Europ.J.Hort.Sci., **70** (3). S. 121–124, 2005, ISSN 1611-4426. © Verlag Eugen Ulmer GmbH & Co. Stuttgart

Effect of the Sharka (*Plum pox virus*) Disease on the Nutrient Status of the Apricot (*Prunus armeniaca* L.) Cultivars 'Harcot' and 'Bebeco' and Expression of Symptoms of the Physiological Disorder Tip Burn on Fruits of the cv. 'Bebeco'.

D. C. Stylianidis[1)], T. E. Sotiropoulos[1)], G. Syrgiannidis[1)], I. N. Therios[2)], A. Mainou[1)], I. Karagianni[1)] and A. Isaakidis[1)]

([1)]N.AG.RE.F., Pomology Institute, Naoussa, and [2)]Department of Horticulture, Laboratory of Pomology, Aristotle University, Thessaloniki, Greece)

Summary

The effect of the sharka (*Plum pox virus*, *PPV*) disease on the chemical composition of leaves and fruits of the *PPV* tolerant apricot cultivar (cv.) 'Harcot', and on the susceptibility to the physiological disorder tip burn of the apricot cv. 'Bebeco' were studied. Leaf analysis revealed that concentrations of N and Fe were increased by 9 and 21 %, while P, K and Ca concentrations were decreased by 32, 15 and 9 %, respectively on infected trees of the cv. 'Harcot' in comparison to the control. No significant differences were observed in chemical composition of fruits from *PPV*-infected and healthy trees of the cv. 'Harcot'. The N/Ca and N/P ratios of leaves infected by the *PPV* were increased by 23.6, and 61.1 % in comparison to the control, respectively. Nitrogen and Zn concentrations of the cv. 'Harcot' were higher, K and Ca concentrations were lower, whereas P, Mg, Fe and Mn concentrations were not altered significantly in comparison to the cv. 'Bebeco'. The ratios N/P, N/Ca, K/Ca, and K+Mg/Ca in leaves and fruits of the cv. 'Bebeco' were significantly higher in comparison to the cv. 'Harcot'. In conclusion, infection of apricot trees of the cv. 'Harcot' by *PPV* may affect their nutrient status (especially the N/P and N/Ca ratios in leaves). Furthermore, low Ca concentration of fruits of the cv. 'Bebeco' in comparison to the cv. 'Harcot', and high ratios of N/Ca, K/Ca, K+Mg/Ca, and N/P are related with the appearance of the physiological disorder tip burn.

Zusammenfassung

Die Wirkung der Scharkakrankheit (*Plum pox virus*) auf den Ernährungszustand von Aprikosen (*Prunus armeniaca* L.) der Sorten 'Harcot' und 'Bebeco' und die Symptomausprägung der physiologisch-bedingten Spitzendürre an Früchten von 'Bebeco'. Es wurden die Auswirkungen der Scharkakrankheit (*Plum pox virus*, *PPV*) auf die chemische Zusammensetzung von Blättern und Früchten der *PPV*-toleranten Aprikosensorte 'Harcot' und auf die Anfälligkeit der Sorte 'Bebeco' gegenüber der physiologisch-bedingten Spitzendürre untersucht. Blattanalysen von infizierten Bäumen der Sorte 'Harcot' zeigten im Vergleich zur Kontrolle einen Anstieg der N- und Fe-Konzentrationen um 9 bzw. 21 %, sowie einen Rückgang der P-, K- und Ca-Konzentrationen um 32, 15 und 9 %.

