for transmission by *C. melanoneura* i.e., successful in the Aosta valley in Italy and unsuccessful in Germany (Mayer et al. 2009; Tedeschi et al. 2003) However, the latter may also be due to differences between vector populations. There are no reports on variation specifically related to climatic conditions but the phytoplasma occurs in large part of Europe indicating adequate variation to establish in different parts of the PRA area.

1.28 - How often has the pest been introduced into new areas outside its original area of distribution?

Never.

Level of uncertainty: low.

Europe is considered as the original area of distribution. AP was first reported in northern Italy in 1950, in the following decades the occurrence of the disease has been reported from a number of countries in Europe (Seemüller et al. 2011). It has never been officially recorded in countries outside Europe (EPPO 2011).

1.29a - Do you consider that the establishment of the pest is very unlikely?

No.

In the PRA-area apple is commonly grown, and more or less the same cultivars are grown as in the countries where the disease is common. On an average the climatic conditions are similar. At least one of the known vectors, *Cacopsylla melanoneura* is known to occur in the PRA-area (Ossiannilsson 1992; Blystad et al. 2011).

<u>CONCLUSION ON THE PROBABILITY OF ESTABLISHMENT</u>

1.29c - The overall probability of establishment should be described.

Very likely

Level of uncertainty: low

The number of host plant species is low. However, host plants are widespread and abundant in the PRA area. The vector *Cacopsylla melanoneura* occurs in parts of the PRA area. The presence of the vectors is dependent on the presence of reproductive host (*Malus*) and alternate overwintering host (i.e. coniferous forests), which are present in large parts of Norway. The climatic conditions are suitable for AP because it has already been restricted outbreaks in Norway. In addition, the disease has been reported in many European countries ranging from Norway in the north to Spain and Greece in the south. The pathogen is considered native because it is widespread in Europe. Establishment is not restrained by competitors or natural enemies. Existing cultural or management practices are ineffective to prevent establishment. The reproduction strategy of the phytoplasma with permanent foci of infection in *Malus* trees and persistent transmission by vectors also favours establishment.

Section B: Probability of spread

Spread potential is an important element in determining how quickly impact is expressed and how readily a pest can be contained. In the case of intentionally imported plants, the assessment of spread concerns spread from the intended habitat or the intended use to an unintended habitat, where the pest may establish. Further spread may then occur to other unintended habitats. The nature and extent of the intended habitat and the nature and amount of the intended use in that habitat will also influence the probability of spread. Some pests may not have injurious effects on plants immediately after they establish, and in particular may only spread after a certain time. In assessing the probability of spread, this should be considered, based on evidence of such behaviour.

1.30 - How likely is the pest to spread rapidly in the PRA area by natural means?

Unlikely.

Level of uncertainty: low.

Natural, rapid spread of AP may occur in orchards and nurseries in restricted areas with the so far known psyllid vectors, *Cacopsylla picta* and *C. melanoneura* (Seemüller et al. 2011). However, they would have slow spreading-activity over areas at a longer distance, and thus rapid spread in the PRA-area as a whole is unlikely.

1.31 - How likely is the pest to spread rapidly in the PRA area by human assistance?

Very likely.

Level of uncertainty: low.

Plants for planting, rootstocks, scions and budwood may rapidly be spread all over the PRA-area by trade or non-profit exchange of planting material between growers and plant breeders.

1.32 - Based on biological characteristics, how likely is it that the pest will not be contained within the PRA area?

Very likely.

Level of uncertainty: low.

AP is contained in the sieve tubes of the host, and thus well protected from adverse conditions on the outside. Spread of infected plant for planting, rootstocks, scions or budwood is very difficult to control.

<u>CONCLUSION ON THE PROBABILITY OF SPREAD</u>

1.32c - The overall probability of spread should be described.

AP may easily be spread by plants for planting, rootstocks, scions, budwood, and psyllid vectors. Plant materials are easily and rapidly spread within the whole PRA-area, and consequently represent a considerable risk for spread of the disease. Psyllid vectors and root bridges may be important for rapid local spread. Long distance spread with psyllids may also occur with plants harbouring infected psyllids.

