

Resistance to plum pox potyvirus in apricots¹

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The susceptibility of 115 apricot cultivars to plum pox potyvirus (PPV) has been examined, since 1981, in the experimental plots of the Pomology Institute at Naoussa and Skydra, Makedonia (GR). Inoculation was assured by aphids, transmitting strain PPV-M (Marcus) from naturally infected trees in adjacent peach orchards. For each cultivar, four to six trees were examined for at least 4 years. Observations on symptoms were made on leaves early in May and on fruits at maturity. Most cultivars expressed severe disease symptoms. Those without symptoms were inoculated by grafting onto heavily infected old apricot trees. The grafted shoots were tested for PPV in the following year by ELISA and on the woody indicator GF305. The cultivars which were rated as resistant after artificial inoculation and ELISA came from North America: Early Orange, Stella, NJA2, Sunglo, Veecot, Harlayne, Goldrich and Henderson. Most of these have been crossed with quality cultivars for the creation of resistant hybrids. The PPV resistance of large numbers of these apricot hybrids is now under investigation.

Introduction

Plum pox potyvirus (PPV) is the causal agent of sharka disease which was noted in Greece 25 years ago (Demetriades & Catsimbas, 1968) and has since spread all over the country, mainly in diseased planting material. Efforts have been made to control the disease by eradication of infected trees and by planting virus-free material. It was observed later that there is PPV resistance in apricot cultivars. The first cultivars to be valued as resistant to PPV were Early Orange and Stella (Syrgiannidis, 1979).

It was then understood that breeding apricots for PPV resistance would give more stable and permanent control of the disease. A programme was initiated and a number of resistant hybrids was created by crossing Early Orange with the Greek cv. Proimo Tiryntos. Two PPV-resistant hybrids were selected: Lito and Pandora (Syrgiannidis & Mainou, 1993). In parallel, since 1981, PPV susceptibility has been evaluated in many of the different cultivars growing in the collections of the Pomology Institute. Among these, cv. Harcot exhibited sharka symptoms only after many years of growth in a heavily infected orchard (Karayiannis, 1989). Three other cultivars (NJA2, Sunglo and Veecot) showed PPV resistance under conditions of natural inoculation in the field (Karayiannis *et al.*, 1991; Karayiannis, 1993).

A systematic study of the reaction of apricot cultivars to PPV has also been undertaken in France and resistance genitors have been incorporated into the apricot breeding programme (Dosba *et al.*, 1991, 1992). Similar studies have been done in Romania (Balan & Stoian, 1993). A method to determine the PPV susceptibility of apricot cultivars has been described in France (Audergon *et al.*, 1993).

Recently, three more cultivars have been added to those known as PPV-resistant in Greece: Harlayne, Goldrich and Henderson. The results of trials on the above-mentioned cultivars are illustrated in the present paper.

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Materials and methods

A total of 115 apricot cultivars was examined for susceptibility to strain PPV-M, in four collections, over the period 1981/1993. Most originated from Europe, USA and Canada. The orchards were established in a randomized complete-block design. There were two replicates for each cultivar and two to three trees per replicate. The space between the trees was 6×6 , 5×6 or 4×5 m. The trees were left under conditions of natural inoculation by aphids transmitting the virus from infected trees in extensive neighbouring peach orchards.

Observations for the appearance of PPV symptoms were made on leaves early in May and on fruits at maturity. A 0–3 scale was used: for leaves 0 = no symptoms, 1 = very slight symptoms, 2 = obvious light green bands around the main veins, 3 = intense symptoms and distortion of the petiole; for fruits, 0 = no symptoms, 1 = rings only around the pedicel, 2 = slight rings at the top of the fruit, 3 = intense rings at the top of the fruit with or without malformations.

Cultivars which showed no symptoms at all were subsequently inoculated artificially, either by grafting them onto heavily infected old apricot trees or by budding infected material onto small trees of the cultivar. Inoculation was carried out at the beginning of September and results were observed in the following May.

The ELISA test (Clark & Adams, 1977) was applied to leaf samples from the shoots inoculated by grafting onto an infected tree, at three points (base, middle, top), in duplicate. It was also applied to trees inoculated by budding. A reaction was considered positive when the mean absorbance of an unknown sample at 450 nm was higher than 1.1 times the healthy control. Some of the grafted or budded trees were also biologically tested on woody indicator GF305, in 1991 and 1992 respectively.

