EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

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Pest Risk Analysis for
Pseudomonas syringae pv. actinidiae

September 2012

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Note: editorial modifications were made since the presentation to the Working Party, but the content has not changed.

Express Pest Risk Analysis for *Pseudomonas syringae* pv. *actinidiae*

Initiation:
Bacterial canker of kiwifruit caused by *Pseudomonas syringae* pv. *actinidiae* was first noticed in the EPPO region in central Italy in 1992, where it remained sporadic and with no economic incidence during 16 years. But in 2008 economic losses started to be observed particularly in the Lazio region and the possible spread of the disease to other kiwifruit producing regions in Italy began to raise concerns. Because *P. syringae* pv. *actinidiae* was an emerging disease in the Mediterranean region, the EPPO Secretariat decided to add it to the EPPO Alert List in 2009. In 2010 it was reported in France, Portugal, New Zealand and Chile; in 2011 in Spain, Switzerland and Australia. The Working Party on Phytosanitary Regulations in June 2011 considered that an express PRA should be conducted.

PRA area: *EPPO region*
Prepared by: *EWG on Pseudomonas syringae* pv. *actinidiae.*
Date: 2011-09-05/09 (plus email consultation post EWG). The risk management part was reviewed by the Panel on Phytosanitary Measures on 2011-11-15.

Composition of the EWG[1]

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[1] Procedure: a letter inviting for nominations was sent to all NPPOs of kiwifruits producing countries in the EPPO region

Summary						
Present phytosanitary risk for (*PRA area*)	High	**X**	Medium		Low	
Level of uncertainty of assessment	High		Medium		Low	**X**

Summary and Conclusions

Summary:

Risk of entry: high
The pest has already entered in the PRA area; thus the risk of entry to new areas is high. Transfer of plants for planting represent the main pathway of entry to new areas as suggested in recent outbreak situations.

Risk of establishment: high
The pest has already established in part of the PRA area. Climatic conditions are suitable in areas where kiwifruit orchards are grown.

Impact: high
Impact is likely to be very high for the producers. In the countries of the EPPO region where the pest is present the disease is reported with a high incidence. In Italy, 4 years after the first recent reports several orchards show up to 80-90 % incidence on kiwi yellow cultivars. With a disease incidence of 40%, 2/3 of the fruit harvest can be lost.

There are no curative treatments available (contrary to some other parts of the world antibiotic treatments are not authorized in many EPPO countries).

Management Measures:
Note that the EWG decided to identify management measures by following the management part of the EPPO Decision Support Scheme (PM 3/5 (5)).
Pathway 1: Plants for planting (except seeds and tissue culture)

- Pest free place of production (for details see question 7.17 and 7.21 of Appendix 5)+ specific handling/packing methods
- Pest free area (for details see Appendix 5 question 7.21)
- Import under special permit and post entry quarantine.

Pathway 2: Pollen

- Pest free place of production (for details see question 7.17 and 7.21 of Appendix 5 (for Pathway 1).
- Pest free area.

Pathway 3: Tissue culture

- Tissue culture produced from mother plants produced in a pest free place of production or pest free area (for conditions see pathway 1)

Other recommendations:

- ***Surveys should be conducted in all kiwifruit growing countries***

Pest Risk Analysis: *Pseudomonas syringae* pv. *actinidiae*

Note: two other bacteria (*P. syringae* pv. *syringae* & *P. viridiflava*) are present in the EPPO region on kiwifruit orchards but their impact is limited compared to *P. syringae* pv. *actinidiae.*

1.Taxonomy

Bacteria; Proteobacteria; Gammaproteobacteria; Pseudomonadales; Pseudomonadaceae; *Pseudomonas*; *Pseudomonas syringae* complex, genomospecies 8.

Population characteristics:
Until now four different *Pseudomonas syringae* pv. *actinidiae* populations can be characterised based on aggressiveness, genomic fingerprinting, 16SrDNA or ITS sequencing, MLST analysis, production of toxins, presence of certain genes (see Appendix 1). From these four populations, two have been detected so far in the EPPO region which differ in aggressiveness.

The population identified in 1992 in Italy (Scortichini, 1994) was less agressive than the one detected in Italy in 2008-2011 (described below) and shows a similar genetic profile to population isolated in Japan (Ferrante & Scortichini, 2010, Marcelletti & Scortichini 2011). This population has not been detected during the recent epidemics in Italy (Balestra & Scortichini, *pers. comm.*,2011).
It should be noted, however, that the populations in Japan and Korea Republic have been described generally as aggressive (Takikawa 1989, Koh *et al*. 2010), but compared to the population appeared in Italy in 2008-2011, they are considered as 'moderately aggressive'. The population from Korea differs from the Japanese one for the occurrence of the coronatine gene (Shim *et al*. 2003).

The population of *P. syringae* pv. *actinidiae* isolated so far during the recent epidemics of bacterial canker in Europe (Italy 2008-2011, France, Portugal and Spain[2]) shows an excellent correlation between the genetic profile based on rep-PCR (BOX-PCR, ERIC-PCR), MLST, the haplotypes (*cts*) and biochemical characteristics in various media suggesting that these epidemics have been caused by the same population (Vanneste *et al.*, 2011a, Ferrante & Scortichini, 2010, Mazzaglia *et al.* 2011, Chapman *et al.* 2011). This population is aggressive and has also been detected in New Zealand (Chapman *et al.* 2011). According to a very recent publication (Marceletti *et al*., 2011), this population did not evolve from the *P. syringae* pv. *actinidiae* population that caused the epidemics in 1984–1992 in Japan and Italy, but rather is the product of a recent independent evolution of the pathovar *actinidiae* for infecting *Actinidia* spp.

The forth population is so far only reported in New Zealand and Australia (Chapman *et al.* 2011; Vanneste *pers. comm.*, 2011). It is described as a population showing a low aggressiveness and appears to be associated with leaf symptoms only.

Please note that this section reflects current information at the date of last review (2011-12-08) and may be submitted to further review by bacteriologist

Common name: bacterial canker of kiwifruit

2. Biology

- ***Host plants:***

***Actinidia* species: *A. deliciosa, A. chinensis, A. arguta,* and *A. kolomikta* are reported as hosts (Takikawa *et al.* 1989, Serizawa *et al.* 1989, Ushiyama *et al.* 1992a & b).**
First field observations made in Italy suggested that damage was more severe on *A. chinensis* (*i.e.* yellow cvs. 'Hort 16A' 'Jin Tao' and 'Soreli') but recent observations indicate that *A. deliciosa (*green cultivars cvs. Hayward', 'Summerkiwi', 'Tsechelidis' and 'Greenlight') show an equivalent sensibility. Progression of the disease is however quicker in *A. chinensis*. In France, both yellow and green cultivars are attacked, but as in Italy, damage is more severe on yellow cultivars. Field observations in Italy and New Zealand indicate that male vines often show symptoms before female vines and are more severely affected (Balestra, Finelli, Scortichini & Vanneste *pers. comm.*, 2011). Based on field observations in Italy 'Tomuri' male vines seem to be less susceptible than 'Matua' male vines (Balestra, Scortichini, Vanneste *pers. comm.*, 2011).

[2] The Swiss population has not yet been characterized.

P. syringae pv. *actinidiae* has been detected on *A. arguta* in France.

- ***Symptoms***

P. syringae pv. *actinidiae* causes brown discolouration of buds, dark brown angular spots surrounded or not by a yellow halo on leaves during spring, flower necrosis and blight, twig wilting and die-back, reddening of the lenticels, cankers with white to reddish (oxidation) exudate on canes, leaders or trunks during late winter, fruit collapse (due to blockage of vessels in the canes). Severely infected vines die.
The most conspicuous symptom is the red-rusty exudation which covers bark tissues on trunks and canes. Also, the presence of white exudates, often abundant, during winter is very typical of the disease. Removal of the bark usually reveals a brown discoloration of the external vascular tissues and reddening of the tissues beneath lenticels (details on symptoms depending on the season are given in Appendix 2).
Since some of the symptoms (leaf spots and flower blight) can also be caused by other phytopathogenic bacteria (*P. syringae* pv. *syringae*, *P. viridiflava*), a laboratory analysis is necessary for confirmation of the presence of the pest (Balestra & Varvaro, 1998; Balestra & Rosetti, 2008). Non-parasitic diseases may also resemble to kiwi bacterial canker.

- ***Epidemiology***

Serizawa *et al.* (1989) describe that damage associated with the *P. syringae* pv. *actinidiae* occurs in two phases. One phase occurs in autumn/winter and involves damage to the main vine structure and in overwintering canes. The other phase occurs in spring and involves the new season's growth (leaves, flowers and canes). The pathogen infects the host through stomata, hydathodes, lenticels, trychomes, leaf scars or wounds, and can progress to the roots where it overwinters (Mazzaglia *et al*. 2010).[3]

The optimum temperature for the growth of *P. syringae* pv. *actinidiae* on new canes is 12-18°C (Serizawa & Ichikawa, 1993d). Temperatures above 20°C are less favorable to the bacterium and Serizawa *et al*. 1993b stated that no symptoms are observed for temperatures above 25°C in Japan. However, in France, Italy and Portugal, symptoms have been observed at temperature above 25°C (Balestra, Picard, Scortichini *pers. comm.*, 2011).

Strong winds and heavy rainfall favor the disease, as recorded for many other bacterial plant diseases. Strong winds during rain may both injure the plants and disperse the bacterial exudate to the wounds and/or natural openings (Serizawa *et al.*, 1989).
Winter frost and late frost ("spring frost") as well as hail favor the occurrence of the disease.
Damages from *P. syringae* pv. *actinidiae* are also increased when high populations of *P. syringae* pv. *syringae* or *P. viridiflava*, two other bacterial pathogens attacking *Actinidia* sp. and frequently recorded in the EPPO region, are present on the plants (Mazzaglia *et al*. 2010, Rossetti *et al.* 2009).

Some papers refer to an epiphytic stage for this bacterium (*e.g.* Vanneste *et al.* 2011, Koh & Nou 2002). There is no published evidence that the bacterium is epiphytic on leaves and observations in Italy seem to exclude such possibility (Balestra, *pers. comm.*, 2011). However, the possibility that it can survive and multiply on the surface of an organ cannot be excluded. This hypothesis is made by Serizawa & Ichikawa (1993a). Experts present in the EWG considered that such survival and multiplication would be limited in time. It should be noted that the pathogen could not be isolated from asymptomatic organs (leaves, canes) in infected orchards during summer in Italy (Balestra, *pers. comm.*, 2011) suggesting that the epiphytic stage is improbable.

Spread mechanisms (see point 11)

- ***Detection and identification***

An EPPO Diagnostic Protocol is under development and a first draft should be available for country consultation in 2012.

  - Morphological identification

P. syringae pv. *actinidiae* should be isolated. For symptomatic samples, non-selective growth media: PPGA (Takikawa, 1989), NSA (Ferrante & Scortichini, 2009 & 2010, Balestra *et al.*, 2008), King B, (Vanneste, 2010, results of testing by the LNPV in 2010) are usually used. The use of semi-selective

[3] Vanneste *et al*. 2011 (KiwiTech bulletin N°68) state that *"the bacterium appears to be able be present dormant in plant material for several years without causing symptoms"* however no study has been published so far to support this statement in particular regarding the lengths of dormancy and in further contacts during the meeting Mr Vanneste confirmed that an infected plant will show symptoms within one year maximum.

media as KBC (Mohan and Schaad, 1987) or NSA supplemented with antibiotics (0.2 mg ml-1 cycloheximide and 0.08 mg ml-1 cephalexin) could facilitate the *P. syringae* pv. *actinidiae*-isolation from materials contaminated by saprophytic or opportunistic microorganisms (Gallelli *et al.* 2011). In order to improve selection from saprophytic population King B modified (by adding boric acid 3 g/l, cycloheximide 200 mg/l and cephalexin 80 mg/l) can be used (Balestra, *pers. comm.* 2011). Populations can be characterised using phenotypic characteristics as described by Takikawa (1989), Scortichini *et al.* (2002), and Vanneste (2010).

- Molecular tests

PCR primer sets were developed for the detection of *P. syringae* pv. a*ctinidiae* (Sawada *et al.,* 1997; Koh & Nou, 2002) however these were not specific to *P. syringae* pv. a*ctinidiae.* Rees-George *et al.* (2010) have developed primers PsaF1/PsaR2 with high specificity. These primers do not allow *P. syringae* pv. *actinidiae* to be distinguished from *P. syringae* pv. *theae*, however this pest has only ever been isolated from tea plants (Scortichini *et al.,* 2002). It can consequently be used for testing suspected plants. Although specificity of these primers is high, the level of detection may not be sufficiently low to allow the test to be used for screening of plants (Rees-George *et al.,* 2010).
A duplex PCR has been developed and allows detection of *P. syringae* pv. *actinidiae* from naturally infected plant material (leaves, wood, flowers), and experimentally contaminated samples of pollen and fruits (spiked samples). This test is specific and allows the distinction from P. *syringae* pv. *theae and P. avellanae* another genetically related *Pseudomonas* pathovar. The sensitivity limit (2X10 CFU/PCR reaction) suggests that the test could be used to detect the bacterium also in symptomless material (Gallelli *et al.,* 2011).
Active research is ongoing to develop reliable tests for asymptomatic material in particular.

A datasheet is available in the CABI Crop Protection Compendium

3. Is the pest a vector? **Yes** ☐ **No** ☑

If a vector, which organism(s) is (are) transmitted and does it (do they) occur in the PRA area?

4. Is a vector needed? **Yes** ☐ **No** ☑

There is no known vector. However, any animal or insect will be a potential vector if it has been in contact with the bacteria on contaminated plants and then comes into contact with a healthy plant.

5. Regulatory status of pest

The pest is regulated by Australia and a draft PRA has been prepared (Biosecurity Australia, 2011). In the United States, importation of *Actinidia* spp. plants for planting is prohibited until a pest risk analysis is completed and appropriate mitigation measures are established. The same applies to pollen but not to fruit and seed.
The pest has been added to the EPPO Alert List in 2009 but no specific regulation exists in the EPPO countries regarding this pest (in particular it is not included in the EU Plant Health Regulation).

