

SOME RESULTS OF 50 YEARS OF RESEARCH ON THE RESISTANCE TO PLUM POX VIRUS

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Summary. – Over 300 references on the resistance of stone fruit species to plum pox virus (PPV) have been utilized for the summarization of relevant information in this review. Methods of testing PPV resistance, procedures of evaluation and characterization of PPV resistance as well as breeding of PPV-resistant cultivars are briefly discussed. Altogether 370 cultivars, hybrids and clones of plum, peach, apricot, nectarine and wild *Prunus* species are tabulated together with the authors who have reported on their immunity, resistance and tolerance.

Key words: plum pox virus; resistance; review

Introduction

Experimental research on the resistance to PPV (family *Potyviridae*, genus *Potyvirus*) began more than 50 years ago. Specialized literature on the PPV resistance of stone fruit species has been published in a lot of national and international journals. More than 300 references on this matter have been utilized and compiled. Main topics of research on the PPV resistance have been the detection of resistant genotypes in the field, experimental testing of the PPV resistance, breeding of resistant cultivars, detection of different types of the PPV resistance as well as genetechnical investigation on virus detection and gene transfer. A drastic increase of number of publications on these topics took place during the last two decades (Table 1).

It was the Bulgarian fruit tree virologist Alexander Christoff who first reported on plum cultivars resistant to PPV in 1947. Among these cultivars he mentioned Anna Späth, Bühler Frühzwetsche, Montfort and The Czar which played later an important role in the control of the “sharka” disease both in growing and breeding resistant cultivars.

Similar reports came later from Yugoslavia (Stancevic and Pavicevic, 1954) and Romania (Pop, 1958). These and most of later reports based on field observations under natural infection pressure and the procedures used have not lost practical importance till now.

Screening for and retesting of PPV resistance

Experimental screening for the PPV resistance was for the first time reported by Minoiu (1973) who used different aphid species for artificial inoculation of plum genotypes. Kegler and Verderevskaja (1985), and Rankovic (1988) used top grafting and chip budding, respectively, for PPV inoculation into plum trees to be tested.

Various methods of PPV inoculation are in use in the present screening practice. Dosba *et al.* (1994) pointed out that the standardization of testing methods appeared difficult because of the delayed response of woody host plants to inoculation, diversity of virus strains, various physiological state of host plants, and different environmental conditions.

Differences in the virulence and pathogenicity of PPV strains are rather important factors in testing and breeding the PPV resistance. In accordance with a certain trend of a rank order of quantitative varietal resistance to PPV, a similar rank order was found for the virulence of PPV isolates for distinct cultivars as well. Isolates causing severe symptoms in several cultivars also showed high virus accumulation in leaves of these cultivars and *vice versa* (Kegler *et al.*, 1985). The differences in varietal resistance as well as the differences in virulence of PPV isolates are unstable.

On the other side, Jordovic (1985) found PPV isolates from peach infecting plum and peach cultivars (except cv.

Table 1. Main topics of research on PPV resistance

Periods	Main topics	Number of publications
1947–1960	Detection of resistant genotypes in field	4
1961–1970	Detection of resistant genotypes in field	7
	Breeding of resistant cultivars	4
1971–1980	Detection of resistant genotypes in field	17
	Screening for PPV resistance	14
	Breeding of resistant cultivars	4
1981–1990	Detection of resistant genotypes in field	17
	Screening for PPV resistance	20
	Breeding of resistant cultivars	7
	Detecting of different types of PPV	6
1991–1998	Detection of resistant genotypes in field	44
	Screening for PPV resistance	68
	Breeding of resistant cultivars	14
	Detecting of different types of PPV	13
	Genetechnical studies	26

Sunlight) and PPV isolates from plum infecting plum cultivars but not peach cultivars. In 1986, Kegler *et al.* described PPV strains CG and DI differing in pathogenicity on plum hybrid K4 which, after artificial infection, reacted hypersensitively with CG strains and chronically with DI strains. Therefore, they supposed the existence of various pathotypes of PPV differing in their ability to infect systemically special genotypes like K4. Other three groups of PPV strains were identified on the basis of immunological properties, size of capsid protein, restriction profile of complementary DNA (cDNA) of the corresponding genomic nucleic acid, and sequence of genomic nucleic acid. These strains represent D strains (type strain is an apricot isolate from south-eastern France) predominating in western Europe, M strains (type strain is a peach isolate from northern Greece) predominating in eastern Europe, and the El Amar strain from apricot in Egypt. Both D and M strains were found in Italy in peaches (Poggi Pollini *et al.*, 1996). PPV strains differ in pathogenesis in plum, peach and apricot as well as in epidemiology, because M strains seem to spread faster and more readily in the nature than D strains (Marenaud and Massonie, 1977; Dosba *et al.*, 1991; Krczal, 1993; Fuchs *et al.*, 1995b; Poggi Pollini *et al.*, 1996). Distinct apricot cultivars do not react with PPV-D but are sensitive to PPV-M and cultivar Stella is resistant to PPV-D but tolerant of PPV-M (Dosba *et al.*, 1991). A PPV strain PPV-SP isolated from peach in Spain could be classified within the serogroup M but it differs from M strains in the expression of the disease as it causes in some peach cultivars the tree decline (Adamolle *et al.*, 1993). Furthermore, strain SoC from sour cherry was

first detected in Moldova. PPV-SoC differs from other PPV isolates affecting plum, peach and apricot by transmission to a wider range of herbaceous and woody host plant species, symptoms and genomic organization (Kalashyan *et al.*, 1989, 1994; Maiss *et al.*, 1989, 1992; Nemchinov *et al.*, 1998). Sour cherry trees show chlorotic rings on leaves, rings on fruits, depressions and necrosis. Clear symptoms appear also on *P. serrulata* and severe necrosis appears in *P. insititia* (Desvignes *et al.*, 1996). It represents a unique PPV strain and a prototype of a new group that contains neither the *RsaI* nor the *AluI* restriction site. The most significant difference is the amino acid valine at the N-terminus of the PPV-SoC coat protein (CP) instead of alanine in other PPV isolates (Maiss *et al.*, 1992).

An isolate of PPV from sweet cherry (PPV-SwC) in southern Italy causes an apical necrosis in this species and lacks *AluI* and *RsaI* sites in the C-terminal region of the CP gene. The PPV-SwC CP has an electrophoretic mobility similar to that of strain PPV-D and faster than that of strain PPV-M. Double-antibody sandwich indirect ELISA of the CP showed that PPV-SwC, although reacting with universal monoclonal antibodies to PPV, failed to react with antibodies specific for strains M and D. It is concluded that PPV-SwC is different from conventional strains of PPV but is closely related to the sour cherry isolate of PPV from Moldova (Crescenci *et al.*, 1994, 1995, 1997). It is hypothesized that PPV-SoC and PPV-SwC belong to a new serological subgroup of PPV strains (Nemchinov *et al.*, 1998). Some differences between several PPV strains are demonstrated in Table 2.

