JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 42, No. 2 (2002)

COMPARISON OF HARMFULNESS OF THE TWO-SPOTTED SPIDER MITE *TETRANYCHUS URTICAE* KOCH AND THE CARMINE SPIDER MITE *TETRANYCHUS CINNABARINUS* (BOISDUVAL) ON GREENHOUSE GROWN CUCUMBER

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Accepted: April 2, 2002

Abstract: Experiment was conducted twice: in spring of 1999 and 2000. Two greenhouse cucumber varieties (Aramis and Corona) with different susceptibility to spider mites were employed to compare the harmfulness of the two-spotted spider mite and the carmine spider mite. Effects of the two-spotted spider mite and the carmine spider mite feeding either on the fruit production or on the content of some organic compounds were measured. Moreover, development of spatially separated populations of the two-spotted spider mite and the carmine spider mite was analysed. Two abiotic parameters were taken into account: temperature and sunlight duration. Increment of the carmine spider mite population density was faster during the season of higher temperature and sunlight duration (spring of 2000). Differences in the development of two-spotted spider mite were not observed. The increase of fruit weight was closely correlated with increase of density of spider mites. The feeding of relatively low populations of the carmine spider mite (up to 5–7 mobile stages per leaf) stimulated the weight increase of fruits collected from Aramis and Corona varieties. The feeding of two-spotted spider mite and the carmine spider mite affected the distribution of organic compounds produced in plants. In quite severely infested leaves (2–3 damage level of De Ponti scale) total amount of sugars and phenolic compounds increased as compared to control leaves.

Key words: *Tetranychus urticae*, two-spotted spider mite, *Tetranychus cinnabarinus*, carmine spider mite, cucumber, harmfulness, populations, sugars, reducing sugars, phenolic compounds

INTRODUCTION

The two-spotted spider mite and the carmine spider mite are very common pests of cucumbers cultivated in greenhouses. In 1990 the carmine spider mite was classified as a novel pest in greenhouses in Poland (Kiełkiewicz et al. 1990), while two-spotted spider mite was indigenous species (Boczek 1995).

Under similar conditions, the development of the carmine spider mite is faster than of the two-spotted spider mite (Witul and Kiełkiewicz 1990). Feeding of spider mites affects physiological processes of host plants, particularly low-density populations stimulate growth and fruit production. An intensive growth reflects in number of formed fruits and in yield increment (Tomczyk et al. 1987). An acceleration of physiological processes is the effect of feeding of low density of spider mites' populations in relatively long time, or medium density spider mites' populations in relatively short time (Tomczyk et al. 1989). In some cases, uninfested parts of the plant react as being influenced by noxious mites (Tomczyk 1981). Presence of pests on the plant induces changes, which compensate feeding-inflicted losses on infested parts of plant. Differences between varieties were observed (Tomczyk and Kiełkiewicz 1998). Reaction of the plant is expressed not only by means of synthesis of new compounds, but also in the alternation of proportions of the present compounds (Kołodziej 1977; Tomczyk 1989). According to Kołodziej (1977), feeding of spider mites changes the proportions in primary products of photosynthesis. While low-density population causes small damages, rapid metabolism of sugars is observed and starch is deposited. However, deposition of soluble sugars and amino acids is restrained. In subsequent period of spider mites' feeding, the increase of carbon incorporation to starch and concentration of soluble amino acids and sugars is observed. It is called "pest-directed metabolism". Most often, the amount of sugars in leaves of pest-damaged plants decreases and the concentration of phenolic compounds increases. It was interpreted as the plant's defence reaction, because these changes were unfavourable for pest survival (Tomczyk 1989).

The objective of this study was to examine the effects of feeding on the host plant of spatially separated carmine spider mite and two-spotted spider mite populations. It comprised changes in fruit production and concentrations of some organic compounds (sugars and phenols). Influence of abiotic factors (temperature and sunlight duration) on population development was determined as well.

MATERIALS AND METHODS

Experiments were conducted in a greenhouse of the Warsaw Agricultural University between April and June of 1999 and 2000. The two-spotted spider mite and the carmine spider mite were reared at the laboratory of Department of Applied Entomology, with exception of the two-spotted spider mite in spring of 2000. Some of individuals were obtained from the laboratory of Institute of Organic Industry, Warsaw. Two varieties of cucumber were used as the host plants: Aramis (limited susceptibility to spider mite infestation) and Corona (susceptible to spider mite infestation). The following treatments were set up:

– control (without spider mites): 14 plants – 7 Aramis, 7 Corona

– infested (with two-spotted spider mite): 14 plants – 7 Aramis, 7 Corona
– infested (with carmine spider mite): 14 plants – 7 Aramis, 7 Corona

Plants infested with the two-spotted spider mite and the carmine spider mite were cultivated in the same chamber, but on separated tables. Additionally, there were tomato plants in between in order to preclude mixing up of populations. Control plants were cultivated in a separate chamber.