6. Distribution

Continent	Present/absent	Distribution
Africa	Absent	
America	Present (South America)	Chile
Asia	Present	China, Japan, Korea Republic
Europe	Present	France, Italy, Portugal, Spain, Switzerland
Oceania	Present	New Zealand, Australia

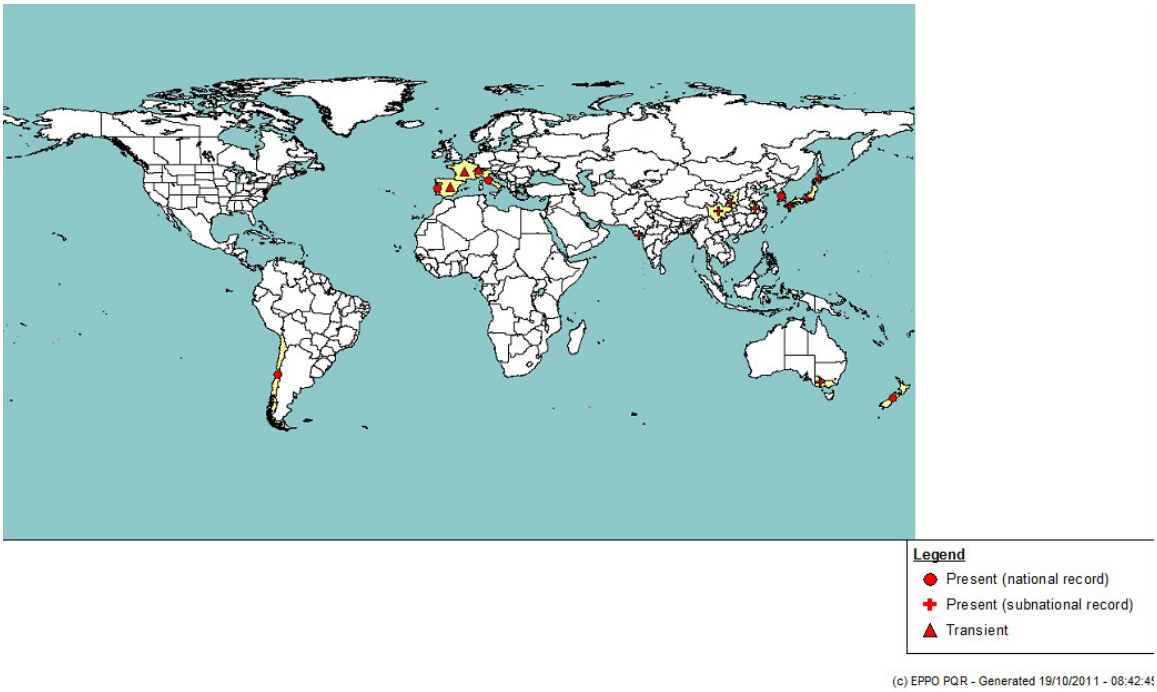

Fig 1. Distribution map of *Pseudomonas syringae* pv. *actinidiae*

Comments on distribution:
P. syringae pv. *actinidiae* was originally described in Japan (Shizuoaka prefecture Takikawe 1989) where it is widespread but its area of origin has not been ascertained.

EPPO region
Distribution in the EPPO region: France (first found in 2010 in Aquitaine and Rhône-Alpes, and in 2011 in Corse, Midi-Pyrénées, Pays de la Loire, Poitou-Charentes), Italy (Calabria, Campania, Emilia-Romagna, Friuli-Venezia Giulia, Lazio, Piemonte, Veneto), Portugal (in March 2010 in Entre Douro-e-Minho province), Spain (detected in 2011 in Galicia) and Switzerland (detected in Geneva canton in June 2011 on a young plantation).
In Greece a survey of kiwifruit plantation has been launched in May 2011. Until August 2011, 106 samples have been collected (88 from orchards and 6 in nurseries). 79 samples were asymptomatic and 27 samples included plant material showing symptoms that could be confused with those of *P. syringae* pv. *actinidiae*. No positive sample was been detected until the end of August 2011 (Holeva, *pers. comm.*, 2011).

Note: since the preparation of the PRA the pest has been detected in Turkey.

Asia: China (Anhui, Hunan, Shaanxi, Sichuan), Japan (Hokkaido, Honshu, Kyushu, Shikoku, Shizuoaka), Korea Republic.

South America: Chile (in 2010 in O'Higgins and Maule regions).

Oceania: Australia (Victoria), New Zealand. It was first detected in New Zealand in 2010 in several kiwifruit orchards of the North Island (mainly in the regions of Hawke's Bay and Bay of Plenty) and in the South Island (Golden Bay, Motueka). In 2011, it continued to spread in New Zealand and was found for the first time in Australia ("mild strain" only).

For the distribution of populations, see point 1 and Appendix 1.

In the literature, several papers mention the presence of *bacterial canker,* in Iran, but the original publication only refers to *P. syringae* pv. *syringae*.
The record of *Pseudomonas* canker of kiwi in California (Opgenorth *et al.*, 1983) refers to *P. syringae.*

7. Host plant distribution

Host Scientific name	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, major/minor host for the pest)
Actinidia chinensis	yes	Orchards in the EPPO region (details in the table below)
Actinidia deliciosa	yes	Orchards in in the EPPO region (details in the table below)
Actinidia arguta	yes	As ornamental vine (no specific data available)
Actinidia kolomikta	yes	As ornamental vine (no specific data available).

The area harvested in the EPPO region in 2009 are presented in the table below by order of importance (ha) (for 2009: source FAO Stat consulted 2011-08-20, for 2010 questionnaire to NPPOs)

Countries	2009	2010 (when available)
Italy	23800	27 619
Turkey	20000	
Greece	5086	
France	4035	4500
Portugal	1405	1495*
Spain	1200	
Israel	399	
Switzerland	18	
Bulgaria	17	
Slovenia	11	
Cyprus	8	
Tunisia-	4	

* (Cruz, *pers. comm.*, 2011)

8. Pathways for entry

Possible pathways	Short description	Probability (not relevant /low/medium/ high)
Plants for planting (excluding seeds) Tissue culture.	Plants for planting of *Actinidia* spp. are the main pathway for long distance spread and are suspected to be at the origin of the outbreaks in France (EPPO, 2010), Spain (Cobos Suarez, *pers. comm.*, 2011) and Switzerland (NPPO, 2011). In Italy there are indications that young plants obtained from micropropagation have been a source of infection (Scortichini, *pers. comm.* 2011)	High
Pollen	Card *et al.* (2007) made a review of plant pathogens transmitted by pollen. In this review they state that there are no pollen-transmitted bacteria. In November 2010, the Ministry of Agriculture and Forestry (MAF Biosecurity) of New Zealand announced that samples of pollen collected (since 2007) tested positive by PCR for *P. syringae* pv. *actinidiae*. Recently, pollen samples collected with a vacuum device from infected and apparently non-infected orchards at the time of sampling were tested positive (Vanneste *et al.*, 2011). Although it was acknowledged that this finding did not	Probability difficult to assess because of the uncertainty. Pollen transmission has not been demonstrated so far. The EWG considered that although evidence is lacking on such transmission, the involvement of pollen in *P. syringae* pv. *actinidiae* transmission should not be excluded and measures

Possible pathways	Short description	Probability (not relevant /low/medium/ high)
	provide sufficient evidence to consider that infected pollen can spread the disease, MAF advised kiwifruit growers to use only pollen tested for *P. syringae* pv. *actinidiae* for implementing artificial pollination. For the moment, the possibility that infected pollen could spread the disease cannot be excluded but more research is needed (EPPO, 2011). Studies on pollen transmission are in progress in Emilia Romagna (Finelli, *pers. comm.*, 2011).	should be identified.
Seeds	There is no reference on seed transmission.	Not considered
Natural spread, *e.g.* intrinsic spread, wind, water, animals (including pollinators)	Data on the epidemiology of the disease is lacking but, like other Pseudomonads bacteria, spread is ensured by heavy rain, strong winds and animals (Balestra 2010b). Restriction on the movement of pollination hives is recommended in New Zealand (Zespri, 2010). A small study was conducted in New Zealand but no conclusive results were obtained (Vanneste, 2010). A further study to evaluate survival of *P. syringae* pv. *actinidiae* on bees and parts of bee hive is in progress (Vanneste, *pers. comm.*, 2011).	Natural spread is considered to happen mostly within or between orchards. For entry into new areas in the EPPO region (*e.g.* Greece and Israel) natural spread has not been considered as a likely pathway.
Cut flowers		Not relevant
Fruits	Although the bacterium can be detected in experimentally contaminated fruits (macerated fruit material spiked with *P. syringae* pv. *actinidiae*), there was no evidence of natural infection of fruits until recently. In a study conducted in Emilia Romagna *P. syringae* pv. *actinidiae* could not be detected by isolation and PCR test using primers developed by Koh & Nou (2002) or Rees-George *et al.* (2010) either on the surface or inside the fruit collected from symptomatic plants (Minardi *et al.*, 2011). A publication is in progress reporting detection in naturally infected fruits (Finelli, *pers. comm.*, 2011). Nevertheless, the question of fruit transmission was discussed at the meeting and the EWG considered that even if fruit infection could be demonstrated, the risk of transmission of the bacterium with commercial fruits to kiwi orchard was as insignificant as evaluated by Roberts & Sawyer (2007) for *Erwinia amylovora* for commercial apple fruits.	Not considered
Wood products		Not relevant
Conveyance		Not relevant
Soil as such	There is no reference on soil transmission.	Not considered

9. Likelihood of establishment outdoors in the PRA area

The pest has already established in the EPPO region in Italy and France. Outbreaks have been detected in Portugal, Spain and Switzerland and all infected plants in the orchards have been eliminated.

At 2011-09-26 three countries have provided official status for this pest:
France Transient, under eradication.
Spain: Transient, under eradication.
Switzerland: Transient, actionable under eradication.

Suitability of climate

The map below shows the distribution of climates that occur in the European Union and their presence in other parts of the EPPO region. Locations of outbreaks are noted by a red dot (outbreaks in Asia and Pacific are also indicated). Based on this, map, it can be concluded that climatic conditions in the EPPO region are favourable for the pest in most if not all areas where kiwifruit is grown.

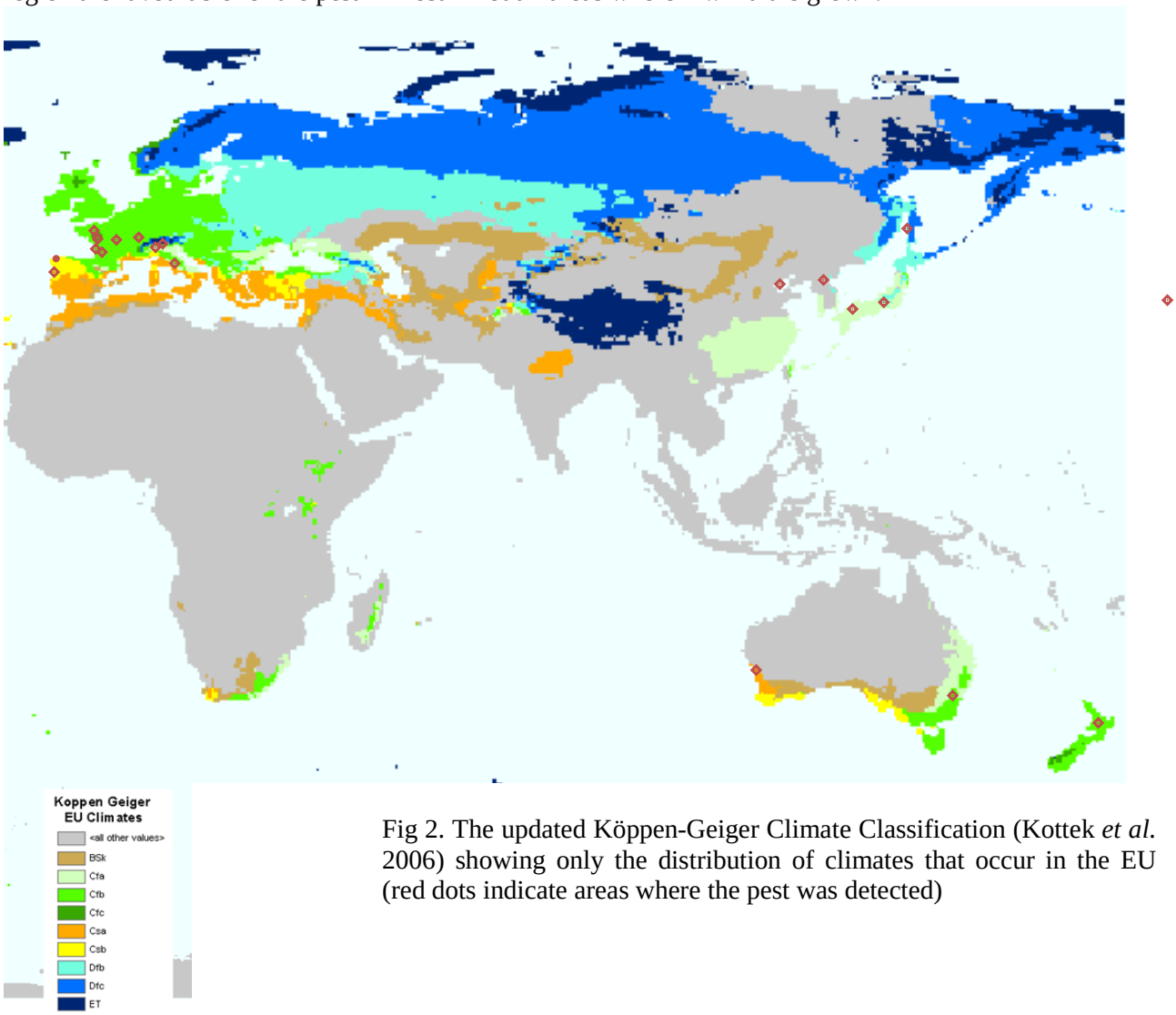

Fig 2. The updated Köppen-Geiger Climate Classification (Kottek *et al.* 2006) showing only the distribution of climates that occur in the EU (red dots indicate areas where the pest was detected)

A Climatic predictive study was performed in France (Reynaud, 2011 – see Appendix 3) using the CLIMEX predictive climatic tool.
This study indicates that *P. syringae* pv. *actinidiae* could establish in most countries where *Actinidia* species are grown, especially in areas with a maritime influence.