In the past, the most common method of detection of PPV resistance was the determination and registration of natural infections as well as variety reactions in the field under high infection pressure by planting virus-free and virus-infected trees and orchards side by side (Petruschke and Schröder, 1995; Rankovic and Sutic, 1980; Hein, 1986; Hartmann, 1990, 1996, 1997; Mainou and Syrgianidis, 1992; Fischer and Männel, 1994; Balan *et al.*, 1995; Erdos *et al.*, 1995; Nyujto *et al.*, 1996; Orlocine Debreceni *et al.*, 1997a, b; Toma *et al.*, 1997). Because most plum cultivars seem to become more susceptible to PPV with increasing age, testing of PPV resistance should extend over at least 8 – 10 years (Trifonov, 1965, 1975). Natural field testing of PPV resistance reveals field resistance to PPV which can be based on immunity and hypersensitivity, on a high quantitative resistance and/or on aphid resistance of the cultivar (Hartmann, 1990; Kegler *et al.*, 1995). Cultivars exhibiting no symptoms have to be artificially inoculated by grafting onto infected older trees (top grafting) (Karayiannis and Mainou, 1993). To investigate the field resistance of plum, Hartmann (1998) planted 6 virus-free trees besides with 6 PPV-infected trees growing on *P. cerasifera* rootstocks "Hamyra" which had been experimentally infected with two PPV strains.

Table 2. Some differences in PPV strains

Serological subgroup	Strains	Symptoms (aphid transmission)		Serological reactions				
		<i>P. domestica</i>	<i>P. cerasus</i>	Monoclonal antibodies				Polyclonal antibodies
		<i>P. armemaca</i>	<i>P. avium</i>	5B	4DG5	A	AL	CP PPV-SwC
		<i>P. persica</i>	<i>P. mahaleb</i>					
P	D	+	–	+	+	–	–	–
P	M	+	–	+	–	+	–	–
P	EA	+	?	+	?	–	?	–
C	SoC	(+)	+	+	–	–	?	+
C	SwC	(+)	+	+	–	–	–	+

Data according to Nemchinov *et al.* (1995, 1996, 1998).

Apart from the field screening, the PPV resistance should be tested also by artificial inoculation, because both procedures complement one another (Hartmann, 1990). The most suitable method of artificial inoculation seems to be grafting carried out as double grafting in the glasshouse or as top grafting in the field. Double grafting is suitable for detection of quantitative PPV resistance, immunity and hypersensitivity in plum (Kegler *et al.*, 1994; Fuchs *et al.*, 1997, 1998). Immune genotypes do not react at all and remain virus-free; hypersensitive plum genotypes react with tip and leaf necroses. However, the hypersensitivity in apricot has never been detected until now. Top grafting as the most massive inoculation method facilitates the detection of all types and different degrees of resistance to PPV (Syrjanidis, 1980; Kegler *et al.*, 1985, 1996; Syrjanidis and Mainou, 1985; Dosba *et al.*, 1992; Polak and Kominek, 1995; Polak *et al.*, 1995, 1996, 1997; Krska *et al.*, 1997). Furthermore, the chip budding and aphid transmission were used successfully as artificial inoculation methods, but in apricot, the aphid transmission led to a higher level of infection as compared to the chip budding (Zawadzka, 1980; Kegler *et al.*, 1983, 1985; Sutic and Rankovic, 1983; Hamdorf, 1984, 1986b, 1992; Bivol *et al.*, 1987, 1988; Dosba *et al.*, 1992). Rankovic (1988) combined both methods by using the chip budding in one tree and aphid inoculation of another tree, whereby a third tree served as control.

Retesting of naturally or artificially infected fruit trees is essential for the characterization of the type of resistance as well as for final evaluation of the PPV resistance of genotypes. In the beginning, herbaceous or woody indicators like *Chenopodium foetidum*, *Prunus domestica* cv. Italian Prune and *Prunus tomentosa* have been used for retesting (Nemeth, 1964; Kegler *et al.*, 1977a, b; Rankovic, 1980). *P. tomentosa* develops symptoms within 30 days. Symptoms caused by PPV-M in *P. tomentosa* can be distinguished from those caused by PPV-D (Damsteegt *et al.*, 1997). The most prevalent and common method of retesting is the manifold

varied serological procedure of ELISA. Its application to retesting became possible when Adams (1978) was able to detect PPV in different tissues of several *Prunus* species throughout the year. Using a single antiserum, the virus was detected in several hundred trees. This suggested that there was little antigenic variation. PPV was detected in samples prepared from leaf and flower buds, petals, young and older leaves, and the skin of ripe fruits. Negative reactions do not necessarily mean the absence of PPV (Rankovic and Vuksanovic, 1981). Nevertheless, the certainty of PPV detection in *Prunus* depends on several variable factors like virus concentration, virus invasion, virus strains, susceptibility and age of host genotypes and environmental influences (Rankovic and Vuksanovic, 1981; Hamdorf, 1982; Grüntzig *et al.*, 1986; Karesova and Pluhar, 1988; Polak, 1989). A serious problem in the plum pox diagnosis is the uneven distribution of PPV in leaves and shoots.

Molecular-biological procedures like polymerase chain reaction (PCR), immunocapture PCR (IC-PCR) (Varveri *et al.*, 1989; Wetzel, 1991; Bittoova *et al.*, 1997), reverse transcription PCR (RT-PCR), tissue print immunoblotting (TPIB) and DNA enzyme immunoassay (DEIA) (Schönfelder *et al.*, 1995; Hoffmann *et al.*, 1997) enabled a dramatic increase of the test sensitivity. For example, as few as 8000 target virus particles per ml of a plant extract could be detected by IC-PCR (Wetzel *et al.*, 1992). A modified RT-PCR for detection of PPV in plum extracts was proved to be 10 times more sensitive than ELISA (Bittoova *et al.*, 1997). On the other side, TPIB was suitable for detection of PPV in the medullary rays and around the conducting elements (Hoffmann *et al.*, 1997). It is interesting that only 36% of the leaf samples tested positive by PCR had visible sharka disease symptoms (Rosales *et al.*, 1996). Although these methods seem sometimes less suitable for testing numerous samples within a short time, they are essential for the investigation of virus invasion in different tissues as well as for the detection of minimal concentrations of the virus. That means that they

are essential for characterization and differentiation of the types of resistance called immunity, resistance and tolerance.

