Plant Protection Service
Ministry of Economic Affairs, Agriculture and Innovation

Pest Risk Analysis for *Plum pox virus*

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Plant Protection Service
Ministry of *Economic Affairs, Agriculture and Innovation*
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Version: 3.0
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Version	3.0
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Changes made on version 1.0 (January 2011)	Removed incorrect record of PPV-W in Lithuania
Changes made on version 2.0 (April 2011)	Included: - recent information on the distribution of PPV particularly PPV-W and PPV-C - additonal information on PPV in cherry trees - more information on vector control and resistant cultivars - information on the transgenic plum cultivar HoneySweet - results from SharCo EU FP7 project on the implemention of the current EU-legislation - new updated information on French national measures - editorials
Organism	*Plum pox virus* (Potiviridae - Potyvirus)
Common name	PPV (acronym) Sharka, Plum pox (English) Variole du prunier, sharka (French) Scharka-Krankheit (German) Vaiolatura delle drupacee (Italian) Viruela del ciruelo (Spanish)
Quarantine status	Europe: EU: IIAII (Council Directive 2000/29/EC) Russia, Turkey, Ukraine Africa East Africa Southern Africa America Argentina Brazil Canada Chile Paraguay United States of America Uruguay Oceania New Zealand (source : EPPO PQR database version 4.6 ; available at http://www.eppo.org/DATABASES/databases.htm)
PRA area	European Union (EU)
Assessors	Ineke Wijkamp & Dirk Jan van der Gaag
Acknowledgements	The authors would like to thank Mr. M. Cambra, Mr. J. Polák, Mr. A. Werkman and Mr. R. Potting for many useful comments and suggestions on a draft version of this PRA.

Table of contents

1. Introduction

Plum pox virus (PPV) is listed as a IIAII quarantine pest in the EU (European Council Directive 2000/29/EC). It is regulated for "Plants of *Prunus* L. susceptible to *Plum pox virus*, intended for planting, other than seeds". The European Council Directive 2000/29/EC includes specific requirements for plants for planting originating from areas where the pest is present to guarantee pest freedom of the crop (Annex IV, PART A, Section I, article 23 for plants originating outside the community and Section II, point 16 for plants originating within the Community) (Appendix III in the present PRA). Despite these requirements, infected plants are intercepted on a regular basis by member states which indicate that the current legislation cannot prevent spread of PPV (completely) within the EU. PPV originates from eastern Europe and is nowadays present in many EU-countries. PPV is naturally transmitted by aphids wich can make it difficult to implement the current EU-requirements for plants intended for planting. Also, an increased use of host plant cultivars that have some degree of tolerance to the disease increases the risk of spread of the disease by movement of infected planting material. On the other hand, the existing requirements for *Prunus* host plants intended for planting can have a large impact for growers since they are not allowed to trade any *Prunus* host plants for at least three growing seasons after the finding of an infection even if it only includes a single plant. These strict measures can be difficult to explain when the pest is already present in a country and (fairly) widespread.

Scope of the document

This PRA gives an overview of the pest status of PPV in Europe, its distribution, impact and control measures applied. The document discusses present and potential control measures. In particular, it is examined whether the current measures as formulated in Annex IV of Council Directive 2000/29/EC may be considered for adaptation.

Pest Risk Analyses are usually made for pests that are non-native to the PRA area and/or which has a limited distribution in the PRA area. However, *Plum pox virus* (PPV) is native to Europe and is already present in a large part of Europe. Hence, spread within Europe by natural means and human activities is the most important pathway by which the virus can spread to areas in Europe which are not (yet) infested. For these reasons, the present document focuses on the situation in Europe: the pest status in the different EU-countries, the probability of spread within the EU, its impact and options to manage the disease. The PRA doest not assess the probability of establishment since PPV is already (fairly) widespread in Europe including both southern, western, eastern en northern countries and PPV is most likely able to establish in any region where host plants are growing.

The probability of spread and entry and the magnitude of impact were rated according to a 3-level scale (low, medium, high) as well as the level of uncertainty.

2. Pest Risk Assessment

Identity of the pest

Name:	Plum pox virus
Synonyms:	Sharka virus
Taxonomic position:	Viruses: Potyviridae: *Potyvirus*
Common names:	PPV (acronym)
	Sharka, plum pox (English)
	Variole du prunier, sharka (French)
	Scharka-Krankheit (German)
	Vaiolatura delle drupacee (Italian)
	Viruela del ciruelo (Spanish)

Taken over from: EPPO datasheet (Anonymous, 1997).

Several strains or subgroups are recognized and classification is based on biology, serology and molecular properties. The two most commonest strains are designated PPV-D and PPV-M (discussed in more detail in the paragraph "Virus strains").

Host range

PPV infects many species of *Prunus* L.. Main hosts are the fruit-producing species of *Prunus*, including apricots (*Prunus armeniaca* L.), peaches (*Prunus persica* (L.) Batsch), nectarines (*Prunus persica* (L.) Batsch var. *nucipersica* (Suckow) C.K.Schneid) and plums (*Prunus domestica* L. and *Prunus salicina* Lindl.) (Anonymous, 1997). Natural infections of cherry isolates of PPV (PPV-C) that spread systemically in the host have been found in sour cherry (*Prunus cerasus* L.) (Nemchinov *et al.,* 1996) and in sweet cherry (*Prunus avium* L.) (Crescenzi *et al.,* 1997). Almonds (*Prunus dulcis* L.) can be infected by PPV but show few symptoms (Festic, 1978, Damsteegt *et al.,* 2007). Next to fruit-producing *Prunus* species, PPV infects many wild or ornamental species of *Prunus* (James & Thompson, 2006; Polák, 2006; Damsteegt *et al.,* 2007; Kalinina *et al.*, 2007; Polák & Kominek, 2009). Damsteegt *et al.,* (2007) showed that 31 out of 33 *Prunus* species and cultivars were systemically infected following aphid transmission with an U.S. isolate of PPV-D and that following grafting of PPV-infected budwood, all 40 species and varieties became infected, although species differed in their susceptibility. They concluded that a wide range of native and ornamental *Prunus* species are susceptible to the U.S. isolates of PPV-D.

Infected *Prunus* plants growing in the wild, along roads or in urban areas may act as a reservoir for stone fruits. *Prunus domestica* growing along roads but also *P. spinosa* L. (blackthorn) and *P. cerasifera* Ehrh. var. *myrobalana* (myrobalan) are for example considered important sources of infection for stone fruit orchards in Czech Republic (Polák, 1997; Polák & Komínek, 2009). The role of *P. spinosa* and other wild *Prunus* species as a natural reservoir may not be conclusive since the presence of infected plants near contaminated orchards does not necessarily mean that these plants act as a source of inoculum. In France, infected *P. spinosa* plants have been found in the vicinity of highly contaminated peach orchards but Labonne & Dallot (2006) considered their role as natural reservoir for Sharka epidemics as unclear and probably negligible. Damsteegt *et al.* (2007) demonstrated experimentally aphid transmission of PPV (North American PPV-D isolate) from 26 out of 28 *Prunus* species and cultivars tested to peach seedlings, including *P. spinosa* and *P. cerasifera*. These results indicate that wild and ornamental *Prunus* spp. can act as a PPV-reservoir for stone fruit orchards.

In addition to *Prunus* species, a large number of herbaceaous species have been shown to be susceptible to PPV such as *Trifolium repens, Trifolium pratense, Lepidium sativum* and *Zinnia elegans* (Brunt *et al.,* 1996; Wang *et al*., 2006; Manachini *et al.,* 2007). It has also been reported that some woody non-*Prunus* species, *Ligustrum vulgare* L., *Euonymus europaeus* L. (Polák, 2001) and *Lycium barbarum* L. (Kroll, 1975; Pribek *et al*., 2001), are hosts of PPV. In the study with *L. vulgare* and *E. europaeus*, PPV polycolonal antibodies were used to detect PPV in naturally infected plants (Polák *et al*., 2001) and cross reactions with other viruses or hosts can, therefore, not be fully excluded (e.g. Cambra *et al.,* 2006a). Canadian studies could not confirm *L. vulgare* and *E. europaeus* as hosts of PPV-D (Wang *et al*., 2006) and Pibek *et al*. (2001) could not confirm the identity of isolates from *L. barbarum* (*L. halimifolium*) and *Datura stramonium* using RFLP.

Limited information is available on whether natural infection of non-*Prunus* spp. occurs in the field and the role of these species to act as a virus reservoir and as a secondary host to aphid species that transmit PPV. The PPV infection of weed species in *Prunus* orchards in Bulgaria and Slovenia was studied by Milusheva & Rankova (2002) and Virscek Marn *et al.* (2004), respectively. Serological analyses of collected samples showed positive results for several common weed species occurring in orchards. In the Bulgarian study, plants that tested positive for PPV, were subsequently tested as possible PPV hosts by inoculation onto indicator plants (Milusheva & Rankova, 2002). It was concluded that numerous cultivated or weedy annual plants can carry potential inoculum. In contrast, extensive surveys of native weed populations in peach orchards heavily infected with Plum pox virus strain D (PPV-D) in the Niagara Region quarantine area, Ontario, Canada, failed to identify natural infection in any of the species examined (Stobbs *et al.*, 2005). The authors conclude that weeds do not appear to represent a significant reservoir of PPV, and consequently are not prominent in the epidemiology of PPV in North America. The contradiction between the results obtained in these European and North American countries may be explained by differences in PPV strains (M in central European surveys and D in North American surveys) and infection levels (Llácer, 2006). It might also be explained by the use of non-specific polyclonal antibodies in ELISA in the European studies and cross reactions with other viruses or hosts (see also above). A more recent study by Manachini *et al.* (2007) revealed the ability of *M. persicae* to transmit PPV-M very efficiently from herbaceous hosts to peach trees under laboratory conditions, and the authors discuss the role of *M. persicae* and its herbaceous hosts as a source of PPV-M in peach orchards.

In conclusion, many *Prunus* spp. are susceptible to PPV. The presence of infected wild and ornamental *Prunus* species have been confirmed in the field and they are considered a potential reservoir of PPV for stone fruit orchards. Several woody non-*Prunus* species have been reported as host and also many herbaceous plants but their host plant status under field conditions is uncertain. Transmission from *Prunus* plants to herbaceous plants and vice versa has been demonstrated experimentally. The role of non-*Prunus* spp. as PPV-reservoir under field conditions remains, however, highly uncertain.

Symptoms and distribution in the plant

General information on PPV has been summarized in a recent review by Wang *et al.* (2006). PPV symptoms in stone fruits may appear on the leaves, bark, fruits, flowers or seeds and the variety in diagnostic symptoms are described in detail in the review. Symptoms range from mild to severe and vary with the virus strain, host species and cultivar, but are also affected by other host- and environmental factors. In general, leaf symptoms are less apparent in apricot than in peach or plum. Symptoms may disappear with the onset of hot weather. Almost all known apricot, plum and peach cultivars are susceptible to PPV, but some remain symptomless or develop very mild symptoms when infected. After initial infection, the disease develops slowly inside the tree, usually affecting only one or a few branches at first, but spreading through the tree as the virus multiplies over a period of several years. Moreover, many trees fail to develop symptoms for several years following infection. Therefore, the lack of symptoms cannot be relied on as proof that the tree is not infected.

According to the experiences of the Czech inspection service, visual detection of PPV is more difficult in peach and nectarine than in apricot and plum. In the Czech Republic, the visual inspection in peach has to be carried out in the second half of May (especially in warmer areas) or in June because the symptoms on leaves disappear in a later period. However, there are not any symptoms observed in most of the peach and nectarine cultivars planted in the Czech Republic (Information obtained from the NPPO of Czech Republic, November 2010). Note that PPV-D is the prevailing strain type in the Czech Republic (about 95% of the isolates, see Appendix I) and symptom development can be more intense with PPV-M (see also the paragraph on “Virus strains”).

Geographical distribution

The PPV epidemic originated in eastern Europe. The disease was described for the first time around 1917/1918 on plums and in 1933 on apricots in Bulgaria (Atanasoff, 1932, 1935). Since then, the virus has progressively spread to a large part of the European continent, around the Mediterranean basin and Near and Middle East, South and North America (Chile, USA, Canada and Argentina) and Asia (China, Kazakhstan, Pakistan and Japan) (Roy & Smith, 1994; Levy *et al.,* 2000; Thompson *et al.,* 2001; Spiegel *et al.,* 2004; Navrátil *et al.,* 2005; Dal Zotto *et al.,* 2006; Kollerová *et al.,* 2006; Maejima *et al.*, 2010). It might also be that at time of detection in Bulgaria PPV was already present in other countries but had never been recognized as such.

The introduction of infected plant propagation material is the most important means of long distance spread of PPV. In addition, the virus can be transmitted by aphid vectors in a non-circulative, nonpersistent manner (Labonne *et al.,* 1995; Manachini *et al.,* 2004; Damsteegt *et al.,* 2007; Moreno *et al.,* 2009). Nowadays, the virus is prevalent in most central, eastern and southern European countries. In several northern European countries, PPV is present to a different extent but is contained through the establishment of certification schemes and supply of virus-free planting material. In some northern countries, PPV is not (known to be) present or has only been found in imported stock material. More details about the pest status of PPV in Europe are discussed below in the paragraph "Current status in Europe" and are presented in Appendix I where references are listed.

According to EPPO PQR database version 4.6 (http://www.eppo.org/DATABASES/databases.htm), PPV is present in the following countries:

Europe
Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, *Czech Republic*, France, Germany, Greece, Hungary, Italy, Lithuania, Luxembourg, Moldova, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine, United Kingdom

Asia
China, India, Iran, Jordan, Kazakhstan, Pakistan, Syria

Africa
Egypt, Tunisia

America
Argentina, Canada, Chile, United States of America

Information not included (yet) in the PQR-database version 4.6:
In 2009, PPV was detected in Japan (http://www.pps.go.jp/english/pestreport/index.html; accessed November 2010; Maejima *et al.*, 2010).

PPV was recently detected in Belarus. Isolates belonging to PPV-D, PPV-Rec and PPV-C have been positively identified in the frame of SharCo EU FP7 project (http://www.sharco.eu/sharco/; pers. comm. T. Malinowski, Research Institute of Horticulture, Skierniewice, Poland. June 2011).

Natural transmission

PPV is transmitted naturally by several aphid species in a non-persistent manner and to different extent. (Anonymous, 1997). There is a wide genetic variability within PPV and transmissibility is strain and even isolate-dependent (see paragraph "Virus strains"). It has also been shown that distinct clones of *Aphis gossypii* transmit PPV with significantly different efficiencies (Labonne *et al.,* 1995). In the same study, a total of 14 species were identified as PPV vectors. It was also shown that the rate of transmission of PPV by aphids is low compared to the rate of transmission of potyviruses which infect annual crops. The authors used the "unrestrictred probing" method that appeared the most sensitive method to study PPV transmission. They used the method for a range of aphid species collected from the field in south-eastern France and found that several species, colonizing *Prunus*, were able to transmit PPV. Next to that, several other aphid species that could be of importance for PPV transmission, e.g. species that are present in high abundance or species that are present on trees and shrubs surrounding orchards, were also able to transmit PPV. Migrant aphid species that do not colonize stone fruit or *Prunus* can be important for PPV spread because extremely high populations of specific migrant species may move into orchards looking for a food source after their preferred host crop matures or is harvested, and subsequently transmit the virus when they alight and probe on leaves of the *Prunus* trees, thereby transmitting the virus.

PPV can be spread rapidly by natural transmission and disease incidences starting in the first year of less than 10 % can reach up to 100% within 5 years (e.g. Gottwald *et al.,* 1995; Varveri*.,* 2006b; see paragraph "Virus strains" for more details). Indications for the distance over which PPV can be transmitted by vectors can be derived from epidemiological studies performed in orchards, but data should be treated with care because of the possible presence of latently infected plants. Dallot *et al.* (2004) studied disease incidence in peach orchards caused by PPV-M in France during a 7 – 10 years period and determined the nearest neighbour distance between newly identified symptomatic trees and previously detected ones. It was shown that 69 – 100 % of diseased trees were found within 12 m, 79 – 100 % within 18 m and the maximum observed distance ranged from 12 – 75 m. In Spain, observations in a peach orchard indicated that natural transmission of PPV-M could have occurred over distances of up to 12 m (Cambra *et al.,* 2006a). Spatial patterns of Sharka in apricot and peach orchards in Spain implicated that PPV-viruliferous aphids preferred to move to trees several tree spaces away instead to move to immediately adjacent trees (Gottwald *et al.,* 1995). Data from another survey from southern France in apricot orchards suggested that aphid transmission of PPV (type of strain not indicated) occurred between orchards located several hundreds meters apart from each other (Morvan, 1988). It was also suggested that altitude differences had an effect on spread of Sharka: disease incidence was much lower in orchards located 25 – 200 m around a deeply located heavily infected orchard, whereas an orchard located 150 m away but at the same altitude showed high diseases incidence levels. Labonne & Dallot (2006) have reported that "PPV dissemination also frequently occurs at longer distances (between orchards). Spatial analysis of a 'focus of disease' encompassing susceptible areas of several hundred hectares showed that 90% of diseased trees were found within 200 m of previously infected ones but dissemination at distances over 600 m was also recorded (Dallot, unpublished)." The authors did not give details of this study. According to Conti (1986), aphid transmission of PPV is up to a distance of 100 – 120 m and in exceptional cases transmission occurs over larger distances (based on data from an unpublished study). In a more recent study, PPV-M did not spread by aphids more than 150 m after 3 years of natural spread (Capote *et al*., 2010). According to J. Polák (pers. communication, November 2010), spread over more than 10 m during 1 year is exceptional in the Czech Republic (results from the SharCo-project, www.sharco.eu).

