

## Evaluation of American Peach Cultivars for Resistance to *Plum pox virus*

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### Abstract

POLÁK J., PÍVALOVÁ J., DOWLER W., MILLER R.W. (2003): Evaluation of American peach cultivars for resistance to *Plum pox virus*. Plant Protect. Sci., 39: 1–6.

Twenty-eight American peach cultivars were screened for their reaction to *Plum pox virus* (PPV). The cultivars were evaluated for the presence and intensity of PPV symptoms in leaves and fruits, and the relative concentration of PPV protein in flowers was determined by ELISA. The results allowed to divide the cultivars into four groups: cultivars Flame Prince, Cotender, Newhaven, Ruby Prince, Sun Prince, Jefferson, Camden and Jersey Queen were characterised as medium resistant to PPV; cultivars Loring, Blaze Prince, June Prince and Legend were classified as tolerant; cultivars Quachita Gold, O'Henry, Crest Haven, Biscos, Sentry, Fire Prince, Carogem, Carolina Belle, Redglobe and Harvester were rated as medium susceptible; and cultivars Bounty, Summer Prince, Gold Prince, Redhaven, Gala and Sunbrite were characterised as highly susceptible to PPV.

**Keywords:** *Plum pox virus*; peach; disease symptoms; virus concentration; ELISA; resistance

Attempts to evaluate the resistance of peach cultivars to *Plum pox virus* (PPV) were started in Europe in the 1990-ies. Experimental collections of peach cultivars were planted close to old peach orchards infected with PPV. The cultivars were evaluated 4–5 years after natural infection. The first results were based mostly on observation of the intensity of PPV symptoms on both leaves and fruits (MAINOU & SYRGIANIDIS 1992; BALAN *et al.* 1995).

The methods for reliable detection of PPV in peach trees have improved, compared to methods used on plums and apricots. DOSBA *et al.* (1986) showed differences in PPV detection in peach trees at different growth stages. POLÁK (1989) detected PPV by ELISA in symptomless peach trees. ALBRECHTOVÁ (1990) studied the distribution of PPV in naturally infected peach trees and found that the detection of PPV in flowers and fruits was more reliable than that in leaves. POLÁK (1995) tried to find the time

period with the highest concentration of PPV in leaves and flowers of infected peach trees. ELISA easily and reliably detected PPV in flower petals during the time of flowering, and in leaves during May and June. OUKROPEC *et al.* (1996) investigated possible sources of resistance to breed peaches resistant to PPV. POLÁK (1996) showed considerable differences in relative concentration of PPV protein among infected peach cultivars. The level of relative concentration of PPV in flowers was positively correlated with the intensity of leaf symptoms.

POLÁK (1998) characterised the resistance of peach cultivars to PPV by the evaluation of both relative concentration of PPV protein in flowers and intensity of leaf and fruit symptoms. He investigated 34 peach and two nectarine cultivars grown in a 15-year-old orchard. The trees were evaluated for natural infection with PPV. The relative concentration of PPV protein was determined by ELISA in

flowers, and found in most cultivars to be positively correlated with the intensity of leaf and fruit symptoms. None of the investigated peach cultivars were immune to PPV. Cultivars Candor, Envoy, Favorita Morettini, Flamencrest, Harcrest, Harmony, Maycrest, Spring Lady, Triestina and Velvet were characterised as having medium resistance to PPV based on severity of symptoms and low relative concentration of PPV protein in flowers. POLÁK (1999) continued to characterise the resistance of peach cultivars to PPV by evaluation of another 21 peach and two nectarine cultivars. Cultivars Harrow-Blood, Maygrand and Universalnyj were classified as medium resistant.

Attempts to characterise further peach cultivars (originated from the USA) for resistance to PPV started in 1999. They were evaluated in a cold greenhouse in the years 2000–2002, and the results are presented in this contribution.