Evaluation and characterization of PPV resistance

Evaluation of PPV resistance is closely connected with the nature of interactions between the virus and the host plant. The first evidence of existence of different types of PPV resistance in plum was given by Sutic and Rankovic in 1981. They found cultivars, hybrids and clones which were either tolerant of or completely (qualitatively?) resistant to PPV, and they clearly differentiated these two types of resistance. Later on, more detailed differences in the types of PPV resistance have been described:

If there are no interactions between the host genotype and the virus, the plant can be classified as immune. Fraser (1985, 1998) characterized **immunity** as "non-host resistance": after virus inoculation, there develops neither an infection by the virus nor a reaction of the host because the host plant and the virus do not exist for one another. The plant cannot be infected. With the exception of the cultivar De Dragasani described by Minoiu and Pattantyus (1997), there was not found any doubtless evidence of a real immunity of *P. domestica* to PPV. This was also the case of peach, but the apricot cultivars Harlayne from Canada and De Olanda from Romania have been described as immune (Dosba *et al.*, 1992; Minoiu and Pattantyus, 1997).

However, if the plant shows reactions there are two possibilities: qualitative (complete, absolute) or quantitative (incomplete, relative) resistance. In both cases interactions occur between the host plant and the virus, i. e. an infection took place. **Qualitative resistance** is characterized by a "yes/no decision". The question is: does a genotype get diseased or not? A qualitatively resistant genotype does not get diseased because the virus is localized in the infection site. Therefore, it is classified as "localizing resistance" by Fraser (1985, 1998). Mostly, this type of resistance is specifically directed against a distinct virus strain or a pathotype and can therefore be overcome. **Quantitative resistance**, however, is not specific for virus strains and can be characterized by a different degree or severity of the disease. The question is not *whether* a genotype suffers but *how much* it suffers. Therefore, there is a gradual decision and the less the virus affects the genotype the more it is resistant. In quantitatively resistant genotypes, the rates of virus infection, virus replication and virus invasion are more or less inhibited. The correlation of traits of quantitative virus resistance is demonstrated in Fig. 1.

To obtain both durability as well as a high level of resistance it seems optimal to combine qualitative and quantitative PPV resistance as it is aimed at the breeding program in Hohenheim (Hartmann, 1998).

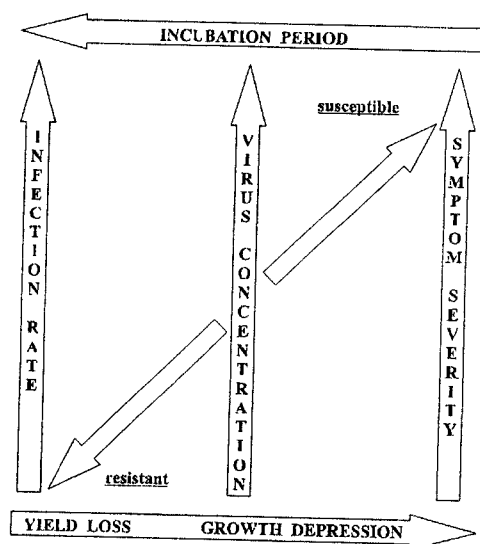


Fig. 1
Correlations of traits of quantitative virus resistance

Tolerance can be assigned to the last mentioned type of resistance although the virus can replicate analogously in a susceptible plant with little or no effect. The plant remains symptomless or it shows very mild symptoms and there are no growth and yield reductions (Cooper and Jones, 1983; Kegler *et al.*, 1993; Faggioli and Barba, 1997).

A kind of "compensation resistance" was found by Rankovic and Ogasanovic (1995). They reported that the susceptible plum cv. Cacanska Rodna compensated its PPV infection which usually caused premature fruit drop by unusually high yields and good fruit quality.

Finally, the aphid resistance can play an important role in protecting stone fruit trees from PPV infection. The incidence of the disease is higher in cultivars susceptible to the virus vectors than in resistant ones. But the degree of vector resistance depends on the aphid species. Cultivars resistant to transmission of PPV by *Myzus persicae* can be susceptible to the virus in case it is transmitted by *Brachycaudus helichrysi* (Massonie and Maison, 1982).

Several traits of resistance have to be taken into consideration. The intensity of the symptoms is the most common trait in the evaluation of PPV resistance. As there is no close correlation between the severity of fruit and leaf symptoms in most cultivars (Petruschke and Schröder, 1995), different methods of calculation of the disease index have to be used. The method of applying a scale from 0 (no symptoms) to 5 (very severe symptoms) proved to be suitable (Krska *et al.*, 1997). As the expression of PPV symptoms depends on environmental conditions, the evaluation of the symptom severity is rather subjective (Petruschke and Schröder, 1994). A measurement of the intensity of leaf

symptoms using the reflectance spectroscopy can objectify this evaluation (Kegler *et al.*, 1990).

Another types of PPV symptoms in plums appear tip necrosis, premature shoot and tree dieback, and bark splitting. These reactions are regarded as different forms of high sensitivity or hypersensitivity of genotypes (Rankovic and Paunic, 1989; Kegler *et al.*, 1994). Regarding the hypersensitivity, Hartmann (1998) found plum genotypes with an irregular localization of the virus. He concluded that the defence reaction might be controlled by several genes. Besides cv. Kirke, cv. Ortenauer is another donor of hypersensitivity in breeding the PPV resistance.

The rates of virus accumulation and virus invasion are important traits for characterization and evaluation of quantitative PPV resistance, too. Both traits closely correlate with leaf symptoms in plum, peach and apricot (Kegler *et al.*, 1986; Dosba *et al.*, 1991; Gabova and Iliev, 1995; Polak, 1996; Fuchs *et al.*, 1997). The virus accumulation is lower in (quantitatively) resistant than in susceptible genotypes and virus invasion is more irregular in resistant ones (Grüntzig *et al.*, 1986; Fuchs *et al.*, 1993, 1997). However, the virus accumulation depends also on the virulence of the virus strain. In comparing several PPV isolates from different plum orchards, Kegler *et al.* (1986) found that certain virus sources caused more severe symptoms on distinct plum cultivars as compared to other virus sources. "Severe" PPV strains caused significantly higher virus accumulations in plum leaves than did mild strains.

Furthermore, the incubation period represents an important trait of quantitative PPV resistance. In glasshouse tests, quantitatively resistant apricot cultivars showed leaf symptoms later and on single leaves only (Fuchs *et al.*, 1997).

Because PPV causes alterations in the metabolism of its host plants, the content of bioantioxidant steroid glycosides (SG) was included in the evaluation of the PPV resistance of plum cultivars together with the expression of symptoms and accumulation of the virus (Lahmatova *et al.*, 1994). SG content in buds correlates with the degree of fruit infection of plums and can be determined spectrometrically (Lahmatova *et al.*, 1997b).