Under northern European conditions, observations suggest that the spread of PPV by aphids is relatively slow in plum orchards (Verhoeven *et al.,* 1998; Blystad & Munthe, 2006). Several factors may contribute to the slow spread of PPV observed in northern Europe, e.g. lower prevalence of aphids than in warmer areas of Europe, the specific strain/isolate present in those countries and/or the host plant. Blystad *et al.* (2007) suggested that the slow spread in Norwegian orchards of PPV-D is probably due to the lower amount of aphids in summertime, the relatively short period that aphids are active on plum, and the aphid species present. In Norway, *Myzus persica* is not known as a problem in plum. It does not survive Norwegian winters except in greenhouses. The suggestion that a lower aphid population in northern Europe limits the natural spread of PPV rather than the type of strain is supported by the observation of high transmission rates of PPV-D in warmer climate areas (discussed in more detail in paragraph "Virus strains").

It is generally accepted that PPV is not transmitted by seed. In an extensive review of the literature by Pasquini & Barba (2006), it has been concluded that vertical transmission of PPV from infected mother plants to progeny seedlings does not occur. This conclusion has again been supported by Zagrai & Zagrai (2008) who did not find transmission of PPV-D and PPV-Rec strains through seeds in Plum.

In conclusion, various studies indicate that natural spread of PPV by vectors will mostly occur over short distances, e.g. less than 100 m, but that transmission over longer distances (several hundreds of meters) cannot be excluded. PPV can almost certainly not be transmitted by seed. Uncertain is the maximum distance over which PPV can be transmitted by vectors.

Virus strains

There is a wide genetic variability within PPV (Wang *et al.,* 2006). Several strains or subgroups are recognized and classification is based on biology, serology and molecular properties. The two most commonest strains are the Dideron strain (PPV-D) and the Marcus strain (PPV-M). Additionally, 5 other strains have been characterized, e.g. PPV-Rec (Recombinant), PPV-EA (El Amar), PPV-W (Winona) and PPV-C (Cherry) (Glasa *et al.,* 2004b; James & Varga, 2005; Candresse & Cambra, 2006) and more recently, PPV-T (Turkey) (Serce *et al.,* 2009). Numerous PPV isolates were described as having different biological and epidemiological characteristics, such as those related to aggressiveness (Quiot *et al.,* 1995), aphid transmissibility (Deborré *et al.,* 1995) and symptomatology (Jarausch *et al*., 2004; Palmisano *et al*., 2010).

1) <u>PPV-D</u> (Dideron)

The PPV-D strain was originally isolated on apricot in France (Kerlan & Dunez, 1979). Currently, it is the commonest strain in Europe (Table 1; see Appendix I for details and references). It is also found in the Western Hemisphere (Chile, USA, Canada). In literature, the PPV-D strain is often considered as the non-epidemic form of PPV (Wang *et al.,* 2006) whereas PPV-M isolates are considered the epidemic form. There are, however, several examples in the literature that this division is not that strict and also depends on other factors, e.g. the specific interaction with the type of host. Epidemiology of PPV-D has been studied in Spain in areas along the Mediterranean coast. The Japanese plum (*P. salicina*) cultivar 'Red Beaut' became an important source of PPV-D inoculum and aphid vectors spread PPV very efficiently to other Japanese and European plum cultivars and apricots (García *et al*., 1991; Llácer *et al*., 1992; Cambra *et al.,* 2006a). The Spanish studies on temporal and spatial spread of PPV-D show that PPV incidence in apricot trees could vary as much as 5% in the first year to 82% in the third year. In an orchard of 182 plum trees in Llutxent, Valencia in 1990 , with 41 Japanese plum cultivars grafted onto *P. marianna* rootstock, the spatial and temporal spread of PPV-D was monitored annually from 1991 to 2003. PPV incidence ranged from 11% in 1991 to 96% in 2003 (Cambra *et al.*, 2004b). PPV-D was not observed to spread through peach cultivars, despite being grown in the vicinity of heavily infected plots of apricot or Japanese plum trees (Cambra *et al.,* 2006a). PPV-D was found in peach grafted on infected *Prunus marianna* rootstocks (Cambra et al., 2006c).

2) <u>PPV-M</u> (Marcus)

The PPV-M strain was originally characterized on peach in Greece (Kerlan & Dunez, 1979) and is present in many southern, eastern, and central European countries (Table 1). PPV-M strain is efficiently vectored by aphids and can spread very rapidly within peach orchards (Wang *et al.,* 2006). The M-strain separates into two subgroups, that seem to prevail in two geographically defined areas, which can be tentatively identified as PPV-M1 (mainly central–eastern Europe isolates) and PPV-M2 (isolates mainly from Mediterranean countries), respectively (Myrta *et al.,* 2001).

3) <u>PPV-Rec</u> (Recombinant)

Recently, a new strain, PPV-Rec, was described and this strain has evolved as a result of recombination between isolates of the D and M strains (Glasa *et al.,* 2004b). PPV-Rec isolates occur in many central and eastern European countries (Glasa *et al.,* 2004b), and former Yugoslavia has been tentatively identified as the origin of PPV-Rec (Glasa *et al.,* 2005). Recent studies have shown that recombinant isolates of *Plum pox virus* (PPV) are present in many European countries (Glasa *et al.,* 2004b; 2005; Appendix I). Nowadays, isolates of the PPV-Rec strain are reported from many European countries including Turkey (Table 1; Appendix I, Candresse *et al.,* 2007) and Pakistan (Kollerová *et al.*, 2006). As the first report of a PPV recombinant was from Yugoslavia (Cervera *et al.,* 1993), it is conceivable that it spread through infected propagating material to other areas. Additionally, the presence of recombinants in a range of cultivars locally, suggests that aphid transmission took place as well, as proven experimentally by Glasa *et al.* (2002b, 2004a). The results from vector transmission studies by Glasa *et al.* (2004a) confirm that all the recombinant PPV isolates are transmitted by aphids; however, the transmission occurred at different rates. Note that previous analyses of the prevalence of PPV strains in Europe brought biased results, confounding PPV-Rec with PPV-M (Dallot *et al.,* 2008). The coat proteins of PPV-Rec and PPV-M have similar serological characterisitics and the strains cannot be distinguished with the monoclonal antibodies used most commonly for typing main PPV strains, MAb AL (Myrta *et al.*, 1998) and MAb 4DG5 (Cambra *et al.,* 1994) (Glasa *et al*., 2004b; Wang *et al*., 2006). In the north-east of Transylvania (Romania) for example, the natural recombinant (PPV-Rec) was detected and results indicated that all the PPV isolates which had been previously typed as PPV-M are actually PPV-Rec (Isac & Zagrai, 2006; Zagrai *et al,* 2008a, 2010). Similar observations were done in Germany, where sequence data indicated that a proportion of the PPV-M strains could be PPV-Rec strains (Jarausch, 2006).

4) <u>PPV-EA</u> (El Amar)
PPV-EA is found on peach, plum and apricot in North Africa (Wang *et al.,* 2006). Preliminary trials on aphid transmission showed that PPV-E1 Amar is aphid-transmissible by *Myzus persicae* Sulzer (P. Maison, personal communication in Wetzel *et al.,* 1991).

5) <u>PPV-C</u> (Cherry)
PPV-C is limited to sweet cherry and sour cherry and to date, it is the only strain known to naturally infect cherry (Wang *et al.,* 2006). It comprises the sour cherry (SoC) and sweet cherry (SwC) isolates described in Moldova (Nemchinov *et al.,* 1996) and Italy (Crescenzi *et al.,* 1997). In the EU, PPV-C has also been reported from Hungary and Romania. In Hungary, PPV-C was detected in symptomless sweet and sour cherry trees during a five-year survey of cherries in the 1990s; no PPV-infected cherry trees were found in recent years (Kölber, 2006). In Romania, PPV-C has a very limited distribution (Isac & Zagrai, 2006).

The situation of PPV in cherry trees is unclear in Bulgaria and the Czech Republic. Kölber *et al.* (2001) has reported on the situation in various Middle and Eastern European countries based on a questionnaire sent to and completed by virologist from the different countries. For Bulgaria PPV-infections levels were reported for among others sweet cherry (11.7%) and sour cherry (31.1%). The PPV-strain was, however, not mentioned and it was not clear if infection levels were based on visual observations and/or test methods. Topchisska *et al*. (2002) reported an PPV-isolate obtained from sweet cherry trees in Bulgaria. They concluded that the isolate belonged to PPV-M based on a positive reaction with a the monoclonal antibody MAb AL. Based on this reaction, it may also have been PPV-Rec since Mab AL cannot distinguish between the M- and Rec-strain (see above). Kölber *et al*. (2001) reported that no PPV-infection had yet been detected in cherry in the Czech Republic. Navratil *et al.* (2004) reported the presence of PPV in a collection of sweet cherry trees in the Czech Republic but could not identify the strain type. In a subsequent report, Navratil *et al*. (2008) identified the isolate from sweet cherry as a member of PPV-Rec based on RNA sequence analysis. All ELISA-tests were negative. Additional information from M. Navratil (pers. comm., June 2011): the concentration of the virus in the trees was very low, PPV-Rec could not be found in the neighbourhood of the trees and transmission studies failed; PPV-Rec in cherry is not considered of importance in the epidemiology of PPV-Rec. There are no other papers confirming PPV-M and/or PPV-Rec isolates naturally infecting sweet or sour cherry trees. Dosba *et al.* (1987) was able to transmit experimentally 3 PPV-isolates originating from Greece, Hungary and France and which varied in their pathogenicity to peach seedlings (strain-type not indicated) by chip budding or through aphids to three cherry rootstocks (*P. mahaleb* cv. SL64, *P. avium* cv. F12-1 and *P. avium* x *P. pseudocerasus* cv. Colt). However, no translocation of the virus in the rootstocks was detected and symptoms disappeared. Desvignes *et al.* (1988) bud-inoculated rootstocks of *P. avium*, *P. cerasus* and *P. mahaleb* with isolates of

PPV-D, PPV-M and PPV-El Amar. PPV could be detected in a few cases shortly after inoculation but not after 7-8 months.

During a survey, Polák & Komínek (2009) did not found PPV-C in selected cherry orchards in the Czech Republic. A survey on PPV was also performed by the SharCo-project by means of a questionnaire and meetings with representatives of the NPPO's of 11 countries (SharCo, 2009). Nine countries were EU-members: Spain, France, Italy, Germany, Poland, Czech Republic, Slovakia, Romania and Bulgaria; two were non-EU members: Serbia and Turkey. None of these countries reported the presence of PPV in cherry despite the fact that PPV has a long history and occurs widespread in many of these countries.

Based on the information above, we conclude that PPV-C is, at the moment, still the only PPV-strain known to naturally infect and reproduce in sweet and sour cherry. The papers from Topchisska *et al*. (2002) and Navratil *et al*. (2008) indicate an uncertainty about the ability of other strains to naturally infect cherry trees.

PPV-C has a broad experimental host-range, as indicated by mechanical transmission to several herbaceous hosts (Kalashyan *et al.,* 1994). In these experiments, the sour cherry isolate was transmitted to a wide range of herbaceous hosts, whereas the conventional Moldavian isolate isolated from plum (strain type not indicated) was only transferred to herbaceous plants with great difficulty. In another study by Crescenzi *et al.* (1997) with an PPV-C isolate from sweet cherry (PPV-SwC), it was demonstrated that the PPV-SwC isolate was able to systemically infect cherry; symptoms were similar to those observed after natural infection. The PPV-SwC isolate could infect peach and myrobalan, whereas, conversely, PPV isolates commonly obtained from these hosts could not systemically infect cherry; virus remained localized after aphid transmission (Dosba *et al.,* 1987).

Recently, PPV-C was isolated from *Prunus lanesianna* and *P. cerasus* x *P. padus,* both used as rootstocks, in Belarus (pers. comm. T. Malinowski, June 2011). This recent finding and the report on the symptomless presence of PPV-C in sweet and sour cherry in Hungary in the 1990s suggest that PPV-C may be more widespread than presently known.

6) <u>PPV-W</u> (Winona)
PPV-W, originally was identified as W3174 in Canada in two European plum trees (James & Varga, 2005). Recently PPV-W isolates have been found in Latvia in the collection of Prunus, in plum hybrid and blackthorn plants imported from Ukraine and Russia. Together with the information on W strain isolate PPV-Moscow 1410, it is likely that PPV-W is more common in the European part of the former Soviet Union than presumed. PPV-W isolates are detected by several polyclonal antibodies and by universal IVIA-5B monoclonal (Glasa et al., 2011; pers. comm. T. Malinowski, June 2011).

7) <u>PPV-T</u> (Turkey)
Recently, a new recombinant group of PPV, found in orchards in the Ankara province of Turkey, was characterized. Partial 5' and 3' genomic sequence analysis on these isolates demonstrated that they are closely related to a recombinant PPV isolate from Turkey, Ab-Tk. These isolates are characterized by a unique recombination in the HC-Pro gene and the name PPV-T (Turkey) is proposed for these isolates (Serce *et al.,* 2009).

<u>Comparison between PPV-D, PPV-M and PPV-Rec: epidemiology and aggressiveness</u>
PPV-D, PPV-M and PPV-Rec are the most commonest strains in Europe (Table 1; Appendix I). The strains may differ in epidemiology and aggressiveness. PPV-M is generally considered the epidemic form and PPV-D the mild form of PPV (Wang *et al.,* 2006) which is supported by examples of severe outbreaks of PPV-M in peach in areas where the PPV-D strain was already present and did not cause severe epidemics in peach (Quiot et al., 1995; Dallot et al., 1998; Cambra & Crespo, 2004; Dallot *et al*., 2004; Di Terlizzi & Boscia, 2006). D-isolates spread naturally in apricot and plum orchards but spread much more rarely from these hosts to peach trees (Quiot *et al*., 1995; Cambra *et al.,* 2008). Also, Glasa et al (2004b) have stated that most PPV-D isolates have a limited ability to infect peach efficiently under field conditions. However, there have been reports where PPV-D spread very efficient in peach: a variant of PPV-D has been described from southern France that was able to induced epidemics in peach (Dallot *et al*., 1998). In

Spain where only the D-strain is present (Cambra *et al.,* 2006a), disease incidence ranged from 34 – 50 and 13 – 17 % in two peach orchards and from 5 – 82, 9 – 34 and 39 -95% in three apricot orchards during a 4 years study (Gottwald *et al*., 1995). These results show that PPV-D can cause epidemics in apricot and to a lesser extent in peach The widespread distribution of PPV-D in plum and myrobalan trees in the Czech Republic also suggest that PPV-D can cause epidemics (Polák, 2002; Polák & Komínek, 2009). During a survey in southern France in 1992-1993, PPV-M was mainly found in peach while PPV-D was mostly found in apricot. Three plum orchards had been part of the survey and PPV-D had been found in two and PPV-M in one plum orchard (Quiot *et al.,* 1995). Survey results from southern France (1992 – 1995) described by Dallot *et al*. (1998) indicated that PPV-M populations in peach orchards were able to evolve on apricot trees in the vicinity but PPV-D populations in apricot orchards did not infect surrounding peach trees. In Slovakia, PPV-M isolates were found almost exclusively in peach orchards, whereas PPV-D and PPV-Rec types were found to be strongly associated with plum orchards (Glasa, 2006). In Austria, however, PPV-isolates from peach were all PPV-D (Laimer *et al*., 2005). J. Polák (personal communication, 2010) did not found differences in epidemic behaviour of PPV-D and PPV-M in peach in the Czech Republic, but PPV-M caused more damage to peach. Gildow *et al*. (2004) showed effective transmission of three North American PPV-D isolates by aphids from PPV-infected peach seedlings to healthy peach seedlings.