Section B: Conclusion of introduction and spread and identification of endangered areas

CONCLUSION RAGARDING INTRODUCTION AND SPREAD

1.33a - Conclusion on the probability of introduction and spread.

The probability of introduction and spread in the PRA area is considerable. The climatic conditions and the apple cultivars grown in Norway are similar to the situation in many countries in Europe where AP is already established. Infected plants for planting not showing symptoms of the disease may be traded or exchanged between growers.

CONCLUSION REGARDING ENDANGERED AREAS

1.33b - Based on the answers to questions 1.15 to 1.32 identify the part of the PRA area where presence of host plants or suitable habitats and ecological factors favour the establishment and spread of the pest to define the endangered area.

Apple is commonly grown in private gardens all over the southern part of Norway. Commercial growing on a large scale is mainly restricted to some areas in the counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in Western Norway, and the counties of Buskerud, Telemark and Hedmark in South Eastern Norway. In conclusion Southern Norway is an endangered area.

Section B: Assessment of potential economic consequences

2.1 - How great a negative effect does the pest have on crop yield and/or quality to cultivated plants or on control costs within its current area of distribution?

Major.

Level of uncertainty: low.

AP affects almost all apple cultivars. It may reduce fruit size by about 50%, weight by 63-70%, and the fruit quality, as well as it may reduce tree vigour and increase susceptibility to powdery mildew (*Podosphaera leucotricha*) (EPPO 1997). Fruit number is usually not affected, but the fruit colour is unsatisfactory and the taste is poor, with the result that as much as 80% of the fruits are unmarketable. The root system may be poorly developed in young trees. When the percentage of diseased trees is high and the production decreases too much, orchards have to be uprooted, often several years within their normal life span (Seemüller et al. 2011). In Italy it has been reported serious damage in several traditional apple-growing areas such as Trentino-Alto Adige (Carraro et al. 2004).

2.2 - How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area without any control measures?

Major.

Level of uncertainty: medium.

In the PRA-area many of the cultivars are the same as in the countries which have serious problems with the disease, and the climatic conditions are not particularly different, consequently the negative effect of the pest could be considerable. The experiences from outbreaks of AP which have occurred in Norway indicate that the damage could be substantial.

Cacopsylla melanoneura is the only vector recorded in Norway, but little is known concerning its distribution in the country. Some investigations indicate that *C. picta* is a more efficient vector than *C. melanoneura* (Pedrazzoli et al. 2007). As long as the presence of *C. picta* in Norway has not been confirmed the possibility for epidemic spread of AP in the PRA-area is uncertain.

2.3 - How easily can the pest be controlled in the PRA area without phytosanitary measures?

Unlikely.

Level of uncertainty: medium.

The pest can be controlled in the PRA area if only certified, disease free planting material is permitted in areas which by surveys and testing are known to be free from AP, and the presence of vectors and their possible infection of AP have been analysed. Such restrictions in the commercial apple production and in private gardens are not realistic.

2.4 - How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?

Major.

Level of uncertainty: medium.

Diseased trees may be severely affected, both concerning tree vigour, fruit yield and quality. Trees may show symptoms every year, or they may recover for some years and later again become affected (Seemüller et al. 2011). Consequently the risk for having to uproot trees and replant new trees to achieve good economy in the apple production is considerable. These measures will be at a substantial cost. More intensive spraying programmes to control psyllid vectors would also be expensive.

2.5 - How great a reduction in consumer demand is the pest likely to cause in the PRA area?

Minor.

Level of uncertainty: low.

Infected trees may produce apples which are small in size, have unsatisfactory fruit colour and poor taste, and consequently the apples will be unmarketable. However, this loss will easily be compensated by the market as consumers will have access to domestically and internationally produced fruit from healthy trees.

2.6 - How important is environmental damage caused by the pest within its current area of distribution?

Minimal.

Level of uncertainty: low.

To our knowledge there have been no reports of environmental damage caused by the pest.

2.7 - How important is the environmental damage likely to be in the PRA area (see note for question 2.6)?

Minimal.

Level of uncertainty: low.

Same comment as question 2.6.

2.8 - How important is social damage caused by the pest within its current area of distribution?

Low.