10. Likelihood of establishment in protected conditions in the PRA area

Kiwi are usually not grown indoors.

11. Spread in the PRA area

Data on the epidemiology of the disease is lacking but like other Pseudomonads, spread is ensured by plants for planting (except seeds), heavy rain, strong winds and animals (Balestra, 2010b). Spread within and between orchards can also be ensured through pruning equipment.

Only one publication gives indications for spread capacity. The study performed in Italy on the progression of the bacterium in an area with yellow kiwifruit orchards (Vanneste *et al.* 2011b) indicates a dispersion capacity of around 10 km from the initial infected orchards in May 2009 and June 2010 (the authors note that Spring 2010 was characterized by cold wet weather and comment that the spread was rapid). Spread is also possible in autumn and winter (Balestra & Scortichini, *pers. comm.*, 2011). (see Fig. 3 below).

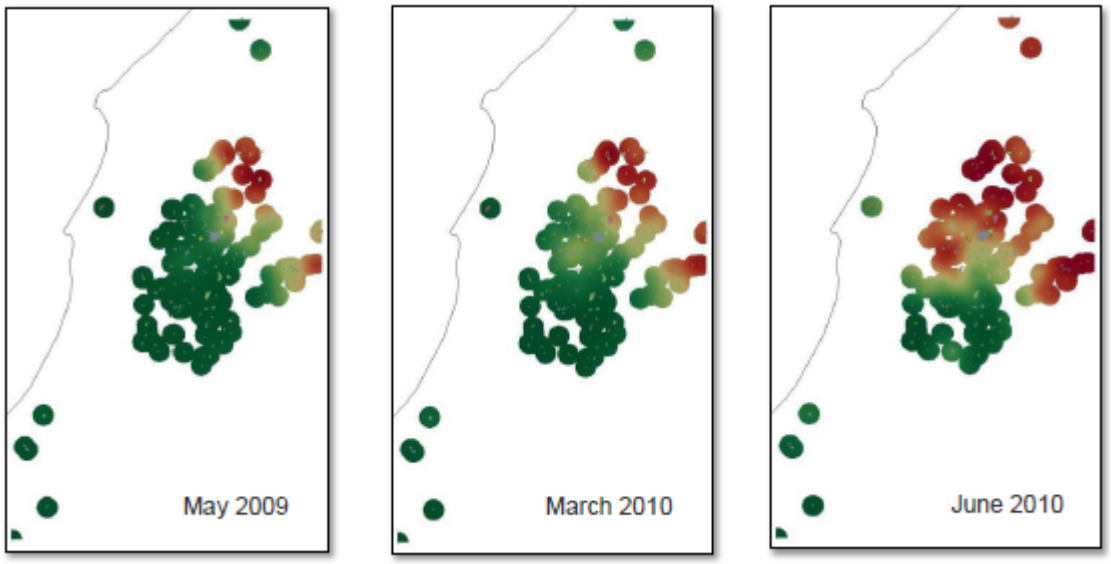

Fig 3. Progression of *P. syringae* pv. *actinidiae* infections in Latina (Vanneste *et al.* 2011b). Each circle has a radius that corresponds to 1km and red colour corresponds to an infected area.

Details on the different modes of spread

Human mediated spread

Plants for planting

Plants for planting of *Actinidia* spp. are the main pathway for long distance spread and are suspected to be at the origin of the outbreaks in France (EPPO, 2010), Spain (Cobos Suarez, *pers. comm.*, 2011) and Switzerland (NPPO, 2011). In Switzerland the bacterium was detected in a small commercial orchard which was planted in spring 2011 with the plants imported from Italy during winter 2011[4].

Equipment and tools

As a wound-infecting pathogen, it is easily transmitted with orchard equipment such as pruning equipment (Renzi *et al.* 2009). Winter pruning practices using contaminated pruning shears have been shown to cause rapid spread of *P. syringae* pv. *actinidiae* (Koh *et al.*, 2010).

Pollen

As explained under point 8, samples of pollen have tested positive for *P. syringae* pv. *actinidiae*. Although it is acknowledged that such detection does not provide sufficient evidence to consider that pollen can spread the disease, such possibility cannot be excluded and more research is needed to clarify this issue. The EWG considered that although evidence is lacking on such transmission, the involvement of pollen in *P. syringae* pv. *actinidiae* transmission should not be excluded and measures should be identified.

Natural spread

Wind and wind driven rain

The pathogen can be dispersed in aerosols and can be carried between trees and adjacent orchards in wind-driven rain. Serizawa *et al.* (1989) noted that the severely affected orchards were concentrated in areas where strong winds blow frequently. In Japan, the disease was not observed in orchards which were well protected with wind-hedges despite the fact that they were adjacent to severely affected orchards (Serizawa *et al.*, 1989). However, in New Zealand infections are detected in orchards where high wind-edges (10-12 m) made with *Cryptomeria* are in place (Scortichini & Balestra, *pers. comm.*, 2011). Vanneste (*pers. comm.*, 2011) explained that, in New Zeland, these windbreaks are not dense enough compared to those in Korea Republic or Japan to prevent spread of *P. syringae* pv. *actinidiae* between

[4] all plants were destroyed in early June 2011.

orchards. In France and Italy, windbreaks are not very common (some were eliminated to facilitate access of the orchards to equipment and to reduce other bacterial disease problems in orchards as windbreaks favor humidity; Finelli & Picard, *pers. comm.* 2011).

Insects (including pollinators)
Insects can carry the bacterium as demonstrated for other bacteria (Balestra 2010b).
The importance of use of bee hives for pollination of kiwi in the EPPO region varies depending on the area. It is more important for organic production (Balestra, *pers. comm.*, 2011).
In the Australian PRA (Biosecurity Australia, 2011) it is mentioned that "*Pollinators may also spread pollen contaminated with P. syringae pv. actinidiae.*"

Water
Some publication refer to the detection of *P. syringae* in surface water (Morris *et al.*, 2010), or clouds (Amato *et al*., 2006). No evidence of the presence of *P. syringae* pv. *actinidiae* in surface water or clouds exists. The implications of such finding for the spread of *P. syringae* pv. *actinidiae* was debated during the meeting. *P. syringae* pv. *actinidiae* is a pathovar of *P. syringae* that does not induce ice nucleation. The ability to induce ice nucleation could help the bacteria being carried down from the clouds by rain or snow. This ability is however independent of the ability of the bacteria to survive in clouds.
P. syringae pv. *actinidiae* has not been detected so far in water used for irrigation; however this is still being investigated.

12. Impact in the current areas of distribution

Incidence of the disease in orchards

Situation in Europe

France
Preliminary data indicate that outbreaks are mainly found on *A. deliciosa*. However it should be noted that *A. deliciosa* forms approximately 90% of the French *Actinidia* spp. production. Disease incidence in the field ranged from few isolated plants up to 30% of infected plants for *A. deliciosa*. However, such incidence of 30% of infected plants was only observed in the Rhône-Alpes region. When infected plants are detected canes are cut to the leader or uprooted consequently no kiwifruit is harvested. In this region, approximately 13,6 ha of *A. deliciosa* have been cut at the grafting point or uprooted. In Aquitaine region, more severe symptoms were noted on *A. chinensis.* In this region, 0.2ha of *A. deliciosa* (Hayward), 8.1ha of *A. deliciosa* (SummerKiwi) and 22.2 ha of *A. chinensis* have been cut at the grafting point or uprooted.

In total 483 samples collected from different individual orchards were tested. The total number of orchards where *P. syringae* pv. *actinidiae* was detected is 115. 72 % of the positive samples are constituted of *A. deliciosa,* 37 % of *A. chinensis* and less than 1% of *A. arguta*. 50 % of the orchards where the bacterium was detected had been planted between 2007 and 2011.

Italy
At the beginning of the epidemic in 2007-2008, symptoms caused by *P. syringae*. pv. *actinidiae* were observed in some *A. chinensis* cultivar Hort I6A orchards in Latium (Balestra *et al.* 2008). The disease caused death of branches, on up to 3-5% of the plants present in the orchard (Balestra *et al.* 2008; Ferrante & Scortichini, 2009).
Balestra *et al.* 2009b reported that in the Lazio region disease symptoms in the field were found mainly on *A. chinensis* plants (cvs. Hort 16A and Jin Tao) and occasionally on A. *deliciosa* plants cv. Hayward in adjacent orchards. Disease incidence in the field on Jin Tao vines ranged from 30 to 50%, with a mean of 40%. In such situation the yield loss can represent 2/3 of the production, *i.e.* considering 30 t/ha as an average yield from healthy kiwi crops, in affected orchards only 10 t/ha are harvested (Balestra, *pers. comm.*, 2011).
Balestra (2009a) reported that the highest disease incidence was associated with *A. chinensis* cultivars, especially in orchards of cv. Hort 16 A (always up to 70%) in Latina and Rome provinces (Lazio region). Kiwifruit plants cv. Jin Tao in the Treviso province (Veneto region) showed a lower disease incidence and severity than in other regions. Vines of *A. deliciosa* cv. Hayward in areas surrounding *A. chinensis* infected orchards only showed 10% disease incidence.
Loreti *et al.* 2011 report that in Lazio, nearly 50% of the producing area of *A. chinensis* has been heavily infected and many plants have been cut at the crown or uprooted.

4 years after the first reports several orchards show up to 80-90 % incidence on *A. chinensis* (Balestra & Scortichini *pers. comm.*, 2011).

Portugal
Balestra *et al.* 2010d: disease incidence as high as 30% was noted in 2010 and incidence has increased up to 80% in 2011 (Renzi *et al.*, 2011).

Spain
In early spring 2011, 80% of the vines in one orchard had twigs, branches and trunks with reddish exudates as well as leaves with angular spots surrounded by a yellow halo. All plants in the infected orchard (25 ha) were eliminated (Abelleira Argibay *et al.*, 2011, Balestra *et al.*, 2011).

Situation in other parts of the world
Australia
In Australia, only the less aggressive *P. syringae*. pv. *actinidiae* population has been detected.

China
No detailed data is available from China but Li *et al.* (2004) refer to evaluation of resistance of cultivars in China. In the Guanzhong area of the Shaanxi province an incidence of 7.95 % is noted (TU Xuan et al, 2011).

Chile
Apart from the initial notification little information is available on the incidence of the bacterium in Chile but a manual of containment has been published in September 2011 (SAG, 2011).

Japan
According to KVH (Kiwifruit Vine Health Inc (KVH) organisation in New Zealand, around 5 % of *A. chinensis* production is affected *by P. syringae* pv. *actinidiae* each year. The disease is being managed by cutting back, strict orchard hygiene and the use of antibiotics (KVH website 2011 history and global experience).

Korean Republic
Koh *et al*. 2010: "the bacterial canker was first detected in 2006 at three *A. chinensis* (cv. 'Hort16A') orchards at a disease incidence of less than 1%. However four of 11 orchards infected with the bacterial canker since 2006 reached 100% infection in 2008 and 2009 leading to the complete destruction of those orchards. Numerous *A. deliciosa* (cv. 'Hayward') orchards have been infected during the past two decades (Koh *et al.* 1994, 2003), but such destruction of an entire orchard had not been previously reported".

New Zealand
In New Zealand on the 8th of December 2011, 909 orchards have been confirmed as infected by the aggressive population of *P. syringae* pv. *actinidiae* representing a total of 4932 ha of affected vine nearly 36 % of the total surface of the kiwi production surface (the surface includes whole area of affectec orchards but the bacterium may affect only part of an orchard) (source: PSA Bulletin 8th December 2011). The situation is considered as 'very worrying' (Vanneste, *pers. comm.*, 2011).

Impact on crop protection costs and cultural practices
Crop protection
Actinidia sp. orchards have so far not necessitated regular sprays with plant protection products. As for many bacterial diseases, curative treatments for kiwi bacterial canker do not exist and it is important to apply preventive treatments at the most suitable periods to prevent infection. These are based on copper treatments, but these treatments are not authorized in all countries or periods of treatments are limited. Development of resistance of *P. syringae* pv. *actinidiae* to copper has been reported in Japan five years after the first report of the disease (Goto *et al.* 1994). Resistant strains have not been reported in Italy so far (Balestra & Stefani, *pers. comm.*, 2011)
Treatments with streptomycin have been allowed in September 2011 for a limited use in New Zealand (source KVH website consulted in September 2011). However, antibiotic treatment of plants is not allowed in Europe. In addition resistance to streptomycin has also been reported in Japan (Goto *et al.* 1994).

Cultural practices
Additional prophylactic measures should be implemented in the orchard to prevent infection *e.g.* disinfection of pruning tools between cuts or at the time of harvest.
Overhead irrigation is not recommended as it will favor the spread of the pest between infected and healthy plants. Overhead sprinklers are used to prevent damage from early or late frost, periods which are favorable for infection. A change in such systems from overhead irrigation to drip irrigation will have financial consequences for farmers.
Inspection efforts of kiwi crops and laboratory examination of suspicious plants are to be intensified, and this may raise the cost of production.

Impact noted in Italy so far
The occurrence of *P. syringae* pv. *actinidiae* has had a deep impact in many producing areas in Italy. An increase in production costs has been registered. Consultants in a producer's cooperative AGRINTESA in Emilia-Romagna and in Zespri Italia evaluated that additional costs related to the presence of *P. syringae* pv. *actinidiae* in a kiwifruit orchard cvs. Hayward and Hort 16 A can range from about 1700 EUR up to more than 3000 € per ha, depending on the severity of the infection (Finelli, *pers. comm.*, 2011). The total normal control costs in a healthy orchard is about 1700 EUR per ha. Such additional costs correspond to the implementation of agronomic preventive practices (treatments, pruning, etc.), as well as costs of monitoring.