Dondini *et al.* (2010) have stated that both PPV-D (Dideron) and PPV-M (Marcus) strains are able to cause severe crop losses in apricot, with the latter strain being the most dangerous. However, only few studies are available in which PPV-M and PPV-D strains were actually compared for aggressiveness on apricot or other stone fruit species. Palmisano *et al.* (2010) reported more severe symptoms on apricot seedlings after inoculation with PPV-M than with PPV-D. Capote *et al*. (2006) did not find symptomatic differences on two Japanese plum cultivars after inoculation with isolates of the M- and D-strain or a combination of them. Jarausch *et al*. (2004) observed more severe symptoms on plum trees (*P. domestica*) infected with PPV-M than with PPV-D in the same plum orchard (observational, no experimental data). Neumüller *et al.* (2005) did not find substantial differences in the reactions of hypersensitive *P. domestica* genotypes whether infected with a PPV-D or a PPV-M strain. In contrast, Polák *et al.* (2005) found a difference in reaction of *P. domestic* cv. Jojo inoculated with a PPV-D, PPV-M and PPV-Rec isolate: plants showed a stronger hypersensitivity response after inoculation with PPV-M and PPV-Rec than with the PPV-D isolate.

A PPV-M isolate was more aggressive than PPV-D, PPV-C and PPV-EA isolates in bud-inoculation experiments with ornamental *Prunus* spp. (Kalinina *et al*., 2007). Damsteegt *et al*. (2007) found that North American D-isolates caused symptoms on *P. triloba* (and other ornamental *Prunus* spp.) while Labonne *et al.* (2004) and Kalinina *et al.* (2007) found *P. triloba* to be tolerant using M-, D-, C- and EA-isolates. Damsteegt *et al.* (2004) concluded also based on the above mentioned study by Gildow et al. (2004) with peach, that North American D-isolates were biologically different from most European D-isolates from peach.

Limited information is available on the epidemic behaviour and aggressiveness of PPV-Rec as compared to PPV-D and PPV-M. Glasa *et al.* (2004b) studied aphid transmission of 4 PPV-Rec isolates (1 from apricot and 3 from plum) and 1 PPV-M isolate (from nectarine) on plum, apricot and peach. Transmission rates varied considerably among isolates. Transmission rates of one PPV-Rec isolate (called “Horomeric”) was similar to that of the PPM-isolate on all *Prunus* genotypes studied. The other 3 PPV-Rec isolates were significantly less efficiently vectored on apricot and 2 of these isolates also on plum than the PPV-M isolate. In another paper presenting partly the same data Glasa *et al*. (2004a) also give transmission data on another peach genotype on which only the “Horomeric”- PPV-Rec isolate was efficiently vectored and no transmission was obtained with the PPV-M isolate. Zagrai *et al*. (2009b) did not found differences in symptoms intensity after inoculation with a PPV-D and a PPV-Rec isolate in four *Prunus* genotypes.

Glasa *et al*. (2010) did not find a clear-cut strain-specific behaviour of PPV isolates in term of competitiveness in mixed infections of PPV-Rec with PPV-D and PPV-M isolates after co-inoculation of *Nicotiana benthamiana* plants and the authors stressed the importance existence of biological variability within single PPV strains.

In conclusion, the three commonest PPV-strains in Europe are PPV-D, PPV-M and PPV-Rec. PPV-M appears generally more severe on peach than PPV-D. For apricot and plum, the differences between PPV-M and PPV-D are less clear. Observations and experimental results reported indicate that PPV-M can be more aggressive on apricot than PPV-D and maybe also on plum. Available information is too limited to make a general statement about the impact of PPV-Rec as compared to PPV-D and PPV-M also because large differences in transmissability among PPV-rec isolates have been reported. Generally, the various results and observations indicate that the impact of PPV-M, PPV-D and PPV-Rec depend on the particular isolate and host plant combination.

Current status of PPV in the EU

Roy & Smith (1994) described the Plum pox situation in Europe and an update of the situation in several countries is given by Capote *et al.*, (2006). Roy & Smith (1994) distinguished three geographical zones in Europe for the Plum pox situation in Europe, based on the presence of PPV and history of spread: (1) In the central and eastern countries in Europe plum pox spread relatively early, with the initial description of the disease around 1917/1918 in Bulgaria on plums (Atanasoff, 1932), in these countries the disease is widespread; (2) the northern and western countries plus Baltic States of Europe in which plum pox levels are very heterogeneous; (3) Mediterranean countries in which PPV spread is relatively recent and there is high risk of further spread. Below, a global description is given for the situation in each of these three zones as proposed by Roy & Smith (1994). However, the situation between countries within each zone can still vary considerably and more detailed information on the pest status and control measures per country is presented in Appendix I, including other European countries (non-EU member states). See also Table 1 for a summary of the pest status per EU-country.

Ad 1. Central and eastern EU-countries (Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia)

PPV originates in Eastern Europe and was described for the first time around 1917/1918 in Bulgaria on plums. In general, the disease is widespread and very damaging in central and eastern Europe (Roy & Smith, 1994). Presence of different PPV strains, e.g. the PPV-D, PPV-M and PPV-Rec strains, and mixed infections suggest a long presence of the virus in several countries of central and eastern Europe (Dallot *et al.,* 2008) . Results from experimental work tentatively identify former Yugoslavia as the original center of dispersion of PPV-Rec isolates (Glasa *et al.,* 2005), isolates that have evolved as a result of recombination between isolates of the D and M strain (Glase *et al.,* 2004b). PPV is endemic in central and eastern European countries and eradication is not considered as an option. Growing resistant or tolerant cultivars is considered to be the most effective option in these areas. (Wang *et al.,* 2006; Bazzoni *et al.,* 2008; Karayiannis & Ledbetter, 2009). The use of tolerant cultivars will decrease the chance of detection and, thereby, increase the probability of spread of the virus with propagation material. In Slovakia PPV recombinants were consistently found in orchards planted in the early 1980s with tolerant plum cultivars from Cacak, Yugoslavia (Glasa, 2006). Planting material of tolerant plum cultivars can represent a possible initial source for rapid spread of PPV recombinants in Slovakia. Note that the situation in Poland, where PPV-M is absent, PPV-D is widespread and few loci of PPV-Rec are present, differs from those in many other countries in this zone. In Romania, PPV-D is also the prevalent strain and PPV-M has not been detected (see also Appendix I and Table 1).

Ad 2. Northern and western EU-countries (Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Sweden, United Kingdom)

PPV is present in northern and western Europe, but to variable extent. In the northern part or Europe, the climatic conditions limit the cultivation of certain host plants of PPV (e.g. apricot, peach and nectarine). Eradication measures have contributed to the absence or low prevalence of the disease in some countries. PPV is absent or only found in a few occasions in Denmark, Estonia, Finland, Latvia and Sweden (Roy & Smith, 1994; Lemmety, 2006; Appendix I). PPV has not been reported from Ireland. PPV is present at low prevalence in the Netherlands and Belgium (Verhoeven *et al.,* 2006; Anonymous, 2010; Appendix I) and at unknown/not-reported prevalence in Luxembourg (EPPO PQR database, version 4.6). PPV is fairly widespread in Austria, France, Germany, Lithuania and the UK (see Appendix I for details and references). In the UK, Belgium, the Netherlands (except from one M- or Rec-isolate from an imported plant), Latvia and Lithuania, only the D-strain has been identified (Mumford, 2006b; Staniulis, 2006; Appendix I). In France, Germany and Austria both PPV-D and PPV-M are present (Laimer *et al*., 2005; Jarausch, 2006; Speich, 2006a). PPV-Rec isolates have been reported from Germany, but sofar not from France (Glasa *et al.,* 2004b; Dallot *et al.,* 2008). In Luxembourg it is not known/not reported which strain is present. In many northern and western EU-countries, the disease is controlled by the use of certified virus-free propagation planting material, inspections in nurseries and orchards and/or large scale ELISA testing for PPV and eradication campaigns. Less favourable conditions for aphid transmission may have contributed to the limited presence in northern Europe as compared to more warmer parts of Europe (see "Natural transmission").

Ad 3. Mediterranean EU-countries (Cyprus, Greece, Italy, Malta, Portugal, Spain)
PPV was detected for the first time in the 1960-80s in countries in this region and information about pest status has become available through surveys in several Mediterranean countries (Roy & Smith, 1994; Capote et al., 2006). In Greece and Cyprus, the M-strain is prevailing, whereas in Spain and Portugal, the M strain is absent; in northern Spain in Zaragoza, the M-strain was not detected anymore, after a PPV-M outbreak was detected and successfully eradicated in 2002 (Cambra *et al*., 2004a). In the Mediterranean countries, various methods are being used for control of PPV, from mandatory eradication programmes to the use of tolerant cultivars to prevent yield losses (See also Appendix I). In Italy, control measures comprise the removal of infected plants and the production of virus-free planting material (Di Terlizzi & Boscia, 2006; Bazzoni *et al*., 2008). In Spain, management of Sharka disease includes the production of certified virus-tested plants, the control of mother plants in nurseries producing standard material and the mandatory and/or voluntary eradication of PPV-D infected trees in some regions. In addition, permanent surveys for early detection and mandatory eradication of PPV-M in all Spanish regions are performed and breeding programs have been set up to introduce apricot resistance to PPV (Cambra *et al.,* 2006a). PPV is established in Greece, despite eradication programmes. Tolerant cultivars of apricot are used at a large scale in Greece, where the cultivation of susceptible cultivars was abandoned almost 15 years ago (Varveri, 2006b).

<u>Note</u>
PPV may already be more widespread than presently known because there is a large trade of stone fruit trees for the private market and trees present in private gardens are often not part of national PPV-surveys. Recent and older findings of PPV in garden centres and/or private gardens (e.g. in Latvia, Sweden and Denmark) suggest that PPV might be present on private properties throughout Europe (see Appendix I for details and references).

In conclusion, PPV originates in eastern Europe and is nowadays present in at least 20 EU-countries including the major producing stone fruit ones and under eradication in another two EU-countries. The current status of PPV in the EU is very complex, e.g. virus incidence differs per country (varying in plum for example from probably 0 to more than 60%; see Appendix I) and also within countries and the pathogen is very divers with respect to biological characteristics. Several strains are recognized. PPV might already be more widespread than presently known, e.g. through trade of infected material for the private market.

Table 1. Pest status of Plum pox virus (PPV) in EU-countries (see Appendix I for details and references)

Country	Present?	Strain			
		PPV-D	PPV-M	PPV-Rec	PPV-C
Austria	+	+	+		
Belgium	+	+			
Bulgaria	+	+	+	+	
Cyprus	+	+?	+		
Czech Republic	+	+	+	+	
Denmark	(+)[1]	(+)	(+)		
Estonia					
Finland					
France	+	+	+		
Germany	+	+	+	+	
Greece	+	+	+		
Hungary	+	+	+	+	+
Ireland					
Italy	+	+	+	+	(+)[2]
Latvia	(+)[1]	(+)			
Lithuania	+	+			
Luxembourg	+	?			
Malta					
Netherlands	+	+			
Poland	+	+		+	
Portugal	+	+			
Romania	+	+		+	+
Slovakia	+	+	+	+	
Slovenia	+	+	+	+	
Spain	+	+			
Sweden					
United Kingdom	+	+			

1) Under eradication
2) Considered free from PPV-C but occasionally found in old cherry trees (Appendix I)

Pathways for spread and introduction

The introduction of infected plant propagation material of *Prunus* spp. is the most important means of long distance spread of PPV. PPV can be symptomlessly present in plants (see "Detection and inspection methods" in "3. Identification and evaluation of management options") and can, therefore, not reliably be detected by visual inspection. The probability of assocation is high considering that PPV occurs fairly widespread in the EU and is endemic in several countries. There is also a large trade volume of fruit plants within the EU and despite current regulation for plants intended for planting of *Prunus* host plants species, several PPV infections have been found in plants originating from EU-countries during the last 10 years (Verhoeven *et al.,* 2008; Scheel, 2009; Table 2).

Import of plants from countries outside the EU also poses a risk for entry. Verhoeven *et al.,* (2008) reported interceptions on plants originating from China (1 interception in 2004), and Serbia/ Yugoslavia (1 in 2000, 1 in 2002 and 4 in 2004).

In Europhyt 29 notifications were found for PPV on *Prunus* plants of which many consignments originated from EU-countries in recent years (Table 2). The total number of infected lots moving in trade is almost certainly higher than the number of notifications for several reasons: *Prunus* host plants originating from countries within the EU are not subjected to standard inspections, the uneven distribution of PPV in plants in combination with the small sample size taken for testing, and the fact that findings on plants originating from other (EU-) countries are not always notified through Europhyt. Most interceptions (15 out of 29) were reported by the Netherlands on plant material originating in other countries. Considering the fact that the Netherlands is a very small stone fruit producing country as compared to southern, central and eastern EU-countries (Appendix II) and do not grow peach nor apricot on a commercial scale, the number of PPV-infected lots moving in trade is likely much higher than the number of notifications in Europhyt. *Prunus* species on which PPV has been notified in Europhyt are: *P. domestica, P. padus, P. persica, P. laurocerasus, P. triloba* and *P. cerasus*.

PPV is especially known as a pest of the stone fruit industry and not for the ornamental industry. Few findings have been reported from nurseries growing *Prunus* spp. for ornamental purposes (see "Economic impact). Hence, infected fruit plant propagating material and fruit plants of *Prunus* spp. intended for fruit production are the most important pathway for the stone fruit industry. However, infected ornamental *Prunus* plants planted in private or public areas near stone fruit orchards may serve as an inoculum reservoir and plants of stone fruit species are also planted in backyards or (small) private orchards. Several findings of PPV in stone fruit species have been reported from backyards or garden centres (e.g. Denmark, Sweden and Latvia, see Appendix I for details and references).

Besides the pathway "plants for planting of *Prunus* spp.", other pathways may be considered:

- Infected fruits. The potential of infected fruits to act as a pathway for PPV has been demonstrated experimentally (Labonne & Quiot, 2001; Gildow *et al*., 2004). However, under practical conditons transfer from infected fruit to plants seems unlikely: transfer might happen if infected fruit would be placed in the vicinity of a host plant but aphids usually do not feed on harvested fruit. Because of this low probability of transfer and the fact that PPV occurs already (fairly) widespread in the EU, this pathway is not further considered in the present PRA.
- Infected branches of susceptible plants. Trade of branches of *Prunus* spp. occurs for decorative purposes. However, for the same reasons as for the pathway "infected fruits", this pathway is not further considered in the present PRA.
- Natural spread by aphids (short distance spread: within and between fields). Relevance of this pathway depends on virus-strain, host plant, aphid species and environmental conditions (see also the paragraph on natural transmission).
- Trade or movement of infected woody plants of non-*Prunus* spp. reported as host plants, such as *Euonymus europea*, *Lycium barbarum and Ligustrum vulgare.* Highly uncertain if these species can serve as natural inoculum reservoir for *Prunus* species (see also paragraph on "Host range").
- Human assisted spread of infected non-*Prunus* species including many herbaceous species (usually short distance, e.g. within a community). Host plant status under natural conditions uncertain as well as their role in the epidemiology of the Sharka disease (see also paragraph on "Host range").

In conclusion, the import and trade of infected plants of *Prunus* spp. from areas where PPV is present is by far the most important pathway for introduction and spread of PPV. The probability of spread by trade of plants intended for planting of *Prunus* host species within the EU is assessed as high with a low uncertainty (rating levels: low, medium, high). Several interceptions on planting material originating from countries outside the EU also indicate a high probability of introduction of PPV through import of plants for planting of *Prunus spp.*

Table 2. Number of notifications of EU-countries for Plum pox virus on Prunus plants (Source: Europhyt, accessed 8 September 2010)

Year	Origin of plants	
	EU-countries	non EU-countries
2009	3	0
2008	3	2
2007	2	4
2006	0	0
2005	0	1
2004	1	3
2003	0	0
2002	0	0
2001	0	1
2000	0	1
1999	0	1
1998	0	1
1997	0	1
1996	0	0
1995	0	5
Total number of notifications	9	20

Economic impact

Németh (1994) has reviewed the economic importance of PPV in Europe. PPV infection affects both quality and quantity of fruit yield especially of plums, peaches and apricot. Crop losses reported from various central and eastern European countries exceeded 75%. Complete crop losses have been reported in susceptible cultivars of plum. Cambra *et al.* (2006b) have estimated world wide costs associated with Sharka management on more than 10,000 million euros over the last 30 years. Compared to peach, apricot and plum, relatively little information is available on the effects of PPV on nectarine, a cultivar group within the botanical species of peach (*P. persica* var. *nucipersica*), possibly because of the much smaller acreage in Europe (Appendix II). Syrgiannidis & Maïnou (1986) tested 25 peach and 8 nectarine cultivars for sensitivity to PPV. Disease symptoms observed on leaves and fruits of nectarine cultivars were in the same range as on the peach cultivars. In a review on the situation of PPV in Canada, Wang *et al.* (2006) have stated that severe symptoms are often observed on nectarine and over 100,000 PPV-infected nectarine trees have been removed from Canadian orchards (J. Moore, unpublished data in Wang *et al.,* 2006). Bicak & Ostrkapa-Meurecan (2007) reported that PPV caused yield losses in nectarine orchards in the Durdevac area in Croatia. These publications indicate that the potential impact of PPV is also high for nectarine.

