CALCIUM SILICATE AND ORGANIC MINERAL FERTILIZER APPLICATIONS REDUCE PHYTOPHAGY BY *Thrips palmi* Karny (THYSANOPTERA: THRIPIDAE) ON EGGPLANTS (*Solanum melongena* L.)

Gustavo Dia de Almeida, Dirceu Pratissoli, José Cola Zanuncio, Victor Bernardo Vicentini, Anderson Mathias Holtz and José Eduardo Serrão

SUMMARY

Thrips palmi *Karny (Thysanoptera: Thripidae) is a phytophagous insect associated with the reduction of eggplant productivity. The aim of this study was to evaluate the effect of calcium silicate and/or an organic mineral fertilizer, together or separately, in increasing the resistance of eggplants to* T. palmi. *The treatments were calcium silicate, organic mineral fertilizer, calcium silicate associated with this fertilizer and the control. Mortality and number of lesions caused by nymphs of this insect on eggplant leaves were evaluated after 3, 6, 9 and 12 leaf applications of these products. The calcium silicate and the organic mineral fertilizer reduced both the population of* T. palmi *and the damage caused by its nymphs, suggesting a possible increase in eggplant resistance to this pest as a result of the treatments.*

SILICATO DE CALCIO Y FERTILIZANTE ORGANOMINERAL INFLUENCIAN LA FITOFAGIA DE *Thrips palmi* (THYSANOPTERA: THRIPIDAE) EN PLANTAS DE BERENJENA (*Solanum melongena* L)

Gustavo Dia de Almeida, Dirceu Pratissoli, José Cola Zanuncio, Victor Bernardo Vicentini, Anderson Mathias Holtz y José Eduardo Serrão

RESUMEN

Thrips palmi *Karny (Thysanoptera: Thripidae) es un fitófago asociado a la reducción de productividad en el cultivo de berenjena. El objetivo del estudio fue evaluar el efecto del silicato de calcio y un fertilizante organomineral, individualmente y asociados, en el aumento de la resistencia de plantas de berenjena al* T. palmi. *Los tratamientos fueron silicato de calcio, fertilizante organomineral, silicato de calcio con fertilizante organomineral y testigo. La mortalidad y el número de lesiones de ninfas en las hojas de la planta de berenjena fueron evaluadas después de 3, 6, 9 y 12 aplicaciones foliares de los productos. El silicato de calcio y el fertilizante organomineral disminuyeron tanto la población de* T. palmi *como los daños producidos por las ninfas, mostrando un posible aumento de la resistencia de las plantas de berenjena a esa plaga.*

Introduction

In Brazil, the eggplant (*Solanum melongena* L) cultivation area is relatively small, but the consumption of this vegetable is increasing, mainly as a result of its nutritive value and medicinal properties, as it helps reduce blood cholesterol levels (Silva *et al*., 1999; Antonini *et al*., 2002). This Solanaceae grows in tropical and subtropical zones and can be cultivated in areas with rather high temperatures, 18-25ºC (Kikuchi *et al*., 2008).

Thrips palmi Karny (Thysanoptera: Thripidae) is a phytophagous insect which reportedly causes damage to plants of 36 families, especially Solanaceae (Smith *et al*., 2005). This pest can reduce the productivity of eggplants (Zhao *et al*., 2007) by causing small silvered lesions on the leaves, deformation of the fruits and, in some cases, death of the plants (Leite *et al*., 2006, Cannon *et al*., 2007b).

Thrips palmi can be controlled with chemical products (Leite *et al*., 2005), but this method may be inefficient, because the populations of this insect can be highly resistant to insecticides (Cannon *et al*., 2007a). Besides, the intensive use of chemical insecticides can cause pest resurgence, and most of such products have high levels of non-target biological action, persistence in the environment and impact on human health, besides reducing the abundance of natural enemies and increasing production costs (Leite *et al*., 2003; Leite *et al*., 2005; Atakan, 2006). The maintenance of natural enemies in an integrated management

KEYWORDS / Resistance Induction /Silicon / *Solanum melongena* / Sustainable Agriculture / Thrips /

Received: 04/25/2008. Modified: 08/28/2008. Accepted: 09/15/2008.