Cost to the government to compensate losses to producers
A financial compensation system has been established for orchards and nurseries in four Italian regions (Emilia Romagna, Lazio, Piemonte, Veneto) for the destruction of plants (*e.g.* in Emilia Romagna in 2010). Depending on the age of the plant and species, the compensation varies from approximately 5000 Eur to 40000 Eur per ha. Compensation is also available for nurseries. In Piedmont, planting of *Actinidia* species is forbidden until the end of 2011. Similar measures have been implemented in Venetto (Finelli, *pers. comm.*, 2011)

In addition official surveys (field monitoring and laboratory analysis) to monitor the disease is will have a cost for NPPOs.

Environmental impact
No environmental impact is recorded.

Social impact
There may be some social impact. Kiwifruit producers are relatively specialized and they have no possibility to compensate for losses by reorienting their productions. There may be a loss of employment (in orchard and in the export chain). In some regions in France, kiwifruit orchards have been recently planted to replace *Prunus* orchards which were eliminated in the framework of the *Plum Pox Virus* eradication programme. Planting kiwifruit orchard was considered as an appropriate reorientation of the production.

13. Endangered area, and overall consequences

Impact in the rest of the region will be similar to the one already noted in Italy and France.

The main producing countries in the EPPO region are Italy, Turkey, Greece and France but production is increasing in other countries such as Spain and Portugal as well.

Importance of *Actinidia* sp. production in the different countries (by order of importance for kiwifruit production)
Italy
Italy produces more kiwifruit than any other country in the world apart possibly from China (Testolin & Ferguson, 2009). In Italy kiwifruit account for c. 3.5% of the total area for fruit production (Testolin & Ferguson, 2009). The main Italian regions producing kiwifruit are (ranked by order of importance): Lazio, Piemonte, Emilia Romagna and Veneto. In terms of marketable gross production, kiwifruit crop is one of the seventh most valuable crops after citrus, apple, table grape, peach, nectarine and pear.

Turkey

Kiwifruit was first introduced to Turkey in 1988 (Yalcin & Samanci, 1997). During the last few years surfaces cultivated have increased. Several areas are favorable for kiwi fruit production: Black Sea, Marmara, Aegean and Mediterranean Region (Yildirim *et al.* 2011). Kiwi is now one of the most favored fruit in the market among about 35 fruit species commercially grown in Turkey.

Greece
The cultivation of kiwifruit in Greece has started in 1972, in the region of Pieria in Central Macedonia. Since then, the cultivation had spread in other regions of Greece, like Kavala, Imathia, Arta, Lamia etc. Nevertheless Pieria region holds the first place as it produces almost 45% of the total kiwifruit national production. The national surface that is been invested in the kiwifruit production is estimated to be at around 5000 ha and the surface is expected to increase (Manossis, 2009).

France
Kiwifruit has been grown in France since about thirty years and France is among the main producers in Europe after Italy. *Actinidia* is produced over half of French territory (in the west and the south) but the main producing areas are in the south-west (Aquitaine, Charente, Midi-Pyrénées) and the Mediterranean basin (Languedoc-Roussillon, Rhône valley, Corsica). Aquitaine alone counts for 43% of the total national kiwi-growing land area and 54% of total volume. It is the leading region for kiwi production in France. The remaining producing areas (to the north) supply local (and in some cases regional) markets.
Most plants for planting used in orchards are produced outside of France.

Spain
In Spain, the northern regions of the peninsula concentrate the biggest part of the kiwifruit cultivated surface: 20% in Asturias, 8% in Basque Country, 5% in Navarre and 4% in Cantabria. Warmer regions like Catalonia or Extremadura represent 9%. In 2009 only the Hayward variety was produced, but there were plans to introduce new varieties like the precocious type or gold kiwifruit (Fernandez, 2009).

Potential impact on exports from EPPO countries
Plants for planting
Italy is the main producer of *Actinidia* plants for planting and many European countries (*e.g.* France, Spain, Portugal) rely on plants from Italian nurseries. The potential impact of the disease on these nurseries is important. Plants for planting originating from Italy are considered to have been the source of infection of new plantations in Switzerland and Portugal (*e.g.* the outbreak which appeared in Switzerland in spring 2011 was on plants imported in the winter period 2010-2011 from Italy see point 11).

Fruits
In 2009-2010 the Italian production was of 463.954 Tonnes, 78% of the production is traded outside Italy (*i.e.* 359 684 t) but most is traded within the EU (see below).
Details

Destination of export of kiwifruit from Italy	Quantity (t)	Percentage of total export
EU	262 509	57
Europe (non EU)	31 691	7
North America	23 173	5
Asia	11 534	2
South America	11 179	2
Meddle East	8 842	2
Oceania	6 336	1
Africa	4 042	1

(source: International Kiwi Organization, report Italy, year 2010)

French kiwifruit production is strongly focused on exports with one third of the kiwifruit production being exported *i.e.* approximately 28 000 tonnes a year (Naudin, *pers. comm.*, 2010). France exports fruits to various countries.

The risk of loss of exports for fruits is limited as fruits are not considered to be a pathway and most trading partners are in Europe.
Import requirements for kiwifruit usually target fruit flies. In Asia and South America few countries regulate the bacterium also on fruits. Few countries request additional inspections indicating that kiwifruits have been produced in *P. syringae* pv. *actinidiae* free areas (see Appendix 4). However the bacterium is now present in all major producing countries except in Turkey and Greece and consequently there is little possibility for importing countries to turn to alternative supplier countries.
However it cannot be excluded that some countries may take a precautionary approach and regulate fruits.

Potential impact on production practices and crop protection
As noted before, *Actinidia* sp. orchards have so far not necessitated regular sprays with plant protection products. The occurrence of the pest has consequently an impact on producers. In addition prophylactic measures should be implemented in the orchard to prevent infection. In non-EPPO countries, antibiotics are used but this is banned in most EPPO countries. A change in irrigation system from overhead irrigation to drip irrigation will have financial consequences for farmers.

14. Overall assessment of risk

Risk of entry is high:
The pest has already entered the PRA area; the risk is thus high. Plants for planting represent the main pathway of entry to new areas as suggested in recent outbreak situations.

Risk of establishment is high:
The pest has already established in part of the PRA area. Climatic conditions are suitable in areas where kiwifruit orchards are grown.

Impact
Impact is likely to be very high for the producers. In the countries of the region where the pest is present the disease is reported with a high incidence. In Italy, 4 years after the first reports several orchards show up to 80-90 % incidence on kiwi yellow cultivars. With an incidence of 40% 2/3 of the fruit harvest can be lost.
There are not curative treatments available (unlike some other parts of the world, antibiotic treatments are not authorized in many EPPO countries).

15. Phytosanitary measures

The measures were determined following the management part of the EPPO decision support scheme for Pest risk analysis. A summary of the measures is presented below and the detailed management section is presented in Appendix 5.

Pathway 1: Plants for planting (except seeds and tissue culture)	Pest free place of production (for details see question 7.17 and 7.21 of Appendix 5) + specific handling/packing methods
	Pest free area
	Import under special permit and post entry quarantine
Pathway 2: Pollen	Pest free place of production (for details see question 7.17 and 7.21 of Appendix 5 (for Pathway 1)
	Pest free area (for details see question 7.21)
Pathway 3: Tissue culture	Tissue culture produced from mother plants produced in a pest free place of production or pest-free area (for conditions see pathway 1)

Effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts	Eradication is possible when performed at an early stage of infection (measures recommended in orchards are presented in Appendix 6).

16. Uncertainty

The epidemiology needs to be better understood to identify the contribution of pathways such as pollen and bees to the overall risk presented by this pathogen

Other aspects of uncertainty include:

- Size of the buffer zone for the PFA and PFPP (specific data in relation to *P. syringae* pv. *actinidiae*)
- Role of pollination hives in transmission
- Length of survival of *P. syringae* pv. *actinidiae* on the plants.
- Distribution of the bacteria in the plant.

As for PRAs performed for other pests, it should be noted that measures have been determined based on the experience with other plant pathogenic bacteria.

17. Remarks

None.

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Appendix 1. Populations of *Pseudomonas syringae* pv. *actinidiae* (Please note that this section reflects current information at the date of last review (2011-12-08))

Sequences /genes	Bio molecular tools	Japan Psa 1	Korea Republic Psa 2	Italy 1992 Psa 1	Italy 2008 Psa 3	France Psa 3	Portugal Psa 3	Spain Psa 3	New Zealand Psa3	New Zealand Psa 4	Australia Psa 4	Reference
Agressiveness	HA=highly aggressive MA moderately agressive LA=little agressive	MA	MA	MA	HA	HA	HA	HA	HA	LA	LA	
16SrDNA gene	PCR amplicons sequencing	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)			Vanneste *et al.*, 2011; Koh *et al.*, 2010.
16S-23S ITS	PCR amplicons sequencing or detection	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)		*Koh et al.*, 2010, Rees-George *et al.*, 2010 ; Balestra *et al.*, 2010; Balestra *et al.*, 2011; Vanneste *et al.*, 2010.
MLST	PCR amplicons sequencing	Psa1	Psa2	Psa 1	Psa3	Psa3			Psa3	Psa4	Psa4	Chapman *et al.*, 2011, Ferrante & Scortichini, 2010 Marcelletti & Scortichini, 2011
Rep-PCR, RAPD, IS50 PCR, GTG PCR	PCR fingerprinting	Reliable differences between Psa1 and Psa2 and also Psa3 strains (see legend) are observed										Ferrante & Scortichini, 2009 & 2010 ; Marcelletti & Scortichini, 2011 ; Mazzaglia *et al.*, 2011, Vanneste *et al.*, 2011.
argK-tox phaseolotoxine	PCR detection	(+)	(-)	(+)	(-)				(-)			*Sawada et al., 1997; Lee et al., 2005; Ferrante and Scortichini, 2010.*
cfl biosynthesis coronatine (CFL-1/CFL-2)	PCR detection	(-)	(+)	(-)	(-)				(-)			Lee *et al.*, 2005; Ferrante and Scortichini, 2010 ; Koh *et al.*,2010.
*cts** citrate synthase	PCR amplicons sequencing	Psa1	Psa1	Psa1	Psa3	Psa3			Psa3	Psa4	Psa4	Vanneste *et al.*, 2010.
Presence of *hop*A1 effecteur	PCR detection	(-)	(-)	(+)	(+)	(+)			(+) (Psa1-Psa3)	(+) (Psa1-Psa3)		Ferrante & Scortichini, 2010, Vanneste *et al.*, 2011 ; Chapman *et al.*, 2011.
Presence of *hrp*W and *avr*D1 genes	PCR amplicons sequencing	Differences between Italian and Japanese strains (strains Psa1) and Italian (strains Psa2) (see legend) are confirmed										Gallelli *et al.*, 2011.

(+): Presence or identity between strains (-): Absence or difference between strains * cts: distinction is based on two bases of difference out of the 535 bases of the *cts* gene between Psa1 and Psa3. **Information in green (Vanneste, pers. comm., 2011).**

Definitions of populations:

Psa1 (Italy 1992 - Japan – 1984)	MA	Virulence is defined upon aggressiveness of the pathogen in the fields described in different countries where past and present epidemics of bacterial canker occurred and occur
Psa2 Korea Republic (1992-2006)	MA	
Psa3 (Italy 2008-2011 - France-Portugal-Spain 2010 – New Zealand (2010))	HA	
Psa4 New Zealand and Australia	LA	According to experience in NZ, LA strain is defined on the base of symptoms of only leaf spots (Chapman *et al.*, 2011)

Appendix 2. **Symptoms caused by *Pseudomonas syringae* pv. *actinidiae***

Season	Organ	Description of symptoms	Pictures
Spring (early)	**Leaf**	**Little dark brown spots with yellow halo on *A. deliciosa* (left) and *A. chinensis* (right)**	
Spring	**Leaf**	**Leaf spot with (left) and without (right) chlorotic halo on *A. chinensis***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Spring (late)	**Leaf**	**Leaf spots on upper (left) and lower (right) surface of A. *chinensis***	
Spring	**Canes**	**Wiltings on *A. chinensis***	

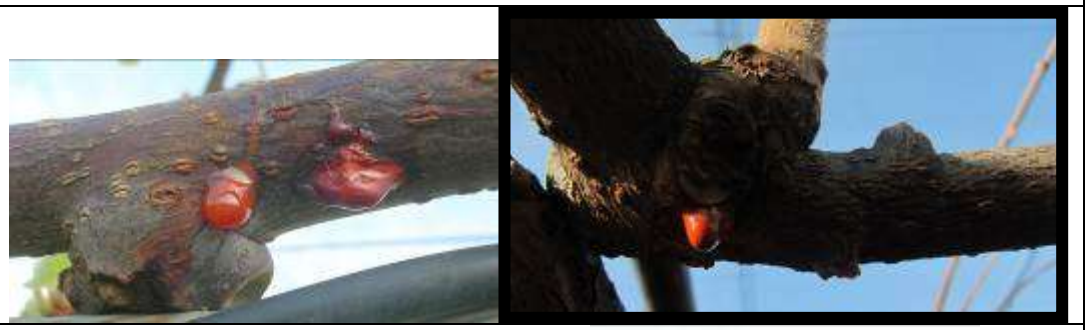
Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Spring	**Flower buds**	**Brownings of flower buds with exudate (left) and whole bud necrosis of *A. chinensis***	
Spring (blossoming)	**Flowers**	**Browning of sepals (left) and floral (right) tissues**	
Spring (early)	**Leader and young Trunk**	**White ooze exudating on *A. deliciosa***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Spring (early)	**Leader**	**Red exudate on *A. chinensis***	
Spring	**Twig and Leader**	**Browning and discolouration below bark on *A. chinensis***	
Summer	**Leader**	**Browning and discolouration below bark and reddening of lenticels on *A. chinensis***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Summer	**Cane**	**Wilting on *A. chinensis***	
Summer	**Leaf and Canes**	**Wilting and rolling of leaves on *A. chinensis***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Autumn	**Leader**	**Cankers with red exudates on *A. deliciosa* (left) and on *A. chinensis* (right)**	
Autumn	**Trunk and Leader**	**Canker with red exudates and reddening of lenticels on *A. chinensis***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Winter	**Whole plant**	**Cankers with red exudates on *A. chinensis***	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 2

Season	Organ	Description of symptoms	Pictures
Winter	**Trunk**	**External canker on *A. chinensis* (left) and brown discoloration on *A. deliciosa* (right)**	
Winter	**Leader**	**Cankers with red exudate on *A. deliciosa* (left) and on *A. chinensis* (right)**	

Pictures provided by Drs. G.M. Balestra (DAFNE – Università della Tuscia, Viterbo, Italy) and M. Scortichini (CRA Frutticoltura, Roma, Italy)

Appendix 3. Climatic prediction for *Pseudomonas syringae* pv. *actinidiae*

Document prepared in collaboration with Philippe Reynaud (ANSES, LSV, FR)

The CLIMEX model is a computer programme aiming at predicting the potential geographical distribution of an organism considering its climatic requirements. It is based on the hypothesis that climate is an essential factor for the establishment of a species in a country.