Five days after planting of seedlings 15 mature females (5 per leaf) were placed onto leaves. Mobile stages of spider mites were counted every week. Afterwards, obtained data were summed and divided by the number of plants in combination to obtain a mean number of mobile stages of spider mites.

On every 4–5 days (except of first 3 weeks after planting), fruits from each plant were collected and their weight and number were assessed. Obtained data were processed as described above.

In the 2000 season, 7 weeks after planting, 6 leaves (of 2–3 damage index in De Ponti scale, De Ponti 1978) from each combination (5 leaves of Aramis, 5 leaves of Corona) were collected and subsequently frozen. Afterwards, they were used for analyses of sugar, reducing sugar and phenol contents.

Spider mite populations' density

Number of mobile stages of spider mites was estimated using a lance dissection microscope. Each leaf on each plant was inspected. Meteorological data were obtained from the Institute of Meteorology and Water Economy, Warsaw.

Spider mites feeding versus fruit production

Since the youngest fruits had become ripe they were collected (respectively from each plant) 2–3 times per week (only fruits of weight approx. >150g), subsequently they were counted and weighted.

Spider mites feeding versus alternations of some organic compounds

To estimate content of some organic compounds, leaf samples (small fragments of leaf blade) of average weight 0.2–0.5 g were ground in a mortar with distilled water or, for analyses concerning phenols, with 80% methanol. Homogenates were centrifuged (15 min, 10,000 rpm) and subsequently diluted with distilled water or 80% methanol, respectively.

Total content of soluble sugars was determined using the anthrone method (Homolka 1961). Content of reducing sugars was determined using the Nelson method (Nelson 1944). Analysis of reducing sugars was repeated in undiluted solution, because of extremely low values (incompatible with standard curve) in diluted extracts. Standard curve was prepared for glucose. For determination of phenolic compounds content, solution was diluted and Folin's reagent was added (Johnson and Schaal 1957). Standard curve was prepared for chlorogenic acid.

RESULTS AND DISCUSSION

Spider mite populations' density

Figure 1 shows the fluctuations in air temperature during the spring of 1999 and 2000. An average air temperature in seasons mentioned above was compared to the