Breeding of PPV resistance

A common objective of all European plum, peach and apricot breeders is to release cultivars resistant to PPV. Atanasoff (1962) selected seedlings from freely pollinated Kjustendilska Sinja Sliva plum trees which remained healthy in the field for several years and which were regarded as PPV-resistant. First results of breeding plum cultivars resistant to PPV were published in 1968 by Christoff (Christoff, 1968a) who used the cultivar Montfort as source of resistance in crossing experiments. The most extensive programs of plum breeding are known from Cacak, Yugoslavia (Rankovic and

Ogasanovic, 1989). Numerous well known resistant plum cultivars like Cacanska Lepotica, Cacanska Najbolja, Valevka and others came from there (Rankovic, 1986; Rankovic and Ogasanovic, 1995). Among others, the plum cultivars Kirke, Stanley, Tuleu gras and Wangenheim were proved to be suitable sources of the PPV resistance (Trifonov, 1971; Jordovic, 1982; Bivol *et al.*, 1987). In the first cycle of breeding the PPV resistance at Hohenheim, Hartmann (1998) used as parents cvs. Ruth Gerstetter, Ersinger and Stanley. Out of 1000 seedlings coming from these crossings 11 were evaluated as resistant and 10 as tolerant. The most suitable source of the PPV resistance was the cultivar Stanley. To increase the level of quantitative PPV resistance, Hartmann (1998) accumulated the genes of resistance by several cycles of crossing and selection. In this regard, the most effective combination was the hybrid Cacaks Beste x Valor.

Common sources of PPV resistance of apricots have been cvs. Early Orange, Goldrich and Stella for apricots (Syrgianidis, 1980; Dosba *et al.*, 1988; Balan *et al.*, 1997), Rio Oso Gem for peaches and Crimson Gold for nectarines (Syrgianidis and Mainou, 1985). At least 250 plum cultivars, 70 apricot cultivars, 20 peach cultivars, 13 nectarine cultivars and 17 wild *Prunus* species have been described to date as "immune" for, "resistant" to and "tolerant" of PPV.

Contradictory pieces of information were found in the literature concerning the evaluation of several cultivars. For example, the plum cv. President was known as "PPV-resistant" since the report by Tökes (1988). But it was called "susceptible" by Orlocine Debreceni *et al.* (1997a). The plum cv. Stanley was classified as "fairly resistant" by Sutic (1977) but as "tolerant" by Seidl (1982). The apricot cvs. Early Orange and Stella have been characterized either as "resistant" or "tolerant" (Marenaud and Mazy, 1975; Syrgianidis, 1980). Cv. Goldrich was called "immune" and "resistant" by Dosba *et al.* (1991) but "susceptible" by Krska *et al.* (1997) and Fuchs *et al.* (1997).

Various reasons can be assumed for these and other contradictory interpretations. Possibly, different PPV strains can cause different reactions in the same genotypes. For example, the apricot cvs. Precoc de Tirynthe, Bebeco, and Modesto did not react with PPV-D but were sensitive to PPV-M. Cv. Stella was resistant to PPV-D and tolerant of PPV-M (Dosba *et al.*, 1991). Therefore, the evaluation of these genotypes depends on the virus strain used. Furthermore, different methods of inoculation as well as different infection doses can lead to different reactions of host plants and, consequently, to different results of evaluation. The differences in reactions after aphid inoculation and chip budding were already mentioned (Dosba *et al.*, 1992). The top grafting of genotypes onto diseased rootstocks or source trees is a more intensive inoculation procedure than the aphid transmission so that a genotype can be registered as field-resistant after aphid inoculation but as sensitive or hypersensitive after top

grafting (Kegler and Grüntzig, 1992). Finally, rootstocks seem to influence the PPV reactions of plum cultivars too. When grafted onto myrobalan rootstock tending to sucker, a plum cultivar gets more often infected than after grafting onto plum rootstock which does not sucker (Minoiu, 1993).

At last but not least, it should be mentioned that some special terms are often used incorrectly. This especially concerns the terms "immunity", "resistance" and "tolerance".

To date, the genetics of PPV resistance is not quite clearly understood, and there is only little information on this subject. Bivol *et al.* (1988) recorded multi-peak distribution curves of plum progenies from crossings in which the cultivar Kirke was involved as a parent. Therefore, a polygenic control of PPV resistance was suggested in these cases. Lahmatova *et al.* (1997) developed an incomplete two-allele crossing scheme with field resistant (r) and tolerant (t) plum cultivars. The coefficient of PPV resistance heritability was 26%. Maternal forms had advantage in the transmission of this sign to progenies (20%). One of the main approaches to improving the PPV resistance is the interspecific hybridization (Dicenta *et al.*, 1996). Field resistance was found in interspecific hybrids of *P. spinosa*. It seems to be dominant in F₁ progenies (Minev and Dragoiski, 1995). Crossing experiments of Dosba *et al.* (1991) with sensitive and tolerant/resistant apricot cultivars resulted in the ratio of 3 (sensitive to PPV) to 1 (tolerant of PPV). Thus the resistance of cv. Stark Early Orange might be determined by two independent dominant genes. The PPV resistance breeding of apricot involves selection of numerous progenies and use of early selection tests. Stella, Manitoba, Kinred, and other apricot cultivars with the susceptibility index of 0 on leaves and fruits over many years were used as parents for apricot progenies in testing the possibility of introducing a good level of resistance into new hybrids. Of the apricot progeny, 75% belonging to the Stella x Excelsor family (resistant x intermediately resistant) had the susceptibility index of 0 on leaves and fruits (Balan *et al.*,

1995). A more detailed knowledge on the genetic control of PPV resistance in different *Prunus* species and genotypes seems necessary for an effective breeding work in the future.

Since Laimer da Camara Machado *et al.* (1991, 1992) first succeeded in transferring the PPV CP gene via *Agrobacterium tumefaciens* strain LBA 4404 to *Prunus domestica* and *P. armeniaca*, numerous reports on successful gene transfer regarding a pathogen-derived PPV resistance in the genus *Prunus* have appeared. Ravelonandro *et al.* (1997) reported on the first *P. domestica* clone resistant to PPV infection produced by genetic engineering. Progenies of the PPV CP transgenic plum clone C-5 were obtained by Scorza *et al.* (1997). The PPV resistance of the plants was evaluated by graft inoculation: all plants remained symptomless and repeated tests by ELISA and IC-PCR were negative. Guo HuiShan and Garcia (1997) succeeded in the transfer of nuclear inclusion b gene sequences of PPV to *Nicotiana benthamiana*. The transformed plants showed a distinct recovery after PPV infection. The authors proposed a model that linked the gene silencing to the RNA-mediated virus resistance.