CLIMEX provides tools for predicting and mapping the potential distribution of an organism based on:

(a) climatic similarities between areas where the organism occurs and the areas under investigation (Match Index),
(b) a combination of the climate in the area where the organism occurs and the organism's climatic responses, obtained either by practical experimentation and research or through iterative use of CLIMEX (Ecoclimatic Index).

For this study, we used method b, by selecting values for a set of parameters that describe the response of PSA to temperature, moisture and climatic stresses.

1. Geographical distribution of the species

The global distribution of *Pseudomonas syringae* pv. *actinidiae* was assembled by ANSES (using available literature and CABI information). The locations are shown on the two maps below. *Please note that the authors were not aware of the outbreak in Spain when this climatic study was perfomed.*

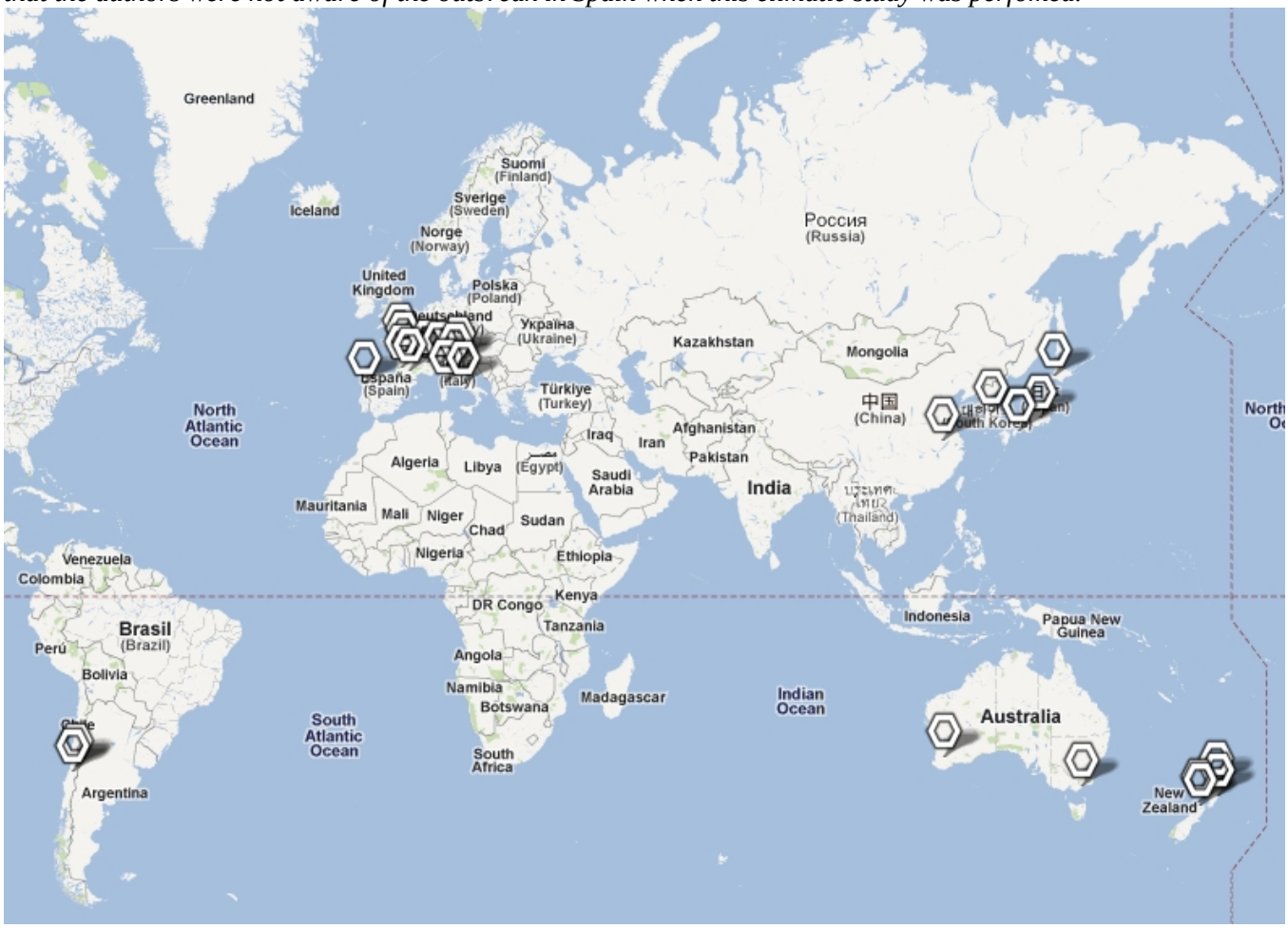


Fig 4. *Pseudomonas syringae* pv. *actinidiae* global distribution
(Source: Rivoal C & Poliakoff F, *pers. comm.* and CABI)

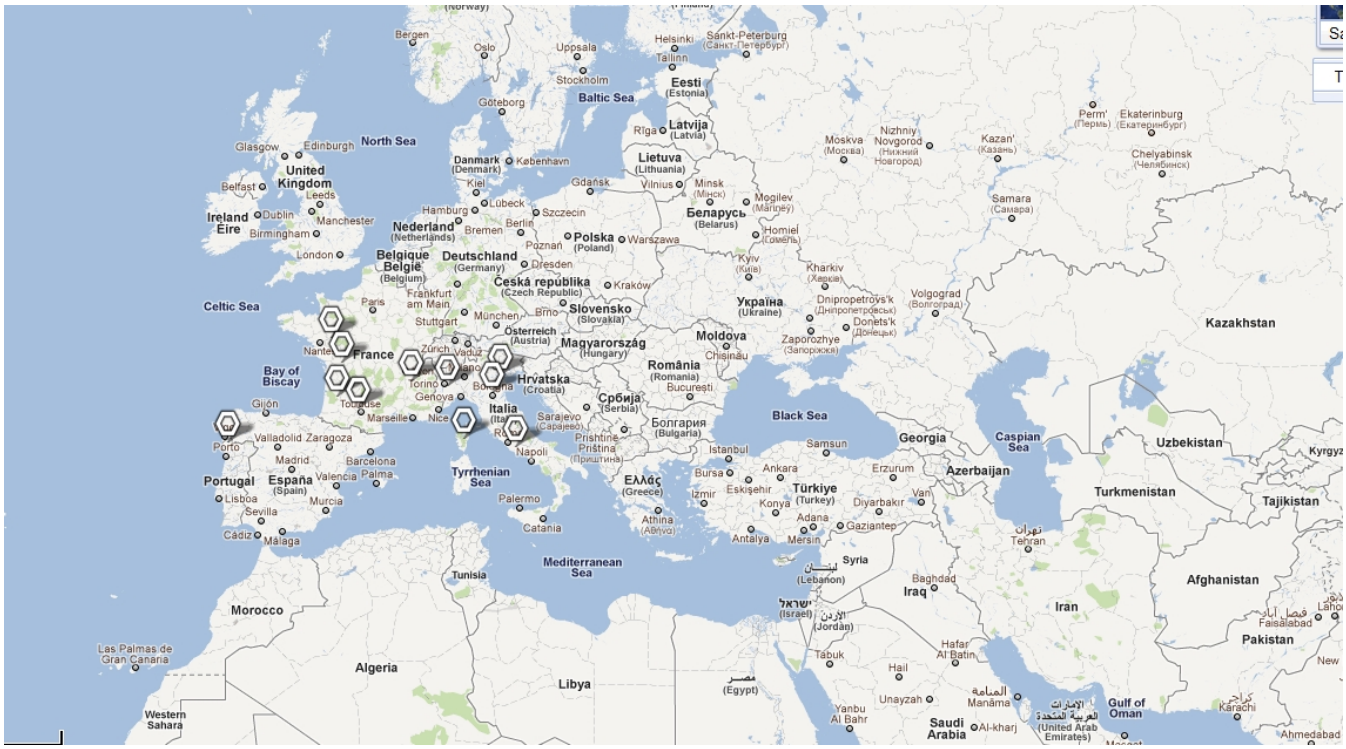


Fig 5. *Pseudomonas syringae* pv. *actinidiae* distribution in the PRA area
(Source: Rivoal C & Poliakoff F, *pers. comm.*, and CABI)

2 Selection of biological parameters

Biological parameters have been used to model the potential distribution of the pest. The Mediterranean template was chosen and then the CLIMEX parameter values were identified using the known biological characteristics (when available through scientific papers) and the current distribution of the disease (Fig 4).

The parameters used in the CLIMEX model for PSA are summarized below.

The moisture index

The moisture range SM0 - SM3 defines soil moisture levels that are suitable for population growth and development. The direct effect of soil moisture on *P. syringae* pv. *actinidiae* is not described in literature and the relationship between soil moisture and both rainfall and evaporation is complex. An iterative use of CLIMEX allowed us to estimate these parameter values with respect to the actual distribution of the pest. In the case of *P. syringae* pv. *actinidiae*, parameters were defined so that the moisture index is sufficiently large to not be limiting for *P. syringae* pv. *actinidiae*.

SM0	SM1	SM2	SM3
0.2	0.5	1.5	2.5

Temperature index

The Temperature Index (TI) describes the response of the species to the temperature. It varies between 0 and 1. Population growth is maximised when TI = 1, and is zero when TI = 0. Four parameters define the range of suitability for temperature. These parameters were first based on Serizawa & Ichikawa (1993d) and Serizawa et al. (1993b). Then parameters were adjusted according to the known distribution of the bacterium. These authors state that *P. syringae* pv. *actinidiae* has an optimum temperature of 12-18°C, temperatures above 20°C are less favorable to the bacterium and no symptom occur above 25°C.

DV0	DV1	DV2	DV3
10	20	25	30

Stresses indices

The stress indices in CLIMEX are set to limit the species' ability to survive during adverse seasonal conditions, and so determine its geographical distribution. Each stress index is associated with a stress

accumulation rate. The rate parameter determines how quickly the species accumulates stress when climatic conditions exceed the stress threshold.

Heat stress (not used)

Cold stress.

Cold Stress Temperature Threshold (average)	Cold Stress Temperature Rate (average)
2	-0.01

Cold stress can occur in three different ways: in the lethal temperature methods, stress occurs in response to excessively low temperatures (either minima or averages). In the degree-day method, stress occurs because the days are not warm enough to maintain metabolism. For *Pseudomonas syringae* pv. *actinidiae*, only the **Cold Stress Temperature Threshold** (Average) (TTCSA) was considered. This parameter represents the mean weekly average temperature below which Cold Stress accumulates (it was set to 2°c) and the **Cold Stress Temperature Rate** (Average) is the rate at which Cold Stress accumulates once average temperatures drop below the threshold value of TTCSA (here -0.01). The parameter was adjusted to fit with the known distribution of the pest.

Dry stress

SMDS	HDS
0.15	-0.02

Moisture can cause stress for a species when it is too dry. Dry Stress can only begin to accumulate once soil moisture drops below SM0 (0.2 in the case of PSA). The Dry Stress Threshold (SMDS) is set to 0.15 and the stress accumulation rate HDS (-0.02) is found to provide the best fit to the distribution data.

3 Results

The Annual Growth Index (GI), which is a combination of growth Indices (e.g. TI, Moisture Index MI) describes the potential for growth of the PSA population during the favourable season. Two stress indices (Cold and Dry) describe the extent to which the population is reduced during the unfavourable season. The Growth and Stress Indices are combined into an Ecoclimatic Index (EI), to give an overall measure of favourableness of the location or year for permanent occupation by the target species. The EI is mapped in Fig 6 to 8.

The areas estimated to be climatically suitable for *P. syringae* pv. *actinidiae* under current climatic conditions are illustrated for the world (see Fig 6). The model output properly reflects the current known distribution of the pathogen around the world. So we consider here that model parameters describe correctly the suitable climatic requirements of the bacterium.

This study shows that the climate is favorable for establishment of the *P. syringae* pv. *actinidiae* in several EPPO countries (see Fig 7) but the pest is clearly limited by cold stress in continental climates and by dryness in northern Africa areas (except along coasts). Other favorable areas include central Africa, Madagascar and east South America. But it's important to stress that CLIMEX only consider the effects of climate on the species. Therefore, the outputs should be interpreted with caution and knowledge on host distribution, competition with other species and human influences (such as effective control methods, irrigation…) on the environment where PSA may occur should be considered.

