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Factors Affecting Herbivory of *Thrips palmi* (Thysanoptera: Thripidae) and *Aphis gossypii* (Homoptera: Aphididae) on the Eggplant (*Solanum melongena*)

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ABSTRACT

The objective of this study was to evaluate effects of total rainfall, mean temperature, natural enemies, chemical composition of leaves, levels of nitrogen and potassium on leaves and density of leaf trichomes on attack intensity of Thrips palmi Karny (Thysanoptera: Thripidae) and Aphis gossypii (Glover) (Homoptera: Aphididae) on plantations of the eggplant (Solanum melongena) in two regions of Minas Gerais, Brazil. Higher numbers of A. gossypii/leaf and T. palmi/leaf were observed in plantations of this eggplant in the Municipalities of Viçosa and Guidoval, respectively. Guidoval had a rainy and hotter weather than Viçosa. T. palmi was almost positivelly correlated with rainfall (r= 0.49, P= 0.0538) while A. gossypii seemed to be more affected by mean temperature (r= -0.31; P= 0.1134). Higher number of aphids in eggplants in Viçosa than in Guidoval could be explained by the higher number of natural enemies such as Adialytus spp. (Hymenoptera: Braconidae), Cycloneda sanguinea (L.) and Exochomus bimaculosus Mulsant (Coleoptera: Coccinellidae) and Chrysoperla spp. (Neuroptera: Chrysopidae) in this municipality. However, only Adialytus spp. was significativelly correlated with aphid populations. Higher number of T. palmi in eggplant plantations of Guidoval than in Viçosa could be due to the absence of its possible Eulophidae parasitoid in the first municipality. The spiders were significativelly correlated with this pest in both municipalities.

Key word: *Aphis gossypii*, natural enemies, plant nutrition, *Solanum melongena*, *Thrips palmi*

INTRODUCTION

The eggplant (*Solanum melongena*) is a tropical and subtropical plant growing in high temperatures which can produce up to 15 kg of fruit/plant (Filgueira, 2000). Among pests of this crop, the aphids *Aphis gossypii* (Glover) (Homoptera: Aphididae) and the thrips *Thrips palmi* Karny (Thysanoptera: Thripidae) (Etienne et al., 1990; Hosoda et al., 1993; Kajita et al., 1996) are very important. Eggplants when severely attacked by thrips present leaves with small size and silver appearance and deformed fruits (Kawai, 1986; Sakimura et al., 1986; Gallo et al., 2002). Aphid attack causes severe damage to eggplant by feeding on sap, rolling leaves, and secreting honeydew (Hosoda et al., 1993; Gallo et al., 2002).

In different crops, *T. palmi* and *A. gossypii* have been controlled primarily with insecticides

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(Hosoda et al., 1993; Kajita et al., 1996), but the extensive use of these pesticides can promote negative impacts on human health and on ecosystems, besides reducing the number of species and density of natural enemies, developing resistance and increasing production costs (Etienne et al., 1990; Nagai, 1990; Hosoda et al., 1993; Kajita et al., 1996). One of the main reasons for the extensive use of insecticides is the lack of informations about factors affecting insect pest control. Such informations could be used to predict attack rates by these insects which could reduce economic losses (Dent, 1995).

Several factors can influence population density of aphids and thrips on eggplants. Temperature and rainfall have been cited as the most important (Walker et al., 1984; Etienne et al., 1990; Nakata, 1995; Kajita et al., 1996), fertilization levels, presence of trichomes and natural enemies. According to Marschner (1995), excess of nitrogen (N) and deficiency of potassium (K) can increase the accumulation of amino acids, allowing the increase in sucking insect population on plants. Trichomes can also negatively affect, by chemical and/or mechanical ways, thrips and aphids populations (Dent, 1995). Natural enemies can also play an important role on the control of these pests on plants (Dent, 1995).

The objective of this study was to evaluate effects of total rainfall, mean temperature, predators and parasitoids, chemical composition of leaves, levels of N and K, density of leaf trichoms and plant age on attack rate of *A. gossypii* and *T. palmi* in five eggplant plantations in two municipalities of Southwest region of Brazil.

