Factors affecting the attack rate of *Bemisia tabaci* on cucumber

Germano Leão Demolin Leite[1], Marcelo Picanço[2], Raul Narciso Carvalho Guedes[2] and Carvalho Carlos Ecole[2]

[1]Universidade Federal de Minas Gerais, Núcleo de Ciências Agrárias, Dep. de Agropecuária, Caixa Postal 135, CEP 39404-006 Montes Claros, MG. E-mail: gldleite@ufmg.br [2]Universidade Federal de Viçosa, Dep. de Biologia Animal, CEP 36571-000 Viçosa, MG. E-mail: picanco@ufv.br, guedes@ufv.br

Abstract – The objective of this work was to determine the effects of rainfall, temperature, predators, parasitoids, plant age, leaf chemical composition, levels of leaf nitrogen and potassium, besides density of leaf trichomes, on attack intensity of *Bemisia tabaci* biotype B on the *Cucumis sativus*. An increase in the number of whitefly adults and nymphs per leaf was observed with plant aging. A higher number of whitefly adults per leaf and eggs cm^{-2} was verified in the apical part than in the middle and bottom part of the plants canopy. However, the higher number of whitefly nymphs was observed in the mid-part than in the apical and bottom part of the plant canopy. The incidence of whitefly nymphs was negatively affected with foliar nitrogen. Pentacosane and octacosane positively affected whitefly adults and the first compound also affected the nymphs of this pest species.

Index terms: *Cucumis sativus*, whitefly, allelochemicals, nitrogen, trichomes.

Fatores que afetam o ataque de *Bemisia tabaci* em pepino

Resumo – O objetivo deste trabalho foi determinar os efeitos de pluviosidade, temperatura, predadores, parasitóides, idade de planta, composição química foliar, níveis de nitrogênio e potássio foliares, assim como de densidade de tricomas, na intensidade de ataque de *Bemisia tabaci* biótipo B em *Cucumis sativus*. Observaram-se maiores números de adultos e de ninfas de mosca-branca por folha com o aumento de idade de plantas. Adultos por folha e ovos cm^{-2} foram encontrados com maior freqüência na parte apical do que na parte mediana e basal do dossel das plantas. Entretanto, observou-se maior número de ninfas desse inseto no terço mediano do que nos terços apical e basal. Nitrogênio foliar afetou negativamente ninfas de mosca-branca. Pentacosano e octacosano afetaram positivamente adultos e o primeiro composto afetou também as ninfas dessa praga.

Termos para indexação: *Cucumis sativus*, mosca-branca, aleloquímicos, nitrogênio, tricomas.

Introduction

Whitefly *Bemisia tabaci* biotype B (Homoptera: Aleyrodidae) debilitates Cucurbitaceae plants by sucking the sap, introducing toxins into the plant's vascular system, coating the leaf with honey dew, which facilitates the growth of soots mold fungi, as well as inducing leaf physiological disorders (squash silverleaf) (Jiménez et al., 1995; Yokomi et al., 1995; McAuslane et al., 1996).

Insecticides for control of whitefly are intensively used. One of the main reasons for this extensive application is the lack of information about the factors which regulates whitefly populations. Such piece of information could facilitate the prediction of the attack by insects, potencially reducing economic losses caused by them (Dent, 1995).

Many factors can influence population density of whitefly in host plants such as weather, levels of nitrogen (N) and potassium (K), age and vigour of plants, type and densities of trichomes, allelochemicals and natural enemies (Dent, 1995; Leite, 2000).

The objective of this work was to evaluate the effects of predators, parasitoids, rainfall, temperature, leaf chemical composition, levels of N and K leaf, density of leaf trichomes, and plant age on attack intensity of whitefly on cucumber under field conditions.

Material and Methods

This experiment was carried out on two cucumber plantations of *Cucumis sativus* var. Joia Agroceres, from April to October 1999, in Guidoval, Minas Gerais State, Brazil. Each cucumber plantation presented 3,000 trellised plants, spaced 1.0 m apart within rows and 0.30 m between rows. Four rows and the first ten plants in the side of each row formed the border of the parcels while the remaining plants were used to collect the data.