Level of uncertainty: medium

Social damage of this pest is not known.

2.9 - How important is the social damage likely to be in the PRA area?

Low.

Level of uncertainty: medium.

Ref. point 2.8

2.10 - How likely is the presence of the pest in the PRA area to cause losses in export markets?

Unlikely.

Level of uncertainty: low.

Apple production in Norway is for the home market, and apples are not exported. Plants for planting and rootstocks are not exported due to restrictions in the plant health regulations in EU and other countries regarding fire blight which is present in Norway.

2.11 - How likely is it that natural enemies, already present in the PRA area, will not reduce populations of the pest below the economic threshold?

Very likely.

Level of uncertainty: medium.

Natural enemies to the pathogen are not known.

2.12 - How likely are control measures to disrupt existing biological or integrated systems for control of other pests or to have negative effects on the environment?

Likely.

Level of uncertainty: medium.

Spraying programmes to control the vectors may have negative effect on the environment and interfere with biological or integrated systems already implemented in the orchard.

2.13 - How important would other costs resulting from introduction be?

Minimal.

Level of uncertainty: low.

Other costs are not known.

2.14 - How likely is it that genetic traits can be carried to other species, modifying their genetic nature and making them more serious plant pests?

Moderately likely.

Level of uncertainty: high.

Inter-species recombination between the two phytoplasmas '*Candidatus* Phytoplasma pyri' and '*C*. Phytoplasma prunorum' has been described, but so far such mechanism has not been confirmed for '*C*. Phytoplasma mali' (AP). It could be considered that if recombination occurs between species it could also occur within species, but this has not been verified (Danet et al. 2011).

2.15 - How likely is the pest to cause a significant increase in the economic impact of other pests by acting as a vector or host for these pests?

Impossible/very unlikely.

Level of uncertainty: low.

Phytoplasmas are not known to be vectors or hosts for other pests.

2.16 - Referring back to the conclusion on endangered area (1.33): Identify the parts of the PRA area where the pest can establish and which are economically most at risk.

Apple is commonly grown in private gardens all over the southern part of Norway. In the central and northern part of Norway apple growing is restricted because of lower average temperatures. Commercial growing on a large scale is mainly restricted to some areas in the counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in Western Norway, and the counties of Buskerud, Telemark and Hedmark in Eastern Norway. Consequently these areas will be at most risk economically for AP to establish in Norway.

Section B: Degree of uncertainty and Conclusion of the pest risk assessment

Estimation of the probability of introduction of a pest and of its economic consequences involves many uncertainties. In particular, this estimation is an extrapolation from the situation where the pest occurs to the hypothetical situation in the PRA area. It is important to document the areas of uncertainty (including identifying and prioritizing of additional data to be collected and research to be conducted) and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs.

It should be noted that the assessment of the probability and consequences of environmental hazards of pests of uncultivated plants often involves greater uncertainty than for pests of cultivated plants. This is due to the lack of information, additional complexity associated with ecosystems, and variability associated with pests, hosts or habitats.

2.17 - Degree of uncertainty: list sources of uncertainty

AP has been detected several times in Norway since 1996, and it is under eradication. The outbreaks so far indicate that the disease may cause considerable damage in fruit orchards in different parts of the country. The experience is also that the disease has caused damage a couple of years, followed by years when no outbreaks are recorded. The incidences in 2010-2011 were the most extensive for a number of years.

Symptoms of AP occur irregularly. Witches' brooms and undersized fruits are typical for newly diseased trees and can be observed for only one or a few years after they first appear. Then, trees often start to recover and may eventually become non-symptomatic for one or more years (Seemüller et al. 2011). Surveys for the disease are based on searching for visual symptoms in the fruit orchard, and positive detections are confirmed subsequently by PCR in the laboratory. Consequently diseased trees with mild or no symptoms may easily be overlooked, indicating a risk for a reservoir of infected trees that at a later stage again may develop symptoms. Symptom-free trees will nevertheless harbour the pathogen, which may at some stage be transferred to other trees by vectors or root contacts.