Ecoclimatic index for PSA from 1 to 100 (used in the maps below)
Index <5: no risk of risk of establishment
5<Index<30 high risk of establishment
Index>30 very high risk of establishment

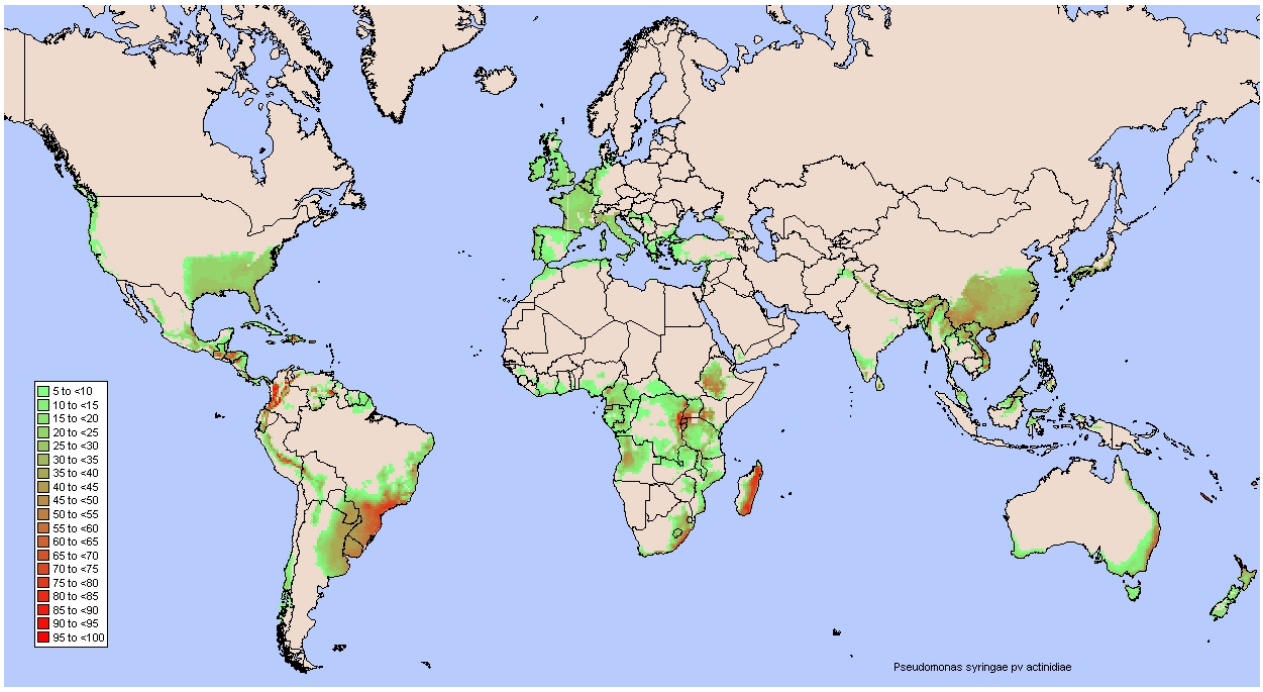


Fig 6. Potential geographical distribution of *P. syringae* pv. *actinidiae* worldwide as fitted by the CLIMEX model (Source : Anses)

Fig 7. Potential geographical distribution of *P. syringae* pv. *actinidiae* with a focus on the EPPO region (Source : Anses)

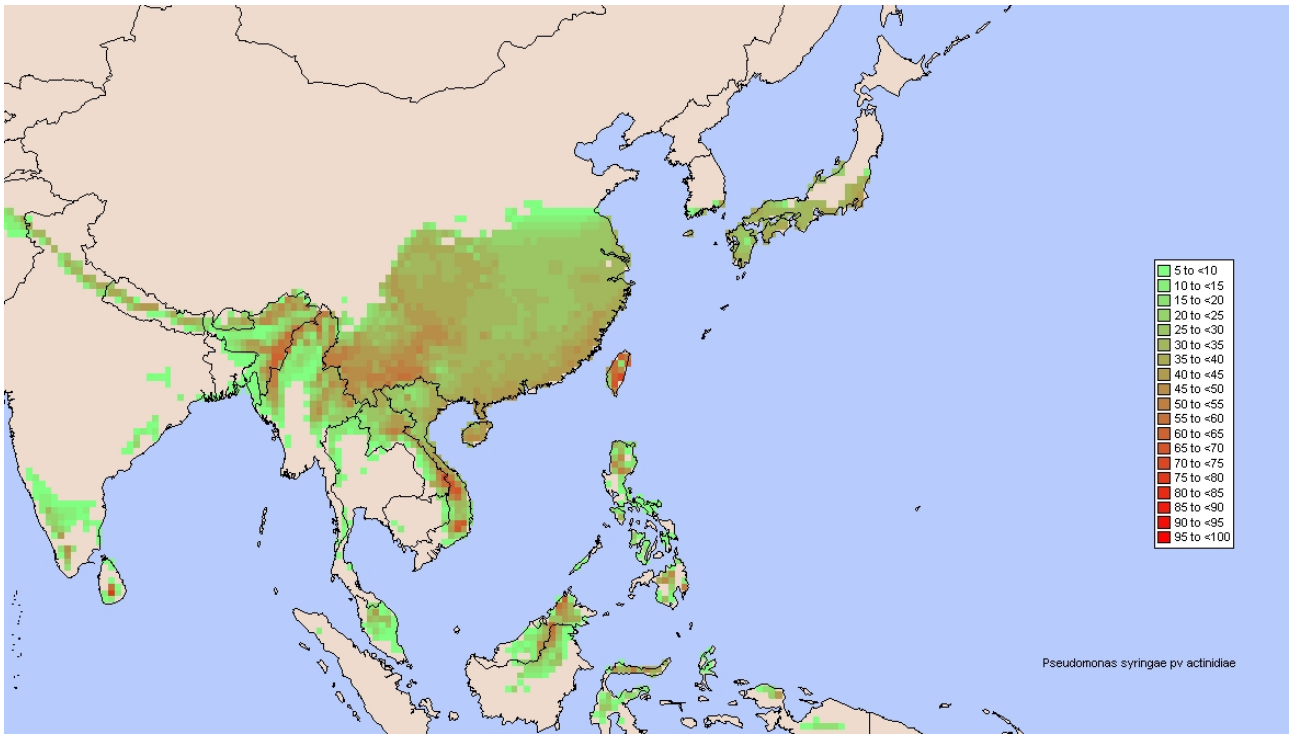


Fig 8. Potential geographical distribution of *P. syringae* pv. *actinidiae* with a focus on Asia (Source : Anses)

Appendix 4. Current phytosanitary requirements for *P. syringae* pv. *actinidiae* (Finelli, Holeva & Zioni, *pers. comm.,* 2011)

Country	Requirements	Import permit needed	Reference
USA	Fruits	Yes	FAVIR database (last accessed 2011-12-08)
	Plants for planting cannot be imported pending PRA.		APHIS website (Federal Order 10.11.2010)
Canada	Fruits: none Plants: none	No	Automated Import Reference System (AIRS) (last accessed 2011-12-08)
Colombia	Fruits free from *P. syringae* pv. *actinidiae* and *P. syringae* pv. *syringae*	Yes	Import Permit
Argentina	Fruits: none	Yes	Import Permit
	Plants: 0.5% of exported lot testing free Tissue culture: none		
Uruguay	Fruits: none	Yes	Import Permit
Russia, Belarus, Ukraine	Fruits: none	Yes	NPPO databases
Turkey	Fruits: none	No	EPPO website (last accessed 2011-12-08)
Israel	Tissue culture: mother plants tested free from *P. syringae* pv. *actinidiae* and grown under Post Entry Quarantine conditions	Yes	Import Permit
	Fruits: only allowed based on bilateral agreement	Yes	Zioni, Israeli NPPO, *pers. comm.*, 2011
South Africa	Fruits: none Tissue culture: Mother-plants tested free for *P. viridiflava*	Yes	Import Permit
China	Fruits: free from *P. syringae* pv. *actinidiae*, coming from registered orchards with IPM	Yes	Bilateral agreement NPPO database
India	Fruits: free from *P. syringae* pv. *actinidiae* and *P. viridiflava*	Yes	NPPO database (last accessed 2011-12-08)
	Plants for planting: not reported		
Vietnam	Fruits: none	No	Currently NPPO is asking for a dossier for PRA
Korea Republic	Fruits: free from *Pseudomonas savastanoi* pv. *savastanoi*		NPPO data base (Bilateral agreements)
Australia	Fruits: none	Yes (electronic)	ICON database
	Plants for planting: conditions under review	Yes	
New Zealand	Fruits: none	Yes (electronic)	NPPO data base (http://www.biosecurity.govt.nz/regs/imports/plants, Import Permit
	Tissue culture: Post Entry Quarantine for *P. syringae* pv. *actinidiae*	Yes	

Appendix 5

PEST RISK ANALYSIS FOR: PRA *Pseudomonas syringae* pv. *actinidiae*

The risk analysis was performed following the EPPO Decision support scheme for PRA PM 5/3(5) for the spread and the management section.

Stage 2: Pest Risk Assessment Section B: Probability of spread

4.01 - What is the most likely rate of spread by natural means (in the PRA area)?

moderate rate of spread

Level of uncertainty: medium

Data on the epidemiology of the disease is lacking but like other Pseudomonads, *Pseudomonas syringae* pv. *actinidiae* spread is ensured by plants for planting (except seeds), heavy rain, strong winds and animals (Balestra, 2010b). Spread within and between orchards can also be ensured through pruning equipment.

Only one publication gives indications for spread capacity. The study performed in Italy on the progression of the bacterium in an area with *A. chinensis* orchards (Vanneste *et al.* 2011b) indicates a dispersion capacity of around 10 km from the initial infected orchards between May 2009 and June 2010 (the authors note that Spring 2010 was characterized by cold wet weather and comment that the spread was rapid). The author considers that the spread noted can be attributed to natural spread and comment that with human spread the patterns would have been different with more jumps of the bacterium between distant orchards (Vanneste, *pers. comm.*, 2011). Spread is also possible in autumn and winter (Balestra & Scortichini, *pers. comm.*, 2011). (see Fig. 1 below).

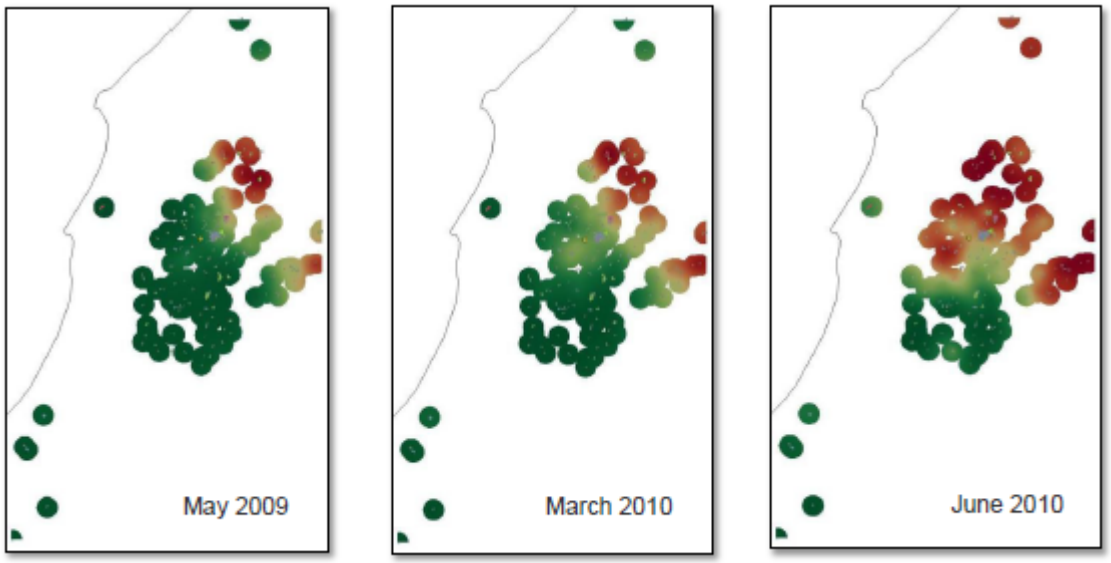


Fig. 1: Progression of *P. syringae* pv. *actinidiae* infections in Latina (Vanneste *et al.* 2011b, in press). Each circle has a radius that corresponds to 1km and red color corresponds to an infected area.

Wind and wind driven rain

The pathogen can be dispersed in aerosols and can be carried between trees and adjacent orchards in wind-driven rain. Serizawa *et al.* (1989) noted that the severely affected orchards were concentrated in areas where strong winds blow frequently. In Japan, the disease was not observed in orchards which were well protected with wind-hedges despite the fact that they were adjacent to severely affected orchards (Serizawa *et al.*,1989). However, in New Zealand infections are detected in orchards where high wind-edges (10-12 m) made with Cryptomeria are in place (Scortichini & Balestra, *pers. comm.*, 2011). Vanneste (*pers. comm.*, 2011) explained that these windbreaks are not dense enough compared to those in Korea Republic or Japan to prevent spread of the bacterium between orchards. In France and Italy, windbreaks are not very common (some were eliminated to facilitate access of the orchards to equipment and to reduce other bacterial problems in orchards as windbreaks favor humidity; Finelli & Picard, *pers. comm.*, 2011).

Insects (including pollinators)

Insects can carry the bacterium as demonstrated for other bacteria (Balestra, 2010b)

The importance of use of bee hives for kiwifruit pollination in the EPPO region varies depending on the areas. It is more important for organic production (Balestra, *pers. comm.*, 2011).

In the Australian PRA (Biosecurity Australia, 2011) it is mentioned that "*Pollinators may also spread pollen contaminated with P. syringae* pv. *actinidiae*."

Water

Some publication refer to the detection of *P. syringae* in surface water (Morris *et al.*, 2010), or clouds (Amato *et al*., 2006). No evidence of the presence of *P. syringae* pv. *actinidiae* in surface water or clouds exists. The implications of such finding for the spread of *P. syringae* pv. *actinidiae* was debated during the meeting. *P. syringae* pv. *actinidiae* is a pathovar of *P. syringae* that does not induce ice nucleation. The ability to induce ice nucleation could help the bacteria being carried down from the clouds by rain or snow. This ability is however independent of the ability of the bacteria to survive in clouds.
P. syringae pv. *actinidiae* has not been detected so far in water used for irrigation; however this is still being investigated.

4.02 - What is the most likely rate of spread by human assistance (in the PRA area)?

high rate of spread
Level of uncertainty: low

Plants for planting

Plants for planting of *Actinidia* spp. are the main pathway for long distance spread and are suspected to be at the origin of the outbreaks in France (EPPO, 2010), Spain (Cobos Suarez, *pers. comm.*, 2011) and Switzerland (NPPO, 2011). In Switzerland the bacterium was detected in a small commercial orchard which was planted in spring 2011. The plants were imported from Italy during winter 2011[5].

Equipment and tools

As a wound-infecting pathogen, it is easily transmitted with orchard equipment such as pruning equipment (Renzi *et al.* 2009b). Winter pruning practices using contaminated pruning shears have been shown to cause rapid spread of *P. syringae* pv. *actinidiae* (Koh *et al.*, 2010).

Pollen

Good pollination is important to increase fruit production; consequently artificial pollination is used in orchards. Samples of pollen have tested positive for *P. syringae* pv. *actinidiae*. Although it is acknowledged that such detection does not provide sufficient evidence to consider that pollen can spread the disease, such possibility cannot be excluded and more research is needed to clarify this issue.