## MATERIALS AND METHODS

**Plant material – infection with PPV.** Twenty-eight American peach cultivars were evaluated for resistance to PPV. Two-year-old peach trees (five trees of each cultivar) were transported from South Carolina to Prague-Ruzyně, Czech Republic, and planted directly into the ground of a cold greenhouse in fall 1998. The trees were infected artificially with *Plum pox virus*, Dideron strain (PPV-D), by both aphids and chip-budding in spring 1999. Inoculation was carried out with adult wingless females of the aphid *Myzus persicae* (Sulz.). The source of PPV were leaves of *Nicotiana clevelandii* × *N. glutinosa* infected with the virus. Twenty aphids were used per plant; acquisition feeding lasted 10 min; inoculation feeding on young peach leaves was 30 min after which the aphids were killed with an insecticide. The trees were double-inoculated by chip-budding, using buds from peach cv. Catherina infected with PPV.

**Evaluation of infected plant material.** The peach cultivars from the USA were evaluated for their reaction to PPV during the years 2000–2002. The presence and severity of PPV symptoms in leaves and fruits were recorded, and the relative concentration of PPV protein was determined in flowers of 20 peach cultivars by ELISA (POLÁK 1998). This criterion has proven to be most important for the evaluation of resistance to PPV.

Criteria to classify cultivars into one of four groups:

1. Group of medium resistant cultivars  
Symptoms on leaves: no symptoms or vein clearing, thickening and brittleness on first (and second) leaves of branches.  
Symptoms on fruits: most fruits without symptoms, occasionally very mild diffuse spots.  
Relative concentration of PPV protein in flowers: 0 to  $2.5 \times 10^{-2}$ .
2. Group of tolerant cultivars  
Symptoms on leaves: vein clearing on the first two or three leaves of branches.  
Symptoms on fruits: very mild diffuse spots or rings on a limited number of fruits.  
Relative concentration of PPV protein in flowers:  $6.25 \times 10^{-3}$  to  $3.91 \times 10^{-4}$ .
3. Group of medium susceptible cultivars  
Symptoms on leaves: vein clearing, mosaic, yellowing and thickening on the first three leaves of branches.  
Symptoms on fruits: mild to medium severe diffuse spots and rings on a limited number of fruits.  
Relative concentration of PPV protein in flowers:  $6.25 \times 10^{-3}$  to  $1.56 \times 10^{-3}$ .
4. Group of highly susceptible cultivars  
Symptoms on leaves: vein clearing, yellowing and mosaic on first three or four leaves of branches.  
Symptoms on fruits: medium severe or severe diffuse spots and rings on most fruits, occasionally mild malformations.  
Relative concentration of PPV protein in flowers:  $1.56 \times 10^{-3}$  to  $1.95 \times 10^{-4}$ .

## RESULTS

After evaluating the symptoms for PPV on leaves and fruits and determining the relative concentration of PPV protein in flowers, the cultivars were grouped into four categories: medium resistant (Table 1), tolerant (Table 2), medium susceptible (Table 3) and highly susceptible (Table 4). None of the investigated American peach cultivars were immune or highly resistant to PPV, based on leaf and fruit symptoms.

Medium resistant to PPV were the cultivars Flame Prince, Cotender, Newhaven, Ruby Prince (Figure 1), Sun Prince, Jefferson, Camden and Jersey Queen (Table 1). There were no symptoms, or vein clearing, thickening and brittleness appeared on the first or on first and second leaves of branches. Most fruits of these cultivars were

Table 1. Non-patented American peach cultivars categorised as medium resistant based on symptoms in leaves, fruits and relative concentration of PPV protein in flowers

Cultivar	Symptoms in leaves	Symptoms on fruits	Relative concentration of PPV in flowers
Flame Prince	vein clearing 1.–2. leaf	very mild diffuse spots – occasionally	0
Contender	vein mosaic 1.–2. leaf	very mild diffuse spots – occasionally	$5.0 \times 10^{-2}$
Newhaven	thickening and brittleness 1.–2. leaf	very mild diffuse spots – occasionally	$5.0 \times 10^{-2}$
Ruby Prince	vein clearing 1.–2. leaf	very mild spots – occasionally	$5.0 \times 10^{-2}$
Sun Prince	no symptoms	nf	$2.5 \times 10^{-2}$
Jefferson	thickening and brittleness 1. leaf	very mild diffuse spots – occasionally	nt
Camden	thickening and brittleness 1.–2. leaf	very mild diffuse spots – occasionally	nt
Jersey Queen	no symptoms	very mild diffuse spots and rings	nt

nt = not tested , nf = no fruits

Table 2. Non-patented American peach cultivars categorised as tolerant based on symptoms in leaves, fruits and relative concentration of PPV protein in flowers

