BIOLOGICAL LETT. 2006, 43(2): 327–334
Available online at http://www.biollett.amu.edu.pl

Spider-mite susceptibility of scab V_f-resistant apple genotypes

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(*Received on 22 November 2005, Accepted on 20 June 2006*)

Abstract: Apple genotypes resistant to scab (*Venturia inaequalis* Cooke Winter), thanks to the gene V_f, were tested for their effect on spider mite populations under field conditions. Spider mite species varied in density between the 5 tested apple genotypes. In communities composed of 2 mite species, the European red spider mite (*Panonychus ulmi* Koch) was the most abundant on cv. Novamac, while the hawthorn spider mite (*Tetranychus viennensis* Zacher) was the most numerous on clone U 211. For both species, the least attractive host plant was cv. Primula. Trees of the hybrid Idared × Liberty were inhabited only by the European red spider mite and its abundance was significantly higher than on apple-trees of other genotypes. Leaves of the above genotypes did not differ in concentrations of soluble proteins, reducing sugars and total phenolics. The results suggest that the varied susceptibility of scab-resistant apple genotypes to spider mites does not result from differences in the concentration of the analysed primary and secondary metabolites.

Key words: *Malus × domestica*, combined resistance to scab and mite pests, *Tetranychus viennensis*, *Panonychus ulmi*

INTRODUCTION

Spider mites comprise an important group of phytophagous mites inhabiting fruit-bearing plants. These pests most often infest apple- and plum-trees, less often they can be observed on pear-trees, sweet cherry, cherry and peach (DĄBROWSKI & REJMAN 1975, BIELAK 1979, WARABIEDA 2000, SKORUPSKA 2003). The structure of the spider mite community (e.g. abundance) is usually highly variable and depends on environmental conditions (WARABIEDA 2000, SKORUPSKA 2003, LENORT et al. 2005). The coexistence of the European red spider mite (*Panonychus ulmi* Koch), almond brown mite (*Bryobia rubrioculus* Scheuten) and lately also two-spotted spider mite (*Tetranychus urticae* Koch) (WARABIEDA 2000, SKORUPSKA 2003, LENORT et al. 2005) was most often observed. The hawthorn spider mite (*Tetranychus viennensis* Zacher) also finds good conditions in older orchards (SKORUPSKA 2003). Infestation by mites influences the blooming, fruiting and yielding of the infested apple trees (BEERS & HULL 1990).

Apple scab is one of the best-known diseases of apple-trees. The disease is caused by a very expansive fungus (*Venturia inaequalis* Cooke Winter), which infects leaves and fruits, less often also flowers and young parts of shoots, in all regions of apple cultivation in the temperate climate. The appearance and development of the disease depend on the presence of a source of infection, susceptibility of the cultivar to infection, and climatic conditions. The most effective method for control of this disease is the cultivation of scab-resistant cultivars. More and more often the scab-resistant cultivars, such as Freedom, Goldstar, Novamac, Rajka, Rubinola, Sawa, Topaz or Witos, are recommended for both conventional and organic farming (PITERA 2000, 2003a). The results of FISHER's (2000) and FISHER & FISHER's (2004) investigations of the scab-resistant Re-cultivars® showed a combined resistance to spider mites and scab in some apple-tree genotypes, such as Rebella, Regine, Reglindis and Releika. However, a combined resistance to spider mites (*T. urticae* and *P. ulmi*) and aphids (*Aphis pomi*, *Dysaphis plantaginae*) could not be detected in Re-cultivars® (HABEKUSS et al. 2000). Clone U 211 (cv. Primula, open-pollinated) is a valuable source of genes for breeding of disease-resistant apple cultivars, because it transmits a low susceptibility to powdery mildew to a high percentage of scab V_f-resistant progeny (PITERA 2003a, b, 2004).