MATERIAL AND METHODS

This experiment was conducted in two eggplant plantations in the municipality of Viçosa, Minas Gerais, Brazil ($20^0$44'38.7" S, $42^0$49'18" W and 649 m), from February to July and from October to December of 1999, and three eggplant plantations in municipality of Guidoval, Minas Gerais, Brazil ($21^0$08'36" S, $42^0$47'54" W and 239 m), from October to December of 1998 and from October to December of 1999. All eggplant plantations was of *Solanum melongena* var. "Natu Nobilis". Cultural practices used in this study were described by Filgueira (2000). Each eggplant plantation had 600 plants, spaced from 1.0 m within rows and 1.5 m between rows. The four outermost rows in each plot and the first ten plants in each side of the rows formed the surrouding border while data were collected from plants in the centre.

The number of aphids, thrips, predators and parasitoids per leaf of 10 plants/plantation was obtained monthly in Guidoval and weekly in Viçosa with the beating tray method (Butler et al., 1993; Stansly, 1995; Miranda et al., 1998a). This method consisted of beating the first expanded leaf of the upper part of plants in a 34 x 26 x 5 cm white tray, and then counting insects present. The insects were collected with an aspirator or with tweezers and individually placed in 8 x 2 cm glass flasks containing 70% ethanol.

Trichome density was evaluated in one leaf from the apical part of the canopy of 10 plants/plantation, monthly collected in both municipalities. The colleted leaves were placed in white transparent plastic bags, immediately sealed, and transported to the laboratory. In the laboratory, these leaves were placed in to 10 cm x 4 cm glass tubes containing 70% ethanol for later use. They were cleared for 2h in NaOH (10%) and for 18 h in sodium hypochlorite (20%) before analysis. This material was stained for three min by immersion in fast green after washing and during dehydration (Johansen, 1940) and mounted between slides with Canadian balsam. Trichomes/mm^2 (adaxial and abaxial) were counted under a microscope in 24 fields (area of one field = 0.60 mm^2) in the central part (a field equidistant between the principal vein and the margin) of each leaf collected (Leite et al., 1999). Trichomes were classified according to Metcalfe and Chalk (1979). Three evaluations were made per month for each of the three plantations.

Level of N and K in leaves of the eggplant was estimated in laboratory condition in one expanded leaf from the upper part of each of 10 plants/plantation, collected monthly in both Municipalities. These leaves were placed in Kraft paper bags, dried in forced air circulation with temperature over 67^oC during three days and then ground in a Wiley mill (20 mesh). Level of K was determined with Flame Photometer (Coleman, Model 22) and N was analysed with the Nessler method (Jackson, 1958). Three evaluations were made for each month for three plantations.

The gas chromatograph/mass spectrometer (GC/MS) analysis was developed, in 1999, with fully expanded leaves from the upper part of 10 plants/plantation, monthly collected in both

municipalities. The leaves were collected and placed in plastic bags, sealed and transported to the laboratory. Fresh leaves (10g) were cut and immersed in a 100 mL bidistilled hexane (24 h). The hexane extract was dehydrated with anhydrous Na_2SO_4, evaporated to dryness at 30°C in a rotatory evaporator, sealed in nitrogen and freezer stored until analysis. One evaluation was monthly carried out for each one of these three plantations.

The hexane extract was analysed by GC/MS (Shimadzu, Model QP 5000) composed by an auto sampler, a computer based system to accumulate data, and a mass spectra database (John Wiley) with 160,000 compounds in the following conditions: initial temperature (33^{0}C), then programmed at 80^{0}C to 20^{0}C/min, and finally at 250^{0}C to 5^{0}C/min. Injector and transfer line temperatures were 180 and 230^{0}C, respectively. The split ratio was five with He gas as the carrier. All analyses were carried on a DB1 fused capillary column (J and W Scientific, USA, 30 m x 0.25 mm and film thickness of 0.25 μm). The mass spectrometer was scanned between 40 – 550 amu and the minimum area utilised for peak integration was 300,000 ions/second. Retention time for the peaks with total ion current (TIC) higher than 3 x 10^6 ions/second were recorded and the compounds identified with mass spectral database. Only compounds with a similarity index higher than 83% were considered and further identification through standards was not attempted.

