SHARCO CONSORTIUM

Pest Risk Analysis for Plum pox virus

PRA issued from the Dutch Plant Protection Services in January 2011 / Revision by the SharCo committee on September 2011

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Version	1.0
Date	January 2011 / September 2011
Organism	*Plum pox virus* (Family *Potiviridae*, genus *Potyvirus*)
Common name	PPV (acronym) Sharka, Plum pox (English), Variole du prunier, Sharka (French), ScharkaKrankheit (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 SharCo assessors: Donato Boscia, Mariano Cambra, Véronique Decroocq, Thierry Candresse, Gérard Labonne, Sylvie Dallot, Miroslav Glasa
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Glossary

Areas: Unless stated, the term ‘area’ is used to define a territory which can be part of a country or of a region and in which the prevalence of PPV is relatively homogeneous, either absent, or present sporadically or highly endemic.

PRA area: corresponds to the zone of application of the European directive 2000/29

1. Introduction

Plum pox virus (PPV) is listed as a 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 (completely) prevent spread of PPV within the EU. PPV originates from Eastern Europe and is nowadays present in many EU-countries. PPV is naturally transmitted by aphids which can make it difficult to implement the current EU-requirements for plants intended for planting. Also, an increased use of host plant cultivars that are tolerant[1] 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 nurserymen since they are not allowed to trade any *Prunus* host plants for at least three growing seasons after the finding of an infection in or near their nursery even if it only concerns a single plant. These strict measures can be difficult to explain when the pest is already present in a country and (fairly) widespread, and may as a consequence, face implementation problems and poor professional adhesion.

Scope of the document

This PRA is a revision made by the SharCo committee of the PRA issued from the Dutch Plant Protection Services as delivered in January 2011. It 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 but this issue will be further detailed in another document, named "SharCo management options". 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 have a limited distribution in the PRA area. However, *Plum pox virus* (PPV) was first detected in Europe and is already present in a large part of Europe (García and Cambra, 2007; Barba *et al*., 2011). Hence, spread within Europe by natural means and by human activities being 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. While PPV is already (fairly) widespread in Europe, the PRA has still to assess the probability of entry and

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[1] *As generally intended, the term "Tolerant" is used to define a germplasm that, following inoculation of PPV, get infected without significant virus restraint (as ascertained by laboratory assay) but remains symptomless on both leaves and fruits. Sometimes, in those tolerant cultivars, symptoms can be observed on leaves but not on fruits or not enough to impact the fruit production. Conversely, with the term "Resistant" is defined the germplasm in which the lack of symptoms is accompanied by the ability of the plant to restrict the multiplication and movement of the virus within the plant. When the resistance is absolute (i.e., the virus is not able to multiply in any kind of plant tissue) the germplasm is defined as "Immune".*

establishment of PPV in PPV-free areas or the entry and establishment of PPV strains not present yet in PPV infected areas, in order to reduce the risk posed by the Sharka disease.

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

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)
	ScharkaKrankheit (German)
	Vaiolatura delle drupacee (Italian)
	Viruela del ciruelo (Spanish)

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

Several strains, types or subgroups are recognized and classification is based on biology, serology and molecular properties. The three most common strains are designated PPV-D, PPV-M and PPV-Rec (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 (*P. persica* (L.) Batsch) including nectarines, plums (*P. domestica* L. and *P. 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 (*P. cerasus* L.) (Nemchinov *et al*., 1996) and in sweet cherry (*P. avium* L.) (Crescenzi *et al*., 1997). Almonds (*P. dulcis* L.) can be infected by PPV but show few symptoms (Festic, 1978, Damsteegt *et al*., 2007a and b). Next to fruit-producing *Prunus* species, PPV infects many wild and ornamental species of *Prunus* (James and Thompson, 2006; Polák, 2006; Damsteegt et al., 2007a and b; Kalinina *et al*., 2007; Polák and Kominek, 2009). Damsteegt et al. (2007a and b) showed that 31 out of 33 *Prunus* species and cultivars were systemically infected following aphid inoculation 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 used.

Infected *Prunus* plants growing in the wild, along roads or in urban areas may act as a reservoir for the pathogen. *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 the Czech Republic (Polák, 1997; Polák and Komínek, 2009). The role of *P. spinosa* and other wild *Prunus* species as a natural reservoir remains partially in doubt since the presence of infected plants near contaminated orchards does not necessarily mean that these wild plants acted as a source of inoculum. In France, infected *P. spinosa* plants have been found in

the vicinity of highly contaminated peach orchards but Labonne and Dallot (2006) considered their role as natural reservoir for Sharka epidemics in Southern France as unclear. Damsteegt et al. (2007a and b) and James and Thompson (2006) demonstrated experimentally aphid transmission of PPV (North American PPV-D isolate) to peach seedlings from 26 out of 28 *Prunus* species and cultivars tested, including *P. spinosa* and *P. cerasifera*. These results indicate that wild and ornamental *Prunus* spp. (*Prunus spinosa* included) have the potential to act as a PPV-reservoir when in proximity to stone fruit orchards.

In addition to *Prunus* species (Llácer and Cambra, 2006), a large number of herbaceous species have been shown to be susceptible to PPV (Llácer, 2006) 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 polyclonal 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 Pribek *et al*. (2001) could not confirm the identity of isolates from *L. barbarum* (*L. halimifolium*) and *Datura stramonium* using RFLP. Detection of PPV targets in several herbaceous plants after aphid inoculation has, however, been reported by PCR (Manachini *et al*., 2007), but this result was not confirmed in other laboratories.

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 and 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 proved as possible PPV hosts by inoculation onto indicator plants (Milusheva and 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). Similar results were obtained in Europe with PPV-M (see SharCo 1rst periodic report, workpackage WPE3). The authors concluded that weeds do not appear to represent a significant reservoir of PPV[2], 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

[2] *In fact, experimental data suggest that PPV isolates from woody plants are not adapted to herbaceous hosts, except after several experimental, forced passages from the initially infected herbaceous plant to the next ones (Salvador et al 2008). Moreover, it has been shown in the SharCo tasks that a PPV isolate, PPV-PS, propagated in Nicotiana clevelandii includes virus variants with mutations in the P1 region that do not affect replication in this host but completely prevent infection in Prunus persica. On the other hand, a PPV chimeric construct including sequences from a peach-adapted isolate, only is able to systemically infect herbaceous plants (N. clevelandii and N. benthamiana) after the introduction of point mutations or a deletion in a small region of the CP N terminus Some of these mutations disturbed virus infection in the woody hosts. This means that the probability for a PPV strain introduced through fruit trees in an orchard to spread in a weed plant, be maintained and then provoke secondary infection back on the fruit trees is very low.*

European studies. However, a more recent study by Manachini *et al*. (2007) revealed the ability of *Myzus persicae* to transmit PPV-M very efficiently from herbaceous hosts to peach seedlings 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. However, since they tested only peach seedlings, not adult peach trees, the situation is not comparable to natural conditions, in orchards. Moreover, the fact that aphids can efficiently transmit from herbaceous plants to peach does not demonstrate that these herbaceous plants are actually reservoirs. The other key point is that these herbaceous plants have to be infected in nature and this remains to be unambiguously shown. In addition, it was not mentioned in the publication the presence of PPV symptoms in the inoculated and tested-positive peach seedlings, suggesting the possibility of false positives.

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 sometimes but not conclusively considered a potential reservoir of PPV for stone fruit orchards. Several woody non-*Prunus* species have been reported (Polák, 2006) as hosts and largely questioned by Glasa and Candresse (2006), and also many herbaceous plants but their infection status under field conditions is uncertain. Transmission from *Prunus* plants to herbaceous plants and *vice versa* has been demonstrated experimentally **but not in natural conditions**. The role of non-*Prunus* spp. as PPV reservoirs under field conditions remains, therefore, highly uncertain.

Symptoms and distribution in the plant

General information on PPV has been summarized by Capote *et al*. (2006), García and Cambra (2007) Cambra *et al.* (2008), Barba *et al*. (2011) and more recently in PaDIL (2011) (http://www.padil.gov.au/pbt/index.php). PPV symptoms in stone fruit trees may appear on the leaves, bark, fruits, flowers or seeds. Symptoms range from mild to severe and vary with the virus isolate, 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, allowing virus to spread unnoticed in orchards[3]. After initial infection, the disease develops slowly inside the tree, usually affecting only one or a few branches at first, but spreads 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.

Geographical distribution

As far as it is known, 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 in Near and Middle East, South and North America (Chile, USA, Canada and Argentina) and Asia (China, Kazakhstan, Pakistan and Japan) (Roy and Smith, 1994; Levy *et al*., 2000; Thompson *et al*., 2001; Spiegel *et al*., 2004; Navrátil *et al*., 2005; Dal Zotto *et al*., 2006;

[3] *Almost all known apricot, plum and peach cultivars are susceptible to PPV, but some remain symptomless when infected. The absence of symptoms greatly reduces their role as reservoir. In France all the transmission assays by aphids using symptomless leaves taken from mature trees were negative. This concerns both apricot and peach trees, with several cultivars, and PPV-D and PPV-M strains. (G. Labonne, personal communication). In general, symptoms are requested prior to transmissibility occurs more readily from material showing symptoms, thus acting as a reservoir. They maybe confused with varieties that show no symptoms on fruits and are thus classified as tolerant while they display symptoms on leaves.*

Kollerová *et al*., 2006; Maejima *et al*., 2010; Barba *et al*., 2011). 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 (Cambra *et al*., 2006b). In addition, the virus is transmitted by aphid vectors in a non-circulative, nonpersistent manner (Labonne *et al*., 1995; Damsteegt *et al*., 2007a; 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 variable 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 propagation 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

In 2009, PPV was detected in Japan (http://www.pps.go.jp/english/pestreport/index.html; accessed November 2010; Maejima *et al*., 2010).

Natural transmission

PPV is transmitted in a non-persistent manner but with variable efficiency by several aphid species (Avinent *et al*., 1994; Labonne *et al*. 1994 and 1995; Moreno *et al*., 2009). It was commonly accepted that there is a wide genetic variability within PPV and that transmissibility is strain and even isolate-dependent (see paragraph “Virus strains”). However, in the course of the SharCo FP7 European SCP (Small Collaborative Project), this statement was not entirely validated (see tasks of WPE2). While differences in transmission efficiencies exist between isolates, differences related to the PPV strain in acquisition and transmission efficiencies are difficult to set out, experimentally, on the three main *Prunus* species (apricot, peach, plum).