As also indicated above (paragraphs on “Symptoms and distribution in the plant” and “Virus strains”), the potential effect on yield by PPV depends of the particular strain or even isolate, the host plant species (cultivar) present, the prevalence of vector species and environmental conditions, affecting both development of the virus and the vector. Additionally, in countries/areas where PPV is already present its impact may increase by introduction of new strains.

The D-strain of PPV is most common in the EU and present in (almost) all member states where PPV is present (Table 1). The M- and the Rec-strain are the second and third most commonest strains in the EU. The exact situation with respect to PPV-M and PPV-Rec is uncertain. PPV-Rec has only recently been characterized and relatively little data on prevalence and spread is available. It also recently turned out that in some cases isolates that had been reported in the past as PPV-M were actually PPV-Rec (Appendix I: Poland, Romania). The M-strain appears generally more severe in peach than the D-strain but D-isolates epidemic on peach have also been described (see paragraph on “Virus strains”). The M-strain is present (to different extent) in the major stone fruit producing countries in the EU, except Poland, Portugal, Romania and Spain. These four countries grow peach with Spain having the second largest area in the EU (Appendix II). Thus, introduction of the M-strain in these countries will probably have an additional impact compared to the PPV-strains already present.

The impact of PPV is especially high for southern, central and eastern Europe where most of the stone fruit is being produced in the EU and conditions (high temperature) are favourable for aphid transmission. Introduction of the M-strain to northern European countries where only the D-strain is present may not lead to additional impact since peach nor apricot is grown in these countries (Appendix II) and the M-strain does not appear to be much more epidemic or agressive in plum than the D-strain (see paragraph on “Virus strains”).

Besides PPV-D and PPV-M, PPV-Rec is also present in many countries (Table 1) and mixed infections with PPV-D have also been found (Zagrai *et al*., 2008a, 2010). Presently, there are no indications that PPV-Rec would be much more epidemic or aggressive than PPV-D but this is uncertain because of limited experimental data in which isolates of PPV-D and PPV-Rec were compared (see paragraph on “Virus strains”).

PPV-C is the only strain known to naturally infect cherry (see “Virus strains”). It has a much more restricted distribution in Europe than PPV-D, PPV-M and PPV-Rec. Spread or introduction into cherry producing areas presently free of this strain can increase the impact of PPV in the EU. No reports however, were found on yield losses in cherry caused by PPV-C, for this reason its impact level is uncertain. The limited occurrence of infected or symptomatic cherry trees reported in the EU suggest that PPV-C has a lower impact for cherry than PPV-D and PPV-M have for plums, peaches and apricots. In Italy, PPV-C is occasionally found in old cherry trees (Di Terlizze & Boscio, 2006). In Hungary, PPV-C was detected in symptomless sweet and sour cherry trees during a five-year survey of cherries in the 1990s; no PPV-infected cherry trees were found in recent years (Kölber, 2006). It has been stated that “ PPV infection of cherries is still considered extremely unusual, being practically unknown throughout most of Europe” (Anonymous, 1997)

Almonds (*Prunus dulcis*) can be infected by PPV but show few symptoms (Festic, 1978; Damsteegt *et al.,* 2007) and “in practice, no severe symptoms or losses have been associated with PPV infection in almond” (Wang *et al.,* 2006).

PPV can infect ornamental and wild *Prunus* spp. (Elibüyük, 2006; James & Thompson, 2006; Kölber, 2006; Mumford, 2006a; Damsteegt *et al*., 2004, 2007; Kalinina *et al.,* 2007; see also "Host plants"). Several of these authors also have reported symptoms on ornamental *Prunus* spp. Kalinina *et al.* (2007) for example found symptoms on *P. americana*, *P. cistena* and particularly on *P. glandulosa* and *P. tomentosa* after bud inoculation showing that PPV can potentially cause damage to ornamental *Prunus* spp. PPV induced symptoms can directly affect the ornamental value of a tree but no reports are known on direct economic losses in ornamental industry. Elibüyük (2006) detected PPV-M in *P. cerasifera* Pissardii (purple cherry plum) during a survey but symptoms were not obvious and it was difficult to visually detect infected trees. In Spain, PPV has never been found in plantations of ornamental *Prunus* species (Cambra *et al*., 2006c). In the Netherlands, PPV was found in 5 out of 2000 – 2500 lots of ornamental *Prunus* species inspected annually from 1974 – 1984 (Verhoeven *et al*., 2008). Stobbs et al. (2005) did not find any PPV-infection in ornamental *Prunus* spp. in Niagara nurseries in Canada. James & Thompson (2006) have stated that “..no direct economic losses have as yet been reported as a result of diminished vigour or tree death of ornamental Prunus,.”. They suggested that the direct economic impact of PPV for ornamental growers may increase with the emergence of new PPV isolates and strains with a broader host range and/or which could be more virulent for ornamental *Prunus* species. Infection of wild *Prunus* spp. is mainly documented as a risk for stone fruit industry because they may act as virus reservoir but PPV has not been reported as a direct environmental risk. PPV has been present in most EU-countries for several decades but no reports of direct effects on native vegetation have been found in literature. We therefore assess the direct impact of PPV for both the ornamental industry and the environment as generally low with a medium uncertainty (medium uncertainty because symptoms have been obtained after inoculation but no reports are known that PPV actually has caused/is causing significant damage in ornamental *Prunus* spp. New strains that might be more epidemic and/or aggressive to ornamental *Prunus* spp. also add to the level of uncertainty.).

New (recombinant) strains have been detected since about 1990 (see "Virus strains) and their additional impact to the more commonly occurring D-, M- and Rec-strains is difficult to assess because of lack of information. They might be more epidemic and/or aggressive than PPV-D, PPV-Rec and PPV-M but this uncertain and presently there are no indications, that the strains PPV-T and PPV-EA pose a higher risk than PPV-D, PPV-Rec and PPV-M. According to J. Polák (pers. comm., 2010) PPV-W has a very low and negligible pathogenicity on plum based on field observations in Canada and unpublished experimental results. However, PPV-W is a very recently descibed strain and pathogenicity may depend on host plant genotype and environmental conditions. More data on pathogenicity of PPV-W may become available in the future following the recent findings in Europe.

The impact of PPV is reduced by several control measures (see Appendix I for details per country and references):

- the use of certified virus free planting material
- removal and destruction of visibly infected trees
- the use of (partial) PPV-resistant cultivars
- the use of agronomicall called PPV-tolerant cultivars

A disadvantage of the use of so-called "PPV-tolerant" cultivars (cultivars that show no or relatively mild symptoms) is that it can increase the risk of spread of PPV by movement of symptomless but infected nursery stock and act as an unseen PPV-reservoir. According to Glasa *et al.* (2004b) PPV accumulates in tolerant plum cultivars at levels comparable to susceptible cultivars (unpublished results) and aphid-vectored spread is efficient. Note that most cultivars indicated as tolerant are not tolerant sensu stricto but develop relatively mild symptoms as compared to non-tolerant cultivars. When we use the term "tolerant cultivars" in the present PRA we mean "agronomically tolerant cultivars". See also Chapter 3 "Identification and evaluation of management options".

In conclusion, the direct potential impact of PPV for the production of plum, apricot, peach and nectarine is assessed as high with a low uncertainty (rating levels: low, medium, high). The impact is especially high for the southern, central and eastern European where most of the stone fruit is growing and natural transmission plays an important role in the spread of the virus. Further spread of the M-strain can increase the impact of PPV also in countries where PPV is already present since the M-strain appears to be more epidemic and cause more severe damage especially on peach. The introduction of PPV - resistant or tolerant cultivars has been the main control measure in areas where PPV is endemic. The impact of PPV for cherry and almond is assessed as low, with a medium and low uncertainty, respectively. The direct impact of PPV for both the ornamental industry and the environment is assessed as low with a medium uncertainty, respectively. The additional impact of relatively new strains of PPV compared to the three most commonest strains PPV-D, PPV-M and PPV-Rec is uncertain but, thus far, do not seem to pose a higher risk than PPV-D, PPV-M and PPV-Rec.

In addition to direct yield effects, the presence of PPV in a country creates difficulties for trade and export of (certified) planting material. This indirect effect has not been further investigated in the present PRA.

3 Identification and evaluation of management options

Introduction

PPV can be managed by multiple approaches such as certification programs for propagation material, vector control, use of resistant or tolerant cultivars and removal of diseased trees. Management strategies can be specifically geared towards the different circumstances, e.g. depending on the geographical zones in Europe and prevalence of the virus. Here, we discuss successively:

I. Methods to manage the disease
   - o detection and inspection methods
   - o vector control
   - o resistant or tolerant cultivars
   - o pest free production areas, places or sites
   - o certification schemes

II. Certification (Council Directive 2008/90/EC and)

III. Current phytosanitary legislation (Council Directive 2000/29/EC)

Management options are only described for the main pathway "Plants for planting of *Prunus* spp." because other pathways are highly uncertain or much less relevant (plants for planting of non-*Prunus* spp., branches of susceptible plants, fruits of *Prunus* spp.) and PPV is already present in many EU-countries.

Methods to manage the disease

Detection and inspection methods

Visual inspection

Visual inspection does allow detection by symptoms, especially during the period of active growth. Diagnostic symptoms range from mild to severe and vary with the virus strain, host species and cultivar (Wang *et al.,* 2006). In general, leaf symptoms are less apparent in apricot than in peach or plum (Travis 2001). Symptoms may disappear with the onset of hot weather. Almost all known apricot, plum and peach cultivars are susceptible to PPV. However, some cultivars show very few symptoms when infected and can act as unseen reservoirs allowing virus to spread unnoticed. Moreover, many trees fail to develop symptoms for several years following infection (Kamenova *et al.,* 1978; Smith *et al.,* 1997; Dicenta *et al.,* 1999; Travis 2001) and most propagation material, besides mother plants, remain for one or at most for two seasons at the nursery which is too short time for the development of symptoms (SharCo, 2009). Therefore, the lack of symptoms cannot be relied on as proof that the tree is not infected. For this reason, absence of virus should be confirmed by large scale routine screening methods, especially in certification schemes for the production of virus free planting material of woody fruit and ornamental crops. The detection method should be sensitive and reliable and allow detection of minor amounts of viral antigen in routine samples.

Detection and diagnosis

An integrated approach, which includes biological indexing and serological and molecular assays using validated reagents and methods, has been recommended in the EPPO protocol for PPV detection and characterization (OEPP/EPPO, 2004). Diagnostic methods have been evaluated by Wang *et al.* (2006). For efficient detection and further strain characterization, a combination of techniques can be used. In spite of the development of many nucleic-acid-based techniques, serological techniques, ELISA in particular, remain the most common approach. ELISA techniques are inexpensive, simple, and suitable for testing a large number of samples and can be easily transferred from laboratory to laboratory. These features make ELISA-based techniques ideal for routine detection assays. There are several broad spectrum antibodies for PPV detection, e.g. the 5B antibody that is developed by Cambra *et al.* (1994) and detects isolates of all known PPV strains. Specific antibodies, e.g. strain specific antibodies may be used to further characterize the isolates (Boscia *et al.,* 1997; Crescenzi *et al.,* 1997b; Myrta *et al.,* 2000) but the

PPV-M and the PPV-Rec strain can, however, not be distinguished by M-specific monoclonal antibodies (e.g. Zagrai et al., 2008a). Nucleic-acid-based techniques can be used to characterize the PPV isolates to the strain level (Wang *et al.,* 2006). Polymerase chain reaction (PCR) based assays are more sensitive but less practical for large scale surveys (López-Moya *et al.*, 2000). However, more recent work has shown the possibility to use real-time RT-PCR at a large scale (Capote *et al.*, 2009).

A draft Annex to ISPM 27:2010 is currently discussed for PPV-detection and characterization and is an update of the EPPO-2004-protocol (https://www.ippc.int/index.php?id=draft_ispm_wkshps&no_cache=1&L=0; accessed November, 2010).

Sampling

Various sampling protocols can be applied. In areas where PPV has not been found, hierarchical sampling methods, a form of group testing where leaves from more trees are combined in one sample, can be used (Hughes *et al.,* 2002; Gottwald 2006). More stringent survey methods have been utilized in high-risk areas adjacent to positive findings (Thompson, 2006). Appropriate sample selection is critical for PPV detection. Focus should be on optimization of sampling protocols that will reduce the chance of missing an infection. Non-detection problems may occur if the virus is not fully systemic at the time of sampling, irregular distribution of PPV within the tree and low virus titers. PPV is known to be unevenly distributed within infected trees, and virus titer can fluctuate during a growing season. Re-sampling at intervals will reduce the chance of missing an infection. An adequate number of leaves must be taken to overcome the irregular distribution of PPV within the tree and ensure that at least one positive leaf is selected. Through detailed sampling of infected peach trees in Ontario, percentages of infected leaves were estimated to range from 2 up to 73% per tree. Low levels of infection can easily be missed. To ensure 95% confidence, a positive sample from a tree with 75% of the leaves infected only requires a sample size of 3 leaves. However, a tree with 10% of the leaves infected requires 29 leaves, which is well above the most stringent sampling protocol used in the Canadian survey. Efforts are being made to maximize the number of leaves sampled per tree, yet still remaining within the detection limits of the ELISA test (Thompson, 2006). In the the European SharCo-project a protocol is being prepared for PPV-detection in nurseries (Cambra *et al*., 2010).

Conclusions detection and inspection methods

- Visual inspection on its own is not sufficiently effective to guarantee pest freedom of planting material, especially not with the use of tolerant cultivars
- Biochemical and molecular methods are available for diagnosis and detection of PPV in planting material. The probability of detection of PPV in an symptomlessly infected plant will largely depend on the sampling intensity because of the irregular distribution of PPV within a plant.
- A draft Annex to ISPM 27:2010 is currently discussed for PPV-detection and characterization and is an update of the EPPO-2004-protocol

Vector control

Reduction of PPV-infections may be achieved by control of aphids but is difficult because of the very short time between acquisition and inoculation (Asjes, 1985; Perring *et al*., 1999). Application of pesticides outside the target field to reduce entry of vector species may be most effective but such an strategy will not be feasible in most cases (Perring *et al*., 1999). Pesticides that interfere with the transmission of the viruses like mineral oil may be effective at the production place. Pyrethroids may also be effective because they can kill the vector before inoculation and reduce probing time of vectors (Perring *et al*., 1999). Asjes (1985) found positive effects against spread of non-persistent viruses in flower bulbs using pyrethroids and mineral oil. In the Netherlands, flower bulb growers use both mineral oil and pyrethroids against infection by non-persistently transmitted virus species (Asjes, 2000; Kock et al., 2009). A drawback of the use of pyrethroids might be their repellent effect which might enhance spread (De Kock *et al*., 2009; Perring *et al*., 1999). Another drawback of pyrethroids is their negative impact on non-target species. Mineral oils have less of these negative side-effects and Vidal *et al.* (2010) tested mineral oil against PPV-infections. They found a lower percentage of PPV-infected plants treated with mineral oil for one *Prunus* rootstock genotype but not for another one. Mineral oil may be ineffective at high inoculum pressures (Simon & Zitter, 1980) and Vidal *et al.* (2010) recommended that mineral oil treatments should be further tested under diverse conditions; such work is currently carried out in the European SharCo-project.

Resistant and tolerant cultivars

(Partially) resistant or (relatively) tolerant cultivars are used in several European countries as a method to control Sharka disease. Kegler *et al.* (1998) have listed genotypes of plum, apricot, peach and nectarine that have been decribed as resistant or tolerant to PPV and research is ongoing on this topic (e.g. Hartmann & Neumuller, 2010; Egea et al., 2010; Vera-Ruiz et al., 2010; Rubio *et al*., 2010; http://www.sharco.eu/sharco/ accessed November 2010; Liverani *et al*., 2011). Note that at present, not enough stone fruit cultivars are available that are fully resistant to PPV; some cultivars are available that are partially resistant or have various levels of tolerance to PPV (pers. comm. G.P. Jongedijk, PropagationNurseriesTheNetherlands, December 2010).