Es konnten keine statistischen Unterschiede in der chemischen Zusammensetzung der Früchte von *PPV*-infizierten und gesunden Bäumen der Sorte 'Harcot' festgestellt werden. Das N/Ca- und N/P-Verhältnis von *PPV*-infizierten Blättern erhöhte sich im Vergleich zur Kontrolle um 23.6 bzw. 61.1 %. Die Stickstoff- und Zn-Konzentrationen waren bei 'Harcot' im Vergleich mit 'Bebeco' höher, die K- und Ca-Konzentrationen geringer und die P-, Mg-, Fe-, und Mn-Konzentrationen unverändert. Die N/P-, N/Ca-, K/Ca- und K+Mg/Ca-Verhältnisse in Blättern und Früchten von 'Bebeco' waren signifikant höher als die von 'Harcot'. Zusammenfassend kann gesagt werden, dass sich die Infektion von Aprikosenbäumen der Sorte 'Harcot' mit *PPV* auf deren Ernährungszustand (vor allem in Hinsicht auf das N/P- und das N/Ca-Verhältnis in den Blättern) auswirken kann. Des weiteren besteht ein Zusammenhang zwischen der im Vergleich zu 'Harcot' geringen Ca-Konzentration der Früchte von 'Bebeco' sowie den hohen Werten beim N/Ca-, K/Ca-, K+Mg/Ca- und N/P-Verhältnis und dem Auftreten der physiologisch-bedingten Spitzendürre.

Key words. calcium – nitrogen – nutrient uptake – potassium – protein content.

Introduction

Plum pox virus (*PPV*) is the most important virus affecting stone fruit trees in Europe. The disease has an immense impact on the stone fruit crops because infected fruit are unmarketable (PUNJA 2001). *PPV* infects all cultivated stone fruits including peach, nectarine, apricot, and cherry (MOUSTAFA et al. 2001). The external symptoms in apricot fruits are not as severe as in plum, but the fruits decays easily and cannot withstand transport. Leaf symptoms of the disease are not conspicuous. However, shortly after foliation, pale green blotches and rings of different sizes appear. Often, the main veins are surrounded by light green bands 1–2 mm in diameter, forming an elliptic pattern. Symptoms appearing on the fruits are variable. On some cultivars chlorotic rings or bands appear on the fruit surface, which may turn brown and become sunken. In most cases, however, infected fruit skin shows no visible symptoms, but symptoms develop on the stone (NEMETH 1986). When infected by *PPV*, the tolerant cv. 'Harcot' showed symptoms of moderate intensity on leaves and of low intensity on fruits, whereas the susceptible cv. 'Bebeco' showed symptoms of high intensity both in leaves and in fruits. VANEK et al. (1992) reported that *PPV* symptoms, in stone fruits, vary considerably with the cultivar, age, nutrient status of the plant and ambient temperature. Mineral nutrition can reduce or enhance the intensity of *PPV* symptoms (NEMETH 1986). Furthermore, various virus diseases exert a positive or negative effect on the nutrient status and other metabolic compounds of leaves and fruits (GYORGY 1976). STYLIANIDIS et al. (2000) observed that fruits of certain apricot cvs., infected by *PPV*, revealed symptoms of the physiological disorder tip burn. Tip burn appears as a cork-like spot at the apical part of the fruit. The ratios N/Ca, K/Ca, K+Mg/Ca, and N/P in leaves and fruits were calculated since they are related to several physiological disorders of fruits (MARCELLE 1995). The objectives of the present research were a) to study whether the infection of apricot trees by *PPV* affects their nutrient status and b) to study whether the physiological disorder tip-burn is related to tree nutrition.

Materials and Methods

The apricot (*Prunus armeniaca* L.) cv. 'Harcot' was grafted on healthy and on *PPV* infected 2 years old GF 677 (peach x almond) rootstocks, and the cv. 'Bebeco' only on infected 2 years old GF 677 rootstocks. Shoots that developed on infected rootstocks showed very early the characteristic symptoms of the sharka disease on leaves and on fruits at the 4th year when trees began to produce fruits. On the contrary, the shoots that developed on healthy rootstocks did not show any symptoms on leaves and fruits till the end of the experiment (5th year). Fruits of the cv. 'Bebeco' exhibited symptoms of the physiological disorder tip burn, whereas fruits of the cv. 'Harcot' did not. Samples from healthy and infected trees were collected as following: leaf samples consisting of fifty leaves were collected at the end of July from the middle of the current year's shoots during the 4th and 5th year after the planting of the trees; fruit samples were collected during harvest. Leaf and fruit samples were collected from 10 trees per treatment (healthy, infected) from the two cultivars. All samples were initially washed with tap water and afterwards twice with distilled water. Leaf samples were dried in a forced draft oven at 68 ° C for 72 h and fruit samples were freeze dried. Tissues were ground in a mill and filtered through a 30-mesh screen. Nitrogen was determined by the Kjeldahl's procedure, P by the ammonium phosphovanadomolybdate method (JACKSON 1970), and K, Ca, Mg, Fe, Mn and Zn by atomic absorption spectroscopy (Perkin-Elmer, 2380). The experimental design employed was the randomised complete block one. Differences between means of ion concentration were evaluated by the Duncan's multiple range test at P=0.05. For comparison of the nutritional ratios in leaves and fruits, the previous test was also adopted after angular transformation of the data.