Results

Susceptibility of apricot cultivars and hybrids to PPV

Of the 115 cultivars examined in the field, only a few were found to be resistant to sharka under conditions of natural inoculation by aphids. In the first collection over the period 1981/1987, only cvs Early Orange and Stella were rated 0 on the plum pox scale. The other 41 were rated between 1 and 3 points on the scale (Amal, Baracca, Bergeron, Blenheim, Blenril, Boccucia, Breda, Bulida, Canino, CXHT, Detski, Dobruganska, Diamantopoulou, Dryanovska, Kasna, Erevani, Festivalna, Fracasso, Grossa del Giardino, Harcot, Harogem, Hatif Colomer, Jubilejna, Kishinievska Rana, Kostjuzenska, Magyarska, Magyarska Najbolja, Mono, Ouardi, Paviot, Precoce de Boulbon, Pr. Tirynthos, Precoce Cremonini, Polonais, Ricordo di Buonamico, Rouge de Rivesaltes, Rouge Tardif Delbard, Sayeb, Screara, Tardif de Bordaneil and Hyperproimo Porou).

In the second collection over the years 1985/1993, cvs NJA2, Sunglo and Veecot were rated zero on the scale, while 15 others (California red, Cegledi bibor, Early Golden, Fracasso, Goldcot, Keschemet Rosa, Koliopoulou, Korai Piros, Ligeti Orias, Bebecou, Moorpark, Paksimagyar, Perfection, Reale d'Imola and San Castrese) were rated 2–3 for PPV susceptibility. In the third collection over the years 1989/1993, cvs Harlayne, NJA2, Veecot and two Greek hybrids were zero-rated, while cv. Badami had inconspicuous symptoms. The other 27 cultivars were rated 2–3 (Ambrosia, Blanco, Bademovidna, Bebecou I.D., Candelo-2, Chirivello, Competna, Corbato, Currot, Gergana, Ginesta, Gitano, Hasiotico, Karakabey, Marculesti, Mitger, Moniqui Borde, Moniqui fino, NJA19, Palabras, Palen, Royal, Rojode Carlet, Septembrinska, Skaha, Sundrop and Tadeo). The Greek hybrids were Lito (G29) and Pandora (A36), derived from Early Orange \times Pr. Tirynthos and inheriting resistance from their female parent. In the fourth collection over the years 1991/1993, cvs Henderson and Goldrich were zero-rated, while 21 others were rated 1–3 (Caldesi Nol, Excelsior, Favorite, Ivonne

Table 1. Reaction of apparently resistant apricot cultivars to artificial inoculation with PPV in the orchards of the Pomology Institute, at Naoussa and Skydra, Makedonia (GR)

Réaction, à l'inoculation artificielle avec le PPV, de cultivars d'abricotier apparemment résistants, dans les vergers de l'Institut de Pomologie à Naoussa et Skydra, Makedonia (GR)

Cultivars	Inoculation by grafting cultivar onto infected tree			Inoculation by budding onto cultivar		
	Year of inoculation	Symptoms on		Year of inoculation	Symptoms on	
		Leaves	Fruits		Leaves	Fruits
Early Orange				1989	—	—
Stella				1989	—	—
NJA2	1991	—	*	1991	—	*
Sunglo	1990	—	*	1992	—	*
Veecot	1987, 1991	—	—	1991	—	*
Harlayne	1992	—	—			
Henderson	1992	—	—			
Goldrich	1992	—	—			
Lito (G29)	1990	—	—			
Pandora (A36)	1986	—	—			

— no PPV symptoms; * no fruits yet obtained.

Liverani, Krupna Skopjanka, Mamaia, Neptun, Olymp, Palumella, Phelps, Portici, Roxana, San Francesco, Saturn, Selenia, Sirena, Sulina, Sulmona, Tilton, Tokaloglu and Venus).

In summary, resistance was found in the already known cultivars Early Orange and Stella, the more recently known NJA2, Sunglo, Veecot, Harlayne, Henderson and Goldrich, and in two Greek hybrids. Most of the other cultivars examined had severe symptoms on leaves and fruits. Almost all the European cultivars were particularly susceptible and the disease caused considerable degradation of the commercial value of their fruit.