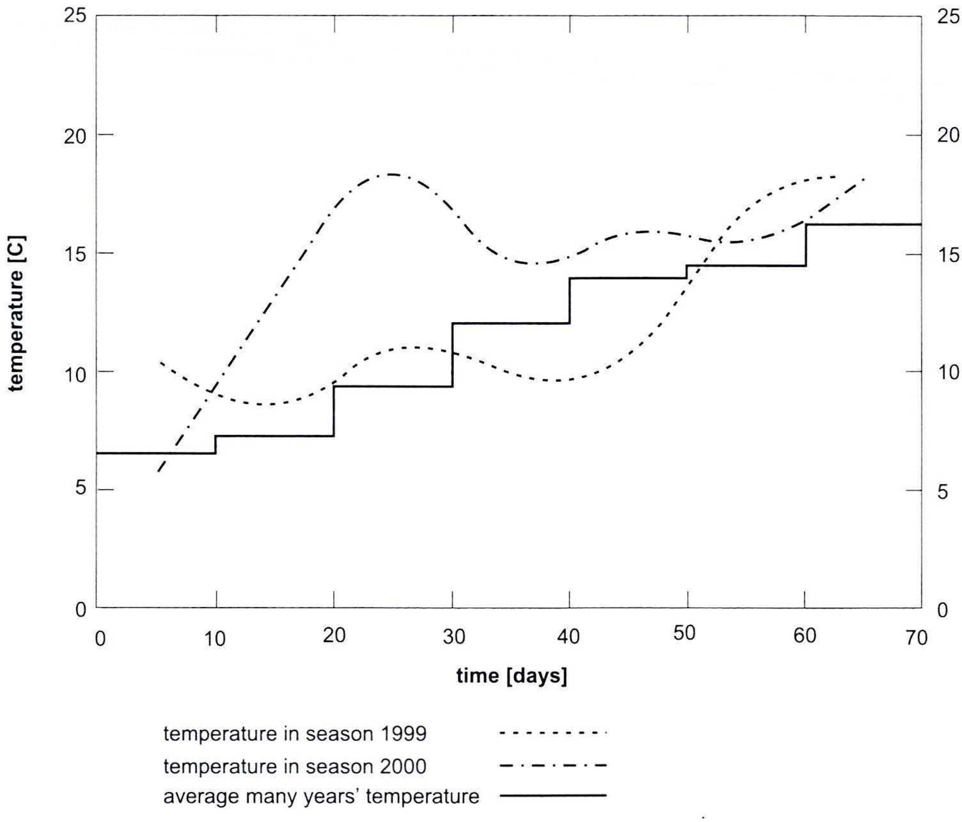

Fig. 1. Air temperature from the beginning of the first decade of April to the end of the first decade of June 1999 and 2000

average many years' temperature. In spring of 1999 air temperature was relatively low, on the contrary, the spring of 2000 was warm, in several periods even very warm.

Figure 2 shows fluctuations in duration of direct sunlight in spring of 1999 and 2000. In spring of 1999 abrupt changes in sunlight duration were noted, in spring of 2000 insignificant fluctuations in average sunlight duration were observed.

A raise of population density of the two-spotted spider mite and the carmine spider mite were different in 1999 and 2000 seasons, respectively (Figs. 3, 4). Temperature requirements for both species are diverse. Düzgünes and Cobanoglu (1983) proved that females of the two-spotted spider mite have the highest fecundity at 24°C, while the carmine spider mite lays the largest number of eggs per female at 30°C. The two-spotted spider mite is cosmopolitan species (Boczek 1995), the carmine spider mite is familiar to the subtropical zones (Dupont 1979). It was supposed, that air temperature was optimal for the carmine spider mite during warm spring of 2000, thus population density rose up to the limitations of the physiological barriers.

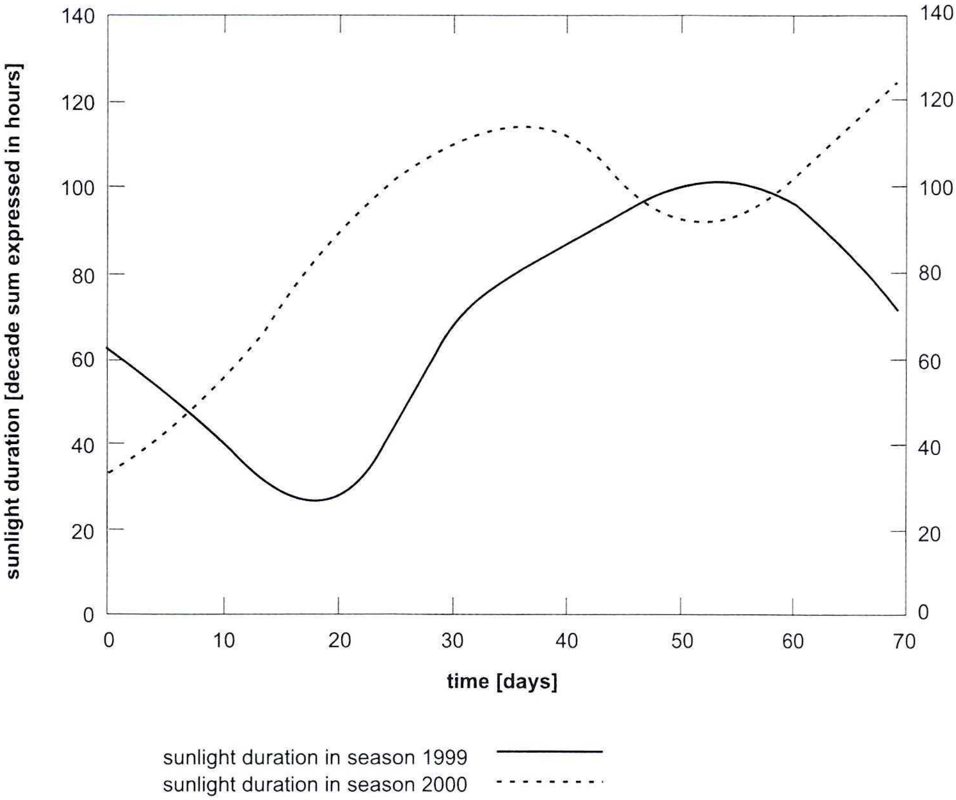

Fig. 2. Sunlight duration from the beginning of first decade of April to the end of the first decade of June 1999 and 2000