The situation and/or prospects for resistance against PPV differs between apricot (*P. armeniaca*), peach (*P. persica*) and plum (*P. domestica*). For apricot, resistance sources are available which are being used in breeding programmes (e.g. Martínez-Calvo *et al*., 2009; Vera-Ruiz *et al*., 2010; Dondini *et al*., 2011). In peach, no sources of resistance have yet been found but resistance has been found in related species. Resistance cultivars might become available in the future using interspecific hybrids as resistance source (e.g. Polák & Oukropec, 2010; Liverani *et al*., 2011). In plum, a high level of resistance has been achieved in plum cultivar Jojo by conventional breeding. The resistance is based on a hypersensitive response of the host plant to infection with the virus. "Jojo" has been found absolutely resistant in tests with isolates of different strains and under field conditions (Hartman, 2002; Neumüller *et al*., 2005; Hartman & Neumüller, 2010; Stefanova *et al*., 2010). The absolute resistance of "Jojo" has been debated by Polák *et al*. (2005), who found a strong hypersensitive response but also transfer of PPV from "Jojo" to the rootstock after inoculation by chip budding with isolates belonging to PPV-M and PPV-Rec. The hypersensitive response in plum may be based on several genes and other promising "hypersensitive" genotypes have been selected (Neumüller *et al*., 2007; Hartmann & Neumüller, 2010). The durability of the hypersensitivity type of resistance is uncertain. A hypersensitive response was earlier reported for the plum genotype "K4", but the resistance was isolate-specific and "K4" was highly susceptible to certain PPV-isolates (Kegler & Grüntzig, 1992; Fuchs *et al*., 1995). A high level of resistance in plum has also been achieved by genetic engineering. A transgenic line called C5 (cv. HoneySweet) transformed with the PPV CP gene appeared to be highly resistant in several field tests in Europe and did not affect virus nor aphid vector populations structures (e.g. Malinowski *et al*., 2006; Capote *et al*., 2008; Zagrai *et al*., 2008b; Ravelonandra & Scorza, 2009). This cultivar is currently not commercially available in Europe but it (and possibly other genetically engineered plum cultivars) may be a solution for the future in plum growing areas where PPV is endemic. If HoneySweet would be approved in the EU and accepted by consumers, a series of PPV resistant plum cultivars could be relatively easily obtained by conventional breeding with HoneySweet as donor of the resistance. The insert providing its resistance is inherited as a single dominant gene, which makes further breeding relatively easy (Ravelonandra *et al*., 1998; Scorza *et al*., 1998; Hily *et al*., 2004).

Pest free production areas, places or sites

Pest free production area.

Sufficiently effective to guarantee pest freedom of the crop. Intensive and frequent surveys, sampling and testing programs will be needed to confirm pest freedom because PPV can be latently be present. Such programs will especially be important in areas where *Prunus* host plants are regularly being imported.

Pest free production place or site – buffer zone

In areas where PPV is present and aphid transmission is common, a buffer zone will be needed around the place or site of production to exclude natural introduction by aphids from the surroundings.

Various studies indicate that natural spread of PPV will mostly occur over short distances, e.g. less than 100 m but that transmission over longer distances (several hundreds of meters) may also occur (see the paragraph "Natural transmission"). Infected hosts without symptoms can be present and act as a reservoir for PPV. Thus, in areas where PPV is present and virus transmission is known to occur, removal of all host plant in an area around a nursery would be necessary to prevent introduction of PPV. The size of the buffer zone should depend on the conditions and the prevalence of the vector and the virus in the area. Based on available information about natural transmission from literature (see :"Natural transmission"), a buffer zone of 500 m will give a high guarantee level that plants will not be infected from the surroundings. This 500 m buffer zone corresponds with eradication measures in the USA where all potentially susceptible plants within 500 m around infected trees are removed (http://www.ars.usda.gov/is/br/plumpox/; accessed November 2010) and recent studies in Canada and USA indicate that distance of 500 m can constitute an excellent buffer zone (M. Cambra, pers. comm., November 2010). The available data indicate that smaller buffer zones (e.g. 250 m) can be effective, especially in areas with low PPV-prevalence, but will increase the risk of incidental introductions from the surroundings compared to a 500 m - buffer zone. Testing frequency and intensity could, therefore, be increased to obtain similar levels of guarantee for pest freedom. Note that the probability that PPV will spread naturally more than 100 m within one season in case of a single of few infected trees is very low but this probability will increase with pest prevalence (number of infected trees and infection levels). The probability of spread will also largely depends on aphid population densities. Thus, the requirements for areas with a low PPV-incidence and where natural transmission occurs at low frequencies could be less stringent (smaller buffer zone) than in areas where PPV is prevalent en natural transmission occurs frequently to obtain similar guarantee levels.

In addition to *Prunus* species a large number of weed species and also some woody non-*Prunus* species are known or have been reported to be susceptible to PPV. These species might act as a inoculum source in or near stone fruit orchards (see "Host range" for details and references). Transmission from weeds to *Prunus* plants has been shown under experimental conditions and if this happens in the field, a *Prunus*-free buffer zone will not work and it will not be feasible to establish a pest free production place in areas where PPV is present. Thus far, transmission under field conditions from non-*Prunus* spp. to *Prunus* spp. has not been demonstrated but can also not be excluded.

Pest free production place or site – physical protection
Complete physical protection against aphids will be effective. Physical protection should be combined with intensive visual inspections for presence of aphids and Sharka-symptoms and testing to check if the physical protection has been effective. In addition, testing is recommended to confirm pest freedom of the crop. Application of insecticides against aphids in the immediate vicinity of the production place or site will decrease the chance that aphids will enter through doors or unintentional openings in screens. Physical protection may not be feasible or too costly for tree nurseries (except for the more basic material, see also below "Certification").

Uncertainties

- Herbaceous plants as well as several woody non-*Prunus* species might act as reservoir of PPV from which aphids might transfer the virus to *Prunus* plants. Although shown experimentally that herbaceous plants can serve as reservoir for PPV, their role in the epidemiology of PPV is presently not well understood (see "Host range").
- The distance over which PPV can be spread by vector-species

Certification (Council Directive 2008/90/EC)

Council Directive 2008/90/EEC of 29 September 2008 is a recast version of Directive 92/34/EEC "on the marketing of fruit plant propagating material and fruit plants intended for fruit production" (http://ec.europa.eu/food/plant/propagation/index_en.htm; accessed November 2010). The directive contains the general requirements for the production of propagation material and fruit plants. Propagation material includes seeds and all plant material intended for the propagation and production of fruit plants. Fruit plants are defined as "plants intended to be planted or replanted, after marketing". The directive stipulates that plant progation material and fruit plants of genera and species listed in the Annex, including *P. amygdalus, P. amerniaca, P. avium, P. cerasus, P. domestica* and *P. persica* may only be marketed if they are either CAC (Conformitas Agraria Communitatis), pre-basic, basic or certified material. The conditions to be met are most strict for pre-basic material and basic-material and least strict for CAC-material. Certified material should be produced directly from basic or pre-basic material.

More specific requirements which must be met for the production of the different types of material are laid down in Commission Directive 93/48/EEC (“setting out the schedule indicating the conditions to be met by fruit plant propagation material and fruit plants intended for fruit production, pursuant to Council Directive 92/34/EEC). The following is stated in relation to plant health:

Article 3

> “...in the case of CAC material the material must, at least on visual inspection, be substantially free from any harmful organisms and diseases impairing quality, or any signs or symptoms thereof, which reduce the usefulness of the propagating material or fruit plant and in particular be free from those organisms and diseases listed in the Annex hereto in respect of the genus or species concerned.
> 2. Any material showing visible signs or symptoms of the harmful organisms or diseases referred to in paragraph 1 at the stage of the growing crop shall be properly treated immediately upon their appearance or, where appropriate, shall be removed.”

Article 6

> In the case of pre-basic, basic and certified material, the requirements set out in Articles 3, 4 (1) and 5 hereof are applicable in so far as the certification schemes referred to in Article 7 hereof do not impose more stringent conditions.

Article 7

> Pending the establishment of a Community certification scheme, pre-basic, basic and certified material shall satisfy the conditions for each respective category as laid down in national schemes of certification provided that they comply, as far as possible, with existing international schemes of certification.

In the EU national certification schemes have been implemented and certified planting material is on the market. The guarantee level that certified plants are completely free of PPV will, however, largely depend on the prevalence of PPV in the area of production, the frequency of aphid transmission, environmental conditions and the intensity (frequency and sample size) by which the material is tested. In the Netherlands, the production of virus-free propagation material is based on the certification scheme published by EPPO (Anonymous, 2001) and has been described by Verhoeven *et al.*, (2008). It includes testing of nuclear stock (grown in aphid-free screenhouses) twice a year and testing of basic material grade 1 plants individually once every year. The categories basic material grade 2, mother trees and stool beds are inspected and randomly tested every year. This system will give a high guarantee for PPV-freedom in areas with a low PPV-prevalence and where aphid transmission occurs only incidentally but will be difficult to implement in areas where PPV is present and aphid transmission occurs frequently: latent infections can remain undetected because not each plant is tested individually and testing is not 100% proof because of the irregular distribution of PPV in the plant.

For CAC-material, testing for viruses is not required and freedom for PPV may be based on visual inspection only under the markeing directive (see also Verhoeven *et al.*, 1998). Under the present phytosanitary legislation (Council Directive 2000/29/EC), there are specific requirements for all plants intended for planting of *Prunus* species susceptible to PPV which means among others that CAC-material must has be derived from material tested for PPV every three years (see further the paragraph below: “Current phytosanitary legislation” and Appendix III).

Note that the lifetime of cultivars of apricot and nectarine in Europe is very short, so implementation of a certification scheme for the production of PPV-free propagation material of these species may be complicated (pers. comm. G.P. Jongedijk, PropagationNurseriesTheNetherlands, December 2010). Also, production of PPV-free planting material in the open will not be possible in areas where PPV is prevalent en natural transmission occurs frequently.

The Council Directive 2008/29/EC does not include requirements for the production of ornamental *Prunus* plants by which PPV can also be spread. Council Directive 98/46/EC (http://ec.europa.eu/food/plant/propagation/index_en.htm) is in place for propagation material of ornamental plants. It requires (article 5 - 1) that "propagating material when marketed: - shall at least on visual inspection, be substantially free from any harmful organisms impairing quality, or any signs or symptoms thereof, which reduce its usefulness". Because PPV can be symptomlessly present, this requirement does not guarantee PPV-freedom of the plants.

It is concluded that based on the nature of PPV (latent infections and naturally transmitted by many vector species) the requirements for the production of fruit plants in the marketing directive on their own are not sufficient to guarantee freedom of PPV of fruit plants and certainly not of *Prunus* ornamentals because they are not included in the Directive. Fruit plants raised under certification schemes including strict testing regimes for PPV (e.g. based on the EPPO-certification scheme) will, however, have a low chance of being infected.

Current phytosanitary legislation (Council Directive 2000/29/EC)

The Council Directive 2000/29/EC requires that plants intended for planting of *Prunus* species susceptible to PPV have been (a) raised under a certification scheme or derived from material maintained under appropriate conditions and tested for PPV at least once during the last 3 complete cycles of vegetation, and (b) no symptoms of disease have been observed at the production place and its immediate vicinity since the beginning of the last 3 vegetative cycles and (c) plants with virus(-like) symptoms have been rogued out (Annex IV, Part A, Section I, article 23.1 and Section II, article 16) (Appendix III)

In areas where PPV-tolerant cultivars are used and/or where transmission by aphids is common, it can be difficult to guarantee pest freedom of the plants:

- Introductions in nurseries can occur by aphid transmission from the surroundings (see also above "Pest free production areas, places or sites"). In areas where the virus is present and aphid transmission is common, testing of material once in a period of 3 years, which is a minimum requirement, will not be sufficient to guarantee pest freedom of the crop.
- The "immediate vicinity" is not defined and may be interpreted differently. PPV may be spread by vectors over several hundreds of meters and a buffer zone of at least 250 m without *Prunus* host plants would be necessary to guarantee pest freedom of the crop especially in areas where vector transmission occurs frequently. PPV can be present in hosts without causing sympoms and removal of all *Prunus* host plant in the buffer zone will be required to guarantee pest freedom (see also above "Pest free production place or site").
- The use of PPV-tolerant cultivars will make frequent and intensive testing of individual trees necessary to guarantee pest freedom of the crop.

For these reasons, the current EU-requirements may be difficult, if not impossible, to implement in areas where the virus and vectors are prevalent or may not give high levels of guarantee that the crop is pest free. Bazzoni *et al.* (2008) have stated that the application of phytosanitary quarantine rules is the basic strategy to control and prevent the spread of Sharka but it is ineffective in the area where Sharka is already endemic. In such areas the search of sources of resistance to PPV and breeding for resistance represents a reasonable solution. Polak (2002) has stated about the situation of PPV in Czech Republic "this high incidence in naturally growing plum and myrobalan trees makes it impossible to grow plum cultivars that are susceptible to PPV; only resistant cultivars can be grown in this country".

In areas where PPV is present at low prevalence PPV-infection cannot be fully excluded as incidental findings in nurseries or in propagation material have been reported from the UK and the Netherlands (Mumford 2006a,b; Verhoeven *et al*., 2006, 2008). If PPV infection is found at propagators applying the official certification scheme in the UK, "...diseased trees are destroyed plus adjacent trees in the same row (for 5 m either side) and in the two adjoining rows (for 10 m). For other propagators, only the diseased trees are destroyed. Movement of material from infected sites can be licensed, but certain criteria apply and the material can only be moved to a local market, e.g. within UK, not exported..." (Mumford 2006b).

A few EU member states (the Netherlands, Poland) have indicated that a shorter period than 3 years is implemented depending on the situation, e.g. in cases where PPV is found in not more than 1 or 2 plants at the place of production. The procedure in such cases may include destruction of the infected plants and the host plants in the vicinity and intensive testing of other host plants at the production place (information received from the NPPO's of the Netherlands and Poland, November 2010).

In France, two surveys per year are obligatory in and around tree nurseries within a radius of 1 km. When PPV is found within 200 m of a nursery (was 500 m before March 2011 when only one survey per year was realized and 200 m when two surveys per year were realized), plants will not be plant passported for three years (Information received from the NPPO of France, August 2011; see also Appendix I).

The EU FP7-project SharCo (Containment of Sharka virus in view of EU-expansion) has made a survey on the implementation of European measures for the containment of the sharka disease in 11 countries of which 9 were EU-countries. The EU-countries were: Bulgaria, Czech Republic, France, Germany, Italy, Poland, Spain, Slovakia and Romania, (SharCo, 2009). It was concluded that the requirements of the 2000/29 were generally poorly implemented, the minimum level of guarantee for the production of PPV-free mother plants in the EU is not achieved and few countries implemented a 3 years suspension period in the case of PPV-contamination in tree nurseries. It was also concluded that a 3 years suspension period is not realistic and too severe: "a determination of the time of suspension based on evaluation of the phytosanitary risk, combined with the systematic use of laboratory tests, would be more realistic and useful for the achievement of the goal."

4. Summary and conclusions

Pest status
PPV is the causal agent of Sharka disease in *Prunus* species. It is especially known as a pest of stone fruit species. The virus originates in eastern Europe and is nowadays present in at least 20 EU-countries including the major producing stone fruit ones and under eradication in another two EU-countries. The five countries (Ireland, Sweden, Finland, Estonia and Malta) where PPV is not (known to be) present have a relatively small area of stone fruit production. PPV might already be more widespread than presently known, e.g. through trade of infected material for the private market but this is uncertain.

The current status of PPV in the EU is very complex, e.g. virus incidence differs per country and also within countries and the pathogen is very divers with respect to biological characteristics. Several strains are recognized. The two commonest strains are PPV-D and PPV-M of which PPV-M appears to spread more rapidly in peaches but within strain-variation may occur. Both PPV-D and PPV-M are widely distributed in central, eastern and southern EU-countries but in some countries PPV-M is absent (Portugal, Poland, Romania, Spain) or has been found at low frequency (Czech Republic). In Germany, Austria and France both PPV-M and PPV-D are present. In other western and northern EU-countries only PPV-D is known to be present (UK, Lithuania, Belgium, the Netherlands) or the strain-type has not been identified or reported (Luxembourg). PPV-Rec is the third most commonest strain in Europe and present in at least 9 EU-member states. Relatively little is known about PPV-Rec because this name has only recently been proposed in 2004 (Glasa *et al.,* 2004). PPV-Rec may be more widespread than presently known because recent results indicate that PPV isolates which had been previously typed as PPV-M are actually PPV-Rec. It also means that the distribution of PPV-M is uncertain since isolates that have reported earlier to be PPV-M proved to be PPV-Rec in recent years. PPV-C is the only strain known to affect cherry (sour and sweet cherry) and has a limited distribution in the EU. It has only been reported from Hungary, Romania and Italy (with a limited distribution). A few other strains, PPV-EA, PPV-W and PPV-T have been found outside the EU and PPV-W recently also in the EU in Latvia. PPV-W and PPV-T are relatively new strains and have been described in 2005 and 2009, respectively.