Thus, the gene transfer seems to have established itself as an alternative way of development of PPV-resistant genotypes besides conventional breeding as well as a tool for investigation of mechanisms of virus resistance. It is regarded as a logical option in all cases in which substantial losses in cultivated crops occur and the natural resistance cannot be found or it is difficult to incorporate it into leading cultivars by breeding (Kanievski and Lawson, 1998). Therefore, both the conventional breeding and the molecular biological approach can obviously much more complement one another in the future.

Genotypes

Genotypes immune from, resistant to and tolerant of PPV, respectively, are compiled in Table 3. The names of the listed cultivars come from the references cited (Table 3).

Table 3. Genotypes described as resistant to or tolerant of PPV

Genotypes	References	Countries of isolation
Plum and prune		
'Abundance'	Hamdorf (1992), Minoiu (1993)	D, RO
'Agen'	Karesova and Pluhar (1988)	CZ
'Agen 303'	Jordovic (1965)	YU
'Agen 707'	Jordovic (1965), Lahmatova <i>et al.</i> (1997a)	YU, MOL
'Albatros'	Minoiu (1988)	RO
'Altanova'	Seidl (1982)	CZ
'Anna Späth'	Christoff (1947), Pop (1958), Minoiu (1973), Sutic (1977), Hartmann (1990), Petruschke (1990)	BG, RO, YU, D
'Ashatan'	Iliev <i>et al.</i> (1990)	BG
'Aurelio Grand'	Lazarova-Topchiiska (1995)	BG
'Banjalucka bjelica'	Festic and Kapitanovic (1990)	YU
'Belle de Louvaine'	Christoff (1947, 1959, 1968a)	BG

'Big Rambeau'	Christoff (1965)	BG
'Big Shugar Prune'	Christoff (1947)	BG
'Bilatrnecka'	Papstein <i>et al.</i> (1997)	CZ
'Blue free'	Hamdorf (1984, 1992), Minoiu (1988), Tökes (1988), Gionchedi (1986)	D, RO, H, I
'Bühler Fruhwetsche'	Christoff (1947), Hartmann (1990, 1997a,b), Petruschke (1990)	BG, D
'Burbank'	Jovicevic (1967), Seidl (1982), Hamdorf (1984, 1992), Lahmatova <i>et al.</i> (1997a)	YU, CZ, D, MOL
'Burburuz'	Minoiu (1988, 1994)	RO
'Cacaks Beste'	Petruschke (1990)	D
'Cacaks Frühe'	Petruschke (1990), Hartmann (1997b)	D
'Cacaks Schöne'	Petruschke (1990), Hartmann (1997b)	D
'Cacanska Lepotica'	Rankovic (1986), Iliev and Sturkova (1986), Tökes (1988), Dragoiski <i>et al.</i> (1995), Lahmatova <i>et al.</i> (1997a)	YU, BG, H, MOL, RO
'Cacanska Najbolja'	Rankovic (1986), Hartmann (1990), Zawadzka <i>et al.</i> (1994), Lahmatova <i>et al.</i> (1994, 1997a), Dragoiski <i>et al.</i> (1995)	YU, D, PL, MOL, RO
'Cacanska Rana'	Rankovic (1986), Hartmann (1990)	YU, D
'Cacanska' II/1/5/59, No. 7	Karesova and Pluhar (1988)	CZ
'California'	Sutic (1977)	YU
'Can'	Elibüyük and Erdiller (1995)	TR
'Carpatin'	Hartmann (1990), Petruschke (1990)	D
'Carter No. 1'	Jovicevic (1967)	YU
'Centenar'	Minoiu (1988), Hartmann (1990), Petruschke (1990)	RO, D
'Chrudimer'	Hamdorf (1984, 1992), Hartmann (1990), Petruschke (1990)	D
'Crvna Ranka'	Jordovic (1965)	YU
'Czar'	Seidl (1983), Karesova and Pluhar (1988)	CZ
'Czernowitzer'	Hamdorf (1984, 1986, 1992), Hartmann (1990), Petruschke (1990)	D
'D'Agcn'	Pop (1958)	RO
'Dame Ambert blanche'	Lazar and Jacob (1969)	RO
'Damson'	Trifonov (1978)	BG
'De Dragasani'	Minoiu and Pattantus (1997)	RO
'Diana'	Minoiu (1988)	RO
'Dimbovita'	Minoiu (1988)	RO
'Dostojnaja'	Papstein <i>et al.</i> (1997)	CZ
'Dzanarica'	Jovicevic (1958)	YU
'Dzhenerika'	Stancevic and Pavicevic (1954)	YU
'Early Blue'	Christoff (1968a)	BG
'Early Red English'	Christoff (1959)	BG
'Early Red Mirabelle'	Christoff (1947)	BG
'Early Reneklode'	Christoff (1947)	BG
'Early Rivers'	Christoff (1947), Cocu <i>et al.</i> (1984)	BG, RO
'Edra jelta afisca'	Sutic and Rankovic (1981)	YU
'Elena'	Petruschke and Schröder (1994), Hartmann (1997b)	D
'Ember'	Jovicevic (1967)	YU
'Enibakanka Red'	Christoff (1965)	BG
'Envoy'	Oukropec <i>et al.</i> (1996)	CZ
'Ersinger'	Sutic (1977), Seidl (1982), Hartmann (1990, 1997b), Petruschke (1990)	CZ, YU, D
'Favorita Moretini 3'	Oukropec <i>et al.</i> (1996)	CZ
'Favorite'	Christoff (1965)	BG
'Fracia Narones'	Papstein <i>et al.</i> (1997)	CZ
'Frontier'	Minoiu (1994)	RO
'Gabrovska'	Christoff (1965), Angciov (1980), Dragoiski <i>et al.</i> (1995)	BG, RO
'Giant'	Elibüyük and Erdiller (1995)	TR
'Green Gage'	Jordovic and Janda (1963), Seidl (1983)	YU, CZ
'Green Reine Claude'	Christoff (1959), Trifonov (1965)	BG
'Große Reneklode'	Christoff (1947)	BG
'Halchaven'	Lazarova-Topchiiska (1995)	BG
'Hamanova svestka'	Karesova and Pluhar (1988)	CZ
'Hanita'	Petruschke and Schroder (1994), Hartmann (1997b)	D
'Harmony'	Polak (1996)	CZ
'Herman'	Hartmann (1990, 1997b), Petruschke (1990)	D
'Hybride Christoff No. 1'	Sutic and Rankovic (1981)	YU
'Ialomita'	Minoiu (1988, 1993), Hartmann (1990), Petruschke (1990)	RO, D
'Imperial'	Jordovic (1965), Iliev <i>et al.</i> (1990)	YU, BG
'Iroquois'	Papstein <i>et al.</i> (1997)	CZ