Cacopsylla melanoneura is the only vector so far detected in Norway. Little is known of its distribution in the country, and fluctuations in populations of the insect between the years. It cannot be excluded that *C. picta* may occur in Norway as long as there has been no systemic surveys for it. Evidently the climatic conditions in Southern Norway allow *Cacopsylla*-species to establish and reproduce, but it is not known to which extent conditions are favourable. These circumstances make it difficult to predict to which extent AP will cause extensive damage in commercial apple orchards in Norway on a permanent basis.

2.18 - Conclusion of the pest risk assessment

Entry

The overall probability of entry is considered as very likely, with a low level of uncertainty.

Plants for planting, scions, budwood and rootstocks are the main pathways for AP, and if contaminated with the pathogen they constitute a great risk for introduction of the disease. This concerns both trade with these commodities nationally and by import.

Insect vectors are only of concern regarding local spread of AP. However, when conditions are favourable for the insects to propagate the spread can be epidemic.

Establishment
The overall probability of establishment is considered as very likely, with a low level of uncertainty.

Apple and some other species of *Malus* are the main hosts of the pest, and the number of host plant species is low. However, host plants are widespread and abundant in the PRA area. The vector *Cacopsylla melanoneura* occurs in parts of the PRA area. The presence of the vectors is dependent on the presence of reproductive host (*Malus*) and alternate overwintering host (i.e. coniferous forests), which are present in large parts of Norway. The climatic conditions are considered as suitable for AP because there have already been restricted outbreaks in Norway. In addition, the disease has been reported in many European countries ranging from Norway in the north to Spain and Greece in the south. The pathogen is considered native because it is widespread in Europe. Establishment is not restrained by competitors or natural enemies. Existing cultural or management practices are ineffective to prevent establishment. The reproduction strategy of the phytoplasma with permanent foci of infection in *Malus* trees and persistent transmission by vectors also favours establishment.

Spread
AP may easily be spread by plants for planting, rootstocks, scions, budwood, and psyllid vectors. Plant material may easily and rapidly spread within the whole PRA-area, and consequently be a considerable risk for spread of the disease. Psyllid vectors and root bridges may be important for rapid local spread. Long distance spread with psyllids may also occur with plants harbouring infected psyllids.

Economic importance
Despite the uncertainty concerning the occurrence of AP-vectors in Norway there is a high probability that AP may cause extensive economic damage in fruit orchards in the country. Apple is commonly grown in private gardens all over the southern part of Norway. In the central and northern part of Norway apple growing is restricted because of lower average temperatures. Commercial growing on a large scale is mainly restricted to some areas in the counties of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Romsdal in Western Norway, and the counties of Buskerud, Telemark and Hedmark in Eastern Norway. Consequently these areas will be at most risk economically for AP to establish in Norway.

Data gaps

Phytoplasmas are internationally known to be capable of causing major economic damage to plant production. Compared to other groups of plant pests, little is known about the phytoplasmas' epidemiology and other biological factors. In Norway, so far there have been no research projects in which phytoplasmas have been included. Many of the evaluations made in the current pest risk assessment have a high level of uncertainty. This uncertainty is due to lack of both international and national research, especially concerning the role of transmission from plant to plant by insect vectors.

Phytoplasmas has so far made more damage in countries with somewhat warmer climate than in Norway. However, it is important to keep in mind that climate changes can influence the future role of phytoplasmas as plant pests in Norway.

Answers to terms of reference

On the basis of the increased findings of "*Candidatus* Phytoplasma mali" (AP) the previous year, the Norwegian Food Safety Authority requests VKM to carry out a pest risk assessment in accordance with the ISPM No. 11 for this pest. The following aspects should be considered specifically in the risk assessment:

1) Probability of introduction, with emphasis on the effectiveness of:

> **a) The specific requirements of Annex 4A point 13.2 in regulations related to plants and measures against pests in relation to preventing the introduction of the pest with plants intended for planting of *Malus* imported to Norway from countries known to be free of fireblight.**
>
> **b) The requirements of "karantenebestemmelser for planter og plantemateriale m.m. som er forbudt å innføre til Norge" in relation to preventing the introduction of the pest with plants intended for planting of *Malus* imported to Norway from countries where fireblight is known to occur.**

The probability of introduction (entry and establishment) in the PRA area is considerable.