Trichome density was evaluated in one leaf, collected monthly, from the apical part of the canopy of ten plants per plantation. The slide preparation and trichomes assessment were carried out as described by Leite (2000). Levels of N and K in leaves of the cucumber were determined monthly in laboratory in one expanded leaf from the upper part of each of ten plants per plantation. These leaves were dried and grinded, then K was determined with flame photometer and N was analysed by the Nessler method. The gas chromatography/mass spectrometry (GC/MS) analysis was performed monthly with fully expanded leaves from the upper part of ten plants per plantation. Fresh leaves (10 g) were cut with scissors and immersed in a 100 mL hexane for 24 hours. The hexane extract was evaporated to dryness at 30°C in a rotatory evaporator, sealed in nitrogen and stored in a freezer until analysis. The hexane extract was analysed with GC/MS and only compounds with a similarity index higher than 84% were considered. The morphological, nutritional and chemical analyzes were performed with three independent monthly evaluations for each of the two plantations.

Direct counting was used to estimate monthly the number of whitefly (Horowitz, 1993; Leite, 2000) adults and nymphs (determined as 4th instar by visual inspection) and predators in the bottom, middle and apical parts of 30 plants per plantation (one leaf per plant). The beating tray method (Miranda et al., 1998) was used to estimate monthly the number of adults of *Encarsia* sp. (Hymenoptera: Aphelinidae) present in one leaf from each part of the canopy of 30 plants per plantation. Nymphal parasitism index, number of whitefly eggs and spatial distribution of the eggs in the cucumber plant were monthly evaluated with 40x magnifying lens. One leaf from each part of the canopy of 30 plants per plantation was collected. For each sample, six fields in the median part (between the median vein and the margin) were analyzed.

Climatic data, total rainfall as well as temperature, were obtained by pluviometer and thermometer (minimum and maximum) installed in the field during the experiment. Density of whitefly, natural enemies and trichomes were subjected to analysis of variance and the Duncan's multiple range test ($p \leq 0.05$). Regression analysis ($p<0.05$) were also carried out.

Results and Discussion

A higher number of whitefly adults and nymphs per leaf was observed on the third month, 22.02 and 30.47, respectively, than on the second, 2.09 and 1.09, respectively, as well as in the first month of evaluation, 0.35 and 3.90, respectively. A higher number of whitefly adults per leaf and eggs cm^{-2} in the apical part, 7.83 and 3.51, respectively, were observed than in the middle part, 4.00 and 0.89, respectively, and in the bottom part, 2.17 and 0.26, respectively, of cucumber canopy plants.

However, a higher number of 4th instar nymphs was observed in the middle part (7.38) than in the apical and bottom parts of the canopy (4.06 and 4.00, respectively). *B. tabaci* lays its eggs on the younger leaves, often found at the apical part of the plants (Liu & Stansly, 1995; Leite, 2000). This may be due to the tenderness or to the higher nutritional quality of these leaves, which favours feeding by whitefly (Lenteren & Noldus, 1990; Leite, 2000). The second instar nymphs do not move much, and, since the plant continues to grow, the adults emerge on the inferior third part of the tomato plant (Liu & Stansly, 1995; Leite, 2000). Simmons also (1999) reported increase in *B. tabaci* populations as pumpkin, eggplant, bean, zucchini and sweet pepper plants aged.

The incidence of whitefly nymphs was negatively affected by foliar N ($y = 97.46 - 18.04x$, $R^2 = 0.81$), but no effect was observed on adults. The peak of foliar N (5.64% on dry matter) was observed 40 days after plant emergence ($y = 3.33 + 0.11x - 0.002x^2$, $R^2 = 0.99$). The foliar K did not affect whitefly in this work. Pentacosane (peak 36.374 min, IS = 94%) ($y = -1.41 + 2.27x$, $R^2 = 0.94$) and octacosane (peak 39.063 min, IS = 93%) ($y = -14.13 + 6.32x$, $R^2 = 0.90$) positively affected whitefly adults while the first compound also affected the nymphs of this pest ($y = -0.20 + 2.94x$, $R^2 = 0.91$). The two other identified peaks, 24.143 min (= α-humulene, IS = 84%)

and 42.805 min (= nonacosane, IS = 93%) (Figure 1), did not correlate with whitefly population. Increasing levels of K caused a reduction in octacosane (y = 12.79 - 3.01x, R^2 = 0.99) and nonacosane (y = 10.24 - 2.49x, R^2 = 0.96), and plant age led to an elevation in nonacosane (y = -0.29 + 0.07x, R^2 = 0.94) concentrations in cucumber plants.