The resistance of the investigated apple-trees and many other genotypes to 5 physiological races of scab results from the presence of the V_f gene (PITERA 2003a, FISHER & FISHER 2004). At the same time it was observed that the scab-resistant apple-tree cultivars showed increased contents of leaf flavonoids (MIKHAILOVA et al. 1994, PICINELLI et al. 1995), which are known to inhibit the development of many mite pests, including spider mites (BIELAK 1979, WARABIEDA & OLSZAK 1995, KOZŁOWSKI 1998, SKORUPSKA 2003).

The aim of the presented research was to check whether apple-trees with a high level of scab resistance show a similar or different susceptibility to spider mites and whether the susceptibility to those pests depends on the chemical composition of leaves.

MATERIALS AND METHODS

The experiment was conducted in the Experimental Orchard of the Warsaw Agricultural University in Wilanów in 2003 and 2004. The structure of the spider mite community and the number of mite specimens were determined on 18-year-old (in 2003) apple-trees of cultivars Novamac, Primula, Witos and clone U 211, characterized by scab resistance (V_f) in the climatic conditions of Poland. Trees on rootstock M.26 grew at the spacing of 4.5 m × 3 m in 4 replications of 3 trees each. In a separate plot, there were 15-year-old (in 2003) ungrafted hybrid trees (Idared × Liberty). On both plots, a minimum program of chemical protection against pests was applied since the time of tree planting. In each year, 4 times from June to August, 10 leaves were collected from current-year shoots of the middle section of the crown from each of 8 randomly selected trees of each cultivar, clone and hybrid. The indicator of the susceptibility of investigated apple-tree genotypes to spider mites was the density of mobile mite specimens and their eggs on leaves. Thus, on the upper

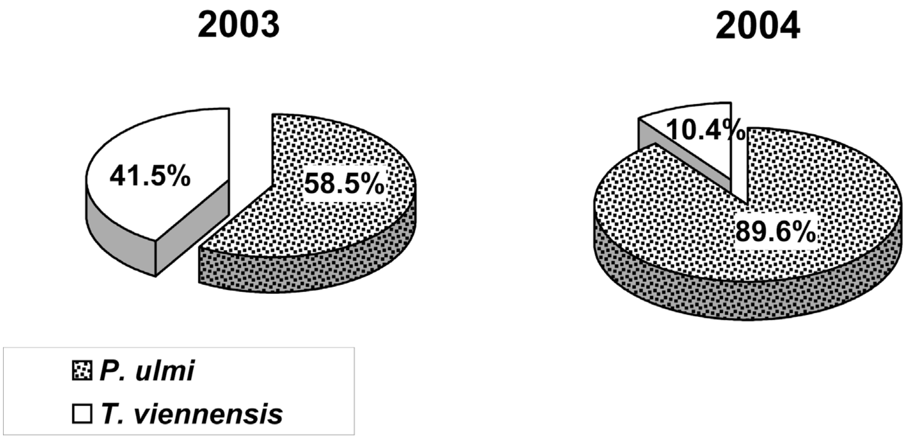

Fig. 1. Proportions of *Panonychus ulmi* and *Tetranychus viennensis* in the mite community

and the lower surface of the collected leaves the number of mobile stages and eggs of mites were determined. In the collected leaves (1–2 g of fresh matter) also the concentration of soluble proteins (BRADFORD 1976), reducing sugars (NELSON 1944), total phenolics (JOHNSON & SCHAAL 1956) and the percentage of dry matter were analyzed. All analyses were done in 3 replications (each replication comprised the weighted amount obtained from 6 leaves). The significance of differences between means was estimated by using the non-parametric Kruskal-Wallis H test (P = 0.05) (Statgraphics Plus 4.1).

RESULTS

In both seasons of the investigations, the coexistence of 2 species of spider mites: *P. ulmi* and *T. viennensis* was observed on some scab-resistant apple-trees. In 2003, *P. ulmi* and *T. viennensis* comprised 58.5% and 41.5% of the total number of mites, respectively. However, in 2004 the proportion of *P. ulmi* in the community increased and it constituted over 89% of the total number (Fig. 1).