In the past, it was demonstrated 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 “unrestricted probing” method that appeared the most sensitive method to study PPV transmission. They used this method for a range of aphid species collected from the field in South-Eastern France and found that several species, colonizing *Prunus* or not, were able to transmit PPV. More recent data (SharCo 2nd

periodic report) show that *A. gossypii* is a 'poor vector' for PPV transmission. There is thus a large number of species that can transmit PPV, and may be some variation in their efficiency can occur, according to the local population of the aphid species concerned. This is associated to a general behavior of every aphid species: when searching for a host plant, a winged aphid lands to a plant leaf more or less at random and it chooses afterwards if it is a suitable host or not by probing the leaf. It acquires or transmits the virus during this step. Thus, the aphid species that could be of importance for PPV transmission are those that are present in great number or that have a high efficiency to acquire and transmit PPV, or both. For example, migrant aphid species that do not colonize stone fruit or *Prunus* can be important for PPV spread because extremely large 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 *Prunus* trees, thereby transmitting the virus. Depending on the region, climate and environment of the orchards, the range of prevalent aphid species is different. Some are more prevalent and more efficient in PPV transmission (*M. persicae* and *A. spirecolae* for example). However, it is worth noting that the population of aphids in every location, including orchards, is made of a large number of species; thus, for non-persistently transmitted viruses, the distinction between colonizing and non-colonizing species is of poor significance: the aphids that spread the virus are those that probe on the infected plants and that are efficient PPV vectors, either colonizing or not the trees. An identification of the main aphid species visiting *Prunus* nurseries is being accomplished in the frame of SharCo project (WPE3).

PPV can 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, 2006; 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.

In Spain, observations in a peach orchard indicated that natural transmission of an eradicated PPV-M focus occurred over distances of up to 12 m (Cambra *et al*., 2006c; Capote *et al*., 2010). Spatial patterns of Sharka dispersion in apricot and peach orchards in Spain implicated that PPV-D--viruliferous aphids prefer to move to hosts several trees away instead of moving to immediately adjacent trees (Gottwald *et al*., 1995). Dallot *et al*. (2003) studied the spatial pattern of diseased trees in 20 peach orchards contaminated by the PPV-M strain. Significant aggregation of diseased trees was found in most orchards but with variable intensity suggesting that aphid dissemination to neighboring trees occurred frequently but was not systematic. In another approach, Dallot *et al.* (2004) studied disease spread within 19 peach orchards caused by PPVM in France during a 7-10 years period. An extended Cox model fitted to the data to assess the influence of eleven variables on tree survival (probability to remain uninfected through time). The nearest-neighbor distance between newly identified symptomatic trees and previously detected ones within orchards as well as the distance to neighboring contaminated orchards had a significant effect on the risk for a tree to become infected through time. These results suggested that PPV dissemination occurred at short distances among neighboring trees (on average on the studied period, 91.6% of the newly infected trees were found within 12 m around infected ones) but also at longer distance between orchards. Data from another survey in southern France in apricot orchards suggested that aphid transmission of PPV (type of strain not indicated) occurs between orchards located several hundreds meters apart from each other (Morvan, 1988). Labonne and 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). According to Conti (1986), aphid transmission of PPV can occur 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, PPVM did not spread more than 150 m after 3 years of natural spread by aphids (Capote *et al*., 2010).

Under Northern European conditions, observations suggest that the spread of PPV by aphid species is relatively slow in plum orchards (Verhoeven *et al*., 1998; Blystad and Munthe, 2006). Several factors may contribute to the slow spread of PPV observed in Northern Europe, e.g. lower prevalence of aphid species 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 of PPV-D in Norwegian orchards is probably due to the lower amount of aphids in Summertime, the relatively short period during which aphids are active on plum, and the aphid species present. In Norway, *M. persicae* 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 but not demonstrated by the observation of high transmission rates of PPVD in warmer climate areas (discussed in more detail in paragraph "Virus strains"). Moreover, even if *M. persicae* is not present in North European countries such as Norway, other aphid species are able transmit the virus. Thus, if the aphids are the cause of slow spreads (which is not proven), it would most probably be due to the lower amount of aphids, not to the absence of a specific aphid species.

It is generally accepted that PPV is not transmitted by seed. In an extensive review of the literature by Pasquini and 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 and Zagrai (2008) who did not find transmission of PPV-D and PPV-Rec strains through seeds in European plum and by Milusheva et al. (2008) who did not find transmission of PPV-M strain through plum seeds and PPV-Rec through apricot seeds.

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. Dallot *et al.* (2004) demonstrated that transmissions over 100m occur regularly, whereas less frequently than shorter transmission distances. Although the extent of these longer distances of dissemination is still under speculation, transmission events over 1 km have never been conclusively reported, thus providing an estimation of the most likely upper limit of long distance transmission.

Virus strains

There is a wide genetic variability within PPV (Candresse and Cambra, 2006; James and Glasa, 2006; Glasa and Candresse, 2005; Serçe *et al*. (2009); SharCo European SCP, Deliverable DE1.2, DE1.3, Milestone ML7, http//www.sharco.eu). Several strains or groups are recognized and classification is based on biology, serology and molecular properties. Initially, the two most common strains were 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 and Varga, 2005; Candresse and Cambra, 2006) and more recently, PPV-T (Turkey) (Serce *et al*., 2009). Numerous PPV isolates were described as having different biological and epidemiological characteristics (López-Moya *et al*., 2000), 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) PPV-D (Dideron)

The PPV-D strain was originally isolated on apricot in France (Kerlan and Dunez, 1979). Currently, it is the most common strain in European apricot and plum orchards (Table 1; see Appendix I for details and references), while it is present at lower extent in peach. In this latter species the natural infection is facilitated when suckers producing rootstocks are used, helping the entrance of the virus through them. Moreover, peach seedlings are much more easily infected than peach cultivars (Cambra *et al*., 2006c). PPV-D is also found in the Americas (Chile, USA, Canada) on peach cultivars, probably infected through peach seedlings used as rootstocks. 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 is, however, a number of examples in the literature showing that this division is not that strict and also depends on other factors, e.g. the specific interaction with the type of hosts. Epidemiology of PPV-D has been studied in Spain in areas along the Mediterranean coast. The tolerant cultivar of Japanese plum 'Red Beaut' became an important source of PPV-D inoculum and aphid vectors spread PPV-D very efficiently to other Japanese plum cultivars and apricots (Cambra *et al*., 2006c). 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.,* 2004a), while a previous study indicates a moderate progress of epidemics in peach orchards (Gottwald *et al.* , 1995) grafted on *P. marianna* rootstocks. 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*., 2006c). Finally, peculiar variants of PPV-D able to spread efficiently within peach orchards have been also described by Dallot *et al*. (1998).

2) PPV-M (Marcus)

The PPV-M strain was originally characterized on peach in Greece (Kerlan and Dunez, 1979) and is present in many Southern, Eastern, and Central European countries (Table 1). PPV-M strain is efficiently vectored by aphid species and can spread very rapidly within peach orchards (Dallot *et al.* 2003; Labonne and Dallot, 2006; Varveri, 2006; Capote et al., 2010). Myrta *et al.* (2001) separates the M-strain by their serological properties 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. As the work was done before PPV-Rec was described, PPV-M2 could could have been confused, in some cases, with PPV-Rec isolates. More recently, Dallot et al. (2011) evidenced two clades within PPV-M strain based on the nucleotide sequences of two genomic regions (P3-6K1 and CP coding regions): Ma was mainly found in the Mediterranean area and Mb mainly in Central and Eastern Europe.

3) PPV-Rec (Recombinant)

The first description of a PPV recombinant was reported by Cervera *et al*. (1993). More recently PPV-Rec was described and accepted as a new PPV type. This strain has evolved as a result of recombination between isolates of the D and M strains (Glasa *et al*., 2004b; García and Cambra, 2007). PPV-Rec isolates are serologically related to PPV-M and PPV-T. 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 PPV are present in many European countries (Glasa *et al*., 2004b; 2005; Appendix I), including Turkey (Table 1; Appendix I, Candresse *et al*., 2007) and Pakistan (Kollerová *et al*., 2006). Because the majority of the typing procedures only target the CP gene, previous analyses on the prevalence of PPV strains in Europe brought biased results, confounding PPV-Rec with PPV-M (Dallot *et al.,* 2008). Indeed, in the North-East of Transylvania the natural recombinant (PPV-Rec) was detected and results indicated that all the PPV isolates which have been previously typed as PPV-M are actually PPV-Rec (Isaac and Zagrai, 2006; Zagrai *et al.,* 2008, 2010). Similar observations were done in Germany, where sequence data indicated that a significant proportion of the PPV-M isolates could belong to the PPV-Rec strain (Jarausch, 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 experimentally demonstrated by Glasa *et al*. (2002a, 2004a). The results from vector transmission studies performed by Glasa *et al.* (2004a) confirmed that the 4 PPV-Rec isolates tested were transmitted by aphids; however, the transmission occurred at different rates. This should be confirmed or refuted by testing more PPV-Rec isolates. PPV-Rec is naturally not detected on peaches (only few exceptions in Bulgaria), which can suppose some kind of host preference.

4) PPV-EA (El Amar)

PPV-EA is found on peach, plum and apricot in North Africa (Wetzel *et al*., 1991; Mazyad *et al.,* 1992). PPV-EA can experimentally infect peach, apricot and plums but in natural conditions, it was found mostly on apricot or Japanese plum (Youssef and Shalaby, 2006; Matic *et al.*, 2011). Preliminary trials on aphid transmission showed that PPV-EA is aphid-transmissible by *M. persicae* Sulzer (P. Maison, personal communication in Wetzel *et al*., 1991).

5) PPV-C (Cherry)

PPV-C is limited to sweet cherry and sour cherry and to date, it is the only strain known to naturally infect cherry (Kalashyan *et al*., 1994; Nemchinov and Hadidi, 1996). It comprises the sour cherry (SoC) and sweet cherry (SwC) isolates described in Moldova (Nemchinov *et al*., 1996) and in Italy (Crescenzi *et al*., 1997). It is detected sporadically in central Europe (Kölber *et al*., 2001) as well as in Eastern Europe (Belarus, Malinowski et al, SharCo WPE1 2nd periodic report) and Russia (SharCo database). Despite of the few and recurrent reports on its presence in central Europe, not a single isolate or sequence has been reported (or can be found in the literature). There are thus serious doubts about the results of these reports. Even if it is present sporadically, spreading has not been demonstrated, yet. Also, for Italy, we would like to remark that the initial and only finding was in a single or in two trees that were eradicated. Consecutively, PPV-C has never been reported again in Italy despite efforts to detect it (Di Terlizzi and Boscia, 2006). It

It was speculated that PPV-C has a broader experimental host-range than other PPV strains, 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 isolates were only transferred to herbaceous plants with great difficulty. In another study by Crescenzi *et al*. (1997) with a PPV-C isolate from sweet cherry (PPV-SwC), it was demonstrated that this isolate was able to systemically infect cherry, and symptoms were similar to those observed after natural infection. The PPV-SwC isolate could infect peach and myrobalan, whereas, conversely, PPV-D and PPV-M isolates commonly obtained from these hosts could not systemically infect cherry so that the virus remained localized after aphid transmission (Dosba *et al*., 1987).

It is worth noting that long-term maintenance, over few months, of the PPV-C isolates in non-Cherry hosts proved to be difficult, thus questioning the broader host-range status of PPV-C. However, it was demonstrated that under experimental conditions SoC can infect 'GF8.1', 'Jaspi', F12.1, 'Edabriz' and 'SL64' at least for 2 years, GF8.1 and Jaspi' being plum hybrids (Bodin *et al.*, 2003).