These compounds have not been reported for cucumber. Although these compounds were identified with a high SI, their identity should be confirmed by other methods. It is necessary to isolate these compounds in large quantities and to identify them through more precise spectroscopic methods as well as to conduct bioassays with the pentacosane and nonacosane since it positively correlated with whitefly. The negative effect of N and positive effect of nonacosane and pentacosane levels on cucumber leaves attacked by whitefly might be an indirect effect, due to this insect population increase, in this work, as plants aging.

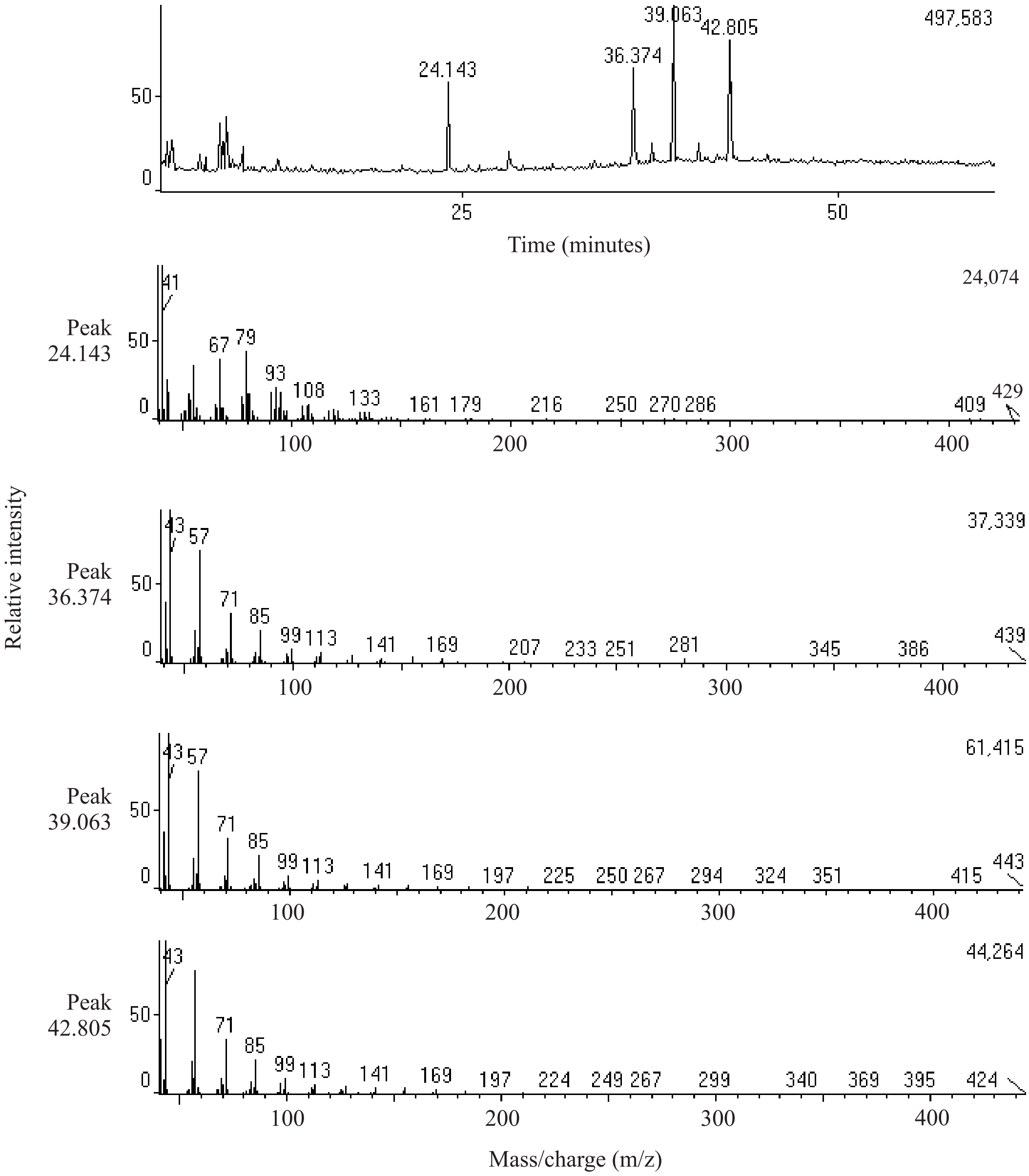

Figure 1. Total ion current of the hexane extract of *Cucumis sativa* and mass spectra of peaks eluting at 24.143, 36.374, 39.063 and 42.805 min. The number in the upper right side of each Figure is the number of ions.

A higher density of tector trichomes mm^{-2} (100% of the trichomes) was observed in the apical (3.23) than in the middle (2.57) and bottom (2.36) parts of the cucumber canopy, and no differences in trichome density were observed between leaf surfaces (adaxial or abaxial). Increasing plant age caused a reduction in trichome density mm^{-2} ($y = 5.81 - 0.05x$, $R^2 = 0.97$). These compounds and also trichomes were not negatively correlated with whitefly populations. This can be explained by the fact that the cucumer has been genetically improved for a long time aiming to increase productivity. For this reason cucumber probably lost compounds and glandular trichomes, which are responsible for their protection against phytophagous arthropods.

Numbers of *Encarsia* sp. (0.0111 per leaf) and spiders [*Architis* (Pisauridae), *Cheiracanthium inclusum* (Miturgidae), *Misumenops* spp. (Thomisidae) and Araneidae] (1.21per leaf), *Cycloneda sanguinea* (Coleoptera: Coccinellidae) (0.09 per leaf), *Chrysoperla* spp. (Neuroptera: Chrysopidae) (0.01 per leaf) and *Orius* spp. (Heteroptera: Anthocoridae) (0.01 per leaf) were low in the area of study. The number of natural enemies was not significantly correlated