Gustavo Dia de Almeida. Agronomical Engineer, Universidade Federal do Espírito Santo (UFES), Brazil. Doctor Student in Plant Technology, Universidade Federal de Viçosa (UFV), Brazil. UFV, Brazil. Address: Departamento de Fitotecnia/ Pós-graduação, Universidade Federal de Viçosa, 36.570-000, Viçosa, Minas Gerais, Brasil. e-mail: gdalmeida.ufv@hotmail.com.

Dirceu Pratissoli. Agronomical Engineer, UFES, Brazil. M.Sc., Universidade Federal de Lavras (UFLA), Brazil. D.Sc., Universidade de São Paulo (USP), Brazil. Professor, UFES, Brazil. e-mail: dirceu@cca.ufes.br.

José Cola Zanuncio. Forest Engineer, UFV, Brazil. M.Sc., USP, Brazil. Ph.D., University of British Columbia, Canada. Professor, UFV, Brazil. e-mail: zanuncio@ufv.br.

Victor Bernardo Vicentini. Agronomical Engineer and M.Sc. student, UFES, Brazil. e-mail: victorbvicentini@hotmail.com.

Anderson Mathias Holtz. Agronomical Engineer, UFES, Brazil. M.Sc. and D.Sc. UFV, Brazil. Professor, Escola Agrotécnica Federal de Santa Teresa, Brazil. e-mail: aholtz@insecta.ufv.br.

José Eduardo Serrão. Biologist, Universidade Federal de São Carlos, Brazil. M.Sc., Universidade Estadual Paulista, Brazil. D.Sc., USP, Brazil. Professor, UFV, Brazil. e-mail: jeserrao@ufv.br

SILICATO DE CÁLCIO E FERTILIZANTE ORGANOMINERAL INFLUENCIAM A FITOFAGIA DE *Thrips palmi* (THYSANOPTERA: THRIPIDAE) EM PLANTAS DE BERINJELA (*Solanum melongena* L)

Gustavo Dia de Almeida, Dirceu Pratissoli, José Cola Zanuncio, Victor Bernardo Vicentini, Anderson Mathias Holtz e José Eduardo Serrão

RESUMO

Thrips palmi Karny (Thysanoptera: Thripidae) é um fitófago associado à redução da produtividade da berinjela. Dessa forma, objetivou-se avaliar o efeito do silicato de cálcio e de um fertilizante organomineral, isolados ou associados, no aumento da resistência de plantas de berinjela ao tripes T. palmi. *Os tratamentos foram silicato de cálcio, fertilizante organomineral, silicato de cálcio associado com fertilizante organomineral e o controle. A mortalidade e o número de lesões de ninfas desse tripes nas folhas das plantas de berinjela foram avaliadas após três, seis, nove e doze aplicações foliares desses produtos. O silicato de cálcio e o fertilizante organomineral reduziram a população de* T. palmi *e os danos das ninfas, mostrando possível aumento da resistência das plantas de berinjela a essa praga.*

program (IPM) is a crucial strategy for the sustainability of the agroecosystem, because of the environmental, economical, social and ecological problems that arise with the use of insecticides (Lemos *et al*., 2005).

The increase in plant resistance after the application of silicon is an established strategy in pest management programs (Gomes *et al*., 2005). This material can be accumulated and polymerized in cell walls, thus providing a mechanical barrier against phytophagous pests (Aguirre *et al*., 2007). This also increases the synthesis of phenolic compounds, lignins and phytoalexins in the damaged areas (Ghanmi *et al*., 2004) and activates endogenous plant chemical defenses (Rains *et al*., 2006), although they are not essential (Fauteux *et al*., 2006). The use of silicon can be made compatible with other strategies of pest integrated management. For example, the application of sodium silicate reduced feeding preference of *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) on wheat plants (*Triticum aestivum*) without affecting the populations of natural enemies (Morães *et al*., 2004). The application of silicate materials could increase the resistance of eggplants to *T. palmi*, as they did reduce the feeding of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) when deposited on stems of sugar cane plants (Kvedaras and Keeping, 2007). Calcium silicate is the largest source of silicate products in the world (Snyder *et al*., 2005). The organic mineral fertilizer (silicate sources, essential nutrients, organic acids and proteins), in association with a silicate source, reduced the severity of *Asperisporium caricae* (Speg) Maubl. on papaya trees, possibly due to silicon deposition on the epicuticular layer, which impedes the penetration of the pathogen in the leaves (Pratissoli *et al*., 2007) and, when administered alone it reduced the oviposition of *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) on bean plants (*Phaseolus vulgaris* L), in choice and no-choice tests (Almeida *et al*., 2008).