Results

Nitrogen and Fe concentrations of leaves of the cv. 'Harcot' from *PPV* infected trees were significantly higher in comparison to the control, while P, K, and Ca were lower (Table 1). Magnesium, Mn and Zn concentrations of leaves of the cv. 'Harcot' were not significantly affected by the *PPV* infection in comparison to the control (Table 1). The cv. 'Bebeco' had a higher nutrient uptake efficiency (except for P, Ca and Fe) than the cv. 'Harcot'. Fruit nutrient status of the cv. 'Harcot' did not show any significant difference between *PPV*

Table 1. Concentration of nutrient elements in leaves and fruits of the apricot cvs. 'Harcot' and 'Bebeco' of *PPV*-infected and healthy trees.

Tissue	Cultivar	N (% d.w.)	P (% d.w.)	K (% d.w.)	Ca (% d.w.)	Mg (% d.w.)	Fe (μg g^{-1} d.w.)	Mn (μg g^{-1} d.w.)	Zn (μg g^{-1} d.w.)
Leaves	'Harcot' infected	2.00 b*	0.19 bc	2.62 c	2.23 b	0.48 b	51.00 a	38.00 b	29.00 b
	'Harcot' healthy	1.83 c	0.28 a	3.08 b	2.54 a	0.49 b	42.00 b	37.00 b	27.00 b
	'Bebeco' infected	2.69 a	0.22 b	3.43 a	2.13 c	0.55 a	42.00 b	56.00 a	44.00 a
Fruits	'Harcot' infected	0.88 e	0.17 c	1.93 d	0.06 d	0.06 c	25.00 c	5.00 c	7.50 d
	'Harcot' healthy	0.80 e	0.18 c	1.91 d	0.06 d	0.06 c	23.00 c	5.00 c	8.00 d
	'Bebeco' infected	1.06 d	0.17 c	1.75 e	0.03 e	0.05 c	23.00 c	6.00 c	13.00 c

*Means within column followed by the same letter are not significantly different (Duncan's multiple range test, 5 %).
d.w. = dry weight

infected trees and the control (Table 1). Nitrogen, and Zn concentrations of fruits from healthy trees of the cv. 'Harcot' were lower, K and Ca concentrations were higher, whereas the P, Mg, Fe, and Mn concentrations were not altered significantly in comparison to the cv. 'Bebeco'. Furthermore, the ratios N/Ca, K/Ca, K+Mg/Ca, and N/P in leaves and fruits were calculated. The N/P and N/Ca ratios of *PPV* infected trees of the cv. 'Harcot' were significantly increased in leaves in comparison to healthy ones (Table 2). The ratios K/Ca, and K+Mg/Ca of leaves of the cv. 'Harcot' were not significantly different between *PPV* infected trees and the control (Table 2). The N/P, N/Ca, K/Ca, and K+Mg/Ca ratios of fruits were not significantly different between *PPV* infected trees and the control. All the previous ratios in leaves and fruits of the cv. 'Bebeco' were significantly higher in comparison to the cv. 'Harcot'.

