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Influence of leaf pubescence on the behavior of the two-spotted spider mite (*Tetranychus urticae*) and the European red mite *(Panonychus ulmi)*

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Summary

Movement behavior of two mite species: two-spotted spider mite (*Tetranychus urticae*) and European red mite (*Panonychus ulmi*) on leaves of some apple cultivars (´Greensleeves´, ´Spartan´ and SA 455-2 selection) with different density of pubescence was analysed. Assessment of the leaf pubescence density was performed using an originally developed quick method based on digital pubescence image analysis. For *P. ulmi*, both stop time and average speed did not depend on kind of leaf. In contrary, *T. urticae* revealed higher movement activity on slight pubescent leaves compared to leaves with high leaf hair density.

Key words: two-spotted spider mite; European red mite; pubescence; apple tree

INTRODUCTION

Panonychus ulmi is a serious pest in apple orchards. In some years, especially during dry and hot summers, *Tetranychus urticae* may also create problems in orchards. There are differences in the levels of mite infestation of apple varieties in field conditions. It may be caused by several factors. One of them is the biochemical characteristics of the leaf tissue, which are responsible for the mechanism of antibiosis (Bielak, 1979). Morphological and anatomical traits of leaves may also influence the population development of mites. Some authors have tried to find a correlation between leaf pubescence and mite population size (Goonewardene et al., 1976, Paiva and Janick, 1980).

In our study we focused on the movement behaviour of the mites on leaves with different densities of leaf hairs.

MATERIAL AND METHODS

Leaves from three kinds of apple varieties were used in this experiment: the cultivar ´Greensleeves´ with very few hairs, ´Spartan´ with medium leaf hair density and the selection SA455-2 with high leaf hair density.

Measurement of leaf pubescence

Six leaves were selected randomly from clusters of each apple cultivar. Under a stereo microscope, 25 mm^2 (5mm x 5mm) was removed from the middle part of the leaf blade and the number of hairs was counted. The length of ten of the hairs was measured using the Inchworm V 2.1 computer program. („Inchworm V 2.1" a computer/video measurement package; Varley et al., 1994).

From a neighbouring part of the leaf, all hair were removed using sticky transparent tape. The tape was put onto a black surface and illuminated to show the white hairs and the black background (Fig. 1.). A picture was produced (magnification 50 x), using a digital camera and analysed with application of Lucia G (Laboratory Imaging Ltd) computer program (Psenner, 1993). The density of leaf hairs was defined as the proportion of the image covered by the hairs.

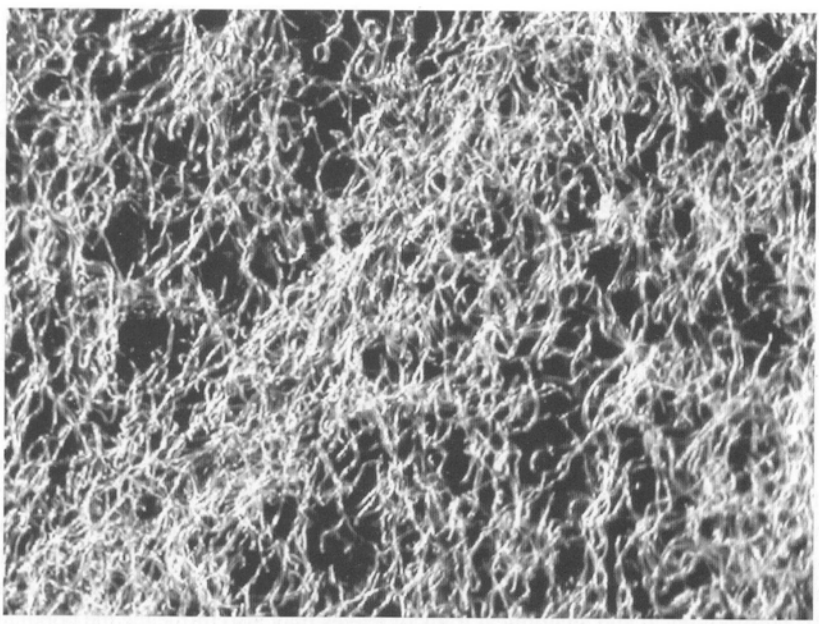


Fig. 1. Hairs from lower epidermis of leave removed using sticky transparent tape for digital image analysis

To compare the two methods of evaluating density of leaf hairs, a nonlinear regression analysis was made. The total length of hairs was set as independent variable whereas the proportion of area covered by hairs as dependent one.

The three mentioned apple cultivars were compared for leaf pubescence. Data from the digital image analysis were worked out by ANOVA procedure. For comparing means, Duncan's multiple range t-test was used.