Total rainfall and mean temperature (minimum + maximum/2) data were colleted daily with pluviometer and thermometer (minimum and maximum), respectively, in the municipality of Guidoval (1999) and by "Estação Climatológica Principal" of the Federal University of Viçosa (UFV), in Municipality of Viçosa (1998-1999). Pearson's correlations ($P \leq 0.05$) were used to evaluate the relationships of total rainfall and mean temperature, natural enemies, leaf chemical composition, leaf N and K levels and leaf trichome density with the number of *A. gossypii* and *T. palmi.*

RESULTS

Higher numbers of *A. gossypii* and *Thrips palmi* per leaf were observed in eggplants in the municipality of Viçosa (0.58 ± 0.37 and 0.24 ± 0.14, respectively) and Guidoval (0.28 ± 0.11 and 0.79 ± 0.41, respectively) (Fig. 1). Guidoval had a rainy and hotter weather in 1999 (23.62 ± 1.34 ^{0}C and 1,588.90 mm, respectively) than Viçosa in 1998 (21.67 ± 0.79 ^{0}C and 1,139.00 mm, respectively) and 1999 (20.85 ± 0.73 ^{0}C and 1,224.80 mm, respectively) (Fig. 2). *T. palmi* was almost positivelly correlated with total rainfall (r= 0.49, P = 0.0538). Eventhough without significance, *A. gossypii* seemed to be more affected by mean temperature (r= -0.31; P = 0.1134).

The main parasitoids observed in eggplant plantations of the municipalities of Viçosa were *Adialytus* spp. (Hymenoptera: Braconidae) (0.10 ± 0.03/leaf) and Eulophidae (Hymenoptera) (0.06 ± 0.02/leaf). In Guidoval, only the parasitoid *Adialytus* spp. (0.16 ± 0.06/leaf) was found. Predators observed in Viçosa and Guidoval, respectively, were spiders [*Architis* (Pisauridae), *Cheiracanthium inclusum* (Hentz) (Miturgidae), *Oxyopes* spp. (Oxyopidae), *Misumenops* spp. (Thomisidae) and Anyphaenidae] (0.11 ± 0.03/leaf and 0.23 ± 0.09/leaf); *Cycloneda sanguinea* (L.) and *Exochomus bimaculosus* Mulsant (Coleoptera: Coccinellidae) (0.01 ± 0.01/leaf and 0.30 ± 0.16/leaf) and *Orius* spp. (Heteroptera: Anthocoridae) (0.01 ± 0.01/leaf and 0.01 ± 0.01/leaf). Others predadors such as *Chrysoperla* spp. (Neuroptera: Chrysopidae) (0.01 ± 0.01/leaf), *Geocoris* sp. (Heteroptera: Lygaeidae) (0.03 ± 0.03/leaf), and Aelothripidae (Thysanoptera) (0.01 ± 0.01/leaf) were observed only in Guidoval. The aphid parasitoid (*Adialytus* spp.) was significatively correlated with aphid populations (r= 0.70, P = 0.0407) and the spiders were significatively correlated with thrips (r= 0.64, P = 0.0065) in both localities.

No significant correlation was found (P> 0.05) between levels of N and K, chemical leaf composition and density of trichomes (100% non glandular) on populations of aphids and thrips in both municipalities studied (Figs. 1 and 3).