6) PPV-W (Winona)

PPV-W is a new strain of PPV, originally identified as W3174-01 in Canada and detected in two European plum trees (James and Varga, 2005). PPV-W has been recorded in Latvia (T. Malinowski, 2011, SharCo 2nd periodic report) and Russia (SharCo database and Sheveleva et al. Acta Horticulturae 899: 49-56). The PPV-W isolates found in Latvia differ significantly from the W3174 Canadian isolate and appears as an original form of PPV-W (Glasa *et al*., 2011). Analyses revealed that PPV-W is a clearly distinct strain however W3174, but not other W isolates, is in fact a triple recombinant W+M+D (Glasa *et al*. 2011). The PPV-W intrastrain variability was shown to be substantially higher than that of all other PPV strains. No further information is currently available on transmission parameters.

7) PPV-T (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 (Serçe et al., 2009). The widespread occurrence of PPV-T isolates in Turkey has been demonstrated (SharCo 2nd periodic report).

Comparison between PPV-D, PPV-M and PPV-Rec: epidemiology and aggressiveness

PPV-D, PPV-M and PPV-Rec are the most common strains in Europe (Table 1; Appendix I). The strains may differ in epidemiology and aggressiveness. However, it is difficult to make properly a comparison between epidemics of the different strains: the data generally did not include precise epidemics monitoring, or did not report upon the environment nearby (contaminated orchards), or the frequency of contamination in the planting material is not properly estimated. The following indications have thus to be taken with care. As stated above, PPV-M is generally considered the epidemic form and PPV-D the mild form of PPV in peach orchards 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 this species (Quiot *et al*., 1995; Dallot *et al*., 1998; Dallot *et al.,* 2004; Di

Terlizzi and Boscia, 2006; Capote *et al*., 2010). 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*., 2006c and 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 efficiently 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), and PPV-D is the only strain present in North America both on plum and peach. In Spain where only the D-strain is present (Cambra *et al*., 2006c), disease prevalence 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 suggests that PPV-D can cause epidemics (Polák, 2002; Polák and Komínek, 2009). This was confirmed for Eastern and Central European countries, within the SharCo WPE1 tasks (SharCo 2nd periodic report). However, SharCo efforts also showed that there are many different forms of PPV-D and that its variability is higher than first expected. This might explain the discrepancies between all those studies. 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 was found in two and PPV-M in one of them (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 spread to apricot trees in the vicinity but that PPV-D populations in apricot orchards generally 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 find differences in epidemic behavior 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 peach seedlings to peach seedlings.

Dondini *et al*. (2010) have stated that both PPV-D and PPV-M 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*. (2006b) 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 (data issued from field observations, no experimental results). 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 isolate. In contrast, Polák *et al.* (2005) found a difference in reaction of *P. domestica* cv. Jojo inoculated with a PPV-D, PPV-M and PPV-Rec isolates: 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*. (2007a) 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 almost not susceptible using

PPV-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 seedlings, that North American PPV-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 seedlings. As stated above, transmission rates varied considerably among isolates. Transmission rates of one PPV-Rec isolate (called “Horomerice”) was similar to that of a PPV-M isolate on all *Prunus* genotypes studied. The other three PPV-Rec isolates were significantly less efficiently vectored on apricot and two of these isolates also on plum than the PPV-M isolate[4]. In another paper presenting partly the same data Glasa *et al*. (2004a) also provided transmission data on another peach genotype on which only the “Horomerice”-PPV-Rec isolate was efficiently vectored and no transmission was obtained with the PPV-M isolate. Zagrai *et al*. (2009) did not find 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 terms 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 of biological variability within single PPV strains. Within the SharCo project, mixed infection of PPV-M, PPV-D and PPV-Rec was also reported, in plum and apricot mostly. Even triple mixed infection was reported in plum, in Serbia (Paunovic and Labonne, SharCo WPE2 2nd periodic report). The prevalence of PPV-Rec is much higher than PPV-D in Bulgaria and Serbia, while in Rumania it seems lower (SharCo WPE2 2nd periodic report). These differences might be due to historical trading flux or agronomical practices in the planting material.

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 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 transmissibility among PPV-Rec isolates have been reported. However, it is essential to note that there exists significant intra-strain variability, especially for the PPV-D and PPV-M strains. If those studies did not use exactly the same isolates, no comparison is possible. While a strain can be characterised by some common biological properties, some isolates may behave quite differently of the other ones. 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.

4 Comment from the authors of this paper: The objective of this experiment was to show that it exists variability among PPV-Rec isolates in the capacity to be aphid-transmitted. The experiment was carried out in a way, that the initial inoculum source for aphid feeding was similar for all isolates (estimated by semi-quantitative ELISA) to avoid a bias with potential differences with different virus titer in source infected leaf. It was also shown that one isolate (very poorly transmissible) had a modified PTK motif (to PIK) in the HCPro coding sequence, which could influence the transmissibility. This can occur in any isolate of any kind of PPV strain, it doesn't appear to be specific to PPV-Rec or PPV-M. It also means that mutation can occur in any PPV isolate of any strain that will modify positively or negatively the infectivity, epidemiology and aggressiveness of the mutated isolate.

3. Current status of PPV in the EU

Roy and Smith (1994) described the Sharka situation in Europe, and an update of the situation in several countries was given by Capote *et al.*, (2006a). Roy and Smith (1994) distinguished three geographical zones in Europe for the Sharka incidence in Europe, based on the actual presence of PPV and history of spread: (1) In the central and eastern countries 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 in which plum pox incidence is very heterogeneous; (3) Mediterranean countries in which PPV spread is relatively recent and there is high risk of further spread. Below, the situation is described for EU-countries in each of these three zones. 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) and the pest status per EU-country is summarized in Table 1.

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

PPV originates from 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 and Smith, 1994). Presence of different PPV strains, e.g. the PPV-D –M and PPV-Rec strains, and mixed infections suggest a long-term presence of the virus in countries of these regions (Dallot *et al.*, 2008). Results from experimental work tentatively identified 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 (Glasa *et al.*, 2004b). PPV is endemic in many areas[5] of Central and Eastern European countries and eradication is not considered as a viable 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 and Ledbetter, 2009). The use of tolerant cultivars[6] will obviously decrease the chance of detection and, thereby, increase the probability of spread of the virus within the propagation material. In Slovakia, PPV–Rec isolates were consistently found in orchards planted in the early 1980s with tolerant plum cultivars from Yugoslavia (Glasa, 2006). Planting material of tolerant plum cultivars has thus represented a probable initial source for rapid spread of PPV-Rec in Slovakia.

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 at variable extent. In the Northern part of Europe, the climatic conditions limit the cultivation of certain hosts of PPV (e.g. apricot, peach). Eradication measures have contributed to the absence or low prevalence of the disease in some countries. PPV is absent or only found in few occasions in Denmark, Estonia, Finland, Latvia and Sweden (Roy and Smith, 1994; Lemmety, 2006; Appendix I). PPV has not been reported from Ireland.

[5] Definition of area: an officially defined country, part of a country or all or parts of several countries [ISPM No. 5 Glossary of phytosanitary terms 2007, International Plant Protection Convention, FAO]. In the case of this Sharka PRA, it concerns a territory which can be part of a country or of a region and in which the prevalence of PPV is relatively homogeneous.

[6] See note #1 on tolerant cultivars. Those tolerant varieties correspond here to trees which present few if no symptoms on both leaves and fruits since they are not detected during visual inspections.

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, Germany, Lithuania and the UK (see Appendix I for details and referencesIn France, PPV is only widespread in some particular regions (South Eastern of France). Sporadic PPV detection occurred in other regions but it was either eradicated or it is (still) under control. In the UK, Belgium, the Netherlands (except from one PPV-M or PPV-Rec isolate from an imported plant) 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, 2006). PPV-Rec isolates have been reported from Germany, but so far not from France (Glasa *et al.*, 2004b; Dallot *et al.*, 2008). In Latvia both PPV-D and W were indentified (Appendix I). 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 favorable conditions for aphid transmission may have contributed to the limited presence of PPV in Northern Europe as compared to 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 and Smith, 1994; Cambra *et al.*, 2006c and d; Capote *et al.*, 2006a). 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 (Capote *et al.*, 2010). In some Mediterranean countries, various methods are being used for control of PPV, from mandatory eradication programmes (France, Spain etc…) to the use of tolerant[7] cultivars to prevent yield losses (Greece) (See also Appendix I). In Italy, control measures comprise the removal of infected plants and the production of virus-free planting material (Di Terlizzi and 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, like it is already in France and within the SharCo consortium (www.sharco.eu). PPV is endemically established in Greece, despite eradication programmes. Tolerant cultivars of apricot are used at a large scale in this country, where the cultivation of susceptible cultivars was abandoned almost 15 years ago (Varveri, 2006). In Italy, PPV-D and then PPV-M are established in some areas (Northern Italy); nowadays, PPV is endemic and eradication programs were terminated in those areas.

Note: 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 centers and/or private gardens (e.g.

[7] Tolerant varieties refer here to cultivars that could display symptoms on leaves but few if no symptoms on fruits.

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 from Eastern Europe and is nowadays present in at least 20 EU-countries including the major producing stone fruit ones. It is under eradication in two other 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 diverse with respect to biological characteristics. 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	Presence	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[3]	(+)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); 3) PPV-W has been recorded in Latvia

4. Pathways for spread and introduction

The introduction of infected plant propagation material of *Prunus* spp. (grafted material and/or rootstocks) is the most important means of long distance spread of PPV. PPV can be symptomless in infected plants and can, therefore, not reliably be detected by visual inspection. The probability of mixed infection 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* 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, especially entry of new PPV strains that might pose extra problems in Sharka management. 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: 1) *Prunus* host plants originating from countries within the EU are not subjected to standard inspections, 2) the uneven distribution of PPV in plants in combination with the small sample size taken for testing, 3) the sampling is done on dormant tissues, it has to be re-grafted and then tested for PPV absence/presence, 4) sometimes PPV is latent and will show up several years later while it went successfully through the quarantine, 5) the fact that findings on plants originating from other (EU-) countries are not always notified through Europhyt, 6) it is known that illegal entry of plant material, without phytosanitary guarantees also occurs in Europe as in any other country. This is obviously a major way of introduction of PPV.

Nearly half of the interceptions (15 out of 29) were reported by the Netherlands on plant material originating from 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 does not grow peach nor apricot on a commercial scale (while being a strong actor in trading of *Prunus* propagation material), the number of PPV-infected lots moving in trade is likely much higher than the number of notifications in Europhyt. This last conclusion does not however take into account the fact the Netherlands is very active in international trade of horticultural products *Prunus* species on which PPV has been notified in Europhyt such as *P. domestica, P. padus*, *P. persica*, *P. laurocerasus*, *P. triloba* and *P. cerasus*[8].

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[9] (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,

[8] Since occurrence of PPV in Padus, Laurocerasus and P. cerasus is rather rare if inexistent, it would be interesting here to retrieve the initial data and perform extra experimental tests. This statement raises the following questions: How was PPV detected ? By indexing ? on what ? By testing of dormant budsticks ?