4.03 - Describe the overall rate of spread

high rate of spread
Level of uncertainty: low

4.04 - What is your best estimate of the time needed for the pest to reach its maximum extent in the PRA area?

Level of uncertainty: medium

The EWG considered that 3 to 5 years are needed for the pest to reach its maximum extent in the PRA area (without any measures)

4.05 - Based on your responses to questions 4.01, 4.02, and 4.04 while taking into account any current presence of the pest, what proportion of the area of potential establishment do you expect to have been invaded by the organism after 5 years?

Level of uncertainty: medium

The entire area

[5] all plants were destroyed in early June 2011.

Stage 3: Pest Risk Management

Note: the EWG performed the management scheme based on available information on the spread capacity of the pest. The only publication available that gives an indication on spread capacity is Vanneste *et al.* (2011b). This publication is in press and a copy was provided to the EWG by the main author. The mean distance for annual spread that can be calculated based on this publication is circa 10 km per year and is considered by the author to correspond to only natural spread. This data was not available when the Italian emergency measures for *P. syringae* pv. *actinidiae* were elaborated. This explains that the recommended size of the buffer zones is different in the Italian emergency measures and those recommended in this express PRA.
The EWG considered that as all outbreaks recorded since 2008 in the PRA area correspond to an aggressive population, elimination of canes of plants on which early leaf spot is noted should be recommended. This is not recommended in the Italian decree nor is typing of the isolated pathogen. The EWG considered that this was important to determine the most suitable measures to be taken.
Regarding eradication measures in orchards or nurseries, elimination of the plants surrounding the infested plants (in at least a five meters radius) should also be recommended as the bacterium may be present on the neighbouring plants without showing symptoms (see biology).
Regarding greenhouses, a distance of 50 meters from kiwifruit orchards is recommended in the Italian emergency measures however this seems to be more a general recommendation than a measure specifically link to *P. syringae* pv. *actinidiae*.

7.01 - Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?

no

7.02 - Is natural spread one of the pathways?

Pseudomonads bacteria spread is ensured by heavy rain, strong winds and animals (Balestra, 2010b). However this mode of spread is more involved in local spread than spread over long distances (*i.e.* to new areas). Consequently it was not considered in the management section.

The pathways identified in the entry section and studied in this section are:

- **Pathway 1: Plants for planting of *Actinidia* spp (except seeds and tissue cultures)**
- **Pathway 2:Pollen**
- **Pathway 3:Tissue culture**

Pathway 1: Plants for planting of *Actinidia* spp (except seeds and tissue cultures)

Background information on kiwi-plant production (Finelli, pers. comm., 2011)

Ten years ago *A. deliciosa* plants were mainly propagated by cuttings and this mode still exists. Cuttings are collected in orchards where plants and fruits present good pomological characteristics.
Cuttings are grown for 2 years in open field nurseries and after that period, plants are ready to being marketed to professional growers. *A. deliciosa* cv. Hayward and its selections and clones (Green Light, Early Green, Tsechelidis) are not grafted on rootstocks.

In the last decade, tissue culture has gained importance. Explants are collected from plants in orchards. The plantlets produced in laboratories are transplanted in pots and kept in protected conditions first and under shadow nets later for a period of "hardening". The length of this period can range from 1 month in summer to 2 months in winter. At the end of such period, the plants can be placed in pots and traded mainly in the non-professional market or transplanted in open field nurseries to produce young plants for the professional market. This outdoor period lasts 1.5-2 years and each plant has a cane to support the vertical growth. In a field nursery there are from 30.000 up to 40.000 plants per hectare.
This propagation system is used for *A. deliciosa* (Hayward and its selections and clones), Summer and relevant pollinators, and for *A. chinensis* (cv. Soreli and Jin Tao, for the latter until 2010)

Until recently, only *A. chinensis* cv. Hort 16 A was grafted on Hayward as a rootstock. The wooden graft was made in January or half-wooden graft in May.

Hayward rootstoks are mainly produced by micropropagation but nearly 30% is produced with cuttings. The starting material is collected in orchards. *A. chinensis* cv. Jin Tao is now also about to be grafted on Hayward.

7.06 - Is the pathway that is being considered a commodity of plants and plant products?

yes

7.09 - If the pest is a plant, is it the commodity itself?

no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)

no

Level of uncertainty: **low**

There are no pest specific requirements for plants for planting in the legislation of EPPO Countries with a legislation aligned to the EU requirements (Plant Health Directive 2000/29). Regarding Israel an import permit is required and the plant must be grown under post-entry quarantine conditions (NPPO of Israel, 2009).
Emergency measures for preventing, controlling or eradicating the bacterial canker of actinidia, caused by *Pseudomonas syringae* pv. *actinidiae* have been adopted in Italy since March 2011

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production?

yes in a Systems Approach

Level of uncertainty: **low**

Possible measure: **Visual inspection at the place of production**

In nurseries visual inspection performed in early spring may allow the detection of small cankers on older kiwi plants for planting but these are not easy to spot. Later in spring symptoms may be observed on leaves (polygonal /circular spots with or without halo). However, the bacteria can also be present in the plant before symptoms appear (Vanneste *et al.* 2011a). No description of symptoms in young plants in nurseries is available but these are not expected to be different to the ones already described.

As symptoms are not specific for the disease, laboratory testing is necessary to confirm the presence of the pest.

In nurseries, inspections should be carried out once a month during winter and every second week during spring, as well as when conditions are conducive to the disease (wet periods). The minimum period during which such inspections should be carried out is one year before dispatch. Although it has been mentioned in Koh & Nou 2002 and in a publication (KiwiTech bulletin N°68) that the "*the bacterium appears to be able be present dormant in plant material for several years without causing symptoms*" no study has been published so far to support this statement in particular regarding the length of latency. Mr Vanneste (*pers. comm.*, 2011) confirmed that his experience is that an infected plant will show symptoms within one year maximum.

Comment on uncertainty:
The level of uncertainty of the answer is considered to be low as it is certain that inspection alone is not sufficient.

7.14 - Can the pest be reliably detected by testing at the place of production?

yes in a Systems Approach

Level of uncertainty: **medium**

Possible measure: **specified testing at the place of production**

Testing of plant material is possible and different methods have been developed to detect and identify the pest including molecular methods which can be used on asymptomatic material as well (an EPPO Diagnostic Protocol is under development and should be sent for country consultation in 2012).

Recommendations on sample size:
The number of plants to be tested should be determined. Sample size should be established following the guidance provided by ISPM n° 31 (a decision on the detection level and on the confidence level requested needs to be made).
There is uncertainty on the distribution of the pest in the plant (which part of the plant should be sampled).

The EWG recommended that the plants should be tested at least once during the period when plants are present in the nursery. The test may be performed before their dispatch a test earlier in the season may allow an early detection. When an additional test is performed, it should be done during the first dormancy period of the plants.

When sampling is performed during the dormancy period of the plants, 3 buds should be taken per plant.

The uncertainty is considered medium due to the possible sampling difficulty.

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?

yes in a Systems Approach
Level of uncertainty: **low**
Possible measure: **specified treatment of the crop**

No curative treatments are available for kiwi bacterial canker. Preventive copper treatments are performed in orchards to prevent infection (when allowed during the growing period on kiwifruit plants). If allowed they can be used in nurseries as well but should be combined with visual inspection and testing. It should be noted that in orchards, excessive use of copper compounds during spring can induce phytotoxicity on the leaves (Scortichini, *pers. comm.*, 2011).

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?

no
Level of uncertainty: **low**

There are scientific reports on the existence of *P. syringae* pv. *actinidiae* resistant germoplasm in China (Li *et al*., 2004, 2005a & b) see below, but no genetic sources of resistance are available for the most common cultivars in Europe.

Actinidia chinensis 'Jinkui', 'Zhonghua Soft' and 'Meiwei Hard' were highly resistant (Li *et al.* 2004).
A. chinensis 'Jinkui' is resistant (Li *et al.* 2005a). The resistance mechanisms were investigated. The density of lenticels in the branches and of stoma on leaves was greater in susceptible cultivars. The length and width of leaves on susceptible cultivars were also greater (Li *et al.* 2005b). 'Huayou', a cross between *A. chinensis* and *A. deliciosa*, has high resistance to kiwifruit bacterial canker (Wang *et al.* 2008).

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?

yes in a Systems Approach
Level of uncertainty: **low**
Possible measure: **specified growing conditions of the crop**

In an area not free from *P. syringae* pv. *actinidiae*, physical isolation can prevent infection of the plants for planting but additional measures will be needed. The following conditions should be met:

Most measures described below are part of the requirements for citrus nursery stock production established in Florida for Citrus nurseries against Xanthomonas axonopodis pv. *citri.* The conditions were considered by the EWG as appropriate for *P. syringae* pv. *actinidiae*

- Production should start from plants for planting free from *P. syringae* pv. *actinidiae* (cuttings or micro propagated material)
- Protection should be ensured from wind driven rain, hail storms and insects *i.e.* plants should be

grown in greenhouses with enclosed sides and tops built to exclude insects, positive pressure and double door. The site should incorporate natural or artificial windbreaks that would reduce wind driven rain and the site should be fenced and all entrance secured.
- Control of persons entering the greenhouse/site should be established
- Appropriate disinfection of equipment and shoes should be ensured.
- Testing of the plants at least once during the production period.

In order to compensate for possible failures in these measures, preventive treatments should be applied (when allowed see question 7.15) and the glasshouse should be located at minimum distance from a kiwifruit orchard to be determined based on local circumstances (in the Florida requirements for Citrus nurseries the distance if of 1.6 km).

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?

no

Level of uncertainty: **low**

Not relevant

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?

yes in a Systems Approach

Level of uncertainty: **low**

No scheme for the production of healthy plant for planting of *Actinidia* sp. exists so far. A draft scheme is being prepared in Italy. A certification scheme should include the requirement that the plants should be produced under protected conditions (see question 7.17) or produced in a pest free area or a pest free place of production (see question 7.21).
As such scheme does not exist so far this is not considered further.

Note: it was not possible to prepare an EPPO scheme for the production of healthy planting material during the EWG as originally envisaged. A first draft is in preparation in consultation with Italian experts.

7.20 – Rate of natural spread

Moderate rate of spread

Level of uncertainty: **medium**

Possible measure: **pest-free place of production or pest free area**

7.21 - The possible measure is: pest-free place of production or pest free area

yes

Level of uncertainty: **medium**

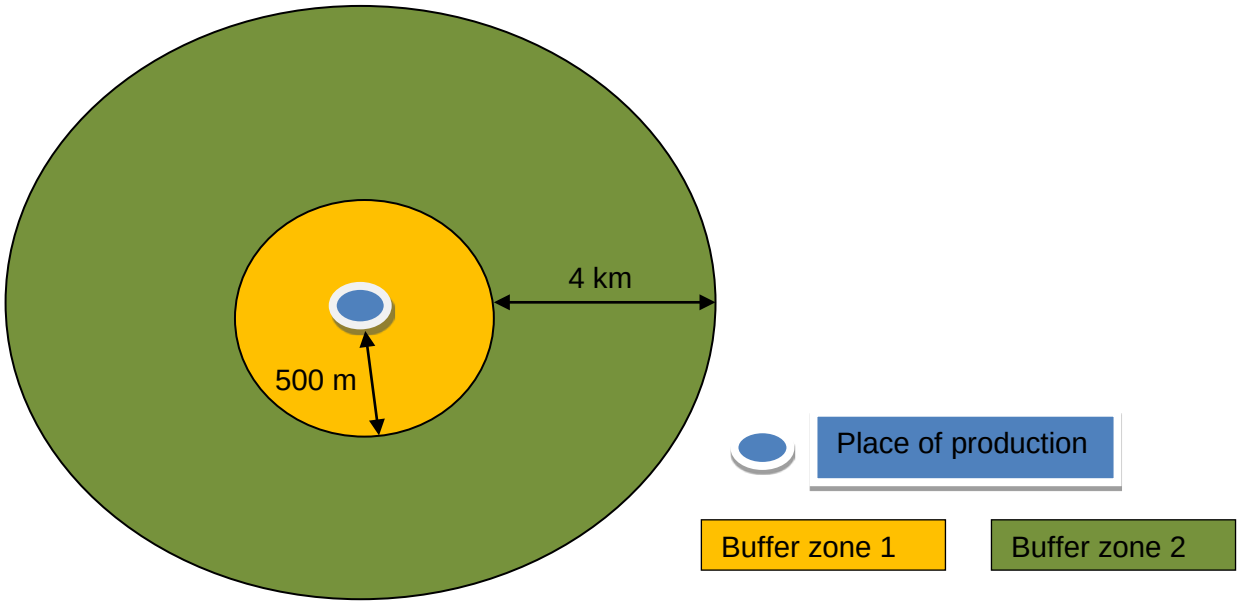
Pest free place of production

A pest free place of production can be a place of production under protected conditions (see question 7.17). In the absence of protected conditions the distance of the place of production from the nearest outbreak of *P. syringae* pv. *actinidiae* should be at minimum 10 km (see question 4.01) and eradication measures should be implemented in the outbreak area.

Establishment and maintenance of the pest free place of production

The measures proposed by the EWG are based on measures in place in the countries of the European Union for another bacterial pathogen, *Erwinia amylovora* (for plants that are intended to be moved to a protected zone *i.e.* the equivalent of a pest free area). However it should be noted that differences may exist between the two pathogens. In particular a comparison of the survival period of *E. amylovora* and *P. syringae* pv. *actinidiae* on *e.g.* leaves, flowers, twigs cannot been made due to lack of data. This is an important element to consider to evaluate whether the measures recommended for *E. amylovora* are appropriate for *P. syringae* pv. *actinidiae*. As some experts consider that *P. syringae* pv. *actinidiae* may be able to survive for a longer period on the plant surface than *E. amylovora* the measures have been adapted in particular when infected plants are detected in the buffer zone of 500 meters, the place cannot be considered free from *P. syringae* pv. *actinidiae* to provide a better security, the measures have consequently been adapted, in particular the measures recommended for *P. syringae* pv. *actinidiae* are similar those recommended for plants for planting of *E. amylovora* host plants intended to be moved to *E. amylovora* protected zones but with stricter measures to be implemented when an outbreak is found in the

different buffer zones. The plants should have been produced in a place of production surrounded by two types of buffer zones



The place of production should be defined as follows:
Production should start from plants for planting (cuttings or micro propagated material) free from *P. syringae* pv. *actinidiae* (i.e. produced in a pest-free area or a pest-free place of production).