with whitefly population and no parasite-infected whitefly nymphs were detected, probably because the number of natural enemies was low in the studied area. However, *Encarsia* sp. and predators *Chrysoperla* spp. and Coccinellidae have been used to control whitefly population in several plants (Legaspi et al., 1996; Liu & Stansly, 1996) and in some cases a positive effect was obtained (Hagler & Naranjo, 1994; Heinz & Nelson, 1996). Whitefly population increased with plants aging probably due to the low number of natural enemies in the studied area.

Temperature and rainfall did not affect whitefly population in cucumber in this work. Hirano et al. (1995), while studying population dynamics of *B. tabaci* in soybean and mung beans in Java and Indonesia, reported that climatic factors were not the main factors regulating the populations of this insect species. These authors reported that one of the major factors responsible for whitefly dynamics seems to be temporal variations in the quantity of host plants in the area. In this work, cucumber plantations were near (10 m) the other vegetable plantations, such as tomato and eggplant, and the population probably migrated from the last plantations.

Conclusions

1. Apparently, nonacosane and pentacosane are positively associated with whitefly population in cucumber; hence, in regions with a high incidence of this pests, cucumber varieties with lower wax leaf content should be choosen.

2. Only when whitefly reached nominal thresholds, should pulverization with selective insecticides be directed towards the leaves in the apical and middle parts of the plants, since these are regions in which the whitefly attack occurs.

3. An increase in the number of whitefly adults and nymphs per leaf is observed as plant aging.

Acknowledgements

To Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) and Universidade Federal de Viçosa (UFV), for financial support; to taxonomists Drs. Antonio D. Brescovit, Ayr de Moura Bello, Celso Oliveira Azevedo, Fernando Vaz-de-Mello and Paulo Sérgio Fiúza Ferreira, for the identification of the material.