During the season of 1999 (relatively low temperature and sunlight duration) the population of the carmine spider mite was denser on variety Corona than on Aramis, in contrast to the season of 2000. The preference for Aramis in spring of 2000 resulted from temperature requirements of the carmine spider mite: Aramis plants are known for their loose structure and high growth rate. Thus direct sunlight readily reaches leaves surface. As a consequence, temperature of leaf blades rises.

Spider mites feeding versus fruit production

In the 1999 season, the largest weight of fruits was obtained from plants infested with the carmine spider mite (from cv. Aramis more than from cv. Corona – Fig. 5). In the 2000 season the largest weight of fruits was obtained from plants in the control combination (Fig. 6).

Because of meteorological circumstances during the 1999 season, population of the carmine spider mite developed much slower (and finally reached lower density) than during the 2000 season. Probably, the carmine spider mite populations of low density (approx. up to 5–7 mobile stages per leaf) stimulate the fruit production of

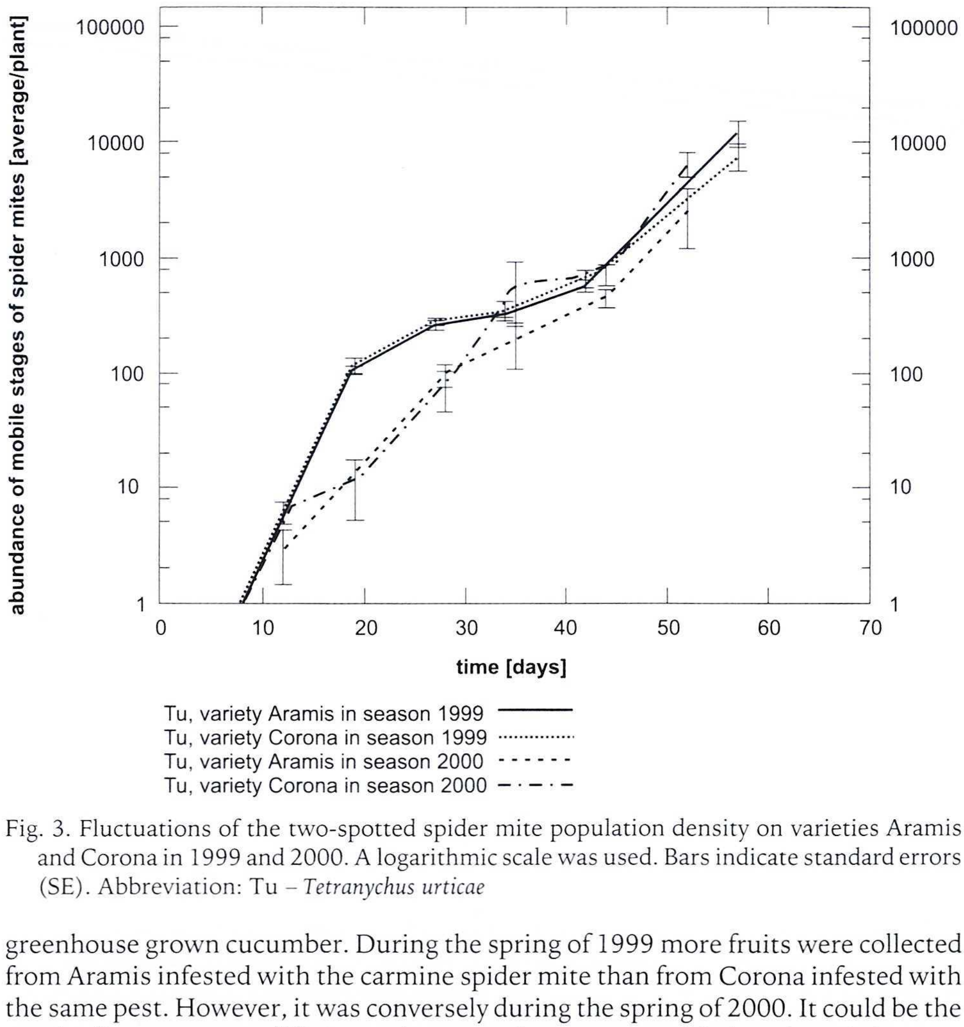

Fig. 3. Fluctuations of the two-spotted spider mite population density on varieties Aramis and Corona in 1999 and 2000. A logarithmic scale was used. Bars indicate standard errors (SE). Abbreviation: Tu – *Tetranychus urticae*