Both spider mite species preferred the lower surface of leaves, so the scanty data on their densities on the upper leaf surface were not taken into account. In 3 apple-tree genotypes (Novamac, U 211 and Witos), *P. ulmi* developed similarly in both seasons (Table 1). The smallest numbers of mite eggs and mobile stages were noted on cv. Primula but only in 2003 (Tables 1 and 3). The European red spider mite was the most numerous on leaves of Idared × Liberty trees (Tables 1 and 3).

T. viennensis was more numerous and developed better in 2003 than in 2004 in all the investigated cultivars and clone U 211 (Table 2). However, *T. viennensis* was less abundant than *P. ulmi* and it did not inhabit Idared × Liberty trees at all.

Leaves of Novamac, U 211, Idared × Liberty, and Primula trees were characterized by a higher dry matter content than Witos leaves (H=9.733; P=0.0452) (Fig. 2). Leaves of the investigated apple genotypes significantly varied in the concentration of reducing sugars (H=18.482; P=0.009). However, they did not vary in the concentration of soluble proteins and total phenolic compounds (Fig. 2).

Table 1. Density of mobile specimens of the European red spider mite (*Panonychus ulmi*) on the lower leaf surface in studied apple-tree genotypes (2003 and 2004)

Sampling date	Novamac	Primula	U 211	Witos	Idared × Liberty
03.07.03	0.3±0.4	0.3±0.4	0.2±0.2	0.6±0.6	0
14.07.03	1.0±0.8 a	0.4±0.2 a	0.6±0.5 a	0.9±0.7 a	7.5±2.6 b
28.07.03	0.5±0.2 a	0.3±0.1 a	0.7±0.3 a	0.4±0.3 a	7.2±3.2 b
21.08.03	0.7±0.2	0.2±0.2	0.6±0.5	0	0.1±0.1
Mean in 2003	0.63	0.3	0.52	0.48	3.7
22.06.04	1.0±0.5	0.9±0.2	0.7±0.2	0.9±0.2	0
05.07.04	0.6±0.3	0.8±0.2	0.6±0.3	0.6±0.3	0
26.07.04	0.8±0.2	0.8±0.4	0.7±0.2	0.6±0.2	0
16.08.04	0.6±0.2	0.5±0.1	0.5±0.3	0.5±0.2	0
Mean in 2004	0.75	0.75	0.63	0.65	0

Data are means (N=80) ± standard deviation. Different letters within rows indicate significant differences (Kruskal-Wallis test, $P<0.05$)

Table 2. Density of mobile specimens of the hawthorn spider mite (*Tetranychus viennensis*) on the lower leaf surface in studied apple-tree genotypes (2003 and 2004)

Sampling Date	Novamac	Primula	U 211	Witos
03.07.03	0.1±0.2	0	0.1±0.1	0.1±0.1
14.07.03	0.3±0.3	0.4±0.4	0.7±0.5	0.6±0.8
28.07.03	0.3±0.2	0.3±0.2	0.3±0.3	0.5±0.4
21.08.03	0.4±0.2	0.3±0.2	0.8±0.5	0.4±0.2
Mean in 2003	0.28	0.25	0.48	0.4
22.06.04	0	0	0.4±0.4	0.3±0.4
05.07.04	0.1±0.2	0	0.3±0.5	0.3±0.3
26.07.04	0	0	0	0
16.08.04	0	0	0	0
Mean in 2004	0.03	0	0.18	0.15

Data are means (N=80) ± standard deviation. No significant differences within rows were detected by Kruskal-Wallis test.