'Jalomita'	Petruschke (1990)	D
'Jelita Butilkovidna'	Sutic and Rankovic (1981), Lahmatova <i>et al.</i> (1997a), Paprstein <i>et al.</i> (1997)	YU, MOL, CZ
'Judy Lady'	Lazarova-Topchiiska (1995)	BG
'Karadjcika'	Christoff (1965)	BG
'Karagöymük'	Elbüyük and Erdiller (1995)	TR
'Katinka'	Petruschke and Schröder (1994), Hartmann (1997b)	D
'Kirke'	Christoff (1965), Lahmatova (1990), Lahmatova <i>et al.</i> (1997b)	BG, MOL
'Klakarska rana'	Festic and Kapitanovic (1990)	YU
'Konigin Ivasons'	Christoff (1965)	BG
'Krikon'	Minoiu (1993)	RO
'Large Sugar Prune'	Paprstein <i>et al.</i> (1997)	CZ
'Locale de Turt'	Minoiu (1993)	RO
'Lörspflaume'	Petruschke (1990)	D
'Magna Glauca'	Jordovic (1957)	YU
'Magnolia'	Lazarova-Topchiiska (1995)	BG
'Mansan'	Minoiu (1994)	RO
'Marianna'	Minoiu (1994)	RO
'McLoughlin'	Fischer and Männel (1994)	D
'Maygrand'	Oukropce <i>et al.</i> (1996)	CZ
'Methley'	Hamdorf (1984, 1992), Gionchedi (1986)	D, I
'Metlas'	Jordovic (1957)	YU
'Minerva'	Minoiu (1988)	RO
'Mirabella jaume de Plovdiv'	Sutic and Rankovic (1981)	YU
'Mirabelle'	Christoff (1959), Petruschke (1990)	BG, D
'Mirabelle de Nancy'	Trifonov (1978), Seidl (1983), Hamdorf (1984, 1992), Iliev <i>et al.</i> (1990)	BG, CZ, D
'Mirabelle Precoc'	Christoff (1947), Seidl (1983)	BG, CZ
'Monsieur Hatif'	Hamdorf (1984, 1992)	D
'Montfort'	Christoff (1947, 1958, 1959, 1965, 1968a), Pop (1958), Trifonov (1965), Lahmatova (1990)	BG, RO, MOL
'Mutna Bjala Rakijniza'	Christoff (1965)	BG
'Nanijska mirobela'	Festic and Kapetanovic (1990)	YU
'Ontario', 'Ontariopflaume'	Jovicevic (1967), Seidl (1983), Hamdorf (1984, 1992), Gionchedi (1986), Petruschke (1990)	YU, CZ, D, I
'Opal'	Hamdorf (1984, 1992), Gionchedi (1986), Iliev <i>et al.</i> (1990), Hartmann (1990), Petruschke (1990), Fischer and Männel (1994)	D, I, BG,
'Ortenauer'	Petruschke (1990)	D
'Oullins Rencklode'	Hamdorf (1984, 1992)	D
'Pacific'	Jordovic (1965)	YU
'Pamjaty Kostinoi'	Lahmatova <i>et al.</i> (1994, 1997b)	MOL
'Pamiaty Vavilova'	Lahmatova (1990), Lahmatova <i>et al.</i> (1994, 1997b)	MOL
'Pech'	Minoiu (1975), Cociu <i>et al.</i> (1984)	RO
'Pescarus'	Petruschke (1990)	D
'Petrovaca'	Festic and Kapetanovic (1990)	YU
'Piestany 9/83'	Ghena and Cepoiu (1979)	RO
'Piestany 9/85'	Ghena and Cepoiu (1979)	RO
'Pitestean'	Hartmann (1990), Petruschke (1990)	D
'Pozegaca Br'	Sutic and Rankovic (1981)	YU
'Pozegaca-clone'	Babovic <i>et al.</i> (1997)	YU
'Pozegaca S'	Sutic and Rankovic (1981)	YU
'Precoc favourite'	Lazar and Jacob (1969)	RO
'Precoc de Rivers'	Christoff (1965)	BG
'Presenta'	Hartmann (1997b)	D
'President'	Tokes (1988), Hartmann (1990, 1997b), Lahmatova (1990), Petruschke (1990), Lahmatova <i>et al.</i> (1994, 1997b)	H, D, MOL
'Pribojka'	Christoff (1965)	BG
'Prune d'Agén'	Christoff (1947)	BG
'Red Afuska'	Christoff (1947, 1965)	BG
'Red Dwarf Myrobalan'	Minoiu (1994)	RO
'Red Glow'	Minoiu (1993)	RO
'Red Malvasinka'	Christoff (1947)	BG
'Regina Claudidia d'Oullins'	Gionchedi (1986), Petruschke (1990)	I, D
('Oullins Rencklode?')		
'Reine Claude'	Pop (1958)	RO
'Reine Claude Doree'	Christoff (1965)	BG