greenhouse grown cucumber. During the spring of 1999 more fruits were collected from Aramis infested with the carmine spider mite than from Corona infested with the same pest. However, it was conversely during the spring of 2000. It could be the result of temperature differences between these seasons. Variety Aramis is more sensitive to high temperatures than Corona (temp. over 30°C causes wilting and decreases photosynthesis intensity), that is why very warm spring of 2000 could considerably inhibit productivity of Aramis plants.

Spider mites feeding versus alternations of some organic compounds

In the 2000 season the effect of the two-spotted spider mite and the carmine spider mite feeding on content of sugars (total and reducing) and phenolic compounds in leaves was examined.

Generally, except of combination with the carmine spider mite on Aramis, the content of total sugars increased in infested plants (Fig. 7). It indicates that spider mites change plant's metabolism to its own profit while their population reaches high density. According to Kołodziej (1977), long lasting feeding may lead to depositing of assimilation products. It is a consequence of inhibited transport from

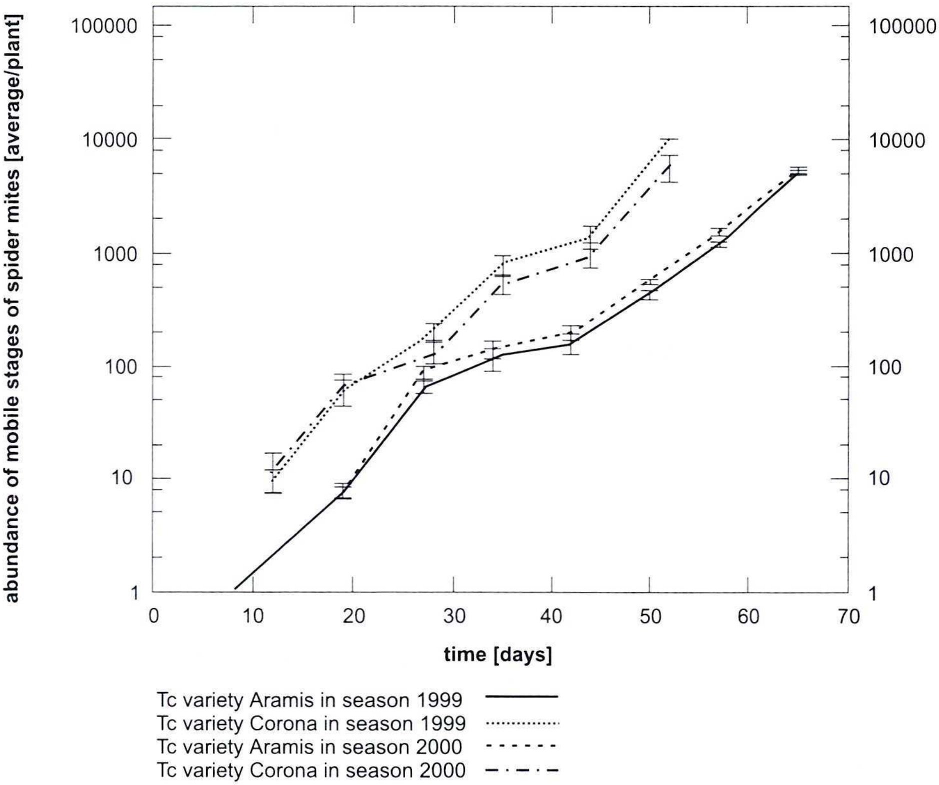

Fig. 4. Fluctuations of the carmine spider mite population density on varieties Aramis and Corona in 1999 and 2000. A logarithmic scale was used. Bars indicate standard errors (SE). Abbreviation: Tc – *Tetranychus cinnabarinus*

leaves to other plant's organs. Tomczyk (1987) suggests, that a decrease of soluble sugars content is a defensive reaction of the plant. It has to be taken into account, however, that leaves collected for analyses were severely damaged by spider mites.