[9] Same comment as above (7), it would be interesting here to list the ornamental species found positive for PPV.

infected ornamental *Prunus* plants planted in private or public areas near stone fruit orchards may serve as an inoculum reservoir. Plants of stone fruit species are also planted in backyards or (small) private orchards for restricted fruit production. Several findings of PPV in stone fruit species have been reported from backyards or garden centers (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 (Labonne and Quiot, 2001; Gildow *et al.*, 2004). The probability of spread or introduction by infected fruits is, however, much lower than by trade of infected planting material (lower probability of transfer to a suitable host) and because PPV occurs already (fairly) widespread in the EU[10], this pathway is not further considered in the present PRA. However, if PPV infected fruits are introduced in PPV-free areas, the risk should be considered as no longer negligible.

- 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. Once again, the situation should be re-evaluated if infected branches are introduced in PPV free areas. As soon as branches present buds, they can always be grafted and thus represent a non-negligible risk.

- Natural spread by aphids (short distance spread: within and between fields). Relevance of this pathway depends on virus-strain[11], 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*. It is however highly uncertain whether these species can serve as natural inoculum reservoir for *Prunus* species (see also paragraph on “Host range”), which is strongly questioned.

- Human assisted spread of infected non-*Prunus* species including many herbaceous species (usually short distance, e.g. within a community). Since the host plant status under natural conditions is clearly uncertain as well as their role in the epidemiology of the Sharka disease, we can consider this pathway as negligible (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, including new isolates or new strains not present (yet) in EU or in some areas. 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.

[10] More data are required to prove transmission in natural conditions from fruits to fruit trees; in the meanwhile, the topic has to be taken with caution. While the dissemination from infected fruits is probably rare, it can impact PPV epidemics if a new strain is introduced or if the virus is introduced in a virus-free area.

[11] More experiments have to be performed to confirm or not present data, comparing several isolates per strain.

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

5. 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 apricots. 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 and 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 and 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), 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 or new isolates.

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 strains are the second and third most common strains in the EU. The exact situation with respect to PPV-M and PPV-Rec is uncertain. PPV-Rec has only recently been recognized and turned out that in many cases isolates that had been reported in the past as PPV-M were actually PPV-Rec (Appendix I: Poland, Romania). PPV-Rec has been shown established in many European countries, mainly on plum. On the contrary, nearly no natural infection of peach with PPV-Rec has been identified under natural conditions (SharCo database). 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 peaches 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 fruits are being produced in the EU and conditions (high temperature) are favorable 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 neither peach nor apricot are grown in these countries (Appendix II) and the M-strain does not appear to be much more epidemic or aggressive than the D-strain in plum (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 and with PPV-M have been found in plum (SharCo WPE2 report and Zagrai *et al*., 2008, 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”). In commercial orchards, the prevalence of PPV-Rec was found higher than PPV-D in Bulgaria and Serbia but not in Rumania (SharCo WPE2 2nd periodic report). These results as well as further analyses on reduced, equilibrated dataset did not evidence a higher prevalence of PPV-Rec than expected in plum and apricot, given the relative prevalence of PPV-D, PPV-Rec and PPV-M. Overall, it is difficult to disentangle the effect of the epidemic properties from historical and anthropogenic factors such as trading or agricultural planting practices of non certified virus-free material.

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 was occasionally found in old cherry trees (Di Terlizzi and Boscia, 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). The behavior of PPV in almonds is still under speculation since it appears that susceptibility is depending on the strain, on the isolate and on the cultivar tested (Dallot *et al.*, 1997; Pascal *et al.,* 2002; Rubio *et al.*, 2003).

PPV can infect ornamental and wild *Prunus* spp. (Elibüyük, 2006; James and 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 report is 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 2,000-2,500 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 and 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 artificial 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. Moreover, ornanemental *Prunus* plants can also be a non-negligible reservoir for the disease, thus impacting sharka spread in the neighbouring nurseries and orchards.

New strains have been detected since 1991 (see "Virus strains") and their additional impact to PPV-D and -M 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 is 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. On plums, PPV-W pathogenicity is still unclear. However the fact that it has been detected in four different countries (Canada, Latvia, Russia and Ukraine) requests further analysis.

Several control measures are currently applied to try to reduce the impact of PPV (see Appendix I for details per country and references):

- ✓ Exclusion through quarantine measures

- ✓ 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 PPV-tolerant cultivars (may increase the impact for non-tolerant host plants in the surroundings)
- ✓ application of pesticides to reduce the vector populations, while this measure is probably without any concern due to the non-persistant transmission of the virus (see paragraph "Natural transmission")

We are reviewing the management measures in the third part of this Risk Management System, as well as discussing them[12]. However, we can already say that the drawback of the use of tolerant cultivars is that PPV can be spread undetected by movement of infected nursery stock, or locally, where PPV is transmitted by aphids over short distances from symptomless infected trees to other trees (see also "Evaluation of management options"). Thus, in orchards that grow tolerant cultivars the impact of PPV will be lower but the use of tolerant cultivars can increase the impact for non tolerant crops in the surroundings. The same risk applies in case of a PPV isolate being latently spread, especially if only visual inspection measures are applied.

In conclusion, the direct potential impact of PPV for the production of plum, apricot and peach 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 member states where most of the stone fruit trees are growing and natural transmission plays an important role in the spread of the virus. Further spread of the PPV-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 more economically damaging especially on peach. The introduction of PPV resistant cultivars could be 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 uncertainty for both. 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 or isolates of PPV compared to the present ones is uncertain and more data are requested to confirm or not if they 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 and, potentially, for export of fruits. This indirect effect has not been further investigated in the present PRA.

6. 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-

[12] In fact, in the SharCo revision, the management options have been listed and extensively detailed in a seperate document, named 'Identification and evaluation of management options for Sharka disease'.

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 diverse with respect to biological characteristics. Several strains are recognized. The three most common strains are PPV-D, PPV-M and PPV-Rec 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 but for France at least some production regions remain free of PPV-M. 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 common strain in Europe and present in at least 9 EU-member states. Relatively little is known about PPV-Rec (Glasa *et al*., 2004b). 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), so far. Other sporadic locations were reported recently in the SharCo project (Belarus, Russia). A few other strains, PPV-EA, PPV-W and PPV-T have been found outside the EU of which PPV-W and PPV-T have recently been described in 2005 and 2009, respectively. Recently, PPV-W was found in Latvia.

Impact

The potential impact of PPV is high (on a 3-level scale: low – medium – high) for the production of plum, peach, and apricot fruits especially in Southern, Central and Eastern Europe where yield losses of up to 100% have been reported in the past. In areas where only the D-strain is present, the introduction of 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 but the use of tolerant cultivars increases the risk of spread of PPV and, thereby, the impact for non-tolerant cultivars present in the same area. The development of new PPV resistant varieties in a near future should provide solutions that will help to lower the impact of the disease. However, the deployment of such resistant cultivars has to be accompanied by supplementary measures such as *Prunus* cultivation guidelines to limit the level of PPV incidence in the production 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, up to now (with a medium uncertainty).

Almond is a host plant but no significant symptoms nor yield losses have been reported and the potential impact of PPV for almond is assessed as low to medium, depending on the strain.

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). However, once again its importance as reservoirs is not negligible.

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 indication that the risk of these new strains is higher than that of PPV-D and PPV-M.

Pathways for spread and introduction

The main pathway for PPV spread 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 weed species and some woody non-*Prunus* species are known to be susceptible to PPV and these species may act as an inoculum source for stone fruit orchards. Transmission from weeds to *Prunus* plants has been shown only under experimental conditions, and may also happen under field conditions but this is uncertain. Thus, movement of infected weed species and other infected non-*Prunus* species will add to spread of PPV but their significance as inoculum reservoir for *Prunus* species is not yet clear.

Management[13] options

The current EU-legislation as laid down in Annex IV of the Council Directive 2000/29/EC has several requirements 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. Moreover, the increased use of PPV susceptible cultivars presenting limited symptoms on fruits increases the risk of spread of PPV by movement of planting material and further spread by aphids locally. Because of the presence of PPV in many EU-countries the experiences obtained with eradication actions and the many interceptions of PPV on

[13] This part is mainly issued from the original PRA, initiated by the Dutch Plant Protection Services and therefore is mostly based on reglementary issues. Within the SharCo revision, the PPV management options have been extensively supplemented in a separate document named 'Identification and evaluation of management options for Sharka disease' and are now based on 'possible' management measures which could be used in the field, by the stakeholders, nurserymen or fruit producers. An evaluation of the different management options has been added to the document.

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 trade of propagation material and plants of *Prunus* species susceptible to PPV originating from 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.

Recommendations for such cultivation guidelines are available in the SharCo deliverable DA1.2. 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 more relaxed (see SharCo cultivation guidelines, deliverable DA1.2).

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 designed 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 include 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. It will also pose a greater threat of spreading of new PPV strains in areas where only PPV-D is present or the introduction of new PPV strains (still) absent in the European Union. This might increase the impact of the Sharka disease in areas where the spreading of some PPV strains are under control or on some *Prunus* fruit production such as Almond or Cherry.

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. To impact on the spreading of the

disease, the plantation of certified material should be obligatory except in areas where PPV is endemic. In other PPV-free or PPV-low incidence areas, 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, thus restricting the use of this propagation material to areas where Sharka is endemic.

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;"

could be replaced by

" -no PPV has been detected following the EPPO and IPPC standards 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 instead 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 (EPPO standards). This is applicable for propagating material but not for mother plant blocks that will remain for years and years in the field. Moreover it has to be accompanied by extra measures (see SharCo cultivation guidelines, deliverable DA1.2)

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 but the risk remains and is not acceptable. This option, quite similar to the present legislation is only feasible in areas with a low PPV-prevalence. In areas where PPV is prevalent and natural transmission occurs frequently, a buffer zone or cultivation under screen or insect-proof facilities will still be needed to produce PPV-free planting material.

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 too few experiments in which the epidemiology and/or aggressiveness of various isolates of the different strains have been compared.

7. References

Anonymous (1997). *Plum pox potyvirus*. In: Data Sheets on quarantine pests for the European Union and for the European and Mediterranean Plant Protection Organization. Prepared by CABI and EPPO for the European Union. Datasheet also available at http://www.eppo.org/QUARANTINE/listA2.htm (accessed August 2010).

Anonymous (2001). Certification scheme for almond, apricot, peach and plum. Bulletin OEPP/EPPO Bulletin 31, 463−478.

Anonymous (2009) Surveillance of the Plum Pox virus in 2009. Official pest report, Plant Quarantine Department, Latvia. Available at https://www.ippc.int/index.php?id=146&tx_pestreport_pi1[showUid]=215821&frompage=146&type=pest_report&subtype=&L=0#item, accessed November 2010.

Anonymous (2010) Fytosignalering 2009. Plantenziektenkundige Dienst, Ministerie van Landbouw, Natuur en Voedselkwaliteit. http://www.vwa.nl/txmpub/files/?p_file_id=2001312 (accessed August 2010).

Atanasoff, D. (1932). *Plum pox*. A new virus disease. Annals of the University Sofia Faculty of Agriculture and Silviculture 11, 49-69.

Atanasoff, D. (1935). Mosaic of stone fruits. Phytopathologische Zeitschrift 8, 259-284.