'Reine Claude Violette'	Christoff (1968a), Elibüyük and Erdiller (1995)	BG, TR
'Reine Claude d'Althann'	Cociu <i>et al.</i> (1984)	RO
'Reine Claude Diaphane'	Papstein <i>et al.</i> (1997)	CZ
'Rene-Claude d'Oullins'	Fischer and Mannel (1994), Lahmatova <i>et al.</i> (1997b)	D, MOL
'Reneklod Hramovih'	Lahmatova <i>et al.</i> (1997b)	MOL
'Renekloda Jandacek'	Papstein <i>et al.</i> (1997)	CZ
'Rosioare de Zalau'	Minoiu (1993)	RO
'Rotemde de Turt'	Minoiu (1988)	RO
'Ruth Gerstetter'	Sutic (1977), Hamdorf (1984, 1992), Hartmann (1990, 1997b), Petruschke (1990)	YU, D
'Sam I'	Ghena and Cepoiu (1979)	Ro
'Sanctus Hubertus'	Petruschke (1990)	D
'Saradja'	Christoff (1965)	BG
'Scoldus'	Minoiu (1988, 1993), Fischer and Mannel (1994), Papstein <i>et al.</i> (1997)	RO, D, CZ
'Scoldus No. 1'	Sutic and Rankovic (1981)	YU
'Sentjabrska'	Dragoiski <i>et al.</i> (1995)	RO
'Septemvrisjka'	Christoff (1968b)	BG
'Serdika'	Christoff (1968b)	BG
'Shiptchenka'	Christoff (1965)	BG
'Silvia'	Minoiu (1988, 1993)	RO
'Simka'	Faggioli and Barba (1997)	I
'Sinakviza'	Christoff (1965)	BG
'Sinja Rakijniza'	Christoff (1965)	BG
'Sofia'	Christoff (1968b)	BG
'Sofia Wonder'	Christoff (1968b)	BG
'Sofusko Chudo'	Videnov (1976)	BG
'Stanley'	Jordovic and Janda (1963), Jovicevic (1967), Jordovic (1982), Seidl (1983), Hamdorf (1984, 1992), Tokes (1988), Hartmann (1990), Iliev <i>et al.</i> (1990), Petruschke (1990), Elibüyük and Erdiller (1995), Lahmatova <i>et al.</i> (1997b)	YU, CZ, D, TR, MOL
'St. Hubertus'	Hartmann (1990)	D
'Strasser Zwetsche'	Petruschke and Schröder (1984)	D
'Strinova'	Marinova <i>et al.</i> (1995)	BG
'Sultan'	Petruschke (1990)	D
'Summer Damson'	Trifonov (1978)	BG
'Tamnos de Bistirta'	Minoiu (1981)	RO
'Tegera'	Hartmann (1997b)	D
'The Czar'	Christoff (1947); Petruschke (1990)	BG, D
'Tokci'	Lazar and Jacob (1969)	RO
'Tuleu gras'	Trifonov (1971), Tokes (1988), Cociu <i>et al.</i> (1984)	BG, H, RO
'Tuleu Timpuriu'	Cociu <i>et al.</i> (1984), Iliev <i>et al.</i> (1990)	RO, BG
'Twilight'	Minoiu (1994)	RO
'Udlinionnaya'	Lahmatova <i>et al.</i> (1994, 1997b)	MOL
'Underwood'	Cociu <i>et al.</i> (1984), Grushin (1990)	RO, RUS
'Üzümerik'	Lazar and Jacob (1969)	RO
'Valasska trnecka'	Papstein <i>et al.</i> (1997)	CZ
'Valjevka'	Hartmann (1990, 1997b), Petruschke (1990)	D
'Valor'	Minoiu (1988), Hartmann (1990), Petruschke (1990)	RO, D
'Victoria'	Papstein <i>et al.</i> (1997)	CZ
'Violet Reine-Claude'	Christoff (1947), Trifonov (1965)	BG
'Wangenheim'	Jordovic (1965)	YU
'Wanzanova'	'Seidl (1982)	CZ
'Washington'	Sutic (1977)	YU
'Winter Damson'	Trifonov (1978)	BG
'Yakub'	Grushin (1990)	RUS
'Yellow Afaz'	Christoff (1959)	BG
'Yellow Afuska'	Christoff (1947)	BG
'K-4'	Kegler <i>et al.</i> (1985), Papstein <i>et al.</i> (1997)	D, CZ
'Khubava Luvenska' x	Iliev <i>et al.</i> (1990)	BG
'Kjustendilska Sinya'		
'Khubava Luvenska' x	Iliev <i>et al.</i> (1990)	BG
'President'		
'Kjustendilska Sinya' x	Iliev <i>et al.</i> (1990)	BG
'Stanley'		
'Tarnina' x 'Kirke'	Papstein <i>et al.</i> (1997)	CZ

(Tulcu Gras' x 'Kjustendilska Sinya') x 'Imperial'	Iliev <i>et al.</i> (1990)	BG
'XV/4 ST'	Papstein <i>et al.</i> (1997)	CZ
Hybrid 'Bo-III-40'	Karesova and Pluhar (1988)	CZ
Hybrid 'Bo-II-65'	Karesova and Pluhar (1988)	CZ
56 immune hybrids	Rankovic and Ogasanovic (1995)	YU

Peach

'Andross'	Syrgianidis and Mainou (1985)	GR
'Coronado'	Syrgianidis and Mainou (1985)	GR
'Elberta'-seedlings	Rankovic and Sutic (1986)	YU
'Envoy'	Polak <i>et al.</i> (1997)	CZ
'Favorita Morettini 3'	Polak <i>et al.</i> (1997)	CZ
'Flavorcrest'	Faggioli and Barba (1997)	I
'June Berta'	Syrgianidis and Mainou (1985)	GR
'Magnific 79'	Balan <i>et al.</i> (1995)	RO
'Navoi'	Balan <i>et al.</i> (1995)	RO
'Pekin 7-22'	Balan <i>et al.</i> (1995)	RO
'Ranger'	Syrgianidis and Mainou (1986)	GR
'Red Diamond'	Lazarova-Topchiiska (1995)	BG
'Redgold'	Lazarova-Topchiiska (1995)	BG
'Rio Oso Gem'	Syrgianidis and Mainou (1985), Lazarova- Topchiiska (1995)	GR, BG
'Spring Lady'	Lazarova-Topchiiska (1995)	BG
'Suncrost'	Balan <i>et al.</i> (1995)	RO
'Superior Pacific Star'	Lazarova-Topchiiska' (1995)	BG
'Superior Super Star'	Lazarova-Topchiiska' (1995)	BG
C2R1 7T1 25	Balan <i>et al.</i> (1995)	RO
TS-1 to TS-10	Rankovic and Sutic (1980)	YU

Apricot

'Antonio Errani'	Faggioli and Barba (1997)	I
'Aprikoz'	Elibüyük and Erdiller (1995)	TR
'Aurora'	Faggioli and Barba (1997)	I
'Badami'	Syrgianidis (1980), Dosba <i>et al.</i> (1988)	GR, F
'Banaesa' 33/13	Sutic and Rankovic (1983)	YU
'Blenril'	Faggioli and Barba (1997)	I
'Brevira'	Fuchs <i>et al.</i> (1998)	D
'Cafona III'	Faggioli and Barba (1997)	I
'Callatis'	Balan <i>et al.</i> (1997)	RO
'Canino'	Faggioli and Barba (1997)	I
'Cegledi Bıborkajsci C 244'	Nyujto <i>et al.</i> (1985)	H
'Chuang Zho Hong'	Polak <i>et al.</i> (1995)	CZ
'Cöloglu'	Elibüyük and Erdiller (1995)	TR
'Dacia'	Balan <i>et al.</i> (1997)	RO
'De Olanda'	Minou and Pattanyus (1997)	RO
'Dulcinea'	Faggioli and Barba (1997)	I
'Early Orange'	Marcnaud and Mazy (1975), Syrgianidis (1980), Karayiannis (1989), Karayiannis and Mainou (1993, 1994)	F, GR
'Farmingdale'	Faggioli and Barba (1997)	I
'Favorit'	Balan <i>et al.</i> (1997)	RO
'Fracasso'	Faggioli and Barba (1997)	I
'Giada'	Faggioli and Barba (1997)	I
'Goldrich'	Karayannis and Mainou (1993, 1994)	GR
'Hacıhaliloglu'	Elibüyük and Erdiller (1995)	TR
'Harcot A 1811'	Dosba <i>et al.</i> (1988), Faggioli <i>et al.</i> (1997)	F, I
'Harlayne'	Dosba <i>et al.</i> (1992), Karayiannis and Mainou (1993, 1994), Polak <i>et al.</i> (1995), Krska <i>et al.</i> (1997)	F, GR, CZ
'Harval'	Polak <i>et al.</i> (1997)	CZ
'Henderson'	Dosba <i>et al.</i> (1992), Karayiannis and Mainou (1993, 1994), Krska <i>et al.</i> (1997)	F, GR, CZ
Hybrids LE-833, LE-806, LE-3276, LE-3184, VA-N3,	Polak <i>et al.</i> (1997)	CZ