The aim of this study was to evaluate the effect of calcium silicate and an organic mineral fertilizer, together or separately, on the resistance increase of the eggplant to *T. palmi.*

Material and Methods

Rearing the insects

Adults of *T. palmi* were collected from commercial eggplant plantations and taken to the laboratory of Entomology of the Center of Agrarian Sciences, Universidade Federal do Espírito Santo (CCA-UFES), in Alegre, Espírito Santo State, Brazil. The insects were reared/maintained in the laboratory on leaves of *Canavalia ensiformis* L., which had been cultivated in a greenhouse with an anti-aphid screen to avoid contamination by other arthropods species. *T. palmi* nymphs were placed on leaves of this plant in plastic containers (15×10×5cm). The adaxial face of the leaf was covered with filter paper and the lateral edges were also lined with paper towel to avoid water accumulation. The petioles of the *C. ensiformis* leaves were wrapped with a moistened cotton ball to reduce water loss. Leaves were replaced when they lost their turgidity and nutritional quality. Pollen grains of *C. ensiformis* were put onto the leaves to increase their nutritional quality for *T. palmi.*

Treatments and evaluations

Calcium silicate (17.45% Si_2O) and the organic mineral fertilizer containing (ppm): 35.00 Si_2O, 100.00 N_2, 25 P_2O_5, 50.00 K_2O, 13.75 S, 0.069 Zn, 0.475 B, 11.25 Fe quelated with HEDTA, 0.375 Mn, 2.75 Cl, 0.75 Cu, 0.075 Mo, 0.875 Co and 87.5 organic C were applied, together or separately, on the leaves using a manual mini-sprayer, after transplanting young eggplants to plastic bags (16×34cm). The calcium silicate was sprayed at a rate of $15g \cdot l^{-1}$ water; and the organic mineral fertilizer at $2ml \cdot l^{-1}$ water. When the two products were applied in association, 4g of calcium silicate and 2ml of the organic mineral fertilizer per liter of water plus the adhesive Hi Ten® ($200g \cdot l^{-1}$ of polioxytilen alquil phenol eter) were used. The plants in the control treatment were sprayed with water plus the adhesive.

The application of calcium silicate and organic mineral fertilizer was done every five days. Ten nymphs of *T. palmi* were inoculated per replication on the abaxial face of the eggplant leaves, two days after the third, sixth, ninth and eleventh application of these products. These plants were then conditioned in cages, protected from external factors such as wind, rain and other organisms. Nymphs of *T. palmi* were introduced onto the eggplants leaves in circular arenas ($0.7854cm^2$) consisting of a rubber ring 1cm in diameter fixed on the leaves of the plants with wood glue and pressed by two disks of fine polystyrene fixed by two wood picks (15×1cm), one at the inferior and the other on the superior part of the eggplant leaf. These wood picks were pressed by an elastic band in their extremities to avoid the escape of the insects.

Mortality was determined by direct observation of dead insects and expressed in relation to the total of *T. palmi* nymphs, while the number of lesions was determined by counting their number on the leaves containing nymphs with the aid of a stereomicroscope, five days after their inoculation. The complete procedure was carried out at a temperature of 25±5°C, a photoperiod of 12/12h and relative humidity of 70±10%.

Statistics

The experiment was carried out in an entirely randomized 4×4 factorial design with four treatments and four numbers of calcium and/or organic mineral applications. Five replicates were used, each with an eggplant. The averages were compared using the Tukey test at 5% probability.