Avinent, L., Hermoso de Mendoza, A., Llácer, G. (1994). Transmission of plum pox potyvirus in Spain. Bulletin OEPP/EPPO Bulletin 24, 669-674.

Bazzoni, A., Didonna, A., Savino, V., Palmisano, F. (2008). Preliminary results of trials evaluating the behaviour to *Plum pox virus* of different apricot crosses. Acta Horticulturae 781, 295-302.

Bicak, L., Ostrkapa-Meurecan, Z. (2007). Sharka of plums (Plum pox potyvirus) and false Sharka (Apple chlorotic leaf spot virus). Glasilo Biljne Zastite 7, 46-48.

Blystad, D.R., Haugslien, S., Ørstad, K., Munthe, T., Knudsen, R., Hjeltnes, S.H. (2007). An outbreak of *Plum pox virus* in Norway. Acta Horticulturae 734, 93-99.

Blystad, D.R., Knudsen, R., Spetz, C., Haugslien, S., Ørstad, K., Cambra, M., Munthe, T., (2010). Survey on Plum Pox virus in Norway. 21st International conference on virus and other graft transmissible disease of fruit crops. Julius Kühn Archiv 427, 351-352.

Blystad, D.R., Munthe, T. (2006). *Plum pox virus* (PPV) in Norway. Bulletin OEPP/EPPO Bulletin 36, 212.

Bodin, M., Glasa, M., Verger, D., Costes, E., Dosba, F. (2003). Distribution of the Sour Cherry Isolate of Plum Pox Virus in Infected Prunus Rootstocks. Journal of Phytopathology 151, 625–630.

Caglayan, K. (2006). *Plum pox virus* (PPV) in Turkey. Bulletin OEPP/EPPO Bulletin 36, 216.

Cambra, M., Boscia, D., Myrta, A., Palkovics, L., Navrátil, M., Barba, M., Gorris, M.T., Capote, N. (2006a). Detection and characterization of *Plum pox virus*: serological methods. Bulletin OEPP/EPPO Bulletin 36, 254-261.

Cambra, M., Capote, N., Cambra, M.A., Llácer, G., Botella, P., López-Quílez, A. (2006c). Epidemiology of Sharka disease in Spain. Bulletin OEPP/EPPO Bulletin 36, 271-275.

Cambra, M., Capote, N., Myrta, A., Llácer, G. (2006b). *Plum pox virus* and the estimated costs associated with Sharka disease. Bulletin OEPP/EPPO Bulletin 36 (2), 202-204.

Cambra, M., Flores, R., Pallás, V., Gentit, P., Candresse, T. (2008). Viruses and viroids of peach trees. Pages 435-466 in: The peach, botany, production and uses. Layne, D.R. and Bassi, D. (eds.). CABI Press. Wallingford. 615 pp.

Cambra, M., Gorris, M.T., Capote, N., Asensio, M., Martínez, M.C., Bertolini, E., Collado, C., Hermoso de Mendoza, A., Mataix, E., López, A. (2004a). Epidemiology of *Plum pox virus* in Japanese plums in Spain. Acta Horticulturae 657, 195-200.

Cambra, M.A., Crespo, J., Gorris, M.T., Martínez, M.C., Olmos, A., Capote, N., Cambra, M. (2004b). Detection and eradication of Plum pox virus Marcus Type in Aragón (Spain). Acta Horticulturae 657, 231-235.

Cambra, M.A., Serra, J., Cano, A., Cambra, M. (2006d). *Plum pox virus* (PPV) in Spain. Bulletin OEPP/EPPO Bulletin 36 (2), 215.

Candresse, T., Cambra, M., Dallot, S., Lanneau, M., Asensio, M., Gorris, M. T., Revers, F., Macquaire, G., Olmos, A., Boscia, D., Quiot, J. B., Dunez, J. (1998). Comparison of monoclonal antibodies & polymerase chain reaction assays for the typing of Isolates Belonging to the D and M Serotypes of Plum Pox Potyvirus. Phytopathology 88, 198-204.

Candresse, T., Cambra, M. (2006). Causal agent of Sharka disease: historical perspective and current status of *Plum pox virus* strains. Bulletin OEPP/EPPO Bulletin 36, 239-246.

Candresse, T., Svanella-Dumas, L., Gentit, P., Caglayan, K., Çevik, B. (2007). First report of the presence of *Plum pox virus* Rec strain in Turkey. Plant Disease 91, 331-331.

Capote, N., Cambra, M., Llácer, G., Petter, F., Platts, L.G., Roy, A.S., Smith, I.M. (2006a). Current status of *Plum pox virus* and Sharka disease worldwide. Bulletin OEPP/EPPO Bulletin 36, 201-350.

Capote, N., Gorris, M.T., Martínez, M.C., Asensio, M., Olmos, A., Cambra, M. (2006b). Interference between D and M types of *Plum pox virus* in Japanese plum assessed by specific monoclonal

antibodies and quantitative real-time reverse transcription-polymerase chain reaction. Phytopathology 96, 320-325.

Capote, N., Cambra, M.A., Botella, P., Gorris, M.T., Martínez, M.C., López-Quílez, A., Cambra, M. (2010). Detection, characterization, epidemiology and eradication of *Plum pox virus* Marcus type in Spain. Journal of Plant Pathology 92, 619-628.

Cervera, M.T., Riechmann, J.L., Martin, M.T., Garcia, J.A. (1993). 3'-Terminal sequence of the *Plum pox virus* PS and o6 isolates: evidence for RNA recombination within the potyvirus group. Journal of General Virology 74, 329-334.

Conti, M. (1986). Epidemiology and vectors of Plum pox virus of stone fruits. Informatore Fitopatologico 36: 23¬26.

Corvo, L.M., Sousa Santos, M., Nolasco, G. (1995). Detection of plum pox virus using a simplified polymerase chain reaction procedure. Acta Horticulturae 386, 383-390.

Crescenzi, A., d'Aquino, L., Comes, S., Nuzzaci, M., Piazzolla, P., Boscia, D., Hadidi, A. (1997). Characterization of the sweet cherry isolate of Plum pox potyvirus. Plant Disease 81, 711-714.

Dal Zotto, A., Ortego, J.M., Raigon, J.M., Caloggero, S., Rossini, M., Ducasse, D.A. (2006). First report in Argentina of *Plum pox virus* causing Sharka disease in *Prunus*. Plant Disease 90, 523.

Dallot, S., Bousalem, M., Boeglin, M., Renaud, L.Y., Quiot, J.B. (1997). Potential role of almond in Sharka epidemics: susceptibility under controlled conditions to the main types of *Plum pox* potyvirus and survey for natural infections in France. OEPP/EPPO Bulletin 27, 539-546.

Dallot, S., Labonne, G., Boeglin, M., Quiot-Douine, L., Quiot, J.B., Candresse, T. (1998). Peculiar Plum pox potyvirus D-populations are epidemic in peach trees. Acta Horticulturae 472, 355-365.

Dallot, S., Gottwald, T., Labonne, G., Quiot, J.B. (2003). Spatial Pattern Analysis of Sharka Disease (*Plum pox virus* Strain M) in Peach Orchards of Southern France. Phytopathology 93, 1543-1552.

Dallot, S., Gottwald, T., Labonne, G., Quiot, J.B. (2004). Factors affecting the spread of *Plum pox viru*s strain M in peach orchards subjected to roguing in France. Phytopathology 94, 1390-1398.

Dallot, S., Kamenova, I., Glasa, M., Pittnerova, S., Kominek, P., Virscek-Marn, M., Mavric Plesko, I., Paunović, S., Jevremović, D., Milusheva, S. (2008). Prevalence and genetic structure of PPV-M in six European countries. Acta Horticulturae 781, 227-234.

Dallot S, Glasa M, Jevremovic D, Kamenova I, Paunovic S, Labonne G (2011): Mediterranean and central-eastern European countries host viruses of two different clades of plum pox virus strain M. Archives of Virology 156: 539-542.

Damsteegt, V.D., Scorza, R., Stone, A.L., Schneider, W.L., Webb, K., Demuth, M., Gildow, F.E. (2007a). *Prunus* host range of *Plum pox virus* (PPV) in the United States by aphid and graft inoculation. Plant Disease 91, 18-23.

Damsteegt, V.D., Stone, A.L., Gildow, F.E., Schneider, W.L., Luster, D.G. (2004). Potential Prunus host range of PPV-PENN isolates by aphid transmission. Acta Horticulturae 657, 201-206.

Damsteegt, V.D., Stone, A.L., Schneider, W.L., Lister, W.D., Gildow, F.E. (2007b). Potential *Prunus* host range of PPV-PENN isolates by aphid transmission. Acta Horticulturae 657, 201-205

Deborré, G., Maiss, E., Jelkman, W. (1995). Biological and molecular investigations of several *Plum pox virus* (PPV) isolates. Acta Horticulturae 386, 253-262.

Di Terlizzi, B., Boscia, D. (2006). *Plum pox virus* (PPV) in Italy. Bulletin OEPP/EPPO Bulletin 36, 210.

Dondini, L. Adami, M., Guidarelli, M., Gaiotti, F., Negri, P.; Tartarini, S., Palmisano, F., Bazzoni, A., Castellano, M., Savino, V., Lain, O., Testolin, R., Rizzo, M., Vivoli, D., Geuna, F., Bassi, D., Boscia, D., Minafra, A. (2010). Strategies to confer resistance to Sharka (PPV) in apricot. Acta Horticulturae 862, 477-482.

Dosba, F., Maison, P., Lansac, M., Massonie, G. (1987). Experimental transmission of *Plum pox virus* (PPV) to *Prunus* mahaleb and *Prunus* avium. Journal of Phytopathology 120, 199-204.

Dragoiski, K., Minev, I., Dzhuvinov, V., Bozhkova, V. (2007). The Strategy for Controlling Sharka in Bulgaria. Acta Horticulturae 734, 259-263.

Dulic-Markovic, I., Jevremovic, D. (2006). Plum pox virus (PPV) in Serbia. Bulletin OEPP/EPPO Bulletin 36 (2), 213-214.

Dzhuvinov, V., Bozhkova, V., Milusheva, S., Gercheva, P.S. (2007). Investigation of Sharka in Bulgaria for the Past Seventy Years. Acta Horticulturae 734, 109-115.

Elibüyük, I.O. (2004). Current situation of Sharka disease in Ankara, Turkey. Phytoparasitica 32, 417-420.

Elibüyük, I.O. (2006). Detection of *Plum pox virus* in ornamental *Prunus cerasifera*. Phytoparasitica 34, 347-352..

García, J.A., Cambra, M. (2007). *Plum pox virus* and Sharka disease. Plant Viruses 1, 69-79.

Gildow, F.E., Damsteegt, V.D., Stone, A.L., Schneider, W.L., Luster, D.G., Levy, L. (2004). Plum pox in North America: Identification of aphid vectors and a potential role for fruit in virus spread. Phytopathology 94, 868-874.

Glasa, M. (2006). *Plum pox virus* (PPV) in Slovakia. Bulletin OEPP/EPPO Bulletin 36, 214.

Glasa, M., Boeglin, M., Labonne, G. (2004a). Aphid transmission of natural recombinant *Plum pox virus* isolates to different *Prunus* ssp. A contribution for understanding the epidemiology of an atypical PPV. Acta Horticulturae 657, 217-220.