VA-F1, VA-E, LE-3216,
LE-3662, LE-3187,
LE-2913, VA-L1,
LE-29353

'Julskij'	Sedlakova (1993), Sedlakova and Gallo (1994)	SK
'Karola'	Sedlakova and Gallo (1993)	SK
'Leronda'	Polak <i>et al.</i> (1995)	CZ
'Mai Chua Sin'	Polak <i>et al.</i> (1995)	CZ
'Nanno'	Faggioli and Barba (1997)	I
'Orange Red'	Fuchs and Grüntzig (1997)	D
'Pavlot'	Gionchedi (1986)	I
'Pelese Giovanniello'	Faggioli and Barba (1997)	I
'Perla'	Faggioli and Barba (1997)	I
'Pisana'	Faggioli and Barba (1997)	I
'Precocce di Porros'	Faggioli and Barba (1997)	I
'Procosede Boulbon'	Elibüyük and Erdiller (1995)	TR
'Rakowski'	Elibüyük and Erdiller (1995)	TR
'Sabbatani'	Faggioli and Barba (1997)	I
'Sam'	Elibüyük and Erdiller (1995)	TR
'San Castrese'	Faggioli and Barba (1997)	I
'Stark Early Orange'	Gionchedi (1986), Dosba <i>et al.</i> (1988, 1992), Polak <i>et al.</i> (1995), Krska <i>et al.</i> (1997)	I, F, CZ
'Stella'	Syrgianidis (1980), Gionchedi (1986), Dosba <i>et al.</i> (1988), Karayiannis (1989), Karayiannis and Mainou (1993, 1994), Polak <i>et al.</i> (1995)	GR, I, F,
'Stella A2382'	Faggioli and Barba (1997)	I
'Sunglo'	Karayiannis and Mainou (1993, 1994)	GR
'Tokaloglu'	Elibüyük and Erdiller (1995)	TR
'Vccot'	Gionchedi (1986), Karayiannis and Mainou (1993, 1994), Sedlakova (1993), Sedlakova and Gallo (1994)	I, GR, SK
'Vegama'	Sedlakova (1993), Sedlakova and Gallo (1994)	SK
'Vcharda'	Sedlakova (1993), Sedlakova and Gallo (1994)	SK
'Virosia'	Fuchs <i>et al.</i> (1998)	D
'Early Orange' x 'Mektep'	Balan <i>et al.</i> (1997)	RO
'Mektep' x 'Skaha'	Balan <i>et al.</i> (1997)	RO
'MR 6915' x 'Goldrich'	Balan <i>et al.</i> (1997)	RO
'NJ A2'	Karayiannis and Mainou (1994)	GR
'VS 9/83'	Sedlakova and Gallo (1993)	SK
'VS 25/38'	Sedlakova and Gallo (1993)	SK
INRA 804 x 669255a	Polak <i>et al.</i> (1995)	CZ

Nectarine

'Charlampidis No. 2'	Syrgianidis and Mainou (1989)	GR
'Crimson Gold'	Syrgianidis and Mainou (1989)	GR
'Delicious'	Syrgianidis and Mainou (1989)	GR
'Fairlane'	Balan <i>et al.</i> (1995)	RO
'Fanthasia'	Syrgianidis and Mainou (1985)	GR
'Harko'	Balan <i>et al.</i> (1995)	RO
'Hatjigeorgiou'	Syrgianidis and Mainou (1989)	GR
'May Grand'	Syrgianidis and Mainou (1989)	GR
'Nectared No. 4'	Syrgianidis and Mainou (1985, 1989)	GR
'Nectared No. 6'	Syrgianidis and Mainou (1985, 1989)	GR
'Nectared No. 8'	Syrgianidis and Mainou (1985, 1989)	GR
'Red Gold'	Syrgianidis and Mainou (1989)	GR
'Stark Sunglo'	Syrgianidis and Mainou (1989)	GR

Prunus spp.

<i>P. americana</i> 'De Soto'	Kegler <i>et al.</i> (1996)	D
<i>P. americana</i> 'Hawkeye'	Kegler <i>et al.</i> (1996)	D
<i>P. americana</i> wild form	Kegler <i>et al.</i> (1996)	D
<i>P. amygdalo-persica</i>	van Oosten (1975)	NL
<i>P. avium</i>	Schuch (1962), Hamdorf (1972, 1975)	D
<i>P. besseyi</i>	Cocu <i>et al.</i> (1984), Minoiu (1994)	RO
<i>P. cerasifera violacea</i>	Kegler <i>et al.</i> (1996)	D
<i>P. davidiana</i>	Oukropec <i>et al.</i> (1996)	CZ

<i>P. mahaleb</i>	Schuch (1962)	D
<i>P. nigra</i> 'Mansan'	Kegler <i>et al.</i> (1996)	D
<i>P. padus</i>	Hamdorf (1972, 1975)	D
<i>P. serotina</i>	Hamdorf (1972, 1975)	D
<i>P. spinosa</i>	Sutic (1965)	YU
<i>P. spinosa</i> 'Schukina'	Kegler <i>et al.</i> (1996)	D
<i>P. triloba</i>	Baumann (1965)	D
<i>P. munsoniana</i> x <i>P. triflora</i>	Kegler <i>et al.</i> (1996)	D
<i>P. persica</i> x <i>P. davidiana</i>	Oukropce <i>et al.</i> (1996)	CZ
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D = Germany; CZ = former Czechoslovakia, YU = former Yugoslavia; MOL = Moldavia; RO = Romania, BG = Bulgaria; H = Hungary; I = Italy, PL = Poland; TR = Turkey; RUS = Russia, GR = Greece; F = France; SK = Slovakia.

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