Results

The mortality of *T. palmi* nymphs did not show any sig-

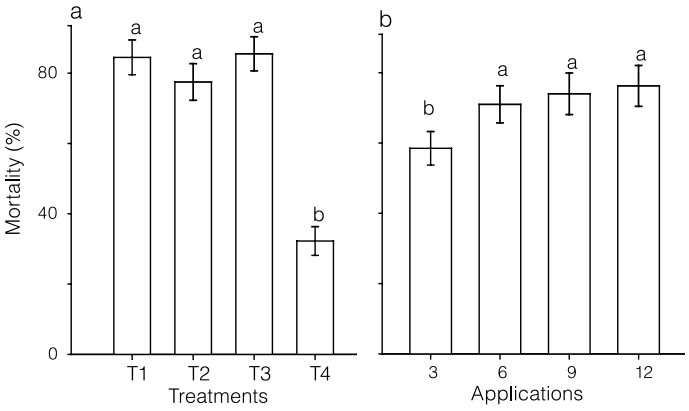

Figure 1. Mortality (±SD) of *Thrips palmi* (Thysanoptera: Thripidae) nymphs on eggplants leaves per treatment (a) and for each number of calcium and/or organic mineral fertilizer applications (b). Treatments: calcium silicate (T1), organic mineral fertilizer (T2), calcium silicate plus organic mineral fertilizer (T3), and control (T4). Temperature: 25 ±5°C, photoperiod: 12 hours, relative humidity: 70 ±10%. Means followed by the same letters are not different by the test of Tukey (P<0.05).

nificant interrelation between the number of applications and the treatments (F= 0.88, df= 9, 64), but the number of applications (F= 13.43, df= 3, 64) and the treatments (F= 137.83, df= 3, 64) showed a significant increase in insect mortality. The numbers of lesions caused by *T. palmi* did decrease significantly as a result of the application of the treatments (F= 2.20, df= 9, 64) and both factors alone, number of applications (F= 104.22, df= 3, 64) and treatments (F= 83.36, df= 9, 64), reduced significantly the number of lesions.

Thrips palmi nymphs showed higher mortality under the treatments with calcium silicate and the organic mineral fertilizer, together or in isolation, than with the control (Figure 1a). There was no significant increase in mortality after the sixth application of the products (Figure 1b).

The number of lesions was significantly higher on eggplant leaves in the control treatment than on plants that had received either calcium silicate and/or the organic mineral fertilizer in all evaluations, but the organic mineral fertilizer isolated was the least efficient one in reducing the number of lesions, differently from the treatments with calcium silicate alone or not. However, the damage caused by *T. palmi* nymphs showed a marked reduction after six applications of these products, with lower efficiency in the treatment with the organic mineral fertilizer alone. The treatment with three applications of calcium silicate was more efficient than those with mineral fertilizer alone, and the association of these two substances had no effect in decreasing the number of lesions in the plants by the nymphs (Figure 2).

Discussion

The higher mortality of *T. palmi* nymphs on eggplants treated with calcium silicate and/or organic mineral fertilizer can probably be attributed to the increase of the plants defense compounds, such as phenolics, lignin and phytoalexins. The oviposition, survival and longevity of *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) were also lower on cucumber plants treated with calcium silicate and acibenzolar-S-methyl (BTH) (Correa *et al*., 2005). Silicon and BTH applications were used to activate enzymes such as chitinase, peroxidase, 1.3-glucanase, polyphenoloxidase, phenylalanine ammonia-lyase proteinase and lipoxygenases in cotton, tomato and wheat plants (Inbar *et al*., 2001). These enzymes are related to an increase of quinone and reactive O_2 species, which have antibiotic properties favoring tissue lignification and, thus, decreasing the nutritional quality and digestibility of the cells (Aguirre *et al*., 2007). This effect causes lignification of the cellular tissues, which reduces their nutritional quality and tissue digestibility (Batista *et al*., 2005), affecting the survival of *T. palmi* nymphs.