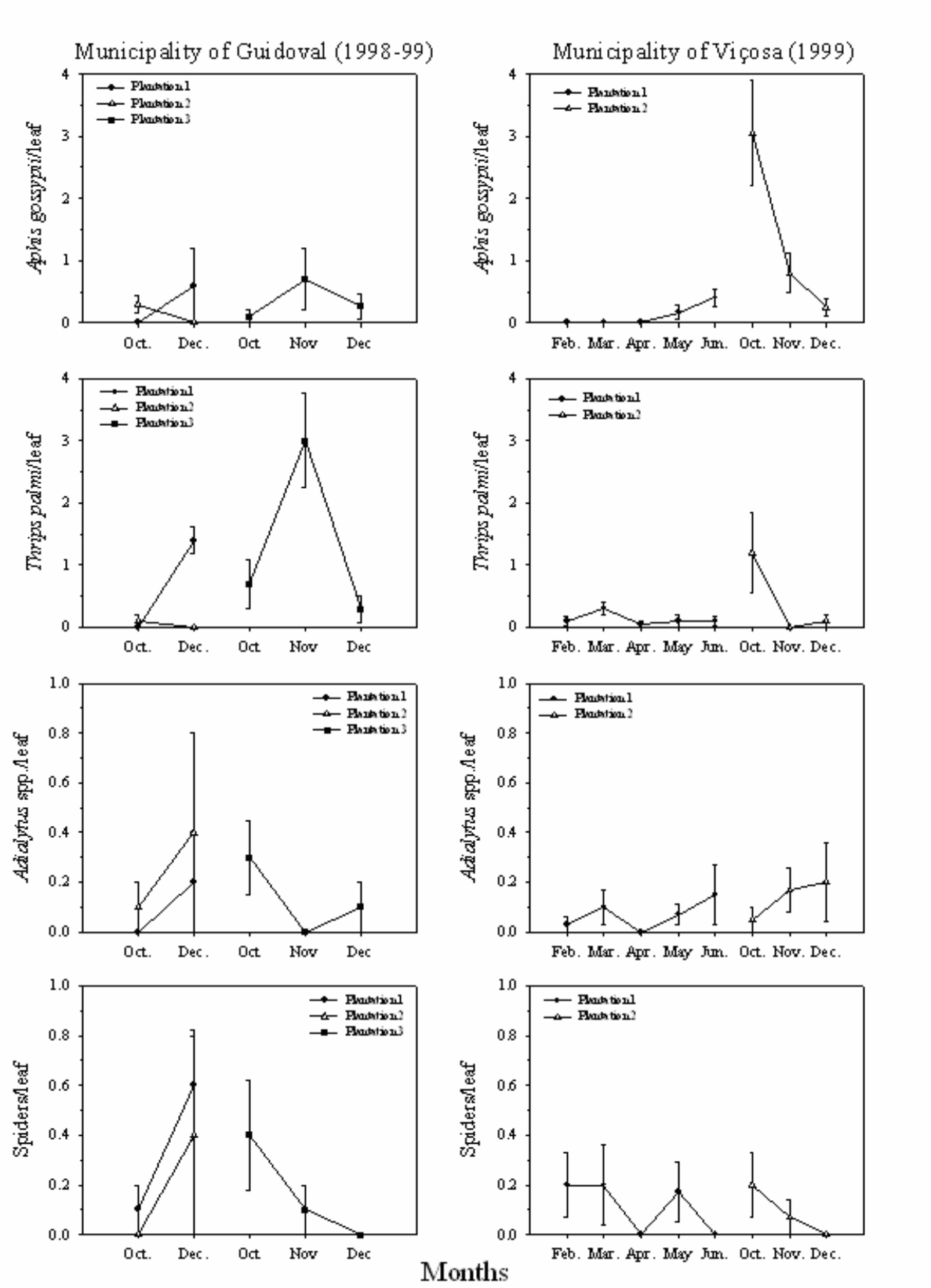

Figura 1 - Population fluctuation of *Aphis gossypii*/leaf, *Thrips palmi*/leaf, *Adialytus* spp./leaf and spiders/leaf in the eggplant (*Solanum melongena*) in the municipalities of Viçosa and Guidoval. Symbols represent mean of 40 leaves for Viçosa and 10 leaves for Guidoval, and vertical bars indicate standard errors of the mean.