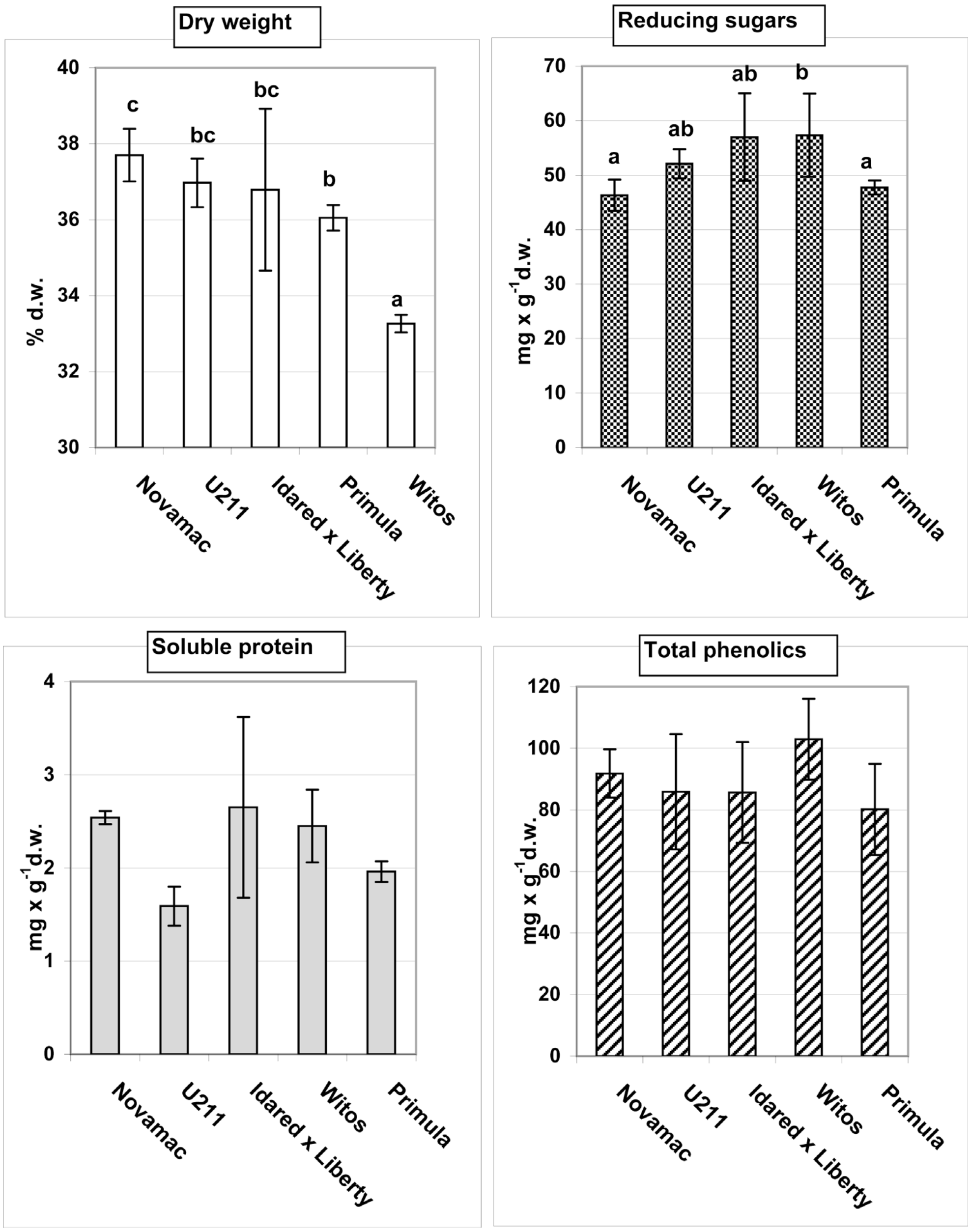

Fig. 2. Biochemical composition of leaves of various apple-tree genotypes. Data are means (N=3) ± SD. Different letters indicate significant differences (Kruskal-Wallis test, P<0.05)

Table 3. Density of *Panonychus ulmi* and *Tetranychus viennensis* eggs on the lower leaf surface of apple-tree genotypes