The high mortality of *T. palmi* nymphs in the treatments with calcium silicate and the organic mineral fertilizer is possibly related to an increase in the hardness of cell tissues of the eggplant, causing feeding difficulties. The nymphs may not be able to scrape the leaves to obtain enough nutrients, due to the direct physical impediment caused by the silicon accumulation in the cellular walls of plants (Heine *et al*., 2007). A similar effect reduced the longevity of *Schizaphis graminum* (Rond.) (Hemiptera: Aphididae) by the physical effect of silica on wheat plants (Goussain *et al*., 2005), and also reduced the feeding of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) caterpillars on sugar cane plants with high silica levels (Kvedaras *et al*., 2007a). The deposition of silica in the cell walls of plant tissues reduces their digestibility and can cause death by starvation of phytophagous insects (Massey *et al*., 2006).

The marked reduction in the number of lesions caused by *T. palmi* nymphs on plants treated with calcium silicate and the organic mineral fertilizer may have been due to physical impediment for the accumulation of silica on the epicuticular layers of the eggplant cells (Epstein, 1999), resulting in more rigid tissues. The increased tissue hardness can wear out the mandibles of *T. palmi* nymphs, because their mandibular apparatus is of the scratching-sucking type. For this reason they can feed only after scratching the tissue surface, thus reducing the damage caused by the insect on eggplants treated with calcium silicate and the organic mineral fertilizer. Corn (*Zea mays* L.) plants treated with silicon resulted in higher mortalities of *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) caterpillars due to the wear and accentuated tear of their mandibles during all instars (Goussain *et al*., 2002). Calcium silicate also increased the cuticle thickness under the surface of the leaves of coffee (*Coffea arabica*) plants, mainly due to a more developed epicuticular wax layer; this reduced the penetration of the fungi *Cercospora coffeicola* and diminished the severity of the disease it causes on the plant (Pozza *et al*., 2004). The increased rigidity of cellular tissues caused by the application of calcium silicate also reduced the damage caused by *E. saccharina* on sugar cane, possibly due to the abrasion of the mandibles of this insect (Kvedaras *et al*., 2007b). The application of silicon reduced the damage caused by sap-sucking *Xylella fastidosa* subsp. *pauca* on *Nicotiana tabacum* plants,

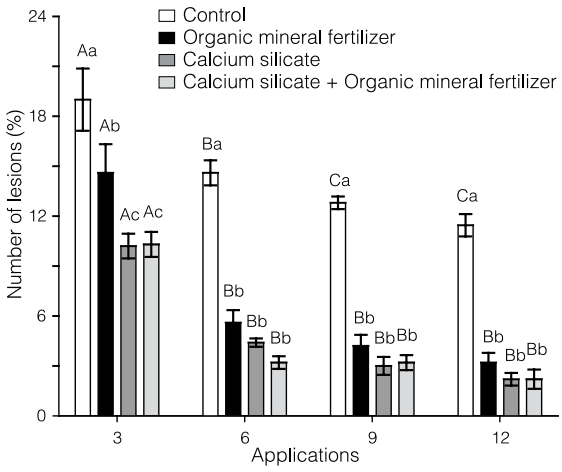

Figure 2. Number of lesions produced by *Thrips palmi* (Thysanoptera: Thripidae) nymphs on eggplant leaves after three, six, nine and twelve applications of calcium silicate, organic mineral fertilizer or calcium silicate associated with the organic mineral fertilizer and in the control. Temperature: 25 ±5°C, photoperiod: 12h, relative humidity: 70 ±10%. Capital letters indicated differences between applications and small letters between treatments in a same application by the test of Tukey (P<0.05).

mainly due to the accumulation and polymerization of the silica in the xylem cells of this plant (Martinati *et al*., 2007).

The increase of mechanical and chemical barriers of plants can hinder feeding by insects, reduce plant damage and increase insect mortality (Ma and Yamaji, 2006). The use of calcium silicate and the organic mineral fertilizer could be an alternative in integrated management programs of *T. palmi* on eggplants. The high insect mortality and the reduction in the number of lesions caused by nymphs of *T. palmi* with six or more applications of calcium silicate and/or the organic mineral fertilizer, suggest that the induced effect depends on a sufficient period of time from application, which was of 30 days after the beginning of the treatments. A single application is not enough to induce the desired resistance level. It is likely that this process involves the accumulation and silica polymerization in cell tissues as well as an increase on the activity of enzymes involved in the synthesis of phenolics and phytoalexins that can increase plant resistance to phytophagy (Aguirre *et al*., 2007; Massey *et al*., 2007).