Glasa, M., Candresse, T. (2005). Partial sequence analysis of an atypical Turkish isolate provides further information on the evolutionary history of *Plum pox virus* (PPV). Virus Research 108 (1-2), 199-206.

Glasa, M., Candresse, T. (2006). Appendix 1 Note concerning the reference to walnut as a natural host of PPV. Bulletin OEPP/EPPO Bulletin 36, 226.

Glasa, M., Malinowski, T., Predajna, L., Pupola, N., Dekena, D., Michalczuk, L., Candresse, T. (2011). Sequence variability, recombination analysis, and specific detection of the W strain of *Plum pox virus.* Phytopathology 101 (8), 980-985.

Glasa, M., Marie-Jeanne, V., Labonne, G., Subr, Z., Kudela, O., Quiot, J.B. (2002a). A natural population of recombinant *Plum pox virus* is viable and competitive under field conditions. European Journal of Plant Pathology 108, 843-853.

Glasa, M., Palkovics, L., Komínek, P., Labonne, G., Pittnerová, S., Kúdela, O., Candresse, T., Subr, Z. (2004b). Geographically and temporally distant natural recombinant isolates of *Plum pox virus* are genetically very similar and form a unique PPV subgroup. Journal of General Virology 85, 2671-2681.

Glasa, M., Paunovic, S., Jevremovic, D., Myrta, A., Pittnerová, S., Candresse, T. (2005). Analysis of recombinant *Plum pox virus* (PPV) isolates from Serbia confirms genetic homogeneity and supports a regional origin for the PPV-Rec subgroup. Archives of Virology 150, 2051-2060.

Glasa, M., Predajna, L., Subr, Z. (2010). Competitiveness of different *Plum pox virus* isolates in experimental mixed infection reveals rather isolate-than strain-specific behaviour. Journal of Plant Pathology 92(1), 267-271

Gottwald, T.R., Avinent, L., Llácer, G., Hermoso De Mendoza, A., Cambra, M. (1995) Analysis of the spatial spread of Sharka (Plum pox virus) in apricot and peach orchards in Eastern Spain. Plant Disease 79, 266-278.

Isaac, M., Zagrai, I. (2006). *Plum pox virus* (PPV) in Romania. Bulletin OEPP/EPPO Bulletin 36, 213.

James, D., Glasa, M. (2006). Causal agent of Sharka disease: new and merging events associated with *Plum pox virus* characterization. Bulletin OEPP/EPPO Bulletin 36, 247-250.

James, D., Thompson, D. (2006). Hosts and symptoms of Plum pox virus: ornamental and wild *Prunus* species. Bulletin OEPP/EPPO Bulletin 36, 222-224.

James, D., Varga, A. (2005). Nucleotide sequence analysis of *Plum pox virus* isolate W3174: evidence of a new strain. Virus Research 110, 143-150.

Jarausch, W. (2006). *Plum pox virus* (PPV) in Germany. Bulletin OEPP/EPPO Bulletin 36, 209-209.

Jarausch, W., Baßler, A., Molla, N., Krczal, G. (2004). First detection and molecular characterisation of PPV-M strains in plum orchards in South-Western Germany. Acta Horticulturae 657, 159-164.

Kalashyan, Y.A., Bilkej, N.D., Verderevskaya, T.D., Rubina, E.V. (1994). *Plum pox virus* on sour cherry in Moldova. Bulletin OEPP/EPPO Bulletin 24, 645-649.

Kalashian, Y., Cernets, A. (2006). Plum pox virus (PPV) in Moldova. Bulletin OEPP/EPPO Bulletin 36(2), 211.

Kalinina, A., Brown, D. C. W., Ravelonandro, M. (2007). Susceptibility of ornamental *Prunus* to Plum pox potyvirus infection. Acta Horticulturae 738, 601-606.

Karayiannis, I., Ledbetter, C. (2009). Susceptibility of certain apricot and plumcot cultivars to *Plum pox virus* infection. Acta Horticulturae 825, 153-156.

Kerlan, C., Dunez, J. (1979). Biological and serological differentiation of strains of Sharka virus. Annales de Phytopathologie 11, 241-250.

Kölber, M. (2006). Plum pox virus (PPV) in Hungary. Bulletin OEPP/EPPO Bulletin 36 (2), 210-210.

Kölber, M., Nemeth, M., Chernets, A., Kalashian, Y., Dulic-Markovic, I., Glasa, M., Isac, M., Kriska, B., Malinowski, T., Zawadzka, B., Minoiu, N., Myrta, A., Navratil, M., Prichodko, Y., Slovakova, L., Topchiiska, M. (2001). Current situation of plum pox disease on stone fruit species in middle and eastern Europe. Acta Horticulturae 550, 73-78.

Kollerová, E., Nováková, S., Šubr, Z., Glasa, M. (2006). *Plum pox virus* mixed infection detected on apricot in Pakistan. Plant Disease 90, 1108.

Labonne, G., Boeglin, M., Monsion, B. (2004). Evaluation of three ornamental *Prunus* as reservoirs of PPV. Acta Horticulturae 657, 255-259.

Labonne, G., Dallot, S. (2006). Epidemiology of Sharka disease in France. Bulletin OEPP/EPPO Bulletin 36 (2), 267-270.

Labonne, G., Lauriaut, F., Yvon, M., Quiot, J.B. (1994). Dissémination du plum pox potyvirus par les pucerons: analyse des vecteurs potentiels du virus dans un verger d'abricotiers. Bulletin OEPP/EPPO Bulletin 24, 681-690.

Labonne, G., Quiot, J.B. (2001). Aphids can acquire plum pox virus from infected fruits. Acta Horticulturae 550, 79-83.

Labonne, G., Yvon, M., Quiot, J.B., Avinent, L., Llácer, G. (1995). Aphids as potential vectors of *Plum pox virus*: Comparison of methods of testing and epidemiological consequences. Acta Horticulturae 386, 207-218.

Laimer, M., Mendonca, D., Myrta, A., Boscia, D., Katinger, H., (2005). Molecular characterization of Austrian *Plum pox virus* (PPV) isolates. Phytopathologia Polonica 36, 25-32.

Lemmetty, A. (2006). *Plum pox virus* (PPV) in Finland. Bulletin OEPP/EPPO Bulletin 36, 208.

Levy L., Damsteegt V., Welliver, R. (2000). First report of Plum pox virus (Sharka disease) in *Prunus* persicae in the United States. Plant Disease 84, 202.

Llácer, G. (2006). Hosts and symptoms of Plum pox virus: Herbaceous hosts. Bulletin OEPP/EPPO Bulletin 36, 227-228.

Llácer, G., Cambra, M. (2006). Hosts and symptoms of *Plum pox virus*: fruiting *Prunus* species. Bulletin OEPP/EPPO Bulletin 36, 219-221.

López-Moya, J.J., Fernández-Fernández, M.R., Cambra, M., García, J.A. (2000). Biotechnological aspects of *Plum pox virus*. Journal of Biotechnology 76, 121-136.

Louro, D., Corvo, L. M. (1986). Occurrence of Sharka in Portugal. Acta Horticulturae 193, 183-187.

Maejima, K., Hoshi, H., Hashimoto, M., Himeno, M., Kawanishi, T., Komatsu, K., Yamaji, Y., Hamamoto, H., Namba, S. (2010). First report of *plum pox virus* infecting Japanese apricot (*Prunus* mume Sieb. et Zucc.) in Japan. Journal of General Plant Virology 76(3), 229-231.

Malinowski, T. (2006). Plum pox virus (PPV) in Poland. Bulletin OEPP/EPPO Bulletin 36 (2), 212-213.

Manachini, B., Casati, P., Aliverti, I., Cinanni, L. (2004). Transmission of PPV-M to *Prunus* persica by Brachycaudus schwartzi and Phorodon humuli (Hem., Aphididae). Journal of Applied Entomology 128, 677-680.

Manachini, B., Casati, P., Cinanni, L., Bianco, P. (2007). Role of Myzus persicae (Hemiptera: Aphididae) and its secondary hosts in Plum pox virus propagation. Journal of Economic Entomology 100, 1047-1052.

Matic, S., Al-Rwahnih, M., Myrta, A. (2006). Diversity of Plum pox virus isolates in Bosnia and Herzegovina. Plant Pathology 55, 11-17.

Matic, S., Elmaghraby, V., Law, A., Reed, C., Myrta, A., James, D. (2011). Serological and molecular characterization of isolates of Plum pox virus strain El Amar to better understand its diversity, evolution, and unique geographical distribution. Journal of Plant Pathology 93 (2), 303-310.

Mazyad, H.M., Nakhla, M.K., Abo-El-Ella, El-Hammady, M.H. (1992). Occurrence of *Plum pox virus* (Sharka) on stone fruit trees in Egypt. Acta Horticulturae. 309, 119-124.

Mikec, I., Kajić, V., Križanac, I. (2006). Plum pox virus (PPV) in Croatia. Bulletin OEPP/EPPO Bulletin 36 (2), 207.

Milusheva, S., Gercheva, P., Bozhkova, V., Kamenova, I. (2008). Experiments on transmission of Plum Pox Virus through Prunus seeds. Journal of Plant Pathology, 90, S1.23-S1.26

Milusheva, S., Kamenova, I., Stoev, A. (2006). Plum pox virus (PPV) in Bulgaria. Bulletin OEPP/EPPO Bulletin 36 (2), 206.

Milusheva, S., Rankova, Z. (2002). *Plum pox* potyvirus detection in weed species under field conditions. Acta Horticulturae 577, 283-287.

Minoiu, N. (1997). Plum diseases and pests, 343-374. In: The Plum, I. Cociu, I. Botu, N. I. Minoiu, I. Modoran. Editure Conphys. Pitesti. Romania.

Moreno, A., Fereres, A., Cambra, M. (2009). Quantitative estimation of *Plum pox virus* targets acquired and transmitted by a single *Myzus persicae*. Archives of Virology 154, 1391-1399.

Morvan, G. (1988). The epidemiology of Plum pox virus in the apricot orchards of southern France: Description of computer tools and main observations. Acta Horticulturae 235, 263-270.

Mumford, R.A. (2006a). *Plum pox virus* (PPV) in the United Kingdom. Bulletin OEPP/EPPO Bulletin 36 (2), 217.

Mumford, R.A. (2006b). Control and monitoring: control of *Plum pox virus* in the United Kingdom. Bulletin OEPP/EPPO Bulletin 36, 315-318.

Myrta, A., Boscia, D., Potere, O., Kölber, M., Németh, M., Di Terlizzi, B., Cambra, M., Savino, V. (2001). Existence of two serological subclusters of *Plum pox virus*, strain M. European Journal of Plant Pathology 107, 845-848.

Myrta, A., Di Terlizzi, B., Savino, V., Martelli, G. (2002). Sanitary status of the Mediterranean stone fruit industry. Acta Horticulturae 582, 83-94.