Impact
The potential impact of PPV is high (on a 3-level scale: low – medium – high) for the production of plum, peach, nectarine and apricot fruits especially in southern, central and eastern Europe where yield losses of up to 100% have been reported in the past and where most of the stone fruit area is located in the EU. In areas where only the D-strain is present, the M-strain poses an additional risk to plant health since it appears to be a more epidemic and aggressive strain on peach and possibly also on apricot and maybe plum. The introduction of tolerant or (partial) resistant stone fruit cultivars has been an important tool to manage PPV in southern, central and eastern Europe. However, the use of tolerant cultivars increases the risk of spread of PPV by movement of symptomless but infected planting material and this planting material may act as an unseen reservoir for nontolerant cultivars present in the same area.

In northern Europe, natural spread of PPV seems to be less important than in other parts of Europe and, the disease is generally controlled by the use of certified propagation material and (voluntary) removal of infected trees. The M-strain may not pose an additional risk to plant health in northern European countries where PPV-D is already present because PPV-M does not appear to be (much) more severe on plum than PPV-D and peach and apricot are not grown in these countries.

PPV-C is the only strain known to affect cherry and can pose a risk to cherry producing areas in Europe. However, the limited occurrence of infected or symptomatic cherry trees reported in the EU suggest that PPV-C can easily be controlled in cherry and has a low impact for the production of cherry (with a medium uncertainty).

Almond is a host plant but significant symptoms nor yield losses have been reported and the potential impact of PPV for almond is assessed as low.

The direct impact for the production of ornamental *Prunus* plants as well as the impact on natural vegetation is assessed as low (with a medium uncertainty).

The additional impact of the relatively new strains PPV-Rec, PPV-EA, PPV-W and PPV-T is difficult to assess. Differences in vector-transmissibility and/or host plant specificity may occur and these strains might impose an additional risk to PPV-D and/or PPV-M but this is uncertain and, thus far, there are no indications that the risk of these new strains is higher than of PPV-D and PPV-M together.

<u>Pathways for spread and introduction</u>
The main pathway for PPV is movement of infected planting material of *Prunus* spp. Many interceptions and findings of PPV on *Prunus* plants originating from countries within and outside the EU show that the probability of spread and introduction of PPV is high despite the current EU-legislation. Natural spread by aphids usually occurs over distances of less than 100 m, but there are indications that transmission over distances of several hundreds of meters can occur.

In addition to *Prunus* species, a large number of herbaceous plant species and some woody non-*Prunus* species have been reported to be susceptible for PPV. These species might act as an inoculum source for stone fruit orchards but their host plant status under field conditions is uncertain. Transmission from herbaceous plant species to *Prunus* plants through aphids has been shown under experimental conditions and may also happen under field conditions but this is uncertain. Thus, the significance of non-*Prunus* spp. as inoculum reservoir for *Prunus* species is not yet clear.

<u>Management options</u>
The current EU-legislation as laid down in Annex IV of the Council Directive 2000/29/EC has several requirement for plants, intended for planting, of *Prunus* species susceptible to PPV to ensure pest freedom. These requirements however, are difficult to implement or may not give a high level of guarantee for pest freedom of the crop in areas where PPV is prevalent and aphid transmission plays a significant role in the epidemiology of the disease. Because of the presence of PPV in many EU-countries the experiences obtained with eradication actions and the many interceptions of PPV on planting material, it is recommended to reconsider the current EU-requirements concerning *Prunus* host plants in relation to PPV. Possible options are:

I. *Strengthening of the requirements for the import and trade of propagation material and plants of Prunus species susceptible to PPV originating in areas where PPV is present. Requirements include a buffer zone without any Prunus host plants around nurseries or complete physical protection and intensive sampling and testing regimes.*

A 500 m buffer zone around the place of production with no host plants of PPV in combination with testing of host plants at the place of production and the place of production found free from PPV for at least one growing season (both visual and in testing) is recommended for obtaining a high level of protection especially in areas where PPV prevalent. A smaller buffer zone (e.g. 250 m) will increase the risk of incidental introductions but in combination with an intensified testing regime will still provide a high level of protection. In areas with a low PPV-incidence and where natural transmission occurs at low frequencies less stringent measures (smaller buffer zones) are needed to establish a similar guarantee level as in areas where PPV is prevalent en natural transmission occurs frequently. The measure buffer zone in combination with testing for trade of propagation material will prevent spread of PPV by movement of propagation material and plants. The measures will have a large impact on the surroundings of the nursery because of the mandatory removal and prohibition of any *Prunus* host plant around the nursery and may be difficult to implement. In areas where PPV is endemic and natural transmission occurs frequently, such strict requirements for planting material will have limited effect on the spread of the Sharka disease.

Complete physical protection against aphids is an alternative for the buffer zone but will probably not be feasible in practice for the majority of nurseries. Physical protection should be combined with intensive visual inspections for presence of aphids and Sharka-symptoms and testing to check if the physical protection has been effective.

In areas where PPV is known not to be present (pest free areas), specific requirements for the production place are not required.

II. Removal (deregulation) of PPV from the Annexes of Council Directive 2000/29/EC,

This option means that there will be no official measures specifically to prevent spread of PPV by movement of propagation material and plants. The Council Directive "on the marketing of fruit plant propagating material and fruit plants intended for fruit production" (92/34/EEG to be replaced by recast version 2008/90/EC) will still be in place. This Council directive contains general requirements on prevention of diseases without specifically mentioning PPV. Plants raised under national certification schemes which includes strict testing regimes for PPV (e.g. based on the EPPO-certification scheme) will have a very low chance of being infected. However, the requirements for CAC material in relation to pests and diseases are only that it needs to be substantially free of diseases based on visual inspection. Thus, this option will not prevent spread of PPV within the EU particularly in relation to the trade of CAC material.

III. Removal (deregulation) of PPV from the Annexes of Council Directive 2000/29/EC, inclusion in the marketing directive

This option is similar to option II but includes the inclusion of PPV in the marketing directive for fruit plant propagation material and fruit plants. This option would require that plants and planting material that are certified have been tested and found free of PPV (according to the certification scheme) and this will be indicated as such on the certificate. Growers can choose for certified planting material which will have a very low chance of being infected. PPV-free areas/buffer zones could be established (by national authorities or industry) to enable the production of certified planting material in countries where PPV is prevalent. PPV could still be spread by trade of CAC-material and ornamental *Prunus* species that are not grown under certification schemes.

IV. Maintaining the quarantine status of PPV but adapting the present requirements for the trade of propagation material and plants of Prunus species susceptible to PPV originating in areas where PPV is present.

One of the present requirements (b) (see Appendix III)

"no symptoms of disease caused by Plum pox virus have been observed on plants at the place of production or on susceptible plants in its immediate vicinity, since the beginning of the last three complete cycles of vegetation;"

is replaced by

" - no symptoms of disease caused by Plum pox virus have been observed on plants at the place of production or on susceptible plants in its immediate vicinity, since the beginning of the last three complete cycles of vegetation,
or
- no symptoms of disease caused by Plum pox virus have been observed on plants at the place of production or on susceptible plants in its immediate vicinity, since the beginning of the last complete cycle of vegetation and absence of the Plum pox virus has been confirmed by official testing using appropriate sampling methods and indicators or equivalent methods."

(the other requirement (a) and (c) remains in place).

This option means that in stead of a period of 3 years with visual observations, one year pest freedom is sufficient when absence of PPV has been confirmed by official testing.

This option will give a lower level of guarantee for pest freedom of the crop than option I (with the buffer zone) but similar, depending on the sampling intensity, to that of the current legislation. In case of the presence of tolerant cultivars at the production place, testing will increase the guarantee level. This option, quit similar to the present legislation is only feasible in areas with a low PPV-prevalence. In areas where PPV is prevalent en natural transmission occurs frequently, a buffer zone will still be needed to produce PPV-free planting material.

<u>Main uncertainties</u>

The main uncertainties in the present PRA are:

- The distribution of PPV and the different PPV-strains in Europe
- The role of herbaceous plants and woody non-*Prunus* species in the epidemiology of the Sharka disease
- The maximum distance over which PPV can be spread by vectors
- Differences in impact between PPV-D, PPV-M and PPV-Rec particularly on apricot and plum. There are few experiments in which the epidemiology and/or aggressiveness of various isolates of the different strains have been compared.

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Appendix I: Pest status and control measures in European countries

EU-countries

Austria	**EPPO-PQR**[1]	Present, limited distribution
	1st report/detected	1961
	Spread/infection levels	Survey conducted in the eastern part of Austria from 1999 - 2003. Presence of PPV confirmed in Styria, another major stone fruit producing area
	PPV strains	PPV-D (163 isolates), PPV-M (10 isolates), 7 isolates unidentified. Intra-strain variability analysis revealed that M-isolates are of the Mediterranean group (PPV-M2)
	Found in:	Plum (*P. domestica*), apricot (*P.armeniaca*), peach (*P. persica*), and blackthorn (*P. spinosa*), cherry/myrobalan plum (*P. cerasifera*)
	Control strategies	PPV-infected trees are removed. In Styria (a major stone fruit producing area) PPV is tried to control by the use of PPV-tolerant plum cultivars from Germany (Szith, pers.comm. (2004) in Laimer *et al.* 2005)
	References	Laimer *et al*., 2005

Belgium	**EPPO-PQR**	
	1st report/detected	1974
	Spread/infection levels	Few occasions: in 1974 on a plum tree and in 1989 in the research station of Rillaar on imported Pixie rootstocks. During a survey in 20 different orchards, two isolated foci of infection were found on five plum trees. All infected trees were destroyed and further tests done in orchards only gave negative results (Roy & Smith, 1994). Updated information from the NPPO of Belgium (2010): a few infected plants have been found in planting material in 2008, 2009 and 2010. No inspections are carried out in orchards nor in pivate gardens. Pest status: "present, at low prevalence and subject to official control".
	PPV strains	PPV-D. Isolate W-Bel confirmed as PPV-D (Candresse et al., 1998). Update 2010 (NPPO of Belgium): only PPV-D found thus far.
	Found in:	Plum, Pixie rootstock
	Control strategies	Growers are provided with virus-free propagation material and orchards are visually inspected twice a year. In doubtful cases, samples are taken and tested by ELISA. Infected trees are destructed (Roy & Smith, 1994)
	References	Roy & Smith, 1994; Candressa *et al*., 1998; NPPO of Belgium, 2010

Bulgaria		
	EPPO-PQR	Present and widespread
	1st report/detected	1932 (first noticed around 1917/1918)
	Spread/infection levels	Spread all over the country. PPV incidence: Sofia (76.6%), Drjanovo (73%), Kyustendil (63.2%), Plovdiv (26.5%) (Milusheva *et al*., 2006).
	PPV strains	PPV-M (47%), PPV-D (17%) and PPV-Rec (18%). Also mixed infections and undetermined strains found (18%) (Dallot *et al*., 2008). Plum: PPV-M (88.3%), PPV-D (5.2%), apricot and peach: only PPV-M. Mixed infections (6.2%), near the Serbia border (Milusheva *et al*., 2006). PPV-Rec confirmed (Glasa *et al*., 2004b)
	Found in:	Infection level: plum (62.2%), apricot (24.3%) and peach (19.5%). *Prunus cerasifera* natural reservoir for PPV (Milusheva *et al*., 2006)
	Control strategies	Certification schemes for the production of virus free planting material of plum; breeding for Sharka-resistant and tolerant cultivars (Dragoiski *et al.* 2007) and establishment of new orchards with slightly sensitive or tolerant cultivars (Milusheva *et al*., 2006).
	References	Atanasoff, 1932; Dallot *et al*., 2008; Dragoiski *et al*., 2007; Dzhuvinov *et al*., 2007; Glasa *et al*., 2004; Milusheva *et al*., 2006

Cyprus		
	EPPO-PQR	Present, limited distribution
	1st report/detected	
	Spread/infection levels	-
	PPV strains	PPV-M is the prevailing isolate (Myrta *et al*. 2002)
	Found in:	-
	Control strategies	-
	References	Myrta *et al*., 2002

Czech Republic	**EPPO-PQR**	Present and widespread
	1st report/detected	Description of symptoms, most likely caused by PPV, in 1926 (Smolák, 1926); PPV detected in 1952 (Smolák & Novák, 1956)
	Spread/infection levels	Present in major stone fruit-growing areas (Navratil, 2006).
	PPV strains	Approximate percentage of distribution: PPV-D (over 95%), PPV-M (2,5%) and PPV-Rec (2,5%). Mixed infections found only exceptionally (Polák & Komínek 2009). PPV-D widespread in all regions and appear to have been introduced earlier to CZ than Rec and M types. PPV-C not present (Navrátil, 2006). PPV-Rec confirmed (Glasa *et al*., 2004b).
	Found in:	Widely distributed in plums, myrobalans, less in apricot and peaches. Not found on sweet cherry and sour cherry. Wild plums and myrobalans are considered main sources and reservoirs of PPV (Polák 1997, 2002, 2007, Polák & Komínek 2009).
	Control strategies	Regulation of PPV in CZ has been performed for decades (since the 60ties of the last century) by phytosanitary and certification legislation. Main measures are as follows (information obtained from the NPPO of Czech Republic, 2010): – official survey before establisment of nurseries; safety distances from host fruit species, later only from infected *Prunus* plants – testing of mother plants on woody indicators (since the 60ties of the last century), later also immunoenzyme methods – prescription of the maximal number of generations in breeding material – prescription of the limit for PPV presence in breeding material – later zero tolerance prescription of the maximal age of mother plants – meticulous visual inspections of breeding material during its planting subsequent inspections before trading
	References	Glasa *et al.*, 2004b; Navrátil, 2006; Polák 1997, 2002, 2007; Polák & Komínek 2009; NPPO of Czech Republic, 2010

Denmark	**EPPO-PQR**	
	1st report/detected	1986
	Spread/infection levels	PPV detected for the first time in 1986 and eradicated. Five new infection sites were detected in the period 2008 – 2010 including a garden centre. Some infections have been traced back to plants originating in other EU MS. One infection is traced forward to an orchard. Infected plants may have been distributed to private gardens in DK. PPV is under eradication in all nurseries and the orchard.
	PPV strains	PPV-D and PPV-M
	Found in:	plum (4) and peach (1)
	Control strategies	Nurseries are inspected twice a year with routine testing of samples. Control strategy in nurseries is based on destruction of infected plant lot or single plants depending on infection level. Destruction of host plants in immediate vicinity and quarantine zones around infected plants. In orchards infected plants are destroyed and surveys are performed with testing of random samples.
	References	Scheel, 2009; Scheel, 2010 (personal communication)

Estonia	EPPO-PQR	
	1st report/detected	
	Spread/infection levels	PPV has been found but did not establish in Estonia (Roy & Smith, 1994)
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	Roy & Smith, 1994

Finland	EPPO-PQR	
	1st report/detected	not found
	Spread/infection levels	So far PPV has not been found in Finland. Climatic conditions limit the cultivation of host plants of PPV
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	Lemmetty, 2006; NPPO of Finland, 2010