In case of reducing sugars, their amount was higher in the infested leaves of cv. Corona (irrespectively of spider mites species – Fig. 8). According to Kołodziej (1977) the decrease of carbon incorporation to the starch is the effect of long lasting feeding and subsequently it increases content of soluble sugars (reducing sugars amongst the others). On the contrary, the content of reducing sugars in Aramis variety was always lower for infested plants, regardless of the spider mite species. It was probably the effect of more intensive transport of reducing sugars to fruits and young leaves.

In case of phenolic compounds, feeding of the carmine spider mite and the two-spotted spider mite increased their content in damaged leaves as compared to control (except of combination: the two-spotted spider mite on Corona, Fig. 9). Kołodziej (1977) claims, that phenolic compounds are deposited in plants during spider mites feeding.

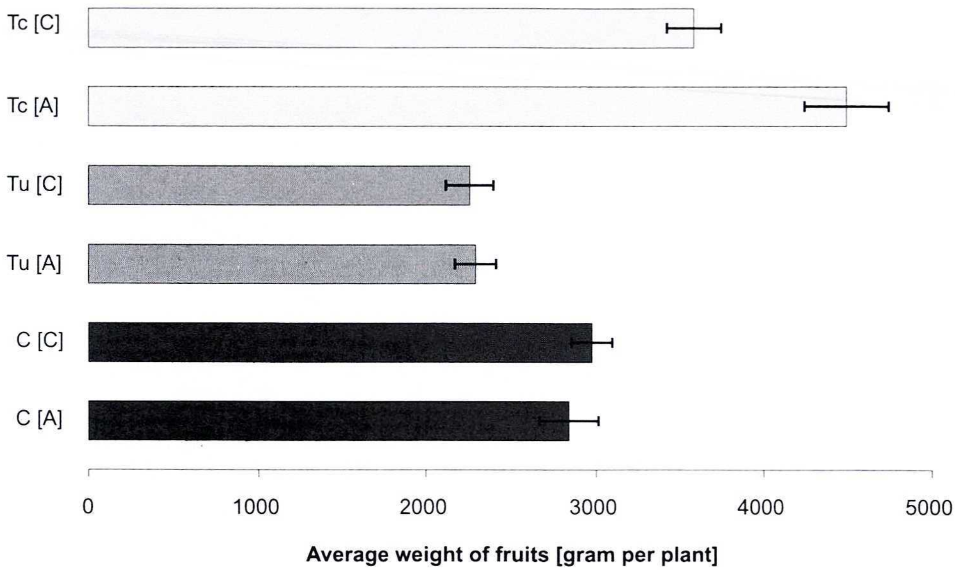

Fig. 5. Average weight of fruits [g] collected during first 8 weeks of yielding per each combination (1999). Bars indicate standard errors (SE). Abbreviations: C – control; Tu – *Tetranychus urticae*; Tc – *Tetranychus cinnabarinus*; [A] – Aramis; [C] – Corona

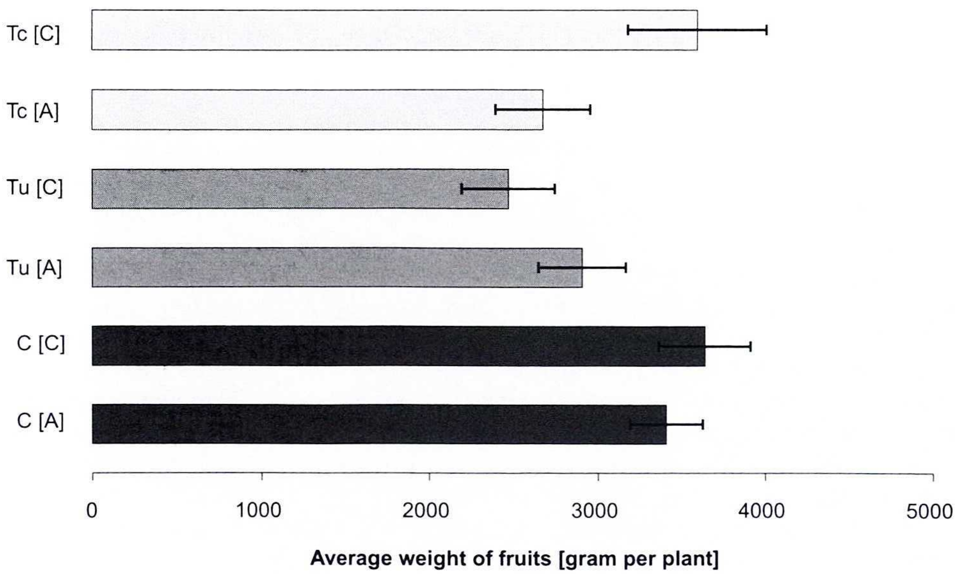

Fig. 6. Average weight of fruits [g] collected during first 7 weeks of yielding per each combination (2000). Bars indicate standard errors (SE). Abbreviations: C – control; Tu – *Tetranychus urticae*; Tc – *Tetranychus cinnabarinus*; [A] – Aramis; [C] – Corona