Cultivar	Symptoms in leaves	Symptoms on fruits	Relative concentration of PPV in flowers
Loring	vein clearing, mosaic 1.–4. leaf	very mild diffuse spots – occasionally	$6.25 \times 10^{-3}$
Blaze Prince	mild vein clearing 1.–2. leaf	very mild diffuse spots – occasionally	$7.81 \times 10^{-4}$
June Prince	mild vein clearing 1.–2. leaf	very mild diffuse spots, rings – occasionally	$3.91 \times 10^{-4}$
Legend	vein clearing 1.–3. leaf	mild diffuse spots – occasionally	$3.91 \times 10^{-4}$

Table 3. Non-patented American peach cultivars categorised as medium susceptible based on symptoms in leaves, fruits and relative concentration of PPV protein in flowers

Cultivar	Symptoms in leaves	Symptoms on fruits	Relative concentration of PPV in flowers
Quachita Gold	mosaic, yellowing	no fruits	$1.25 \times 10^{-2}$
O'Henry	vein clearing, mosaic 1.–3. leaf	very mild spots	$6.25 \times 10^{-3}$
Crest Haven	vein clearing, mosaic 1.–5. leaf	mild diffuse spots	$6.25 \times 10^{-3}$
Biscoe	vein clearing, mosaic 1.–3. leaf	very mild spots	$3.12 \times 10^{-3}$
Sentry	severe vein clearing 1.–3. leaf	medium severe diffuse, mild malformations	$3.12 \times 10^{-3}$
Fire Prince	yellowing 1. leaf	mild diffuse spots	$1.56 \times 10^{-3}$
Carogem	yellowing + thickening, brittleness 1.–2. leaf	mild diffuse spots	$1.56 \times 10^{-3}$
Carolina Belle	vein clearing, yellowing 1. leaf	medium severe diffuse spots	nt
Redglobe	yellowing + thickening, brittleness 1.–2. leaf	medium severe diffuse spots, rings	nt
Harvester	vein clearing, thickening and brittleness 1.–2. leaf	no fruits	$1.25 \times 10^{-2}$

nt = not tested



Figure 1. Fruits of PPV medium resistant peach cv. Ruby Prince, very mild spots



Figure 2. Fruits of PPV tolerant peach cv. June Prince, very mild diffuse spots and rings



Figure 3. Fruits of PPV medium susceptible peach cv. Fire Prince, mild diffuse spots



Figure 4. Fruits of PPV highly susceptible peach cv. Gold Prince, medium severe diffuse spots and rings, mild malformations



Figure 5. Fruits of PPV highly susceptible peach cv. Sunbrite, severe diffuse spots and rings, mild malformations

without visible symptoms, but very mild diffuse spots appeared on a limited number of fruits. The relative concentration of PPV protein in flowers was very low ( $0$  to  $2.5 \times 10^{-2}$ ).

Rated tolerant were the cultivars Loring, Blaze Prince, June Prince (Figure 2) and Legend (Table 2). They showed vein clearing on the first two, three, or even four leaves of branches. Very mild diffuse spots or rings appeared on a limited number of fruits. The relative concentration of PPV protein in

flowers was high ( $6.25 \times 10^{-3}$  to  $3.91 \times 10^{-4}$ ), comparable to that of highly susceptible cultivars.

Medium susceptible were the cultivars Quachita Gold, O'Henry, Crest Haven, Biscos, Sentry, Fire Prince (Figure 3), Carogem, Carolina Belle, Redglobe and Harvester (Table 3). Vein clearing, mosaic, yellowing and thickening and brittleness were found usually on the first two or three leaves of branches. Mild to medium severe diffuse spots and/or rings appeared on a limited number of fruits. The relative concentration of PPV protein in flowers varied from  $6.25 \times 10^{-3}$  to  $1.56 \times 10^{-3}$  and usually was lower than in tolerant cultivars.