Activity of mites on leaves of contrasting leaf hair density

The research was conducted on the cultivar 'Greensleeves' and selection SA455-2. One female of *T. urticae* and *P. ulmi* were placed on a rectangular segment of leaf (12mm x 9mm). Using a video camera and the Inchworm computer program, recordings of movement were made. The mite was regarded as stationary if no movement was recorded for a period greater than one second. The program computed the instantaneous speed of the mite, the average speed, and its stop time. The time of recording for each pair of mites was 1 hour (12 five-minute sections). The experiment was replicated six times. Data were analysed using ANOVA procedure. Duncan's multiple range t-tests was used for comparing means.

RESULTS

Measurement of leaf pubescence

A comparison of the two methods of determining leaf pubescence showed a high degree of conformity between proportion of the leaf area covered by hairs and the total length of hairs (Table 1).

Table 1
Leave pubescence of selected apple varieties

Cultivar	Density of leaf pubescene (Proportion of the leaf surface covered by hairs)	No. of hairs per 25 [mm²]	Average length of hairs [mm]	Total length of hairs [mm]
'Greensleeves'	0.096±0.034 a	72±20.76 a	1.19±0.086 a	93.36±29.11 a
'Spartan'	0.289±0.031 b	238±30.51 b	1.38±0.044 ab	329.41±41.10 b
SA 455-2	0.543±0.021 c	633±35.79 c	1.61±0.096 b	1017.03±79.55 c

Means ± SE followed by the same letter are not significantly different ($P<0.05$; Duncan's multiple range t-test)

The regression analysis confirmed the accordance of the methods. However, at high level of hair density the relationship becomes less linear, as increasing proportion of hair overlap (Fig. 2). Because the digital image analysis method is relatively simple and rapid, compared to the traditional method of measuring leaf pubescence, it seems to be a very useful tool in similar studies.

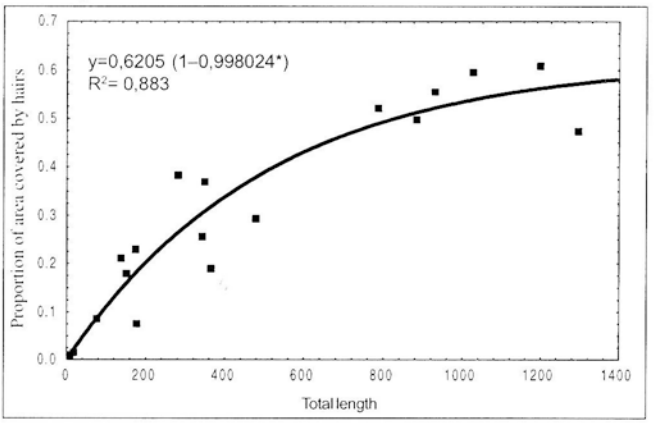
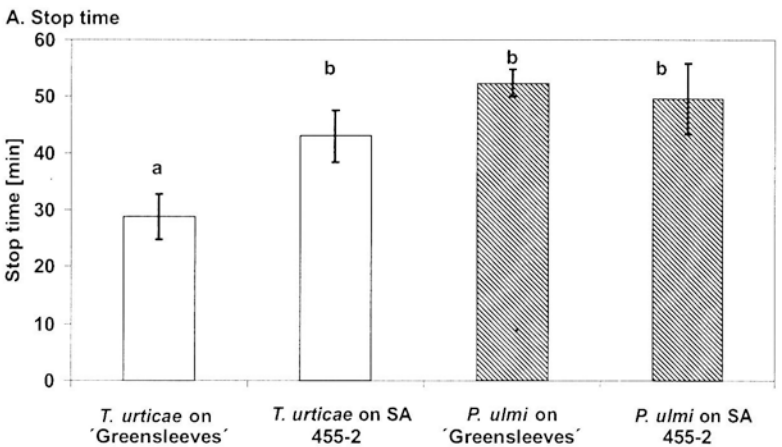


Fig. 2. Regression equation relating proportion of area covered by hairs (y) to total length of hairs (×)

Activity of mites on leaves with different leaf hair density

Research on the influence of the leaf hairs density on mite movement behavior, showed that there were differences between *P. ulmi* and *T. urticae*.

P. ulmi was less active compared to *T. urticae* on the leaves from cultivars ´Greensleeves´ and SA455-2. The hairiness of the leaves did not affect the movement behaviour of this mite. *T. urticae* showed a significantly lower movement activity on the leaves with high density of leaf hairs (SA 455-2) (Fig. 3 A.). The average speed of this mite was higher on leaves from the cultivar ´Greensleeves´ (Fig. 3 B.).