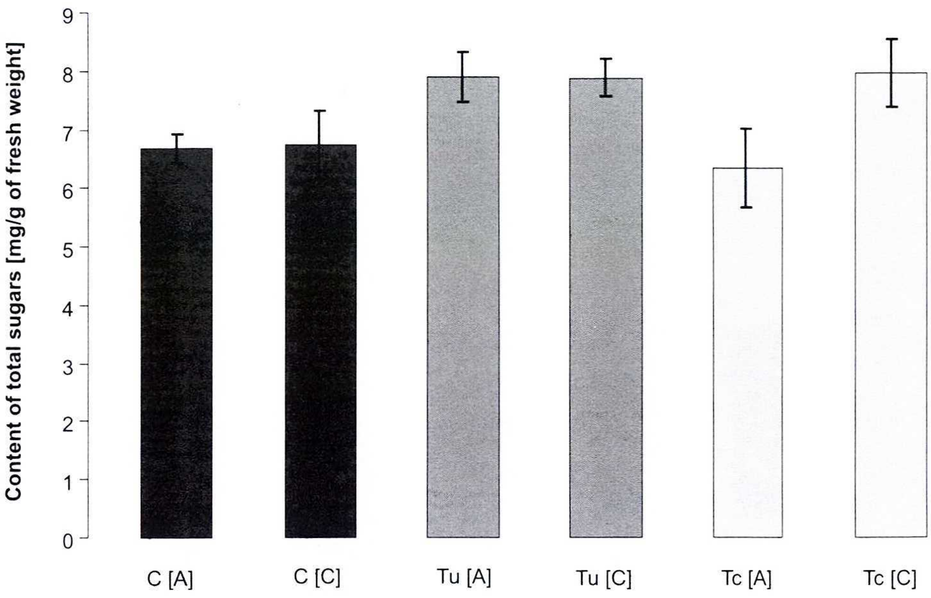

Fig. 7. Content of total sugars [mg per gram of fresh weight]. Bars indicate standard errors (SE). Abbreviations: C – control; Tu – *Tetranychus urticae*; Tc – *Tetranychus cinnabarinus*; [A] – Aramis; [C] – Corona

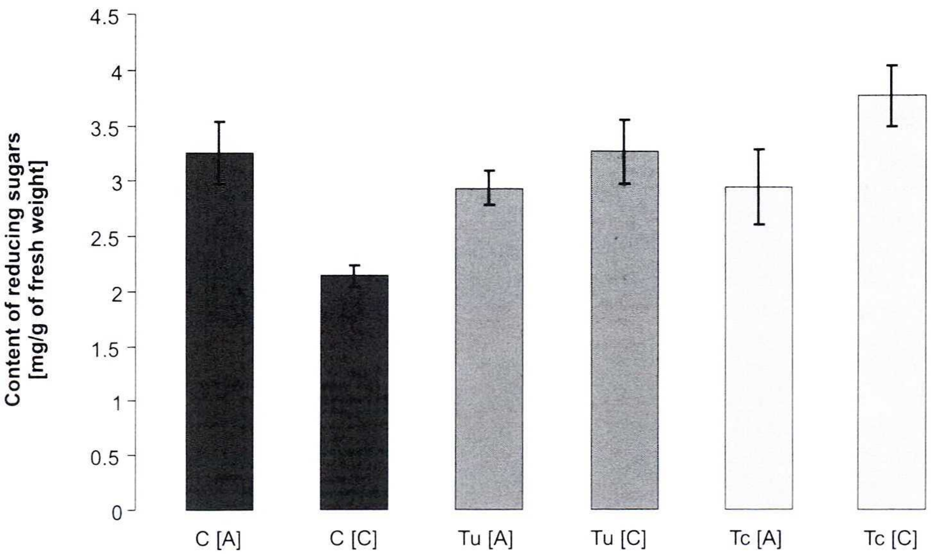

Fig. 8. Content of reducing sugars [mg per gram of fresh weight]. Bars indicate standard errors (SE). Abbreviations: C – control; Tu – *Tetranychus urticae*; Tc – *Tetranychus cinnabarinus*; [A] – Aramis; [C] – Corona