Highly susceptible to PPV were cultivars Bounty, Summer Prince, Gold Prince (Figure 4), Redhaven, Gala and Sunbrite (Figure 5) were rated as (Table 4). Symptoms on leaves were distinct. Yellowing, mosaic and vein clearing appeared on the first, second, third and sometimes on the fourth leaves of branches. Severe or medium severe diffuse spots and rings appeared on most fruits. They usually also showed mild malformations. The relative concentration of PPV protein in flowers was very high ( $1.56 \times 10^{-3}$  to  $1.95 \times 10^{-4}$ ).



Table 4. Non-patented American peach cultivars categorised as highly susceptible based on symptoms in leaves, fruits and relative concentration of PPV protein in flowers

Cultivar	Symptoms in leaves	Symptoms on fruits	Relative concentration of PPV in flowers
Bounty	yellowing 1.–2. leaf	severe diffuse spots, rings	$1.56 \times 10^{-3}$
Summer Prince	yellowing 1. leaf	medium severe diffuse spots	$7.81 \times 10^{-4}$
Gold Prince	vein clearing 1.–2. leaf	medium severe diffuse spots, rings	$7.81 \times 10^{-4}$
Redhaven	vein clearing, mosaic 1.–3. leaf	diffuse spots	$3.91 \times 10^{-4}$
Gala	no symptoms	medium severe diffuse spots	$1.95 \times 10^{-4}$
Sunbrite	severe yellowing, mosaic 1.–3. leaf	severe diffuse spots, rings	nt

nt = not tested

## DISCUSSION

Two-year-old trees of American peach cultivars were infected artificially with PPV and differences in susceptibility to the virus were proved. These results verified those of MAINOU and SYRGIAMIDIS (1992) who found that all peach cultivars react to PPV infection with symptoms of various intensity on leaves and fruits. They also agree with those obtained by POLÁK (1998, 1999) who rated 55 peach cultivars of different origin and did not find any immune or highly resistant cultivar. The results by BALAN *et al.* (1995), who found some more resistant cultivars, were not confirmed by us. However, the majority of cultivars we classified were different.

However, we found that three vegetative seasons were not enough to completely evaluate the reaction of peach cultivars for their reaction to PPV. It was not possible to determine the relative concentration of PPV in flowers of seven cultivars because of a shortage of flowers. Symptoms of PPV on fruits could not be evaluated in two cultivars because there were no fruits. In spite of these shortcomings, the 28 American peach cultivars could be divided into four groups of reactions: medium resistant (8 cultivars), tolerant (4 cultivars), medium susceptible (10 cultivars) and highly susceptible (6 cultivars) to PPV. Presumably, so far no peach cultivar has been found that is immune or highly resistant to PPV.

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Received for publication January 2, 2003  
Accepted after corrections March 24, 2003

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**Souhrn**

POLÁK J., PÍVALOVÁ J., DOWLER W., MILLER R.W. (2003): **Hodnocení amerických odrůd broskvoně na rezistenci k viru šarky švestky**. Plant Protect. Sci., **39**: 1–6.

Dvacet osm amerických odrůd broskvoně bylo vyhodnoceno na rezistenci k viru šarky švestky, *Plum pox virus* (PPV). Byla hodnocena přítomnost a intenzita příznaků PPV na listech a plodech. V květech byla stanovena relativní koncentrace PPV proteinu. Odrůdy broskvoně byly rozděleny do čtyř skupin: 1. Flame Prince, Cotender, Newhaven, Ruby Prince, Sun Prince, Jefferson, Camden a Jersey Queen středně rezistentní k PPV; 2. Loring, Blaze Prince, June Prince a Legend tolerantní k PPV; 3. Quachita Gold, O'Henry, Crest Haven, Biscos, Sentry, Fire Prince, Carogem, Carolina Belle, Redglobe a Harvester středně náchylné k PPV; 4. Bounty, Summer Prince, Gold Prince, Redhaven, Gala a Sunbrite velmi náchylné k PPV.

**Klíčová slova:** virus šarky švestky; broskvoň; příznaky choroby; koncentrace viru; ELISA; rezistence

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