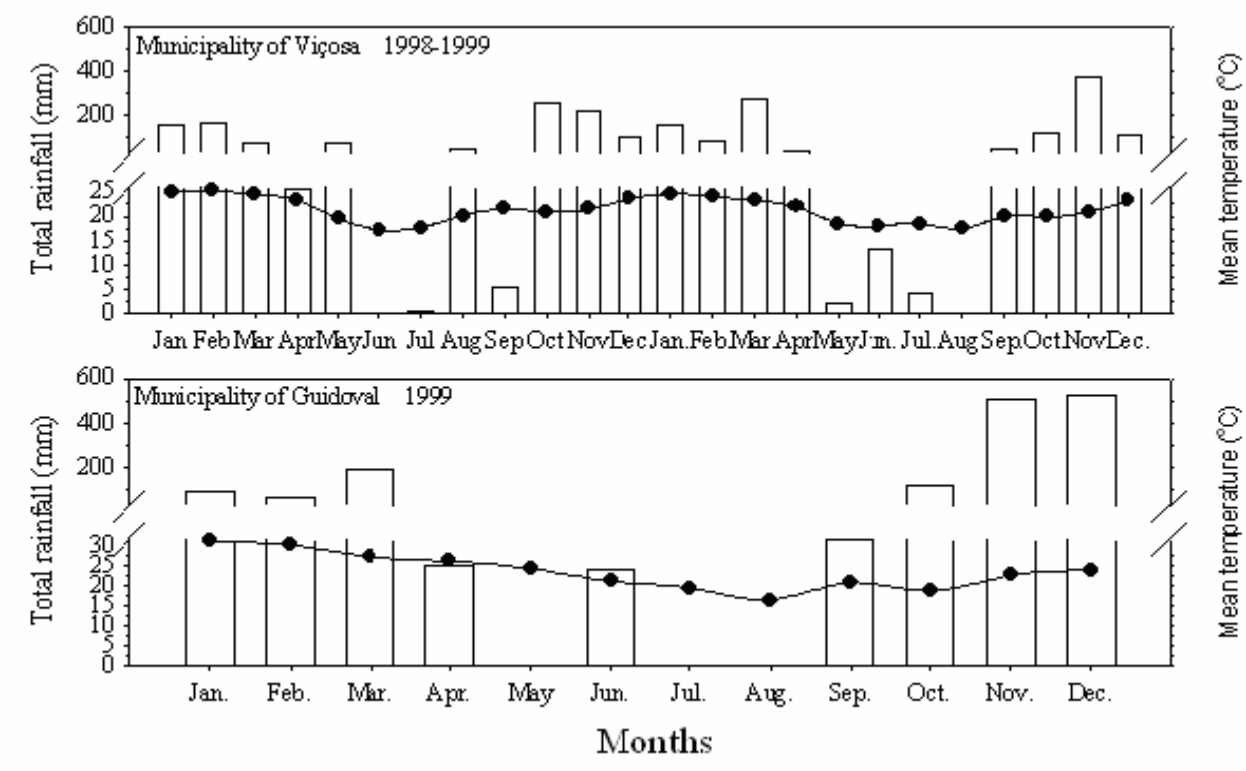

Figura 2 - Total rainfall distribution (mm) and mean temperature (minimum + maximum/2) (ºC) in the municipalities of Viçosa (1998-1999) and Guidoval (1999). Symbols represent, in general, the rainfall accumulated and the mean temperature for 30 days.

Higher density of star trichomes/mm^2 with one vertical and four to five horizontal arms was observed in the abaxial (5.92 ± 0.27) than in the adaxial face (2.04 ± 0.34) of eggplant leaves.

No differences between faces of leaves were found for density of long simple and non ramified trichomes (0.25 ± 0.06). This last type of trichome represented about 11% of their total number.

Three peaks with retention time of 25.503, 28.292 and 48.362 min. were recorded for the total ion current with hexane extract of *M. solanum* leaves on GC/MS analysis (Fig. 4). The peak at 25.503 was identified as palmitic/hexadecanoic acid with a similarity index (SI) of 87%. The peak at 28.292 min was identified as 11,14,17 eicosatrienoic methyl ester acid/myrcenol /1-tetradecen-3-yne/ 1,6,9-tetradecatriene /3-tetradecen-5-yne with a SI of 83%, while the peak at 48.362 min was identified as octacosane with a SI index of 93%.

DISCUSSION

A. gossypii is most important pest of eggplants in regions with milder temperature and *T. palmi* in those with higher temperatures. Thrips were weakly correlated with total rainfall and no correlation with temperature was observed. This showed an indirect effect of mean temperature because rainfall occurred during periods of higher temperature in this region (convective rain). High temperatures and rainfall usualy are important mortality causes of aphids in the field (Walker et al., 1984; Nakata, 1995; Picanço et al., 1997) and this factor can also regulate populations of thrips, because the rain washes nymphs and adults of this pest from eggplant leaves (Etienne et al., 1990; Kajita et al., 1996). On the other hand, temperature increase favours populations of thrips, reducing developmental period (Lorini and Dezordi, 1990; Gonçalves, 1997).