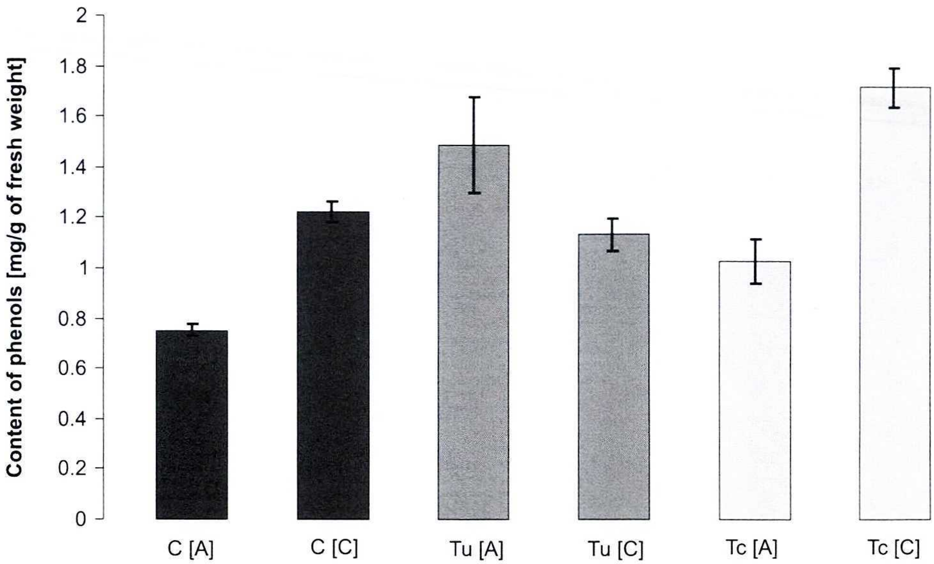

Fig. 9. Content of phenols [mg per gram of fresh weight]. Bars indicate standard errors (SE). Abbreviations: C – control; Tu – *Tetranychus urticae*; Tc – *Tetranychus cinnabarinus*; [A] – Aramis; [C] – Corona

Generally, one may conclude, that spider mite feeding can influence the distribution of organic compounds in the plant. However, differences between contents of soluble sugars and phenolic compounds in leaves of plants infested with the two-spotted spider mite and the carmine spider mite were not revealed.

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POLISH SUMMARY

PORÓWNANIE SZKODLIWOŚCI PRZĘDZIORKA CHMIELOWCA *TETRANYCHUS URTICAE* KOCH I PRZĘDZIORKA SZKLARNIOWCA *TETRANYCHUS CINNABARINUS* (BOISDUVAL) NA OGÓRKU SZKLARNIOWYM

Eksperyment został przeprowadzony dwukrotnie: w 1999 i w 2000 roku. Użyto dwóch odmian ogórka szklarniowego (Aramis i Corona) różniących się podatnością na przędziorki. Jako miarę szkodliwości przędziorków wzięto pod uwagę: wpływ żerowania przędziorka chmielowca i przędziorka szklarniowca na owocowanie oraz na zawartość wybranych substancji organicznych. Prześledzono także rozwój odseparowanych przestrzennie populacji obu badanych gatunków przędziorków z uwzględnieniem wpływu wybranych czynników abiotycznych (temperatura i usłonecznienie). Zauważono, że przyrost zagęszczenia populacji przędziorka szklarniowca był intensywniejszy podczas sezonu o wyższej temperaturze i usłonecznieniu. W przypadku przędziorka chmielowca nie zauważono korelacji pomiędzy rozwojem populacji a zmieniającymi się warunkami abiotycznymi. Przyrost masy owoców był ściśle związany z tempem rozwoju szkodnika. Zauważono, że żerowanie relatywnie małych populacji przędziorka szklarniowca (do 5–7 stadiów ruchomych na liść) stymulowało przyrost masy owoców na odmianach Aramis i Corona. Żerowanie prędziorka chmielowca i przędziorka szklarniowca wpłynęło na dystrybucję substancji organicznych produkowanych przez badane rośliny. W dość silnie porażonych liściach (2–3 w skali De Pontiego) zwiększyła się zawartość cukrów ogólnych i fenoli.