Genotype	*Panonychus ulmi* 2003	*Panonychus ulmi* 2004	*Tetranychus viennensis* 2003	*Tetranychus viennensis* 2004
Novamac	2.63±0.96 a	4.15±0.95 b	1.35±0.7 a	0.3±0.57 b
Primula	1.03±0.4 a	1.17±0.57 a	1.55±0.5 a	0.02±0.01 a
U 211	1.98±1.72 a	1.72±0.62 ab	1.95±0.87 a	1.25±0.5 b
Witos	2.63±0.55 a	1.65±0.55 ab	1.80±1.0 a	0.37±0.7 b
Idared × Liberty	45.9±8.1 b	0	0	0
Kruskal-Wallis test	H=9.425 *P*=0.043	H=7.882 *P*=0.0485	H=1.099 *P*=0.777	H=8.619 *P*=0.0348

Data are means (for 4 sampling dates; N=320) ± standard deviation. Different letters within columns indicate significant differences (Kruskal-Wallis test, $P<0.05$)

DISCUSSION

Our findings showed that spider mites occurred on all tested scab V_f-resistant apple-tree genotypes, but their abundance varied. The European spider mite preferred to feed and lay eggs on cv. Novamac, while clone U 211 was chosen by the hawthorn spider mite. Of the scab-resistant genotypes with V_f-resistance, only cv. Primula was characterized by a low susceptibility to both spider mite species. Similar results were obtained by FISHER & FISHER (2004), who tested 11 Re-cultivars® with the V_f gene and found that only 3 of them are resistant to *T. urticae* and *P. ulmi*. KOZŁOWSKI (1998) demonstrated the lowest fecundity and highest mortality of another microarthropod species, the apple rust mite (*Aculus schlechtendali* Nalepa), on cv. Primula. While comparing the population parameters of two-spotted spider mite and hawthorn spider mite on 12 cultivars of scab-resistant apple-trees, SKORUPSKA (2003) found that both mite species developed best on cultivars Novamac and Freedom and worst on Primula and Pionier.

It is evident from the data presented that in two-species communities, *P. ulmi* was the dominant species, which corresponds with the data reported by LENORT et al. (2005). On the other hand, *P. ulmi* did not prevail over other mite species in other studied communities (HABEKUSS et al. 2000, SKORUPSKA 2003). The lower number of hawthorn spider mites observed in 2004 than in 2003 was probably due to weather conditions. It must be stressed that the number of spider mites on the genotypes of scab V_f-resistant apple-trees in both seasons was not high. Only on Idared × Liberty seedlings the number of mobile stages of mites in the summer months in 2003 was close to the value described as being able to cause serious damage to the crop. It was surprising that a relatively high number of mites was recorded on ungrafted apple trees, located in the selection breeding plot, where the application of chemical pesticides was rare. It seems that the high number of mites on Idared × Liberty trees was probably a result of lambda-cyhalotriene (Karate Zeon 050 CS) treatment against the apple blossom weevil (*Anthonomus pomorum* L.). During 2 years of our study, this pyrethroid was applied once on both experimental tree plots on 15 April 2003.

The deficit in the level of some primary metabolites (significant in the mite diet) and/or the excess of some unpalatable secondary metabolites (e.g. some phenolics) can reduce the food uptake by mites and thus play a role in plant resistance to mite pests (DĄBROWSKI 1988, TOMCZYK 1989, KIEŁKIEWICZ 2003). Several studies showed the effect of a high level of phenolic compounds in the leaves of various apple cultivars on the reduction of the value of spider mite population parameters or the rate of population development (BIELAK 1979, SKORUPSKA 2003). Most of the investigated here apple-trees were inhabited with various densities of spider mites but did not differ significantly in the concentration of primary metabolites (soluble protein, reducing sugars) or total phenolic compounds in leaves. However, the concentration of flavonoids in the scab V_f-resistant apple leaves showed significant differences between genotypes (data not presented). The relative importance of these differences for mite feeding preference should be evaluated in future experiments.

In conclusion, our data on feeding preferences and abundance of mites indicate that the apple genotypes that carry the V_f gene of resistance differ in spider-mite susceptibility. Therefore, further studies will be necessary to explain the mechanism of resistance to mite-pests in the scab V_f -resistant apple genotypes.

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Associate editor: ANNA SKORACKA