Myrta, A., Di Terlizzi, B., Savino, V., Martelli, G. (2003). Virus diseases affecting the Mediterranean stone fruit industry: a decade of surveys. Pp 15 – 23 in: Myrta A., Di Terlizzi B., & Savino, V. (eds). Virus and virus-like diseases of stone fruits, with particular reference to the Mediterranean region. Bari: CIHEAM (Centre International de Hautes Etudes Agronomiques Méditerranéennes) Options Méditerranéennes, Série B : N. 45.

Navrátil, M., Safarova, D., Karesova, R., Petrzik, K. (2005). First incidence of Plum pox virus on apricot trees in China. Plant Disease Note 89, 338.

Navrátil, M. (2006). Plum pox virus (PPV) in the Czech Republic. Bulletin OEPP/EPPO Bulletin 36 (2), 208.

Nemchinov, L., Hadidi, A. (1996). Characterization of the Sour Cherry Strain of *Plum Pox Virus*. Phytopathology 86, 575-580

Nemchinov, L., Hadidi, A. Maiss, E., Cambra, M., Candresse, T., Damsteegt, V. (1996). Sour cherry strain of Plum pox potyvirus (PPV): Molecular and serological evidence for a new subgroup of PPV strains. Phytopathology 86, 1215-1221.

Nemeth, M. (1994). History and importance of plum pox in stone-fruit production. Bulletin OEPP/EPPO Bulletin 24, 525-536.

Neumüller, M., Hartmann, W., Stösser, R. (2005). The hypersensitivity of European plum against *Plum pox virus* (PPV) as a promising mechanism of resistance. Phytopathologia Polonica 36, 77-83.

Palmisano, F., Bazzoni, A., Tavano, D., Didonna, A., Castellano, M., Savino, V. (2010). Experimental screening of an apricot cross for resistance to *Plum pox virus* (M and D strains). Acta Horticulturae 862, 501-506.

Pascal, T., Pfeiffer, F., Kervella, J. (2002). Preliminary observations on the resistance to Sharka in peach and related species. Acta Horticulturae 592, 699-706.

Pasquini, G., Barba, M. (2006). The question of seed transmissibility of *Plum pox virus*. Bulletin OEPP/EPPO Bulletin 36, 287-292.

Paunović S., Jevremović D. (2010): Health status of pome and stone fruit planting material imported to Serbia. Proceedings of the 21st International Conference on Virus and other Graft Transmissible Diseases of Fruit Crops, Neustadt, Germany, Julius-Kühn-Archiv, 427, 300-303.

Polák, J. (1997). On the epidemiology of *Plum pox virus* in the Czech Republic. Ochrana rostlin 33, 81-88.

Polák, J. (2001). European spindle tree and common privet a new natural hosts of *Plum plox virus*. Acta Horticulturae 550, 125-128.

Polák, J. (2002). Distribution of *Plum pox virus* in the Czech Republic. Plant Protection Science 38, 98-102.

Polák, J. (2006). Hosts and symptoms of Plum pox virus: Woody species other than fruit and ornamental species of *Prunus*. Bulletin OEPP/EPPO Bulletin 36, 225-226.

Polák J. (2007) Viruses of blackthorn and road-bordering trees of plum, myrobalan, sweet and sour cherries in the Czech Republic. Plant Protect. Sci., 43, 1-4.

Polák, J., Pívalová, J., Svoboda, J. (2005). Prune Cv. Jojo Resistance to Different Strains of *Plum Pox Virus*. Plant Protection Science 41(2), 47-51.

Polák J., Komínek P. (2009). Distribution of *Plum pox virus* strains in natural sources in the Czech Republic. Plant Protection Science 45, 144-147.

Pribek, D. Palkovics, L., Gaborjanyi, R. (2001). Molecular characterization of *Plum pox virus* almond isolate. Acta Horticulturae 550 (1), 91-95.

Prichodko, Y. (2006). *Plum pox virus* (PPV) in Russia. Bulletin OEPP/EPPO Bulletin 36 (2), 213.

Putallaz, O., Kerautret, I., Crausaz, P.-H., Buchmann, B., Bünter, M., Balmelli, C., Besse, S., Klay, A. (2009). Sharka: Quarantäne Krankheit im Griff Schweizerische Zeitschrift für Obst und Weinbau 24, 10-13.

Putallaz, O., Kerautret, I., Crausaz, P.-H., Bünter, M., Buchmann, B., Balmelli, C., Besse, S. (2010). La Sharka en Suisse: bilan et perspectives. Revue suisse Vitic. Arboric. Hortic. 42(1), 65-67.

Quiot, J B., Boeglin, M., Admolle, C., Candresse, T., Labonne, G., Renaud, L.Y. (1995). Behaviour of two isolates of *Plum pox virus* inoculated on peach and apricot trees: First results. Acta Horticulturae 386, 290-297.

Ramel, M.E., Gugerli, P., Bünter, M. (2006). Plum pox virus (PPV) in Switzerland. Bulletin OEPP/EPPO Bulletin 36, 215-216.

Ranković M., Ogašanović D., Paunović S. (1994): Breeding of plum cultivars resistant to sharka (plum pox) disease. Acta Horticulturae, 359, 69-74.

Roy, A.S., Smith, I.M. (1994). Plum pox situation in Europe. Bulletin OEPP/EPPO Bulletin 24, 515-523.

Rubio, M., Martínez-Gómez, P., Dicenta, F., Weber, W.E. (2003). Resistance of almond cultivars to *Plum pox virus* (Sharka). Plant Breeding 122, 462-464.

Salvador, B., Delgadillo, M.O., Sáenz, P., García, J.A., Simón-Mateo, C. (2008). Identification of Plum pox virus pathogenicity determinants in herbaceous and woody hosts. Molecular Plant Microbe Interactions 21(1), 20-29.

Scheel, C. (2009). First outbreak in 2008 of Plum Pox Virus in Denmark since 1986. EPPO Workshop on eradication, containment and contingency planning. Nova Gorica (SI), 2009-02-/12. Available at http://archives.eppo.org/MEETINGS/2009_conferences/eradication/brochure_eradication.pdf (accessed August, 2010).

Serçe, C.U., Candresse, T., Svanella-Dumas, L., Krizbai, L., Gazel, M., Caglayan, K. (2009). Further characterization of a new recombinant group of *Plum pox virus* isolates, PPV-T, found in orchards in the Ankara province of Turkey. Virus Research 142, 121-126.

Sheveleva, A., Chirkov, S., Nemova E. (2011). Detection of a new Winona-like *Plum pox virus* isolate in naturally infected canadian plum (*Prunus nigra*) in Russia. Acta Horticulturae 899, 49-56.

Smolák, J. (1926) Služba informační. Druhá výroční zpráva, stav pro choroby rostlin na Mčlníce za rok 1925–1926 90-95.

Smolák, J., Novák, J.B. (1956). A contribution to the virology of fruit trees. Acta Universitatis Agriculturae 1, 99-118.

Speich, P. (2006). *Plum pox virus* (PPV) in France. Bulletin OEPP/EPPO Bulletin 36, 208-209.

Spiegel, S., Kovalenko, E., Varga, A., James, D. (2004). Detection and partial molecular characterization of two Plum pox virus isolates from plum and wild apricot in southeast Kazakhstan. Plant Disease 88, 973-979.

Stamo, B., Myrta, A. (2006). *Plum pox virus* (PPV) in Albania. Bulletin OEPP/EPPO Bulletin 36 (2), 205.

Staniulis, J. (2006). *Plum pox virus* (PPV) in Lithuania. Bulletin OEPP/EPPO Bulletin 36 (2), 211.

Stobbs, L. W., van Driel, L., Whybourne, K., Carlson, C., Tulloch, M., van Lier, J. (2005). Distribution of Plum pox virus in residential sites, commercial nurseries, and native plant species in the Niagara region, Ontario, Canada. Plant Disease 89, 822-827.

Syrgiannidis, G.D., Maïnou, A. CH. (1986). Study of the sensitivity to Sharka (Plum pox) virus of 33 peach and nectarine varieties. Acta Horticulturae 193, 217-222.

Thompson, D. (2006). Control and monitoring: control strategies for Plum pox virus in Canada. Bulletin OEPP/EPPO Bulletin 36 (2), 302-304.

Thompson, D., McCann, M., McLeod, M., Lye, D., Green, M., James, D. (2001). First report of Plum pox potyvirus in Canada. Plant Disease 85, 97.

Varveri, C. (2006). Epidemiology of *Plum pox virus* strain M in Greece. Bulletin OEPP/EPPO Bulletin 36, 276-278.

Verhoeven, J.Th.J., Haas, A.M., de Roenhorst, J.W. (1998). Outbreak and eradication of *Plum pox potyvirus* in the Netherlands. Acta Horticulturae 472, 407-411.

Verhoeven, J.Th.J., Roenhorst, J.W., Jongedijk, G.P. (2006). *Plum pox virus* (PPV) in the Netherlands. Bulletin OEPP/EPPO Bulletin 36, 211-212.

Verhoeven, J.Th.J., Roenhorst, J.W., Jongedijk, G.P. (2008). Occurrence and control of *Plum pox virus* in the Netherlands Acta Horticulturae 781, 197-202.

Virsček Marn, M., Mavrič, I., Urbančič-Zemljič., M., Skerlavaj, V. (2004). Detection of Plum pox potyvirus in weeds. Acta Horticulturae 657, 251-254.

Virscek Marn, M., Mavric, I. (2006). Plum pox virus (PPV) in Slovenia. Bulletin OEPP/EPPO Bulletin 36 (2), 214-214

Virsček Marn, M., Mavrič Plesko, I. Zindovic, J. (2008). Discovery and characterization of Plum pox virus isolates in Montenegro. Plant Pathology 57, 393.

Wang, A., Sanfacon, H., Stobbs, L.W., James, D., Thompson, D., Svircev, A.M., Brown, D.C.W. (2006). *Plum pox virus* in Canada: progress in research and future prospects for disease control. Canadian Journal of Plant Pathology 28, 182-196.

Wetzel, T., Candresse, T., Ravelonandro, M., Delbos, R.P., Mazyad, H., Aboul-Ata, A.E., Dunez, J. (1991). Nucleotide sequence of the 3′-terminal region of the RNA of the El Amar strain of Plum pox potyvirus. Journal of General Virology 72, 1741-1746.

Youssef, S.A., Shalaby A. (2006). *Plum pox virus* (PPV) in Egypt Bulletin OEPP/EPPO Bulletin 36, 208.

Zagrai, L., Zagrai, I. (2008). Non-transmission of *Plum pox virus* D and Rec strains through seeds in plum. Bulletin UASVM Horticulture 65, 523.

Zagrai, L, Zagrai I., Ferencz, B., Gaboreanu, I., Kovacs, K., Petricele, I, Popescu, O., Pamfil, D., Capote, N. (2008). Serological and molecular typing of *Plum pox virus* isolates in the north of Romania. Journal of Plant Pathology 90 (1, Supplement), 41-46.

Zagrai, I., Zagrai, L., Ferencz, B., Petricele, I., Pamfil, D., Popescu, O., Briciu, A., Festila, A. (2009). Serological and molecular typing of *Plum pox virus* isolates in the Transylvania, Romania. Notulae Botanicae, Horti Agrobotanici, Cluj-Napoca. 37(1), 265-272.