Discussion

GYORGY (1976) reported that protein content of leaves in *PPV* infected plum trees of the cv. 'Besztercei', was 4–5 % higher in comparison to the control. Accumulation of certain amino acids in plants is well documented under stress conditions (MARSCHNER 1995). This could explain the higher total N concentration that was found in our experiment in leaves of *PPV* infected trees in comparison to the control. MOHONLY and SRIDHAR (1982) concluded that in rice plants infected by the *Tungro virus disease*, proline accumulation was higher than that of the control. On the contrary, in sour cherry trees infected by the *Prunus necrotic ringspot virus*, N, P, Ca, and Mg contents of leaves were lower in comparison to the control (BAUMANN and VON OLFERS 1976). Virus diseases exert a positive or negative effect on plant nutrient status and vice-versa, application of certain nutrients to the soil can affect plant sensitivity to virus infection (FOSTER 1957). More specifically, BRIERLY and STUART (1962) reported that high N fertilization increased the susceptibility of onions to *Yellow dwarf virus*. FOSTER (1957) reported that tobacco infection by the *Tobacco mosaic virus* was a function of plant N concentration. He concluded that tobacco plants sufficient to N were more susceptible to the virus in comparison to N deficient ones. Furthermore, high P concentration in tobacco plants combined with low K concentration increased susceptibility of plants to the virus. BODIN et al. (2003) reported that any condition that enhance plant growth favours virus spreading into the plant. VANEK et al. (1992) concluded that infection of the peach rootstock GF-31 by the *PPV* was enhanced when plants had high N content or low Ca and K content. GYORGY (1976) studied the effect of *PPV* on the nutrient status and fruit quality of the plum cv. 'Besztercei'. She concluded that in fruits of infected trees, sugars, dry matter, and anthocyanin contents in the peel decreased, while amino acids, organic acids, and protein contents increased in comparison to the control. However, in our study there was no significant increase in total N concentration of fruits from infected and healthy trees that could be ascribed to high protein content. GYORGY (1976) concluded that in infected trees, Cu and Zn content of young leaves were higher during spring but at the end of the summer there was no significant difference between infected trees and the control. Finally, in infected trees, activity of glucose-6-phospho-dehydrogenase, and peroxidase increased while that of esterase remained unaltered.

The ratios, N/Ca, K/Ca, K+Mg/Ca, and N/P in leaves and fruits of both apricot cvs., were calculated because they are related to some physiological disorders of fruits (MARCELLE 1995). STYLIANIDIS et al. (2000) reported that symptoms of internal breakdown in fruits were observed in the apricot cvs. 'Bergeron', 'New Jersey A2', 'Bulida' and 'Lito'. These cultivars showed a higher ratio of N/P in leaves and fruits in comparison to other cultivars that did not present internal breakdown symptoms in fruits such as 'Pella' and 'Bebeco'. WILLS and SCOTT (1976) reported that N fertilization resulted in an increase of the percentage of fruits that showed internal breakdown symptoms. On the contrary, P fertilization had the opposite effect. The N/P and N/Ca ratios of *PPV* infected trees of the cv. 'Harcot', were increased by 61.1 and 23.6 % in leaves and 16.4 and 10.1 % in fruits, respectively, in comparison to the control.

Our hypothesis that infection of apricot trees by *PPV* may affect their nutrient status (especially the

Table 2. Ratios of N/P, N/Ca, K/Ca and K+Mg/Ca of leaves and fruits of the apricot cvs. 'Harcot' and 'Bebeco' of *PPV*-infected and healthy trees.

Cultivar	Fruit N/P	Leaf N/P	Fruit N/Ca	Leaf N/Ca	Fruit K/Ca	Leaf K/Ca	Fruit K+Mg/Ca	Leaf K+Mg/Ca
'Harcot' healthy	4.44 b*	6.53 c	13.33 b	0.72 c	31.83 b	1.21 b	32.83 b	1.40 b
'Harcot' infected	5.17 b	10.52 b	14.67 b	0.89 b	32.17 b	1.17 b	33.17 b	1.39 b
'Bebeco' infected	6.23 a	12.23 a	35.33 a	1.26 a	58.30 a	1.61 a	60.00 a	1.88 a
Alteration (in %) 'Harcot' healthy / 'Harcot' infected	+16.44	+61.10	+10.05	+23.60	+ 1.07	– 3.30	+ 1.04	– 0.71
Alteration (in %) 'Harcot' healthy / 'Bebeco'	+40.32	+87.29	+165.00	+75.00	+83.16	+33.06	+82.76	+34.29

*Means within column followed by the same letter are not significantly different (Duncan's multiple range test, 5 %).