France	EPPO-PQR	Present, limited distribution
	1st report/detected	1960 (Labonne & Dallot, 2006). 1970 on imported Prunus plants (Speich, 2006).
	Spread/infection levels	PPV-D, present since 1970. SE-France (Rhône Valley, Mediterranean Coast. 2005: prevalence relatively low (0.3% of the trees). Less than 1% of the orchards have more than 10% of their trees affected. Some areas free (Garonne Valley - plum) or slightly affected with PPV-D (Lorraine region - plum). After 1987, increase in the virulence and spread of the virus, caused by PPV-M. Nowadays PPV-M represents 98% of the cases in France. Most severely affected area in Drôme department mainly on peach trees, to a lesser extent on apricot trees (Speich, 2006). Information from the NPPO of France (received November 2010): Present in all stone fruit producing areas, the Midi-Pyrenées, which covers about 10% of the total stone fruit area, excepted. SE-France with about 63% of the total stone fruit area most affected: in 2009 PPV known to be present on 15% of the stone fruit area. NE-France: in Lorraine first findings before 2000; Alsace PPV first found in 2000. SW-France (L'Aquitaine): first found in 2006, present in restricted areas.
	PPV strains	PPV-M (78%), PPV-D (22%). No PPV-Rec found or mixed infections. (Dallot *et al*., 2008). Epidemics related to the PPV-M strain introduced in the mid-1980s are the most problematic (Quiot *et al.*, 1995)
	Found in:	peach, apricot, plums
	Control strategies	Total eradication not feasible. In most cases containment of PPV is achieved by active surveillance and systematic destruction of infected trees. Nurseries producing multiplication material of Prunus are under strict phytosanitary control (Speich, 2006). A strict program to control the aggressive PPV-M strain has been in place since the early 1990s (complete removal of affected orchards with disease incidence is >10 to 20%; or removal of symptomatic trees at incidence of <10%. Combined with strict quarantine procedures, protection of nurseries, certification of virus-free material. New PPV-M infections within orchards subjected to roguing resulted from exogenous sources of inoculum, disease development of latent infected trees, as well as infected trees overlooked within the orchards during visual surveys (Dallot *et al*., 2004). Information from the NPPO of France (received in November 2010 and updated information in August 2011): Requirements from November 2008 – February 2011 according to the national French law: an intensive survey is required when Sharka is observed in an orchard. This survey concerns all orchards of the "departement" (french territorial division) where the PPV was observed in at least one "commune" (administrative district). It is obligatory to remove infected plants both in orchards as in nurseries. If 10% (in the region Rhône-Alpes 5%) or more of the plants show symptoms all plants at the production site/orchard should be destroyed. A survey is obligatory around tree nurseries within a radius of 1 km. When PPV is found within 500 m (200 m when 2 surveys per year were realized) of a nursery, plants will not be plant passported. Since March 2011, the national law in France has changed and include now the following requirements: - an intensive survey is required when Sharka is observed. This survey concerns all orchards within a 2.5 km radius (a minimum of two surveys on all *Prunus* plants within a 1.5 km radius, and a minimum of one survey in all orchards between a 1.5 and 2.5 km radius). A survey is also obligatory in all new orchards (2 surveys per year during 3 years) and in non contaminated areas (a minimum of 1 survey every 6 years). It is obligatory to remove

		infected plants in orchards. If 10% or more of the orchard show symptoms, all plants present in the orchard should be destroyed. Each region has the possibility to reduce this threshold (In Rhône-Alpes, the removal of all plants is obligatory when 5% or more of the plants show symptoms). -In line with the council directive 2000/29, it is also obligatory to remove infected plants in nurseries. Two surveys are obligatory in France in and around all tree nurseries within a radius of 1 km. When PPV is found within 200 m of a nursery, all *Prunus* plants of the production place are not eligible for plant passports for 3 years. -Moreover, it is not allowed to plant *Prunus* trees when the mean infection level in an area of 1 km^2 is over 2% (this requirement is not only valid for commercial growers and orchards but also for private persons, amenity trees etc.). When the mean infection level is between 1 and 2%, three surveys per year have to be conducted during a period of 3 years. -The removal of all susceptible plants in the direct environment, i.e. within a few metres, of a nursery or orchard is obligatory.
	References	Dallot *et al*., 2004; Dallot *et al*., 2008; Labonne et al., 1995; Labonne & Dallot, 2006; Quiot *et al*., 1995; Speich, 2006; NPPO of France, 2010 and 2011

Germany	**EPPO-PQR**	Present and widespread
	1st report/detected	1960s
	Spread/infection levels	PPV is most widespread in Germany and was found in all regions and in all host plants (Jarausch, 2006).
	PPV strains	PPV-D is most widespread and found in all regions and in all host plants. PPV-M was found in East Germany and Ortenau and Kaiserstuhl, and near Stuttgart in Baden-Württemberg in plum (Jarausch, 2006). PPV-Rec confirmed (Glasa *et al*. 2004b)
	Found in:	host plants sampled: plum, apricot, peach, myrobalan in orchards as well as wild species of blackthorn and myrobalan (Jarausch, 2006)
	Control strategies	-
	References	Glasa *et al*., 2004b; Jarausch, 2006

Greece	**EPPO-PQR**	Present and widespread
	1st report/detected	1967
	Spread/infection levels	Widespread throughout the country. High incidence, especially in regions of intensive apricot and peach cultivation (NE Peloponnese for apricot, W Macedonia for peach)
	PPV strains	PPV-M strains more prevalent than PPV-D
	Found in:	apricot, peach, plum, not found in almond, sweet and sour cherry
	Control strategies	Cultivation of tolerant apricot cultivars. Research focuses on virus control through cross protection development of transgenic plants that confer resistance to PVV
	References	Varveri, 2006

Hungary	**EPPO-PQR**	Present and widespread
	1st report/detected	1948
	Spread & Infection levels	Widepread throughout the country. Infection rates of older plum, peach and apricot orchards are high, while they are low in almonds.
	PPV strains	PPV-M, PPV-D, PPV-Rec, PPV-C. PPV-M types more frequent, incidence of PPV-D types is increasing. PPV-C found in symptomless sweet and sour cherry trees in the 1990s; surveys in recents years did not reveal any new PPV-C infected trees (Kölber, 2006). PPV-Rec isolates characterized by Glasa *et al*. (2004b)
	Found in:	Plum, peach, apricot, almonds, cherry, ornamental Prunus (nuclear stocks, arboretums and/or street trees). Infection rates of older plum, peach and apricot orchards are high, low in almonds. PPV-C was detected in symptomless sweet and sour cherry trees (Kölber, 2006).
	Control strategies	-
	References	Glasa *et al*. 2004b; Kölber, 2006

Ireland	**EPPO-PQR**	
	1st report/detected	-
	Spread/infection levels	No reported records
	PPV strains	-
	Found in:	-
	Control strategies	Inspectorate are aware of this harmful organism and inspect host material for it (NPPO of Ireland, November 2010).
	References	NPPO of Ireland, 2010)

Italy	**EPPO-PQR**	Present, limited distribution
	1st report/detected	1973
	Spread/infection levels	Most parts of the country, widespread in the stone fruit orchards of Northern Italy (Bazzoni *et al*. 2008).
	PPV strains	PPV-M, PPV-D, PPV-Rec, (PPV-C) PPV-D: initially, slow spread to most parts of the country, mainly through infected propagation material. In 1996, introduction of PPV-M, causing major epidemics in many regions of Northern Italy and occasionally discovered in other regions. PPV-Rec present. PPV-C was reported from sweet cherry (trees destroyed), presently considered free from PPV-C although occasionally found in old cherry trees (Di Terlizzi & Boscia, 2006)
	Found in:	plum, apricot, peach, (cherry).
	Control strategies	Eradication is compulsory since 1996: effectiveness varies according to the different situations (e.g. type of strain). D and Rec strains are more easily contained, more difficult for PPV-M or in areas where PPV is already endemic (Bazzoni et al. 2008, Di Terlizzi & Boscia, 2006). Eradication of infected trees and the production of virus-free plant material are not sufficient to control and eradicate the disease, especially in the areas where the virus is already endemic. "The production in highly infected regions could be possible with tolerant or resistant cultivars" (Bazzoni et al. 2008)
	References	Bazzoni *et al*. 2008; Di Terlizzi & Boscia, 2006

Latvia	**EPPO-PQR**	-
	1st report/detected	reported in 2009; detected in 2008
	Spread/infection levels	First detection in plum cv. 'Emma Lepermann' in a small private garden in Dobele region in 2008. Later in same year, PPV was found in three more regions – Balvi, Aizkraukle and Jēkabpils. In 2009, PPV was detected only in Dobele region. In 2010, no positive samples (NPPO of Latvia, 2010). Pest status: present, under eradication (Anonymous, 2009)
	PPV strains	PPV-D (first reported by NPPO of Latvia in 2008; there is no information about other strains)
	Found in:	plum
	Control strategies	All PPV-infected trees are uprooted and burned. Nurseries are visually inspected twice a year and orchards are visually inspected once a year. Samples are taken and tested by DAS-ELISA and/or RT-PCR. Production of virus free propagation material of plum.
	References	Anonymous, 2009; NPPO of Latvia, 2010

Lithuania	**EPPO-PQR**	Present, few records
	1st report/detected	1995
	Spread/infection levels	Survey 1998-2002: 14 locations in 9 regions sampled; 865 plum tree samples out of 1553 trees tested positive for PPV. Survey 2003–2004: 23 out of 123 plum samples positive for PPV, some of them in two new locations.
	PPV strains	PPV-D (Staniulus, 2006)
	Found in:	plum
	Control strategies	"In 5 outbreaks of the virus, all plum trees were uprooted and burned, in the other 9 localities only contaminated trees and the neighbouring trees were uprooted and burned."
	References	Staniulis, 2006

Luxembourg	**EPPO-PQR**	Present, no details
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Malta	**EPPO-PQR**	
	1st report/detected	Never detected
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	Myrta *et al*., 2003; NPPO of Malta, November 2010

Netherlands		
	EPPO-PQR	Present, few records
	1st report/detected	1965
	Spread/infection levels	Limited occurence in orchards and incidentally in nurseries (Verhoeven *et al*., 2006; 2008). Present, at low prevalence (Anonymous, 2010).
	PPV strains	PPV-D (Collection of 9 isolates originating from 1991 - 2005: 8 PPV-D and 1 PPV-M or another PPV-strain; this non PPV-D isolate had been isolated from imported planting material (E. Meekes, Naktuinbouw, 2010, personal communication)
	Found in:	plum
	Control strategies	Certified virus-free propagation material, followed by inspections in nurseries and orchards, as well as large scale ELISA testing for PPV. Eradication campains in earlier days.
	References	Verhoeven *et al*., 1998; Verhoeven *et al*, 2006, 2008; Anonymous, 2010

Poland		
	EPPO-PQR	Present and widespread
	1st report/detected	1962
	Spread/infection levels	Survey 1999-2002: PPV present in 12 out of 16 provinces (Malinowski, 2006).
	PPV strains	Mainly PPV-D (Malinowski, 2006). Updated information: all Polish isolates reported earlier to be PPV-M (Malinowski, 2006) proved to be PPV-Rec; majority of the PPV isolates PPV-D (different subtypes), and there are few isolated cases of PPV-Rec; PPV-C never found, last survey conducted in 2010 (T. Malinowski, 2010, personal communication)
	Found in:	plum, peach, apricot, nectarine
	Control strategies	Before accession to the EU: quarantine organism, obligatory eradication on all *Prunus* hosts. Surveys included commercial and non-commercial sites (private gardens, wild plants). Infected plants were destructed. Specific requirements for nurseries depending on the infection level. After accession to the EU: quarantine organism on *Prunus* plants intended for planting other than seeds. Surveys at production sites of propagation material and the immediate vicinity of these sites.
	References	Malinowski, 2006; T. Malinowski, 2010 (personal communication); NPPO of Poland, 2010

Portugal		
	EPPO-PQR	Present, limited distribution
	1st report/detected	1984
	Spread/infection levels	At present, the disease has been maintained at a rather low level (pers. comm. L. M. Corvo in Roy & Smith, 1994). First record on apricot (1984) in S-Portugal (Algarve). Later also found on plum in central-west Portugal (Louro and Corvo, 1986) and Azorean Islands (Mendonca et al. 1998)
	PPV strains	PPV-D (Corvo *et al.* 1995)
	Found in:	Apricot, plum (Louro and Corvo, 1986) and peach (Mendonca et al. 1998)
	Control strategies	Systematic surveys on susceptible cultivars of plum and apricot, in nurseries and orchards deriving from imported material and in areas where the risk of infection is high. Plants are visually inspected and tested (DAS-ELISA and/or testing on indicator GF305). In commercial orchards, removal of trees, if more than 20% of trees are infected the whole orchard is destroyed. At present, the disease has been maintained at a rather low level (Roy & Smith, 1994)
	References	Louro & Corvo, 1986; Roy & Smith, 1994; Corvo *et al*., 1995

Romania	**EPPO-PQR**	Present and widespread
	1st report/detected	
	Spread/infection levels	Present in all stone fruit-growing areas
	PPV strains	PPV-D, PPV-Rec, PPV-C, (PPV-M?) and mixed infections Indication that PPV-M typed isolates are actually PPV-Rec. PPV-C has a very limited distribution (Isac & Zagrai, 2006). All PPV isolates typed as PPV-M by serological analysis proved to be PPV-Rec. PPV-D is the prevalent strain. PPV-Rec is also present both in singular and mixed infections (PPV-D + PPV-Rec). Muntenia-area: 68% PPV-D, 8% PPV-Rec, 24% PPV-D+Rec; Bistrita-area: 46.5% PPV-D, 34.9% PPV-Rec, 18.6% PPV-D+Rec (Zagrai *et al*., 2008a, 2009a, 2010) .
	Found in:	All stone-fruit species are more or less infected by PPV
	Control strategies	Information from the NPPO of Romania (July 2011): In 2006, before accession to EU, PPV was considered a quarantine organism and all *Prunus* hosts from nurseries, production sites of propagation material, plantations or in their immediate vicinity, other orchards were monitored. Since 2008, a new monitoring program was developed and implemented and the main ojectives are to avoid the dissemination of PPV in nurseries and production sites of propagation material and to verify the compliance of the plants with the requirements listed in Council Directive 2000/29/EC.
	References	Isac & Zagrai, 2006; Zagrai *et al*., 2008a, 2009a, 2010; NPPO of Romania, 2011.

Slovenia	**EPPO-PQR**	Present, limited distribution
	1st report/detected	1987
	Spread/infection levels	Surveys 1995-1998 confirmed an overall presence of PPV. Since 2000, survey focussed on production sites of propagation material. PPV was also detected in imported propagation material (4 out of 18 consignments in 2000 and 2001). In 2002, a decease of the incidence of PPV infection in nurseries, lowest level in 2004 (not found in nurseries). In 2005, new PPV infections were found in nurseries, probably introduced by aphids (Virscek Marn & Mavric, 2006).
	PPV strains	PPV-M (74%), PPV-D (10%), and PPV-Rec (10%). Also mixed infections found (6%) (Dallot *et al*., 2008).
	Found in:	Hosts with PPV infections not specifically mentioned. So far, PPV has not been detected in sweet and sour cherries (Virscek Marn & Mavric, 2006)
	Control strategies	Surveys and eradication. Purpose of surveys since 1995 is to prevent and control the spread of Sharka and to establish pest-free production sites. Eradication of PPV-infected propagation material (Virscek Marn & Mavric, 2006)
	References	Dallot *et al*., 2008; Virscek Marn & Mavric, 2006.

Slovakia	**EPPO-PQR**	Present and widespread
	1st report/detected	~1950
	Spread/infection levels	At present, a high incidence of PPV can be noted in all fruit-growing areas, mainly in plum orchards (Glasa, 2006).
	PPV strains	PPV-Rec (49%), PPV-D (27%), and PPV-M (24%). No mixed infections found (Dallot *et al*., 2008). It was noted that PPV-Rec recombinants were consistently found in orchards planted in the early 1980s with tolerant plum cultivars from Cacak, former Yugoslavia/Serbia (Glasa, 2006).
	Found in:	plum, peach. PPV-D and PPV-Rec types were found to be strongly associated with plum orchards, PPV-M were found almost exclusively in peach orchards. So far, no natural infection has been identified in cherry (Glasa, 2006)
	Control strategies	Field dispersal of PPV is favoured by the absence of compulsory eradication efforts. Planting material of tolerant plum cultivars probably represents a possible initial source for rapid spread of PPV Rec (Glasa, 2006).
	References	Dallot *et al*., 2008; Glasa *et al*. 2004b; Glasa, 2006

Spain	**EPPO-PQR**	Present, limited distribution
	1st report/detected	1984
	Spread/infection levels	Endemic presence of PPV-D in important growing areas along Mediterranean coast. The tolerant cultivar 'Red Beaut' became an important source of inoculum and aphid vectors spread PPV very efficiently to other Japanese plum cultivars and apricots (Cambra *et al*., 2006c).
	PPV strains	PPV-D. PPV-M not present any more. Not detected in Spain: PPV-Rec, PPV-C, PPV-EA or PPV-W (Cambra et al., 2006a). All isolates are PPV-D, with one exception: a PPV-M outbreak detected and successfully eradicated in Zaragoza in 2002; extensive surveys in 2002–05 in this area confirmed the eradication of PPV-M in Spain (Cambra *et al*., 2004a).
	Found in:	Plum, apricot, peach. "PPV has never been detected in plantations of almonds, cherries or ornamental *Prunus* species" (Cambra et al., 2006). The Spanish Prunus industry is based on the production of early cultivars of Japanese plum 'agronomically tolerant' to PPV, and production of peaches.
	Control strategies	Certification and production of PPV-free plant material in nurseries; PPV-free plants are produced without any risk of infection in areas where PPV is absent such as Aragón and Navarra (Ebro Valley) (Cambra et al., 2006d). Mandatory and voluntary eradication of PPV-D infected trees in some regions and permanent surveys for early detection. Mandatory eradication of PPV-M in all Spanish regions. Additionally, conventional breeding programmes for apricot resistance to PPV (Cambra *et al*. 2006a). "The majority of Japanese plum cultivars show little or no symptoms in fruits. Consequently, growers are not eradicating PPV-D from Japanese plums and the virus is spreading from these usually symptomless reservoir trees to healthy ones" (Cambra *et al*., 2006a).
	References	Cambra *et al*., 2004a; Cambra *et al*., 2006a,c