A possible explanation for the higher number of aphids in eggplant plantations of Viçosa was the presence of higher number of aphid parasitoids as *Adialytus*, ladybugs and Neuroptera species than

in Guidoval. On the other hand, only the aphid parasitoid was significatively correlated with aphid populations. Parasitoids of genus *Adialytus* could be limiting factor for population increase of *A. gossypii* in eggplants in the municipalities of Viçosa and Guidoval. Natural enemies of aphids have been related in several vegetables promoting good control rates. Hooks et al. (1998) observed faster reduction on number of individuals of *A. gossypii* in zucchini due to parasite (Braconidae) with higher number of mummified aphids besides the presence of entomopathogenic fungi and coccinellid and syrphid larvae on this plant. The presence of predatory ladybugs *C. sanguinea* and *Sciminus* sp., Syrphidae larva (Diptera), adults of *Condylostylus* spp. (Diptera: Dolichopodidae), spiders and Braconidae parasitoids were showed by Miranda et al. (1998b) on tomato plants attacked by aphids, being only the ladybugs correlated with number of aphids. Higher number of thrips in eggplant plantations in Guidoval than in Viçosa could also be explained by absence of possible Eulophidae parasitoids in the first municipality.

Parasitoids Eulophidae and predators Anthocoridae have been considered the most important natural enemies of thrips in different places (Venzon et al., 1999; Funderburk et al., 2000; Tagashira and Hirose, 2001). The spiders were found during all period of eggplant cultivation and in spite of being generalists, they should receive more attention.