AP is reported from the following countries in the EPPO region:

Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Moldova, the Netherlands, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine. It has been recorded from some other countries, but these are unconfirmed reports. Some countries have had outbreaks of the disease, but it has been eradicated and is no longer present.

The climatic conditions in the countries were AP so far is known to occur is similar to the conditions in Norway. The disease has been detected several times at different locations in the country during the years from 1996 to 2011, at times causing considerable damage.

The only pathway for introduction of AP to Norway is plants of *Malus* for planting, including scions, budwood and rootstocks. According to the current plant health regulations for Norway, *Malus* can only be imported from countries known to be free from fire blight. This applies today to only Estonia and Finland in Europe. Currently the only import of apple trees to Norway from other countries is through a two-year quarantine system for breeding purposes.

EPPO recommends that plants of apple for planting should come from a source found free from AP during the previous growing season. From countries where the disease occurs, the plants must additionally be no further than the second generation from the mother plant and must be tested by an EPPO-approved method (OEPP/EPPO 2006). The EPPO certification scheme for fruit trees (EPPO Standards PM 4/27(1)) covers AP (EPPO 1999) and should give a high security for phytoplasma-free planting material.

In the European Union AP is listed in Council Directive 2000/29/EC, Annex I A II – "Harmful organisms known to occur in the community and relevant for the entire community". Annex IV A I.22.2 specifies import requirements.

In Norway "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests", specific requirements for *Malus* imported to Norway are put down in Annex 4A point

13.2. These requirements are very similar to the recommendations by EPPO and the requirements in the EU Council Directive. If exporting countries follow these rules phytoplasma-free planting material could be imported with little risk.

However, there are several critical points in these regulations which have to be properly addressed to minimize the risk when importing *Malus* to Norway. The most important point is to what extent surveys for AP have been made in the exporting country. The surveyors must know the disease symptoms well. These may not always be characteristic, and can be easily overlooked. In addition, the frequency and number of samples taken for analysis by PCR in the laboratory for the possible presence of the pathogen is an essential point to minimize the risk when *Malus* is imported. Without any laboratory testing of the planting material the regulations and measures may have limited effect to control the disease.

It is forbidden to import plants for planting of *Malus* from countries in which the fire blight-causing bacterium *Erwinia amylovora* is present except through quarantine. Since fire blight is found in most European countries, there is almost no import of *Malus* today. Whether plants for planting are imported from countries with fire blight or without, equal strict requirements for freedom from AP are necessary to ensure low AP risk at import.

2) Identification and evaluation of potential pathways for spread under Norwegian conditions, with emphasis on their importance related to domestic spread of the pathogen.

Plants for planting, scions, budwood and rootstocks are the pathways of main concern both for import and for spread of the disease in the country. These pathways are important both for spread locally and for long distances. For short distance spread, insect vectors may also be important. So far, only *Cacopsylla melanoneura* has been detected in Norway. Little is known of its distribution in the country and fluctuations in the population size from year to year. It cannot be excluded that *C. picta* may occur in Norway as long as there has been no systematic surveys for it. These circumstances make it difficult to predict to which extent AP will cause extensive damage in commercial apple orchards in Norway.

3) The effectiveness of the specific requirements of Annex 4B point 3 in regulations related to plants and measures against pests in relation to preventing the spread of the pest with plants intended for planting of *Malus* produced in Norway.

The requirements of Annex 4B point 3 concerns the production of *Malus* in Norway. They are equal to the requirements for such production in countries intending to export *Malus* to Norway. The experiences with the spread of AP in Norway so far may indicate that the efficacy of these requirements is not sufficient. Local spread may be explained by the presence of insect vectors, but the long-distance spread to parts of the country with high mountains in between could only be explained by the spread by infected planting material. In our view the requirements for pathogen freedom in an area can become an efficient tool to prevent spread only if the requirements are based on adopted methods for surveying and samples taken for laboratory testing for possible presence of the pathogen. It is well known that infection of AP may only show weak symptoms or no symptoms at all. Consequently the pathogen may easily be overlooked. Vector control needs to be considered at places of production like nurseries to minimize possible spread.