Conclusion

Six or more leaf applications of calcium silicate, and/or the organic mineral fertilizer, in a period of 30 days, can cause a higher mortality of *T. palmi*, thus reducing the damage by this pest, probably due to the silicate deposition on the cellular tissues of eggplants turning them more resistant.

ACKNOWLEDGEMENTS

The authors acknowledgements the funds received from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), and TECNOBIOLBRASIL S.A.

REFERENCES

Aguirre C, Chávez T, García P, Raya JC (2007) El silicio en los organismos vivos. *Interciencia 32*: 504-509.

Almeida GD, Pratissoli D, Holtz AM, Vicentini VB (2008) Fertilizante organomineral como indutor de resistência contra a colonização da mosca branca do feijoeiro. *Idesia 26*: 29-32.

Antonini ACC, Robles WGR, Tessarioli Neto J, Kluge RA (2002) Capacidade produtiva de cultivares de berinjela. *Hort. Bras. 20*: 646-648.

Atakan E (2006) Associations between *Frankliniella* spp. and *Orius niger* populations in cotton. *Phytoparasitica 34*: 221-234.

Batista GF, Campos MJ, Donizete SC, Marcos GM (2005) Resistance induction in wheat plants by silicon and aphids. *Sci. Agric. 62*: 547-551.

Cannon RJC, Matthews L, Collins DW (2007a) A review of the pest status and control options for *Thrips palmi*. *Crop Prot. 26*: 1089-1098.

Cannon RJC, Matthews L, Collins DW, Agallou E, Bartlett PW, Walters KFA, Macleod A, Slawson DD, Gaunt D (2007b) Eradication of an invasive alien pest, *Thrips palmi*. *Crop Prot. 26*: 1303-1314.

Correa RSB, Morães JC, Auad AM, Carvalho GA (2005) Silicon and acibenzolar-s-methyl as resistance inducers in cucumber, against the whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) Biotype B. *Neotrop. Entomol. 34*:429-433.

Epstein E (1999) Silicon. *Annu. Rev. Plant Physiol. Plant Mol. Biol. 50*: 641-664.

Fauteux F, Chain F, Belzile F, Menzies JG, Bélanger, RR (2006) The protective role of silicon in the *Arabidopsis*–powdery mildew pathosystem**.** *P. Natl. Acad. Sci. USA 103*: 17554-17559.

Ghanmi D, McNally DJ, Benhamou N, Menzies JG, Bèlanger RR (2004) Powdery mildew of *Arabidopsis thaliana*: a pathosystem for exploring the role of silicon in plant-microbe interactions. *Physiol. Mol. Biol. Plant P. 64*: 189-199.

Gomes FB, de Morães JC, dos Santos CD, Goussain MM (2005) Resistance induction in wheat plants by silicon and aphids. *Sci. Agric. 62*: 547-551.

Goussain MM, Morães JC, Carvalho JC, Nogueira NL (2002) Efeito da aplicação de silício em plantas de milho no desenvolvimento biológico de lagarta-do-cartucho *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae). *Neotrop. Entomol. 31*: 305-310.

Goussain M, Prado E, Morães JC (2005) Effect of silicon applied to wheat plants on the biology and probing behaviour of the greenbug *Schizaphis graminum* (Rond.) (Hemiptera: Aphididae). *Neotrop. Entomol. 34*: 807-813.

Heine G, Tikum G, Horst WJ (2007) The effect of silicon on the infection by and spread of *Pythium aphanidermatum* in single roots of tomato and bitter gourd. *J. Exp. Bot. 58*: 569-577.

Inbar M, Doostdar H, Gerling D, Mayer RT (2001) Induction of systemic acquired resistance in cotton by BTH has a negligible effect on phytophagous insects. *Entomol. Exp. Appl. 99*: 65-70.

Kikuchi K, Honda I, Matsuo S, Fukuda M, Saito T (2008) Stability of fruit set of newly selected parthenocarpic eggplant lines. *Sci. Hortic. 115*: 111-116.