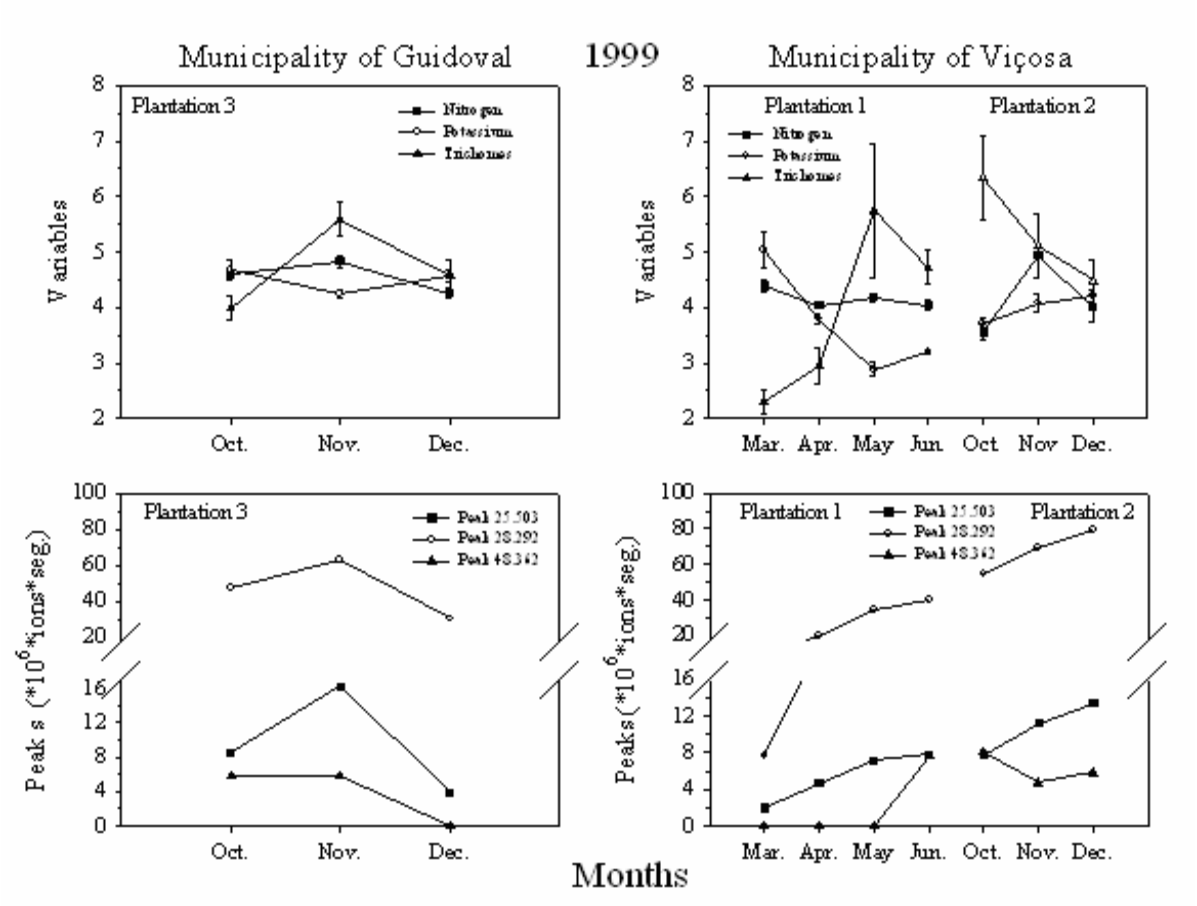

Figura 3 - Nitrogen and potassium contents (% of dry matter), density of trichomes (adaxial +abaxial/2) per mm^2 and peaks at 25.503, 28.292 and 48.362 min (retention time) datained from extract of eggplant (*Solanum melongena*) in the municipalities of Viçosa and Guidoval. Symbols represent means of three evaluations and vertical bars indicate standard errors of the mean for nitrogen, potassium and trichomes and one evaluation for peaks.

In this study, no effect of levels of N or K on leaves of eggplant with aphids and thrips was detected, what might be explained to low variations on levels of these compounds on leaves of this plant during the experimental period. Several authors have mentioned that high N levels were associated with aphids and thrips infestations on lettuce, tomato and cotton (Kennedy, 1958; Brodbeck et al., 2001; Cisneros and Godfrey, 2001; Nevo and Coll, 2001) being a key factor for increasing number of aphids in cotton (Cisneros and Godfrey, 2001). However, Leite et al. (1999) showed no effect of 100 and 300 mg/kg and 0 and 200 mg/kg of N and K, respectively, in the soil on attack intensity of *M. persicae* on *L. esculentum* and on *L. hirsutum* f. *glabratum* (PI 134417) in greenhouse. The increase on level of K was associated to reduction of pests as this chemical element was included in the synthesis of the RNA polimerase (Tanzini et al., 1993; Marschner, 1995; Leite, 1997).

Compounds observed in this work were not present in the trichomes since they were non-glandular types.