4) The probability of eradication of the pathogen from commercial apple production in Norway following the present requirements and control measures.

AP was detected for the first time in Norway in 1996. It may have been present already around 1970, probably with the introduction of the new apple cultivar ‘Aroma’, which is known to be very susceptible to the pathogen. In a survey from 1996 to 1999 AP was detected in a total of 15 fruit orchards and one nursery in the counties of Telemark, Vestfold, Sogn og Fjordane, and Hordaland (Blystad 1999). Diseased trees were eradicated, and to a limited extent new surveys were made the following years. Very few new incidents were reported during the years until 2010 when the disease was detected in 19 orchards, in some of the same district as 10 years before. A surveying programme has been started in 2011 and will continue in 2012. It may provide better knowledge about the present distribution of AP in Norway.

The present requirements and control measures carried out by the Norwegian Food Safety Authority, when there is an outbreak of AP, consist mainly of eradication of diseased trees. To take scion or budwood from trees in an orchard or nursery where the disease is present is prohibited, and orders may be given to carry out a spraying programme to control vectors. These measures are strict and comparable to what has been demanded in other countries. However, these measures apparently do not give sufficient control of the disease in Norway. Most likely some diseased trees remain undetected because of weak symptoms or no symptoms at the point when surveys were carried out. These trees, and vectors harbouring the phytoplasma, will remain reservoirs for AP, and a high risk for transmitting the pathogen to new trees either by vectors present in the orchard, or by scions and budwood being taken to produce new trees. Consequently, the probability to eradicate AP from districts in Norway where the disease has been present for a number of years with the present control measures is not likely. However, it should be possible to avoid the disease to spread to new districts which yet are not known to be contaminated. This would imply strict measures allowing only certified, disease-free planting material to be used in the area.

5) The economic consequences for fruit production and plant production of

a) Maintaining the present and transitional control measures as a future regime.

Despite the uncertainty concerning the occurrence of vectors in Norway and their importance in spreading the disease there is a high probability that AP may cause extensive economic damage in fruit orchards and nurseries in the country. The outbreaks in Norway so far have been limited; the most extensive damage has been for the nurseries. Most probably the present control measures, combined with regular survey-programmes, testing of trees in areas where the disease has been recorded, and extensive use of disease-tested planting material, may keep the disease at a low level of damage. But these measures could be at a high cost, both for official bodies and for the fruit growers and nurseries.

b) Deregulating the pest, i.e. the pest should be considered as a quality pest.

Without any measures there would most likely be a rapid build-up of inoculum of the pathogen, and the damage to the fruit production most likely would be considerable. Depending on the system of control in the exporting country the probability may be considerable that infected trees not showing symptoms could be imported to Norway. Considering the pathogen as a quality pest, to keep the risk as low as possible it would be necessary to have a certification scheme for the production of plants for planting, including among other things regular testing for the pathogen with appropriate methods. Such regulations would have to apply both for plant production in Norway and in possible exporting countries. Fruit growers and nurseries would have to closely watch their own production for disease symptoms, and if necessary take samples for laboratory testing. They should also have a programme for insect vector control. Most likely the consequences by deregulating the pathogen and considering it as a quality pathogen, with some control measures being performed may keep the disease at a low level, at least in commercial fruit orchards. However, as long as the vector situation in Norway is mainly unknown, the uncertainty regarding the level of damage the disease may cause is high.

6) Change in probability of spread and potential damage of the pest as a result of possible future climate change.

Presently Norway most likely is at the border of the northern distribution of AP. Considering that development and growth of the pathogen is favoured by warm temperatures it is likely that the damage to the trees would be more extensive, comparable to the situation in countries in Southern Europe. A change in climate most likely would influence the occurrence of the vectors, which could result in a more rapid and extensive local spread than previously experienced in Norway.

References

Baric S, Berger J, Cainelli C, Kerschbamer C, Letschka T, Via JD (2011). Seasonal colonisation of apple trees by '*Candidatus* Phytoplasma mali' revealed by a new quantitative TaqMan real-time PCR approach. Eur J Plant Pathol 129:455-467.