References

DENT, D.R. **Integrated pest management.** London: Chapman and Hall, 1995. 356p.

HAGLER, J.R.; NARANJO, S.E. Qualitative survey of two coleopteran predators of *Bemisia tabaci* (Homoptera: Aleyrodidae) and *Pectinophora gossypiella* (Lepidoptera: Gelechiidae) using a multiple prey gut content ELISA. **Environmental Entomology**, v.23, p.193-197, 1994.

HEINZ, K.M.; NELSON, J.M. Interspecific interactions among natural enemies of *Bemisia* in an inundative biological control program. **Biological Control**, v.6, p.384-393, 1996.

HIRANO, K.; BUDIYANTO, E.; SWASTIKA, N.; FUJII, K. Population dynamics of the whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), in Java, Indonesia, with special reference to spatio-temporal changes in the quantity of food resources. **Ecological Research**, v.10, p.75-85, 1995.

HOROWITZ, A.R. Control strategy for the sweet-potato whitefly, *Bemisia tabaci*, late in the cotton-growing season. **Phytoparasitica**, v.21, p.281-291, 1993.

JIMÉNEZ, D.R.; YOKOMI, R.K.; MAYER, R.T.; SHAPIRO, J.P. Cytology and physiology of silverleaf whitefly-induced squash silverleaf. **Physiological and Molecular Plant Pathology**, v.46, p.227-242, 1995.

LEGASPI, J.C.; NORDLUND, D.A.; LEGASPI JUNIOR, B.C. Tri-trophic interactions and predation rates in *Chrysoperla* spp. attacking the silverleaf whitefly. **Southwestern Entomologist**, v.21, p.33-42, 1996.

LEITE, G.L.D. **Fatores que influenciam a intensidade de ataque de mosca-branca em tomateiro**. 2000. 46p. Dissertação (Doutorado) - Universidade Federal de Viçosa, Viçosa.

LENTEREN, J.C. van; NOLDUS, L.P.J.J. Whitefly-plant relationships: behavioural and ecological aspects. In: GERLING, D. (Ed.). **Whiteflies**: their bionomics, pest status and management. Andover, Hants, UK: Intercept, 1990. p.47-89.

LIU, T.X.; STANSLY, P.A. Oviposition by *Bemisia argentifolii* (Homoptera: Aleyrodidae) on tomato: effects of leaf factors and insecticide residues. **Journal of Economic Entomology**, v.88, p.992-997, 1995.

LIU, T.X.; STANSLY, P.A. Oviposition, development, and survivorship of *Encarsia pergandiella* (Hymenoptera: Aphelinidae) in four instars of *Bemisia argentifolii* (Homoptera: Aleyrodidae). **Annals of the Entomological Society of America**, v.89, p.96-102, 1996.

McAUSLANE, H.J.; WEBB, S.E.; ELMSTROM, G.W. Resistance in germplasm of *Cucurbita pepo* to silverleaf, a disorder associated with *Bemisia argentifolii* (Homoptera: Aleyrodidae). **Florida Entomologist**, v.79, p.206-221, 1996.

MIRANDA, M.M.M.; PICANÇO, M.; LEITE, G.L.D.; ZANUNCIO, J.C.; DECLERCQ, P. Sampling and non-action levels for predators and parasitoids of virus vectors and leaf miners of tomato plants in Brazil. **Mededelingen Faculteit Landbouwwetenschappen Universiteit Gent**, v.63, p.519-523, 1998.

SIMMONS, A.M. Nymphal survival and movement of crawlers of *Bemisia argentifolli* (Homoptera: Aleyrodidae) on leaf surfaces of selected vegetables. **Environmental Entomology**, v.28, p.212-216, 1999.

YOKOMI, R.K.; JIMÉNEZ, D.R.; OSBORNE, L.S.; SHAPIRO, J.P. Comparison of silverleaf whitefly-induced and chlormequat chloride-induced leaf silvering in *Cucurbita pepo*. **Plant Disease**, v.79, p.950-955, 1995.

Received on March 22, 2005 and accepted on May 8, 2006