Zagrai I., Zagrai L., Festila A., Clapa D., Baias I. 2011. Implementation of Certification Standards for Obtaining Nuclear - Stock Plum Material in Romania. Book of Abstracts - Second Balcan Symposium on Fruit Growing, september 5-7, 2011, pg. 11. Acta Horticulturae, in press.

Zagrai, I., Zagrai L., Preda, S., Kelemen, B., Petricele, I., Popescu, O., Pamfil, D., Isac, M. (2010). Genetic diversity of *Plum pox virus* Isolates in Muntenia, Romania. Romanian Biotechnological Letters 15(3), 5303-5309.

Zagrai, L., Zagrai, I., Petricele, I., Kelemen, B., Pamfil, D., Popescu, O., Briciu, A., Festila, A. 2009 - Serological and Molecular Typing of Plum pox Virus Isolates in the Moldavia, Romania. Bulletin UASVM, Horticulture 66(1-2)/2009: 241-248. ISSN 1843-5254.

Zagrai, I., Zagrai, L., Preda, S., Isac, M., Cardei, E. 2010. Incidence of Plum Pox Virus in Romanian Plum Orchards. Bulletin UASVM, Horticulture 67(1-2)/2010: 488, ISSN 1843-5254.

Appendix I: Pest status [14]and control measures in European countries

EU countries

Austria	**EPPOPQR1**	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. Intrastrain variability analysis revealed that Misolates 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	**EPPOPQR**	
	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	PPVD. Isolate WBel confirmed as PPV-D (Candresse et al., 1998). Update 2010 (NPPO of Belgium): only PPV-D found thus far.
	Found in:	Plum, Pixie rootstock

[14] An update should be soon issued from extensive data gathered in the course of the SharCo FP7 collaborative project. Data will be freely available on the SharCo website at www.sharco.eu.

	Control strategies	Growers are provided with virusfree 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; Candresse et al., 1998; NPPO of Belgium, 2010

Bulgaria	**EPPOPQR**	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	**EPPOPQR**	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	**EPPOPQR**	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 fruitgrowing 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	**EPPOPQR**	
	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	**EPPOPQR**	
	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	**EPPOPQR**	
	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	**EPPOPQR**	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. SEFrance (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 PPVM. 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 MidiPyrenées, which covers about 10% of the total stone fruit area, excepted. SEFrance 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. NEFrance: in Lorraine first findings before 2000; Alsace PPV first found in 2000. SWFrance (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 PPVM strain introduced in the mid1980s 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 PPVM 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 virusfree material. New PPVM 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 November 2010): Since November 2008 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 RhôneAlpes 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 of a nursery, plants will not be plant passported.
	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

Germany	**EPPOPQR**	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 BadenWürttemberg 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	**EPPOPQR**	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 PPV
	References	Varveri, 2006

Hungary	**EPPOPQR**	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 (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. PPVC was detected in symptomless sweet and sour cherry trees (Kölber, 2006).
	Control strategies	
	References	Glasa et al. 2004b; Kölber, 2006

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

Italy	**EPPOPQR**	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 (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 PPVM or in areas where PPV is already endemic (Bazzoni et al. 2008, Di Terlizzi & Boscia, 2006). Eradication of infected trees and the production of virusfree 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	**EPPOPQR**	
	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), PPV-W (Malinowski et al., 2010. SharCo 2nd periodic report.
	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	**EPPOPQR**	Present, few records
	1st report/detected	1995
	Spread/infection levels	Survey 19982002: 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	**EPPOPQR**	Present, no details
	1st report/detected	
	Spread/infection levels	
	PPV strains	

	Found in:	
	Control strategies	
	References	

Malta	**EPPOPQR**	
	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	**EPPOPQR**	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 virusfree 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	**EPPOPQR**	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 noncommercial 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	**EPPOPQR**	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 SPortugal (Algarve). Later also found on plum in centralwest 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	**EPPOPQR**	Present and widespread
	1st report/detected	According to Minoiu (1997) PPV was found by Traian Savulescu in 1922, but the systematic research on the disease started in the 1960.
	Spread/infection levels	Present in all stone fruitgrowing areas. PPV is spread with high incidence in all areas of plum cultivation. A recent large scale survey (2006-2009) revealed an average rate of PPV infection in Romanian plum orchards of 68.5% (Zagrai et al., 2010). Majority of the orchards recorded an infection rate over 70%.
	PPV strains	PPVD, PPVRec, PPVC, (PPVM?) and mixed infections Indication that PPVM typed isolates are actually PPVRec. PPVC has a very limited distribution (Isac & Zagrai, 2006). All PPV isolates typed as PPVM by serological analysis proved to be PPVRec. PPVD is the prevalent strain. PPVRec is also present both in singular and mixed infections (PPVD + PPVRec). Muntenia area: 68% PPVD, 8% PPVRec, 24% PPVD+Rec; Bistrita area: 46.5% PPVD, 34.9% PPVRec, 18.6% PPVD+Rec; Transylvania (including Bistrita) area: 70,0% PPVD, 18,0% PPVRec, 12,0% PPVD+PPVRec; Moldova area: 84,0% PPVD, 12% PPVRec (Zagrai et al., 2008, 2009, 2010). To date, only PPVD was found in apricot (Zagrai et al., unpublished results). No data are available about PPV strains in peach.
	Found in:	All stonefruit species are more or less infected by PPV. The plum is the most affected.
	Control strategies	Propagation of virus-free Prunus associated with the development and use of PPV resistant plum varieties are trying to be implemented as the most efficient strategy for PPV containment in Romania. As a first step, a certification program based on EU requirements (EPPO standards), was recently implemented at Fruit Research & Development Station Bistrita (Zagrai et al., 2011), Also, breeding programs focus on PPV resistance are in progres in three different research institutions.

	References	Minoiu, 1997; Isac & Zagrai, 2006; Zagrai et al., 2008, 2009, 2010, 2011

Slovenia	**EPPOPQR**	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 decrease 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	PPVM (74%), PPVD (10%), and PPVRec (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 PPVinfected propagation material (Virscek Marn & Mavric, 2006)
	References	Dallot et al., 2008; Virscek Marn & Mavric, 2006.

Slovakia	**EPPOPQR**	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	PPVRec (49%), PPVD (27%), and PPVM (24%). No mixed infections found (Dallot et al., 2008). It was noted that PPVRec 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. PPVD and PPVRec types were found to be strongly associated with plum orchards, PPVM 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	**EPPOPQR**	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, PPV-T or PPV-W (Cambra et al., 2006c). 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., 2004b; Capote et al., 2010).
	Found in:	Plum, apricot, peach. "PPV has never been detected in plantations of almonds, cherries or ornamental Prunus species" (Cambra et al., 2006c). 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; PPVfree plants are produced without any risk of infection in areas where PPV is absent such as Aragón and Navarra (Ebro Valley) (Cambra et al., 2006c). 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. 2006c). "The majority of Japanese plum cultivars show little or no symptoms in fruits. Consequently, growers are not eradicating PPVD from Japanese plums and the virus is spreading from these usually symptomless reservoir trees to healthy ones" (Cambra et al., 2006c).
	References	Cambra et al., 2004b; Cambra et al., 2006c ; Capote et al., 2010.

Sweden	**EPPOPQR**	
	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	**EPPOPQR**	Present, limited distribution
	1st report/detected	1965

	Spread/infection levels	In 1980s well established in the main plum growing areas (Kent and the West MidlandsWelsh 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%) (MatthewsBerry, 2008).
	References	Mumford, 2006a,b; MatthewsBerry, 2008

Non-EU countries

Albania	**EPPOPQR**	Present, limited distribution
	1st report/detected	survey mid 1990?
	Spread/infection levels	Surveys mid 1990s: PPV endemic in SE (60100% 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	**EPPOPQR**	
	1st report/detected	
	Spread/infection levels	
	PPV strains	
	Found in:	
	Control strategies	
	References	

Belarus	**EPPOPQR**	
	1st report/detected	
	Spread/infection levels	
	PPV strains	

	Found in:	
	Control strategies	
	References	

Bosnia and Herzegovina	**EPPOPQR**	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: PPVD (57%), PPV-Rec (29%). Peaches: PPV-M. Apricot, myrobalan and blackthorn: PPV-M or PPV-D.
	Found in:	Most affected were 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 PPVfree areas and effective inspections of imported propagation material should be encouraged in the control strategy against Sharka.
	References	Matic et al., 2006

Croatia	**EPPOPQR**	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	**EPPOPQR**	
	1st report/detected	
	Spread/infection levels	
	PPV strains	
	Found in:	
	Control strategies	
	References	

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

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

Moldova, Republic of	**EPPOPQR**	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, PPVC 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 virusfree plum cultivars.
	References	Kalashian & Chernets, 2006

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

Montenegro	**EPPOPQR**	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	**EPPOPQR**	Present, limited distribution
	1st report/detected	1998
	Spread/infection levels	Surveys 19982003: 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 20072008 (Blystad et al., 2010).
	PPV strains	PPVD
	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	**EPPOPQR**	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	**EPPOPQR**	
	1st report/detected	
	Spread/infection levels	
	PPV strains	
	Found in:	
	Control strategies	
	References	

Serbia	**EPPOPQR**	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	The most prevalent strain overall is PPV-Rec (54,2%), followed by PPV-D (25,5%), PPV-M (7,3%) and mix infection (13%).
	Found in:	plum, apricot, peach, myrobalan plum (P. cerasifera), blackthorn (P. spinosa),
	Control strategies	Total eradication not feasible. Control of stone fruit propagation material intended to be imported to Serbia, inspection and analysis at the entry point of the material. In 2005, a new law on production of planting material was accepted that proscribes: certification schemes to improve the sanitary status of planting material; visual inspection and ELISA testing of each mother plant of stone fruits each year; 1km buffer zone around MPs and 500 m around nurseries; destruction of individual PPV-infected mother trees with one year suspension of mother plantation; visual inspection of the nursery and testing of plant suspected to be infected. Eradication program was conducted from 1985-1987 in Western Serbia. New eradication program conducted in 2007 for establishment of PPV-free zone on 1,100 ha for production of planting material. Breeding program of tolerant and resistant plum cultivars.
	References	DulicMarkovic & Jevremovic, 2006; Paunovic & Jevremovic, 2010; Labonne, Paunovic and Jevremovic, 2011: SharCo second periodic report WPE2,; SharCo diliverable DA1.1, 2009); Ranković M., Ogašanović D., Paunović S. (1994)

Switzerland	**EPPOPQR**	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	**EPPOPQR***	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	**EPPOPQR***	Present, limited distribution
	1st report/detected	1967
	Spread/infection levels	Thirteen locations in the IvanoFrankivsk, Lviv, Chernivci and Crimea regions of Ukraine. PPVinfection 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 virusfree regions.
	References	Kondratenko & Udovychenko, 2006

Vatican City	**EPPOPQR***	
	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, Ireland and United Kingdom

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[15] 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.,

[15] This list might have to be updated since PPV has been detected on several Prunus cerasus species (sweet and sour cherries) and PPV outbreaks have been reported on Prunus mume (Japanese apricot).

- *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.