Blystad, D-R. (1999): Forekomst av heksekost på eple i Norge. Konfidensiell rapport på oppdrag fra Landbrukstilsynet Planteinspeksjonen. 25. januar 1999. Planteforsk Grønn rapportserie.

Blystad, D-R., Toppe, B., Brurberg, M-B. & O. Sørum (2011): New cases of apple proliferation disease in Norway. Bull. Insectology LXIV (Supplement) 2011.

Carraro, L. Ermacora, P. Loi, N. & Osler, R. (2004): The recovery phenomenon in apple proliferation-infected apple trees. J. Plant Pathology 86: 141-146.

Ciccotti, A.M., Bianchedi, P.L., Bragagna, M., Deromedi, M., Filippi, M., Forno, F. & L. Mattedi (2008): Natural and experimental transmission of *Candidatus* Phytoplasma mali by root bridges. Acta Hort. 781: 459-469.

Cieslinska, M. & H. Morgas (2011): Detection and identification of *Candidatus* Phytoplasma prunorum, *Candidatus* Phytoplasma mali and *Candidatus* Phytoplasma pyri in stone fruit trees in Poland. J. Phytopathol 159: 217-222.

Cieslinka, M. & Morgas, H. (2011): Detection and identification of “Candidatus Phytoplasma prunorum”, “Candidatus Phytoplasma mali” and “Candidatus Phytoplasma pyri” in stone fruit trees in Poland. J. Phytopathol. 159: 217-222.

Danet, J.L., Balakishiyeva, G., Cimerman, A., Sauvion, N., Marie-Jeanne, V., Labonne, G., Lavina, A., Batlle, A., Krizanac, I., Skoric, D., Ermacora, P., Serce, U.S., Caglayan, K., Jarausch, W. & X. Foissac (2011): Multilocus sequence analysis reveals the genetic diversity of European fruit tree phytoplasmas and supports the existence of inter-species recombination. Microbiology 157: 438-450.

Edland, T. (2004): Sugande skade- og nyttedyr i frukthagar. Grønn kunnskap 8 (4), 176 pp.

EPPO (2011): EPPO Plant Quarantine Data Retrieval system PQR 5.0.

EPPO (2009): PM 5/3(4). Guidelines on Pest Risk Analysis. Decision-support scheme for quarantine pests. European and Mediterranean Plant Protection Organization.

EPPO (1999). PM 4/27(1). Certification schemes. Pathogen-tested material of *Malus*, *Pyrus* and *Cydonia*. European and Mediterranean Plant Protection Organization.

EPPO (1997): EPPO Data Sheets on Quarantine Pests pp 959-962.

FAO (2006): ISPM No. 11 (2004). Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms. International Standards for Phytosanitary Measures No. 1 to 24 (2005 edition).

FAO (1990): ISPM No. 5 (2010). Glossary of Phytosanitary Terms. International Standards for Phytosanitary Measures No. 1 to 24.

Fauna Europaea (2011). *Fieberiella florii*.
http://www.faunaeur.org/full_results.php?id=193873

Jarausch, W., Lansac, M. & Dosba, F. (1996): Long-term maintenance of nonculturable apple-proliferation phytoplasmas in their micropropagated natural host plant. Plant Pathol. 45: 778-786.

Kunze, L. (1989): Apple proliferation. In: Virus and viruslike diseases of pome fruits and simulating noninfectious disorders. Ed. by Friedlund, P.R., Cooperative extension, Washington State University, Pullman.

Lauterer P. & D. Burckhardt (1997): Central and West European willow-feeding jumping plant-lice of the genus *Cacopsylla* (Hemiptera: Psylloidea). Entomological Problems 28(2), 81-94.

Lemmetty, A., Tuovinen, T. & R. Kemppainen (2011): '*Candidatus* Phytoplasma mali' infected *Cacopsylla picta* found in apple orchards in South-Western Finland. Bulletin of Insectology 64 (Supplement), 257-258.

Maixner, M. (2010): Phytoplasma epidemiological systems with multiple plant hosts. pp. 213-232 In: Phytoplasmas: Genomes, Plant Hosts and vectors. Ed. by P.G. Weintraub & P. Jones, CAB International.