N/P and N/Ca ratios in leaves) proved to be valid. There were significant differences between the two cultivars as regards nutrient uptake efficiency. Furthermore, it can be concluded that low Ca concentration of fruits and high ratios of N/Ca, K/Ca, K+Mg/Ca, and N/P are related with the appearance of the physiological disorder tip burn of fruits.

References

BAUMANN, G., and C. von OLFERS 1976: Influence of increased nitrogen supply on mineral composition and growth of sour cherry trees in the acute and in the chronic course of Stecklenberg disease. Acta Hort. **67**, 67–76.

BODIN, M., M. GLASA, D. VERGER, E. COSTES and F. DOSBA 2003: Distribution of the sour cherry isolate of plum pox virus in infected *Prunus* rootstocks. J. Phytopath. **151**, 625–628.

BRIERLY, P., and N.V. STUART 1962: Influence of nitrogen nutrition on susceptibility of onions to yellow dwarf virus. Phytopath. **36**, 297–301.

FOSTER, R.E. 1957: Host nutrition affects virus infection. Phytopath. **67**, 98–101.

GYORGY, B. 1976: Biochemical changes of plums caused by plum pox virus. Acta Hort. **67**, 77–81.

JACKSON, M.L. 1970: Soil chemical analysis. Constable and Co Ltd, London.

MARCELLE, R.D. 1995: Mineral nutrition and fruit quality. Acta Hort. **383**, 219–226.

MARSCHNER, H. 1995: Mineral nutrition of higher plants. Academic Press, Amsterdam.

MOHONLY, K. and R. SRIDHAR 1982: Physiology of rice tungro virus disease: Proline accumulation due to infection. Physiol. Plant. **56**, 89–93.

MOUSTAFA, T.A., M.L. BADENES, J. MARTINEZ-CALVO and G. LLACER 2001: Determination of resistance to sharka (plum pox) virus in apricot. Sci. Hort. **91**, 59–70.

NEMETH, M. 1986: Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, Dordrecht.

PUNJA, Z.K. 2001: A method for evaluating resistance in apricot to sharka (Plum pox virus). Can. J. Plant Path. **24**, 99–102.

STYLIANIDIS, D., I. THERIOS, A. MAINOU, A. ISAAKIDIS, A. MANGANARIS, G. SYRGIANNIDIS and T. SOTIROPOULOS 2000: Preliminary observations on the physiological disorders of apricots. Agr. Crop Anim. Husb. **3**, 17–23.

VANEK, G., J. KOTUC, M. KOLBER, M. NEMETH and L. SZOKE 1992: Study of ecological factors influencing attacks by plum pox virus. Acta Hort. **309**, 143–149.

WILLS, R.B.H. and K.J. SCOTT 1976: Influence of nitrogen and phosphorus fertilizers on the relation between apple volatiles and storage breakdown. J. Hort. Sci. **51**, 177–179.

Received June 3, 2004 / Accepted February 14, 2005

Addresses of authors: D. C. Stylianidis, Egnatia 5, 59100 Veria, T. E. Sotiropoulos (corresponding author), A. Mainou, I. Karagianni, and A. Isaakidis, N.AG.RE.F., Pomology Institute, P.O. Box 122, 59200 Naoussa, G. Syrgiannidis, Kampiti 5, 59200 Naoussa, and I. N. Therios, Department of Horticulture, Laboratory of Pomology, Aristotle University, 54124 Thessaloniki, Greece, e-mail: thosotir@alfanet.gr.