Sweden	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	PPV was first found in 1979 on a single apricot tree (*Prunus armeniaca*) in a private garden. The tree was destroyed. The second finding was in 1982 on a plum tree (*Prunus domestica*), also in a private garden. The tree was destroyed.
	PPV strains	-
	Found in:	-
	Control strategies	PPV is looked for during the yearly surveys at the nurseries producing, buying and selling susceptible plants.
	References	NPPO of Sweden, 2010

United Kingdom	**EPPO-PQR**	Present, limited distribution
	1st report/detected	1965
	Spread/infection levels	In 1980s well established in the main plum growing areas (Kent and the West Midlands-Welsh borders). Not found in Scotland or Northern Ireland, limited outbreaks in Wales. Precise situation regarding the incidence of PPV in commercial fruit orchards in England is unknown, as wide scale surveys have not been carried out since the 1970s. However, given the low incidence in propagating material, it is thought that PPV is likely to be uncommon in actively managed orchards, although it is likely that some infected orchards do still exist, especially older, unmanaged or abandoned ones (Mumford, 2006b).
	PPV strains	Only the D-strain has ever been identified.
	Found in:	Plum and damson and wild blackthorn (Prunus spinosa) growing in hedges adjoining infected orchards. Not found in cherry or any other *Prunus* spp. (Mumford, 2006a)
	Control strategies	Annual surveys are limited to propagation material (in line with EU plant passporting regulations). Surveys show that the incidence of PPV in this material is very low (1994–2006, infection rate of about 0.2%) (Matthews-Berry, 2008).
	References	Mumford, 2006a,b; Matthews-Berry, 2008

Non-EU countries		
Albania	**EPPO-PQR**	Present, limited distribution
	1st report/detected	survey mid 1990?
	Spread/infection levels	Surveys mid 1990s: PPV endemic in SE (60-100% plum trees infected). PPV foci N & central. Apricot/peach few trees infected (Stamo & Myrta, 2006)
	PPV strains	PPV-M dominant, PPV-D and PPV-Rec less prevalent. Also mixed infections found. PPV-C or PPV-EA not found. PPV-Rec confirmed (Glasa et al., 2004b)
	Found in:	Plum, apricot, peach
	Control strategies	not mentioned
	References	Stamo & Myrta, 2006; Glasa *et al*., 2004b

Andorra	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Belarus	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Bosnia and Herzegovina	**EPPO-PQR**	Present, no details
	1st report/detected	Survey 2004?
	Spread/infection levels	Endemic in many areas. The widespread distribution and the presence of different PPV strains suggest a long presence of the virus in the country. 2004 survey: highest infection in the central part of the country (41%).
	PPV strains	PPV-D, PPV-M and PPV-Rec + coexistence of different PPV in same orchard, but no natural mixed infections. Plum: PPV-D (57%), PPV-Rec (29%). Peaches: PPV-M. Apricot, myrobalan and blackthorn: PPV-M or PPV-D.
	Found in:	Most affected was plum (21%), peach, apricot, myrobalan and blackthorn. Not found in cherry. PPV found in commercial orchards, gardens, nurseries and in trees bordering these plantings.
	Control strategies	Effective control measures are hindered by presence everywhere. Use of resistant cultivars, the establishment of local nursery production in PPV-free areas and effective inspections of imported propagation material should be encouraged in the control strategy against sharka.
	References	Matic *et al*., 2006

Croatia	**EPPO-PQR**	Present and widespread
	1st report/detected	Survey 1994?
	Spread/infection levels	PPV is present in all parts of Croatia, but not evenly distributed. Survey in nurseries 1994-2003: average infection level of motherplants was 3.5% (Mikec et al. 2006).
	PPV strains	PPV-D and PPV-M found, no PPV-EA and PPV-C (Mikec *et al.,* 2006)
	Found in:	plum, peach, nectarine, apricot, sweet and sour cherry. Not found in almond and Myrobalan (Mikec et al. 2006).
	Control strategies	Sanitation of infected trees in nurseries (Mikec *et al*., 2006)
	References	(Mikec *et al*., 2006)

Iceland	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Liechtenstein	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Macedonia	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Moldova, Republic of	**EPPO-PQR**	Present, limited distribution
	1st report/detected	~1960s
	Spread/infection levels	Widespread. Infection rates: 24–54% on plum, 10–40% on apricot, 2–10% on peach, and 5–15% on wild Prunus species.
	PPV strains	Strains not mentioned, PPV-C confirmed on sour cherry (1985)
	Found in:	plum, apricot, peach, cherry, wild prunus
	Control strategies	PPV infected trees are only eradicated in nurseries. Breeding for resistant of tolerant plum cultivars Thermotherapy is applied in vivo to obtain virus-free plum cultivars.
	References	Kalashian & Chernets, 2006

Monaco	**EPPO-PQR**	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Montenegro	**EPPO-PQR**	Present, no details
	1st report/detected	2006
	Spread/infection levels	Data about PPV infection is scarce. Sharka symptoms were observed in 2002 by Mijuskovic, and more recently confirmed during surveys of plum orchards in 2006. Mild to severe symptoms were found in 15 orchards, usually only on some trees (Virscek Marn *et al*., 2008).
	PPV strains	PPV-D, PPV-Rec; Majority of samples are PPV-Rec (Virscek Marn et al., 2008).
	Found in:	plum
	Control strategies	Not mentioned
	References	Virscek Marn *et al*., 2008

Norway	**EPPO-PQR**	Present, limited distribution
	1st report/detected	1998
	Spread/infection levels	Surveys 1998-2003: Western part, 1% of trees, due to infected stock material (Blystad et al., 2007). PPV infected stock probably imported around 1970 or earlier (Blystad & Munthe, 2006). Surveys 1998 – 2008: about 1% of 75,000 trees found infected. PPV on 61 farms or nurseries from which 5 detected in 2007-2008 (Blystad *et al*., 2010).
	PPV strains	PPV-D
	Found in:	plum, apricot
	Control strategies	Surveys and eradication work is continuing (Blystad & Munthe, 2006; Blystad *et al*., 2010)
	References	Blystad & Munthe, 2006; Blystad *et al*., 2007; Blystad *et al*., 2010

Russia	**EPPO-PQR**	Present, limited distribution
	1st report/detected	
	Spread/infection levels	PPV was mainly found in collections of botanical gardens, research institutions and also on some farms in several regions (Moscow, Tula, Kursk, Vologda, Krasnodar, Tambow, Voroneg). Infection percentages varied from 30% to 80%.
	PPV strains	unknown/not reported
	Found in:	European and Japanese plum, apricot, sweet and sour cherry, almond and blackthorn
	Control strategies	Studies of plum cultivars (European and Japanese plum) for tolerance to PPV are in progress.
	References	Prichodko, 2006

San Marino	EPPO-PQR	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

Serbia	EPPO-PQR	Present and widespread
	1st report/detected	1935
	Spread/infection levels	Widespread; due to the movement of noncertified planting material, the rate of infection has been high over the whole territory (Dulic-Markovic & Jevremovic, 2006)
	PPV strains	PPV-M (52%), PPV-Rec (26%), PPV-D (5%). Also mixed infections and undetermined strains found (17%) (Dallot *et al.,* 2008).
	Found in:	peach, plum, apricot
	Control strategies	In 2005, a law on planting material: certification schemes to improve the sanitary status of planting material. Breeding of tolerant and resistant plum cultivars. (Dulic-Markovic & Jevremovic, 2006)
	References	Dulic-Markovic & Jevremovic, 2006; Dallot *et al.*, 2008

Switzerland	EPPO-PQR	Present, few records
	1st report/detected	1967
	Spread/infection levels	After first observation in 1967, an eradication program was started and PPV only occurred sporadically (Ramel et al., 2006). In 1998 and 1998, PPV was found in a few occasions and in 2003 in one occasion which led to more field inspections in following years. From 2004 - 2008, PPV was found in 39 plum orchards and 29 apricot orchards. In 2009, PPV was found in 39 out of 81 orchards inspected. Increase related with ending of import stop from countries where PPV is widespread in 2001.
	PPV strains	Mainly PPV-D; only few occurences of PPV-M in the German speaking part of Switzerland (Putallaz *et al*., 2010)
	Found in:	plum, apricot
	Control strategies	Since eradication of PPV infected material after the 1967 outbreak, periodical inspections and random tests of imported planting material were performed. In 2004, PPV again present in orchards of plum and apricot. Inspection and eradication continues and includes monitoring and inspection of growers and provides financial compensation and information to them through federal and regional plant protection services (Ramel et al., 2006). From 2004 - 2008, 3413 plum and 737 apricot trees were removed (Putallaz *et al*., 2009).
	References	Ramel, *et al*. 2006; Putallaz *et al*., 2009; Putallaz *et al.*, 2010

Turkey	**EPPO-PQR***	Present, limited distribution
	1st report/detected	1968
	Spread/infection levels	Limited distribution. Present in Marmara (adjacent to Europe) and Cental Anatolia. Surveys showed that eastern Mediterranean region and eastern Anatolia are completely free of Sharka (Caglayan, 2006). Commonly found in apricot, plum and peach trees in Ankara (Elibüyük, 2006).
	PPV strains	PPV-M, PPV-D (Elibüyük, 2004), PPV-Rec (Candresse *et al*., 2007) and PPV-T (Serçe *et al*., 2009). PPV-M strain is the most common strain in Turkey (Caglayan, 2006).
	Found in:	peach, plum, apricot and almond (Caglayan, 2006), ornamental *Prunus cerasifera* (Elibüyük, 2006).
	Control strategies	-
	References	Caglayan, 2006; Candresse *et al*., 2007; Serçe *et al*., 2009

Ukraine	**EPPO-PQR***	Present, limited distribution
	1st report/detected	1967
	Spread/infection levels	Thirteen locations in the Ivano-Frankivsk, Lviv, Chernivci and Crimea regions of Ukraine. PPV-infection levels in 2005; 8.2% in nurseries and 42.8% in productive orchards
	PPV strains	unknown/not reported
	Found in:	plum, cherry, apricot, peach and stone fruit rootstocks
	Control strategies	Control of the situation of PPV in nurseries of plum, cherry, apricot, peach and stone fruit rootstocks in order to avoid the spread of the virus via planting material into virus-free regions.
	References	Kondratenko & Udovychenko, 2006

Vatican City	**EPPO-PQR***	
	1st report/detected	
	Spread/infection levels	-
	PPV strains	-
	Found in:	-
	Control strategies	-
	References	-

[1]Pest status according to EPPO - PQR database version 4.6 (http://www.eppo.org/DATABASES/databases.htm)

Appendix II: Area (1000 ha) of *Prunus* fruit orchards in the EU (Data extracted from Eurostat on 30-08-2010, last update 10-08-2010 (Eurostat))

Country[1]	**Totals**[2]		**Peaches**		**Apricots**		**Sweet and sour cherries**		**Plums**		**Nectarines**		**Other stone fruit n.e.s**[3]		**Almonds**	
	2008	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
Austria	**1.1**	**1.1**	0.2	0.2	0.5	0.5	0.2	0.2	0.2	0.2						
Bulgaria	**47.2**	**33.9**	6.0		7.5		15.4	17.0	16.4	16.9					1.9	
Cyprus	**5.1**	**5.1**	0.4	0.4	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.1	0.1	3.6	3.6
Czech Republic	**6.7**	**6.7**	1.0	1.0	1.4	1.4	2.8	2.8	1.5	1.5						
Denmark[4]		**1.8**						1.7		0.1						
Estonia	**0.0**						0.0		0.0							
France	**58.4**		8.0		14.0		10.8		17.2		6.8		0.3		1.3	
Germany	**14.0**	**13.8**					8.9	8.7	5.1	5.1						
Greece	**73.7**		36.9		5.3		8.2		0.8		5.7		2.3		14.5	
Hungary	**39.4**	**38.1**	7.6	7.4	6.1	5.4	17.2	17.3	8.3	7.8					0.2	0.2
Italy	**235.9**	**235.1**	60.1	59.8	18.6	18.4	29.7	29.7	14.5	14.0	33.0	32.9	0.5		79.5	80.3
Latvia	**0.4**						0.2		0.2							
Lithuania	**2.4**	**2.4**					0.9	0.9	0.9	0.9			0.6	0.6		
Luxembourg	**0.9**	**0.9**					0.1	0.1	0.8	0.8						
Malta[5]	**0.1**	**0.1**	0.1	0.1												
Netherlands	**1.0**	**1.0**	0.0	0.0			0.7	0.7	0.3	0.3			0.0	0.0		
Poland	**72.1**	**72.3**	3.2	3.4	1.7	1.8	46.1	46.1	21.1	21.0	0.0	0.0	0.0	0.0		
Portugal	**52.9**	**52.9**	5.8	5.8	0.6	0.6	6.3	6.3	2.0	2.0					38.2	38.2
Romania	**87.4**	**85.8**	1.6	1.6	2.9	2.6	7.6	6.8	75.3	74.7	0.0	0.1				0.0
Slovakia	**1.7**	**0.8**	0.7	0.6	0.2	0.2	0.2		0.6							
Slovenia	**0.6**	**0.1**	0.5		0.0	0.0	0.1	0.1	0.0							
Spain	**629.4**	**738.9**	49.7	49.7	89.0	97.1	75.7	90.0	201.4	200.1	25.9	25.9			187.7	276.1
Sweden[6]		**0.2**						0.1		0.1						
United Kindom[5]	**1.3**						0.4		0.9							

1) No data from: Belgium, Finland and Ireland
2) Data from 2009 are incomplete
3) Other stone fruit not elsewhere specified
4) Data for 2010 obtained from C. Scheel (Danish Plant Protectorate)
5) Data from FAOstat: peaches and nectarines (in table indicated under "peaches"), plums and sloes (*P. spinosa*), cherries
6) Data for 2010 from Yearbook of agricultural statistics 2010 (Offical Statistics of Sweden), available at www.jordbruksverket.se. Statistics only include holdings with at least 200 m^2 greenhouse area or 2,500 m^2 outdoor cultivation.

Appendix III: current EU-legislation for Plum pox virus (Council directive 2000/29/EC)

Plants of following species of *Prunus* L., intended for planting, other than seeds, originating in countries where Plum pox virus is known to occur:
— *Prunus amygdalus* Batsch,
— *Prunus armeniaca* L.,
— *Prunus blireiana* Andre,
— *Prunus brigantina* Vill.,
— *Prunus cerasifera* Ehrh.,
— *Prunus cistena* Hansen,
— *Prunus curdica* Fenzl and Fritsch.,
— *Prunus domestica* ssp. *Domestica* L.,
— *Prunus domestica* ssp. *insititia* (L.) C.K. Schneid.,
— *Prunus domestica* ssp. *Italica* (Borkh.) Hegi.,
— *Prunus glandulosa* Thunb.,
— *Prunus holosericea* Batal.,
— *Prunus hortulana* Bailey,
— *Prunus japonica* Thunb.,
— *Prunus mandshurica* (Maxim.) Koehne,
— *Prunus maritima* Marsh.,
— *Prunus mume* Sieb and Zucc.,
— *Prunus nigra* Ait.,
— *Prunus persica* (L.) Batsch,
— *Prunus salicina* L.,
— *Prunus sibirica* L.,
— *Prunus simonii* Carr.,
— *Prunus spinosa* L.,
— *Prunus tomentosa* Thunb.,
— *Prunus triloba* Lindl.,
— other species of *Prunus* L. susceptible to *Plum pox virus*.

Without prejudice to the provisions applicable to the plants, listed in Annex III(A)(9) and (18), and Annex IV(A)(I)(15) and (19.2), official
statement that:

(a) the plants, other than those raised from seed, have been:
— either officially certified under a certification scheme requiring them to be derived in direct line from material which has been maintained under appropriate conditions and subjected to official testing for, at least, Plum pox virus using appropriate indicators or equivalent methods and has been found free, in these tests, from that harmful organism,
or
— derived in direct line from material which is maintained under appropriate conditions and has been subjected, within the last three complete cycles of vegetation, at least once, to official testing for at least Plum pox virus using appropriate indicators or equivalent methods and has been found free, in these tests, from that harmful organism;

(b) no symptoms of disease caused by Plum pox virus have been observed on plants at the place of production or on susceptible plants in its immediate vicinity, since the beginning of the last three complete cycles of vegetation;

(c) plants at the place of production which have shown symptoms of disease caused by other viruses or virus-like pathogens, have been rogued out.