Tests on artificially inoculated resistant cultivars

Table 1 shows the results of artificial inoculation of the apparently resistant cultivars. No symptoms were seen on leaves or fruits, whichever type of inoculation was used (grafting onto an infected tree or inoculation by budding), but some cultivars had still not formed fruits at the time of latest scoring.

The ELISA test was always negative for leaf samples taken on the original trees exposed only to natural inoculum. It was similarly negative for samples from the resistant cultivars after artificial inoculation, by grafting or budding, except that one leaf sample of cv. Goldrich gave a positive reaction to ELISA in May. Repetition of the same test in September gave a negative reaction.

When some of the artificially inoculated resistant cultivars or hybrids (Lito, Veecot, Sunglo, NJA2) were tested on GF305, uniformly negative results were obtained.

Discussion

The few apricot cultivars found to be PPV-resistant (Early Orange, Stella, NJA2, Sunglo, Veecot, Harlayne, Henderson and Goldrich) all originate from North America. Additional

research is needed to confirm the resistance of cvs Goldrich and Henderson. All the resistant cultivars are auto-incompatible. However they have been used as genitors in crosses with quality cultivars (Karayiannis *et al.*, 1993) with the aim of creating PPV-resistant hybrids. At least half these hybrids will inherit auto-incompatibility, an undesirable characteristic. A rather large number of hybrids has been obtained so far. An evaluation and selection programme will indicate which of these hybrids combine PPV resistance with high fruit quality, productivity and other valuable characteristics.

Until such hybrids have been selected and released to growers, it is imperative to limit the spread of the disease. This can be done by regular surveillance of nurseries and orchards, eradication of infected trees and control of aphids.

Résistance de l'abricotier au plum pox potyvirus

La sensibilité d'environ 115 cultivars d'abricotier au plum pox potyvirus (PPV) est étudiée depuis 1981 à l'Institut de Pomologie à Naoussa et Skydra, Makedonia (GR). La contamination est assurée par les pucerons qui transmettent la souche PPV-M (Marcus) à partir d'arbres naturellement infectés des vergers de pêcheurs adjacents. Pour chaque cultivar, 4–6 arbres ont été examinés sur une période d'au moins 4 ans. L'observation des symptômes a été effectuée sur les feuilles au début mai et sur les fruits à la maturité. La majorité des cultivars a exprimé des symptômes sévères. Ceux qui ne présentaient pas de symptômes ont été inoculés par greffage sur de vieux abricotiers fortement contaminés. L'année suivante, la présence du virus dans les pousses greffées a été évaluée à l'aide du test ELISA et de l'indicateur ligneux GF305. Les cultivars qui présentaient un haut niveau de résistance après inoculation artificielle étaient d'origine nord-américaine: Early Orange, Stella, NJA2, Sunglo, Veecot, Harlayne, Goldrich et Henderson. La plupart ont été utilisés dans des croisements avec des cultivars de qualité pour la création d'hybrides résistants. La résistance de nombreux abricotiers hybrides au PPV est actuellement à l'étude.

Устойчивость культиваров абрикоса к plum pox potyvirus

Начиная с 1981 изучалась чувствительность 115 культиваров абрикоса экспериментальных посадок Института помологии в Науссе и Скидре области Македония в Греции к plum pox potyvirus (PPV). Инокуляция осуществлялась тлями, передающими соседним персиковым садам вирусный штамм PPV-M (Marcus) от деревьев, зараженных естественным путем. Для каждого культивара в течение 4 лет под наблюдением находились 4–6 деревьев. Наблюдения за листьями и за созревшими плодами проводились в начале мая. Большинство культиваров проявляли тяжелые симптомы заболевания. Культивары, у которых признаки заболевания не обнаруживались, инокулировались прививкой на сильно пораженные абрикосовые деревья. На следующий год привитые побеги испытывали на наличие вируса PPV с помощью метода ELISA и на древесном индикаторе GF305. Следующие североамериканские культивары были отнесены к устойчивым после искусственного заражения и испытания методом ELISA: Early Orange, Stella, NJA2, Sunglo, Veecot, Harlayne, Goldrich, Henderson. Большинство из них были скрещены с качественными культиварами для получения устойчивых гибридов. В настоящее время исследуется устойчивость большого числа гибридов абрикоса к вирусу PPV.

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