Marcone, C., Jarausch, B. & Jarausch, W. (2010): *Candidatus* Phytoplasma prunorum, the causal agent of European stone fruit yellows: an overview. J. Plant Pathology 92: 19-34.

Mayer, C.J., Jarausch, B., Jarausch, W., Jelkmann, W., Vilcinkas, A. & J. Gross (2009): *Cacopsylla melanoneura* has no relevance as vector of apple proliferation in Germany. Phytopath. 99: 729-738.

OEPP/EPPO 2006: Diagnostic Candidatus *Phytoplasma mali* Bulletin OEPP/EPPO 36: 121-125.

Ossiannilsson, F. (1992): The Psylloidae (Homoptera) of Fennoscandia and Denmark. Fauna Entomologica Scandinavia 26. 347 pp.

Pedrazzoli, F.,Gualandri, V.,Forno, F.,Mattedi, L.,Malagnini, V.,Salvadori, A.,Stoppa, G.& C. Ioriatti (2007):Acquisition capacities of the overwintering adults of the psyllid vectors of '*Candidatus* Phytoplasma mali. Bull. Insectology 60: 195-196.

Pizzinat, A., Tedeschi, R. & A. Alma (2011): *Cacopsylla melanoneura* (Foerster): aestivation and overwintering habitats in Northwest Italy. Bulletin of Insectology 64 (Supplement): S135-S136. ISSN 1721-8861.

Seemüller, E. & Harris, H. (2011): Plant Resistance. pp. 147-169 In: Phytoplasmas: Genomes, Plant Hosts and vectors. Ed. by P.G. Weintraub & P. Jones, CAB International.

Seemüller, E. & B. Schneider (2007): Differences in virulence and genomic features of strains of '*Candidatus* Phytoplasma mali', the apple proliferation agent. Phytopath. 97: 964-970.

Seemüller, E. & B. Schneider (2004): '*Candidatus* Phytoplasma mali', '*Candidatus* Phytoplasma pyri' and '*Candidatus* Phytoplasma prunorum', the causal agents of apple proliferation, pear decline and European stone fruit yellows, respectively. Intern. J. Systematic and Evolutionary Microb. 54: 1217-1226.

Seemüller, E., L. Carraro, W. Jarausch, & B. Schneider (2011): Apple proliferation phytoplasma. pp. 67-73 in: Virus and virus-like diseases of pome and stone fruits, ed. by Hadidi A., Barba, M. Candresse, T. & W. Jelkmann, APS-Press.

Seemüller, E. Kiss, E. Sule, S. & Schneider, B. (2010): Multiple infection of apple trees by distinct strains of '*Candidatus* Phytoplasma mali' and its pathological relevance. Phytopathology 100: 863-870.

Statistics Norway (2011): http://www.ssb.no/english/

Tedeschi, R., Visentin, C., Alma, A. & D. Bosco (2003): Epidemiology of apple proliferation (AP) in northwestern Italy: evaluation of the frequency of AP-positive psyllids in naturally infected populations of *Cacopsylla melanoneura* (Homoptera: Psyllidae). Ann. appl. Biol. 142: 285-290.

Tedeschi, R., Lauterer, P., Brusetti, L. Tota, F. & Alberto Alma (2009): Composition, abundance and phytoplasma infection in the hawthorn psyllid fauna of northwester Italy. Eur J. Plant Pathol 123: 301-310.

The Norwegian Food Safety Authority (2011a): Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests. http://www.mattilsynet.no/regelverk/forskrifter/forskrift_om_planter_og_tiltak_mot_planteskadegj_rere_7741.

The Norwegian Food Safety Authority (2011b): Forvaltningspraksis for karanteneskadegjøreren heksekost på eple er midlertidig endret. http://www.mattilsynet.no/planter/plantehelse/produksjon_omsetning/forvaltningspraksis_for_karanteneskadegj_reren_heksekost_p__eple_er_midlertidig_endret_86961

The Norwegian Food Safety Authority (2010): Påvisning av plantesjukdommen heksekost på eple i 2010 http://www.mattilsynet.no/smittevern_og_bekjempelse/planter/hendelser/p_visning_av_plantesjukdommen_heksekost_p__eple_i_2010_86958