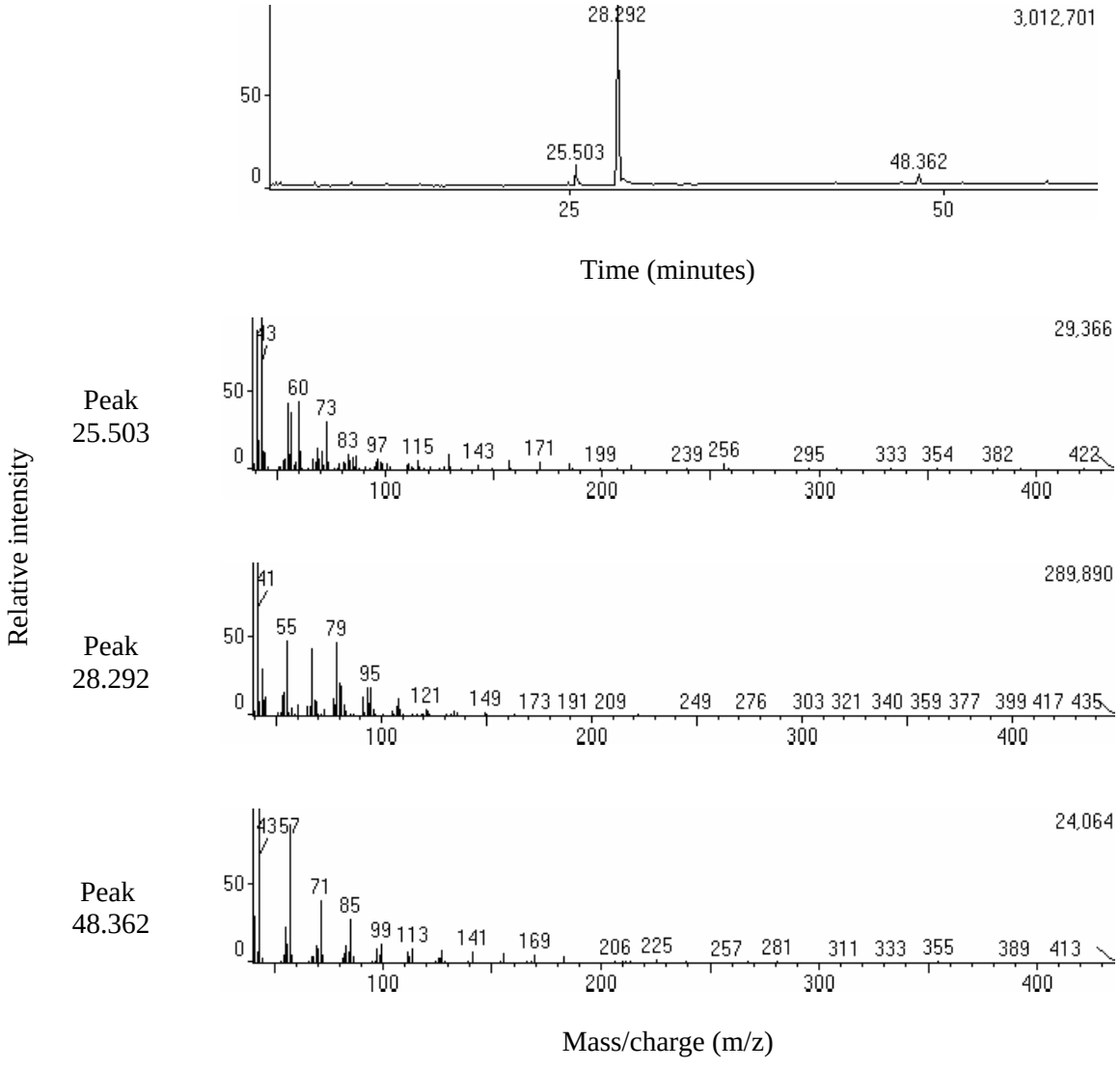

Figure 4 - Total ion current of hexane extract of eggplant (*Solanum melongena*) and mass spectra of peaks eluting at 25.503, 28.292 and 48.362 min. Numbers in the upper right side of each figure represent the number of ions recorded.

These compounds and also tricomes were not correlated with aphids and thrips populations. This could be explained by the fact that eggplant had been genetically bred for a long time aiming increasing productivity. For this reason, the eggplant could be losing compounds and glandular tricomes which played important role on the resistance to arthropods.

Eggplant plantation in regions with milder temperatures presentled higher possibilities to present problems with *A. gossypii* as well as in regions with higher temperature could have problems with *T. palmi*. Natural enemies, especially the parasitoid *Adialytus* spp. could be important controlling agents of the *A. gossypii* population in eggplant.

RESUMO

O objetivo deste estudo foi avaliar os efeitos de pluviosidade total, temperatura média, inimigos naturais, composição química foliar, níveis de nitrogênio e potássio foliar e densidade de tricomas na intensidade de ataque de Thrips palmi Karny (Thysanoptera: Thripidae) e Aphis gossypii (Glover) (Homoptera: Aphididae) em plantações de berinjela (Solanum melongena) em dois municípios de Minas Gerais, Brasil. Observou-se maiores números de A. gossypii e T. palmi por folha em plantações de berinjela nos municípios de Viçosa e Guidoval, respectivamente. Guidoval teve o clima mais chuvoso e quente do que Viçosa. T. palmi correlacionou positivamente com pluviosidade (r= 0,49; P= 0,0538) enquanto A. gossypii parece ser mais afetado por temperatura média (r= -0,31; P= 0,1134). Maior número de pulgões em berinjela em Viçosa do que em Guidoval poderia ser explicado pelo maior número de inimigos naturais, tais como, Adialytus spp. (Hymenoptera: Braconidae), Cycloneda sanguinea (L.) e Exochomus bimaculosus Mulsan (Coleoptera: Coccinellidae) e Chrysoperla spp. (Neuroptera: Chrysopidae) no último município. Entretanto, somente Adialytus spp. correlacionou significativamente com pulgões. O maior número de T. palmi em plantações de berinjela em Guidoval do que em Viçosa pode ser devido a ausência do parasitóide Eulophidae no primeiro município. As aranhas correlacionaram significativamente com esta praga em ambos os municípios.

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