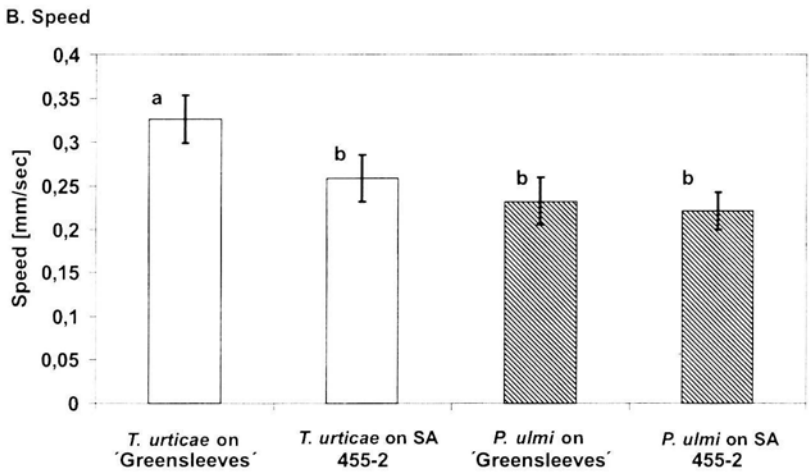


Fig. 3. Movement behavior of *T. urticae* and *P. ulmi* on selected apple cultivars (A – Stop time, B – Speed). Means ± SE followed by the same letter are not significantly different (P<0.05; Duncan's multiple range t-test)

DISCUSSION

The speed of the movement of *T. urticae* was probably influenced by leaf pubescence. It is more complicated for stop time interpretation. Females of *T. urticae* may spend more time feeding on leaves SA 455-2 selection, because they preferred heavy pubescence. However it is possible that behaviour of this mite was influenced by biochemical composition or anato-morphological structure of leaves. At all events *T. urticae* seems to be more active than *P. ulmi* both seeking of oviposition and feeding places. It is possible that this is one of the reasons for wider host plants range of two-spotted spider mite.

Opinions on the influence of leaf pubescence on development of mite populations are divergent. Bengston (1970) observed more *T. urticae* on the apple cultivar 'Delicious' (relatively hairless leaves), compared to 'Spartan' and 'McIntosh' (strong pubescence). Warabieda et al., (1997) found significantly more mites of this species on cultivars with heavily pubescent leaves compared to cultivars with less leaf hair density. Goonewardene (1976) stated that apple selections with an abundance of hair were more infested with *P. ulmi* than selections with few hairs. On the contrary, Bielak (1979) has found that the cultivar 'Jonathan' (heavy pubescence) was more resistant to *P. ulmi* infestation, as compared to cultivars with a lower density of hairs. Leaves of this cultivar had higher level of phenolic compounds and this could have influenced the population size of the mites. Downing and Moilliet (1967) observed more *P. ulmi* on the cultivar 'Delicious' (low pubescence) then on 'McIntosh' and 'Spartan' (heavy pubescence). At the same time on the cultivar 'Delicious' they found fewer predacious phytoseiid mites (*Metaseiulus occidentalis* and *Neoseiulus caudiglans*) than on 'Spartan' and 'McIntosh'.

Some authors emphasise the positive role of leaf domatia on the lower surface of leaves. These structures, such as tufts of hairs in the vein axils seem to provide refuges for predatory arthropods (Walter and O'Dowd, 1992). Mites benefit from leaf domatia by improving microclimate and creating a safe place for ovipositing (Walter, 1996). Most of the authors are of the opinion that leaf domatia contribute to an increase in numbers of predatory mites and in consequence – to reduction of phytophagous mites. However, any benefits resulting from pubescence on the leaf surface are likely to apply to phytophagous mites as well on predators. This may be one of the reasons that some experiments do not support the thesis about influence of leaf pubescence on reduction of pest infestation. In our opinion plants with pubescent leaves will be less infested by pest mites if the surroundings are rich with predatory species. From a practical point of view, it is very important to create conditions for an increase in biodiversity.

These results show that the reasons for the greater abundance of mites on different host plants are complicated. Success of development of mite populations is related to several factors and pubescence is only one of them.

In our opinion, however, the study on the moving behaviour of mites may be helpful in determining the role of the leaf pubescence in host-plants and prey-predator relationships.

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Wpływ kutnera liścia na zachowanie przędziorka chmielowca (*Tetranychus urticae*) i przędziorka owocowca (*Panonychus ulmi*)

Streszczenie

Celem pracy była analiza zachowania dwóch gatunków przędziorków: przędziorka chmielowca (*Tetranychus urticae*) oraz przędziorka owocowca (*Panonychus ulmi*) na liściach jabłoni różniących się gęstością kutnera. Badania przeprowadzono na odmianach: 'Greensleeves' charakteryzującej się słabym kutnerem liścia i 'Spartan' o średnio gęstym kutnerze oraz na siewce SA455-2, której liście posiadają gęsty kutner. Dla przędziorka owocowca, wielkość badanych parametrów ruchu takich jak: szybkość przemieszczania się oraz czas pozostawania w jednym miejscu, nie była uzależniona od rodzaju liścia. W przypadku przędziorka chmielowca, stwierdzona została większa aktywność ruchowa i szybkość przemieszczania się na liściach odmiany o słabej gęstości kutnera. Analiza gęstości kutnera liści jabłoni, przeprowadzona została z wykorzystaniem własnej, szybkiej metody bazującej na cyfrowej analizie obrazu.