The plants produced in the place of production should be inspected once a month during winter and every second week during spring as well as when conditions are conducive to the disease (wet periods). The minimum period during which such inspections should have been carried out before dispatch is one year. For the period during which the plants are present in the nursery the plants should be tested at least once even in the absence of suspicious symptoms. This test should be done before dispatch. When another test is performed, it should be done during the first dormancy period and the other one. Preventive copper treatments should be applied during period conducive to the disease.
The company should have requirements in place regarding disinfection of tools, vehicles and equipment on the premise.

Buffer zone 1
A first buffer zone of 500 m radius should be established around the place of production where there should be:

- either no *Actinidia* plants or
- the hosts plants in the buffer zone should be inspected and tested at the same frequency than the place of production.

The pest free place of production status is maintained as long as no infected plants are confirmed in the place of production and the first buffer zone. If the pest is detected in these zones, the plants for planting cannot be certified free from *P. syringae* pv. *actinidiae*. Eradication measures should be implemented as soon as possible and all infested plants eliminated. Investigations should be conducted on the origin of the infection. No plants of kiwifruit should be grown on the site for at least one complete cycle of vegetation of Kiwi plants. Reinstatement of a place of production can only be allowed after a period which should correspond at least one complete cycle of vegetation of Kiwi plants provided that no infected plants are detected in the first buffer zone and eradication measures are implemented in the case of an outbreak in the second buffer zone (see below)

Buffer zone 2
A second buffer zone of 4 km radius should be established around the first buffer zone and inspections should be carried out in winter, spring and autumn to detect the possible presence of the bacterium. All plants showing symptoms of *P. syringae* pv. *actinidiae* and confirmed positive should be destroyed and measures described in Appendix 6 are implemented.

Pest-free area (PFA)
PFA established in a country where P. syringae *pv.* actinidiae *is present.*
System to establish freedom
To establish an area free from *P. syringae* pv. *actinidiae*, specific surveys should be carried out in kiwifruit orchards (surveys should include sampling of asymptomatic plants as well). Orchards should be selected based on their age (at the time of preparation of the PRA plantations of 2 to 6 years seem to be more attacked), geographical representativity (to be representative of the entire area to be declared as a PFA).
In areas where geographic isolation is not considered adequate to prevent introduction to or reinfestation of the PFA a buffer zone should be established. Factors that should be considered in the establishment and effectiveness of a buffer zone include: host availability, climatic conditions, the geography of the area, -capacity for natural spread (see question and human mediated spread and the ability to implement a system to monitor the effectiveness of buffer zone (e.g. surveillance system). At the EWG a recommendation to establish a buffer zone of 50 km radius (corresponding to 5 times the mean 10 km spread) was made and specific surveys should be conducted in this zone following the same principle as described above.
Inspections should be carried out in winter, spring and autumn (for symptomatology refer to Appendix 2)
Inspections carried out should be documented and a work plan established.

Phytosanitary measures to maintain freedom
The establishment of a new orchard in the PFA area and in the buffer zone should be declared to the NPPO.
All plants planted in the PFA (including the buffer zone) should be guaranteed free from *P. syringae* pv. *actinidiae* and information on the origin of the plant should be recorded.
Information should be provided to the general public so that plants planted in gardens fulfil the same requirements than those to be planted in orchards.
Measures should be documented.
Preventive treatments should be carried out in the orchards (when allowed).

System to verify that freedom is maintained
Specific surveys should be carried out annually in the PFA and the buffer zone following the same principle as mentioned above.
Inspections carried out should be documented and a work plan established.

PFA established in a country where P. syringae *pv.* actinidiae *is absent*
The same requirements as above apply. If the country is near to a country where the pest is present the size of the PFA may be reduced to take into account the necessity of a buffer zone of 50 km radius from the nearest place where the pest is present. Exchange of information between neighbouring countries is in such case necessary.

The level of uncertainty was considered as medium as the measures are determined based on measures for another similar pest.

Options at harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

yes in a Systems Approach
Level of uncertainty: **low**

Latent infection will not be detected

7.23 - Can the pest be reliably detected by testing of the commodity (*e.g.* for pest plant, seeds in a consignment)?

yes in a Systems Approach
Level of uncertainty: **medium**
Possible measure: **specified testing of the consignment**
If combined with inspection during growing season a testing is recommended before dispatch. For general comments on sampling please see question 7.14.

The uncertainty is considered medium due to the possible sampling difficulty.

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

no
Level of uncertainty: **low**

No curative treatment is available.

Biosecurity Australia (2011) recommends that cuttings should be submitted to a hot water treatment at 50°C for 30 min. However, no reference on the efficacy of such treatment is available nor information on the plant response.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?

no
Level of uncertainty: **low**

Not relevant

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?

yes in a Systems Approach
Level of uncertainty: **low**
Possible measure specific handling/packing methods

When the nursery is located in an area where the pest is present, the EWG considered that it was necessary to ensure that packing of plants should be done without contacts with plants not produced in the same site of production. The packing and transfer should also be conducted such as to avoid exposure of plants to potential external infection (i.e. plants packed and loaded in closed premises and vehicles to avoid infection).

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?

yes
Level of uncertainty: **low**

Possible measure: import of the consignment under special licence/permit and post-entry quarantine
The post entry quarantine should last one year to allow symptoms to appear (see comment on the fact that one year is sufficient in question 7.13).

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?

no
Level of uncertainty: **low**

Planting is the intended use; no limitations can be envisaged.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?

no
Level of uncertainty: **low**

The measures that could be taken in the importing country are regular surveys of the orchards to detect possible infected sites at an early stage. In case of detection of an outbreak, destruction of plants should be implemented very quickly upon detection confirmation (see Appendix 6 for the measures to be implemented in orchards). However relying only on this measure will not be effective.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

The following measures have been identified:

Q.	Standalone	In a Systems Approach	Possible Measure	Uncertainty
7.13		X	visual inspection at the place of production.	low
7.14		X	specified testing at the place of production.	medium
7.15		X	specified treatment of the crop.	low
7.17		X	specified growing conditions of the crop.	low
7.20		X	pest-free place of production or pest free area.	medium
7.23		X	specified testing of the consignment.	medium
7.26		X	specific handling/packing methods.	low
7.27	X		import of the consignment under special licence/permit and post-entry quarantine.	low

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?

no

Level of uncertainty: **medium**

7.32 - For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level?

yes

Level of uncertainty: **medium**

Some measures should be combined *i.e.* visual inspection, testing at the place of production and before dispatch, preventive treatments. Most contribute to the designation of a pest free place of production.

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

Level of uncertainty: **medium**

Specific data is lacking but in the EPPO region there seem to be few nurseries producing kiwifruit plants for planting (Finelli and Picard, *pers. comm.*, 2011). The impact will be important at individual nursery level but globally the impact is likely to be low.

There is little detailed information on the production of ornamental species of *Actinidia* spp.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

Level of uncertainty: **low**

At the national level of countries it seems that measures implemented for the production (or importation) of healthy plants for planting will be more cost effective than supporting costs for eradication or elimination of infected plants.

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?

yes

Possible Measures:

- Pest free area
- Pest free place of production (protected conditions or conditions as defined in question 7.21).
+ specific handling/packing methods.
- Import of the consignment under special licence/permit and post-entry quarantine.

Pathway 2: Pollen

7.06 - Is the pathway that is being considered a commodity of plants and plant products?

yes

7.09 - If the pest is a plant, is it the commodity itself?

no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)

no

Level of uncertainty: **low**

No specific requirements are in place for kiwifruit pollen used in orchards or pollination in EPPO countries.

7.13 - Can the pest be reliably detected by visual inspection at the place of production (if the answer is yes specify the period and if possible appropriate frequency, if only certain stages of the pest can be detected answer yes as the measure could be considered in combination with other measures in a Systems Approach)?

yes in a Systems Approach

Level of uncertainty: **low**

Possible measure: **Visual inspection at the place of production**

Visual inspection of plants at the orchards where pollen is collected should be conducted. The bacterium can be detected in the orchard but latent infection could occur. The inspections should be carried out at the end of winter and until pollen is collected every 10 days. No symptom should have been seen on the plants in the place of production since the preceding growing period.
Combination of this measure with a test of pollen is recommended.

7.14 - Can the pest be reliably detected by testing at the place of production? (if only certain stages of the pest can be detected by testing answer yes as the measure could be considered in combination with other measures in a Systems Approach)

Testing of the harvested pollen is considered under question 7.23

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?

yes in a Systems Approach

Level of uncertainty: **low**

Possible measure

Specified treatment of the crop

Preventive treatments of the orchard is possible when allowed (see 7.15 previous pathway).

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars? (This question is not relevant for pest plants)

no

Level of uncertainty: **low**

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?

yes in a Systems Approach

Level of uncertainty: **medium**

Possible measure

Specified growing conditions of the crop (see question 7.17 for the first pathway)
Growing plants under protected conditions for the production of pollen is possible but no information is available on whether this is economic.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?

no

Level of uncertainty: **low**

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?

yes in a Systems Approach
Level of uncertainty: **low**

Same comment as previous pathway

No scheme for the production of healthy plant for planting of *Actinidia* sp. exists so far. A draft scheme is being prepared in Italy. A certification scheme should include the requirement that the plants should be produced under protected conditions (see question 7.17) or produced in a pest free area or a pest free place of production (see question 7.21).
As such scheme does not exist so far this is not considered further.

7.20 - Based on your answer to question 4.01 (moderate rate of spread with medium uncertainty), select the rate of spread.

moderate rate of spread
Level of uncertainty: **medium**
Possible measure: **pest-free place of production or pest free area.**

The same conditions as recommended for plants for planting should be applied.

7.21 - The possible measure is: pest-free place of production or pest free area
Can this be reliably guaranteed?

yes
Level of uncertainty: **medium**

See conditions as recommended for the previous pathway.

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

no
Level of uncertainty: **low**

No symptoms on pollen.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?

yes in a Systems Approach
Level of uncertainty: **low**
Possible measure: **Specified testing of the consignment**

Tests are available

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

no
Level of uncertainty: **low**

No data is available at the moment for the hot treatment of commercial lots of pollen.
Trial research conducted by Plant & Food Research has confirmed that exposing *P. syringae* pv. *actinidiae* to certain temperature-time combinations is an effective way of killing *P. syringae* pv. *actinidiae* while maintaining the viability of the pollen. Research is still ongoing. But press releases indicate the following time/duration combination: 45 °C for 30 mn.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment? (This question is not relevant for pest plants)

no
Level of uncertainty: **low**

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?

no
Level of uncertainty: **low**

7.27 - Can the pest be reliably detected during post-entry quarantine?

no

Level of uncertainty: **low**

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?

no

Level of uncertainty: **low**

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?

no

Level of uncertainty: **low**

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.13		X	visual inspection at the place of production	low
7.15		X	specified treatment of the crop	low
7.17		X	specified growing conditions of the crop	medium
7.20		X	pest-free place of production or pest free area	medium
7.23		X	specified testing of the consignment	low

yes

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?

no

Level of uncertainty: **low**

7.32 - For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level?

yes

Level of uncertainty: **low**

Some measures should be combined i.e. visual inspection, preventive treatments in the orchard, testing at harvest, but most contribute to the designation of a pest free place of production for pollen.

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

Level of uncertainty: **low**

So far pollen has not been subjected to any requirements so there will be an impact on its trade

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

Level of uncertainty: **high**

If pollen is confirmed as a pathway the measures will be cost effective at the level of the importing countries.

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?

Yes
See below

Possible Measures:

- Pest free area
- Pest free place of production (protected conditions or conditions as defined in question 7.21 first pathway).

Pathway 3: Tissue cultures

Tissue culture should be produced from healthy mother plants and which are grown in a pest free area or a pest free place of production and individually tested. For the conditions for protected conditions and pest free places of production, see pathway 1.

Appendix 6. Measures recommended upon a finding of an outbreak in orchards and in buffer zones around places of production of plants for planting and pollen

General measures: all equipment should be disinfected, infected material should be appropriately handled and preferably destroyed onsite. To apply all routine hygiene measures

Suspected symptoms of *P. syringae* pv. *actinidiae*

Identification up to population level

Early leaf spot only and identification of the aggressive population
Or
identification of the less aggressive population

yes

Cut cane to the leader
Check vessels for absence of brownish coloration
Disinfect the cut and tools before and after each plant.

Increased surveillance of the orchard

New symptoms
Aggressive population

no

Leaf spots and wilting
or
Cane wilting
or
cane dieback
or
Exudate
or
Twig canker

In the infected orchard

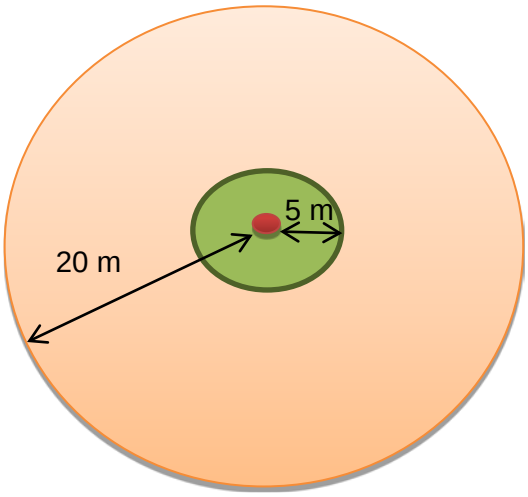
Uprooting of the infected plants and of other plants situated in at least 5 m radius around each infected plant

For all plants located within at least 20 m from the infected plant, cut canes to the leader
Disinfect the cut and tools before and after each plant.

Increased surveillance of the orchard

Preventive treatments

No replanting before the new growing period and disinfection of soil (for remaining roots)



In orchards located in at least 10 km radius around the infected orchard

Cut canes to the leader (in particular 2 to 4 year old organs) after harvest.