Kvedaras OL, Keeping MG (2007) Silicon impedes stalk penetration by the borer *Eldana saccharina* in sugarcane. *Entomol. Exp. Appl. 125*: 103-110.

Kvedaras OL, Keeping MG, Göebel FR, Byrne MJ (2007a) Larval performance of the pyralid borer *Eldana saccharina* Walker and stalk damage in sugarcane: Influence of plant silicon, cultivar and feeding site. *Int. J. Pest Manage. 53*: 183-194.

Kvedaras OL, Keeping MG, Göebel FR, Byrne MJ (2007b) Water stress augments silicon-mediated resistance of susceptible sugarcane cultivars to the stalk borer *Eldana saccharina* (Lepidoptera: Pyralidae). *Bul. Entomol. Res. 97*: 175-183.

Leite GLD, Picanco M, Zanuncio JC, Marquini F (2003) Factors affecting mite herbivory on eggplants in Brazil. *Exp. Appl. Acarol. 31*: 243-252.

Leite GLD, Picanco M, Jham GN, Moreira MD (2005) *Bemisia tabaci*, *Brevicoryne brassicae* and *Thrips tabaci* abundance on *Brassica oleracea* var. acephala. *Pesq. Agropec. Bras. 40*: 197-202.

Leite GLD, Picanco M, Zanuncio JC, Carvalho CE (2006) Factors affecting herbivory of Thrips palmi (Thysanoptera: Thripidae) and *Aphis gossypii* (Homoptera: Aphididae) on the eggplant (*Solanum melongena*). *Braz. Arch. Biol. Technol. 49*: 361-369.

Lemos WP, Zanuncio JC, Serrão JE (2005) Attack behavior of *Podisus rostralis* (Heteroptera: Pentatomidade) adults on caterpillars of *Bombyx mori* (Lepidoptera: Bombycidae). *Braz. Arch. Biol. Technol. 48*: 975-981.

Ma JF, Yamaji N (2006) Silicon uptake and accumulation in higher plants. *Plant Sci. 11*: 392-397.

Martinati JC, Laçava PT, Miyasawa SKS, Guzzo SD, Azevedo, JL, Tsai SM (2007) Reduction of the symptoms caused by *Xylella fastidiosa* subsp. *pauca* through application of benzothiadiazole and silicon. *Pesq. Agropec. Bras. 42*: 1083-1089.

Massey FP, Ennos AR, Hartley SE (2006) Silica in grasses as a defence against insect herbivores: contrasting effects on folivores and a phloem feeder. *J. Anim. Ecol. 75*: 595-603.

Massey FP, Ennos RA, Hartley SE (2007) Herbivore specific induction of silica-based plant defences. *Oecologia 152*: 677-683.

Morães JC, Goussain MM, Basagli MAB, Carvalho GA, Ecole CC, Sampaio MV (2004) Silicon influence on the tritrophic interaction: wheat plants, the greenbug *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae), and its natural enemies, *Chrysoperla externa* (Hagen) (Neuroptera: Chrysopidae) and *Aphidius colemani* Viereck (Hymenoptera: Aphidiidae). *Neotrop. Entomol. 33*: 619-624.

Pozza AAA, Alves E, Pozza EA, Carvalho JG, Montanari M, Guimarães PTG, Santos DM (2004) Efeito do silício no controle da cercosporiose em três variedades de cafeeiro. *Fitopatol. Bras. 29*: 185-188.

Pratissoli D, Almeida GD, Jesus WCJr, Vicentini VB, Holtz AM, Cocheto JG (2007) Fertilizante organomineral e argila silicatada como indutores de resistência à varíola do mamoeiro. *Idesia 25*: 63–67

Rains DW, Epstein E, Zasoski RJ, Aslam M (2006) Active silicon uptake by wheat. *Plant Soil 280*: 223-228.

Silva ME, Santos RC, O'Leary MC, Santos RS (1999) Effect of aubergine (*Solanum melongena*) on serum and hepatic cholesterol and triglycerides in rats. *Braz. Arch. Biol. Technol. 42*: 339-342.

Smith RM, Cuthbertson AGS, Walters KFA (2005) Extrapolating the use of an entomopathogenic nematode and fungus as control agents for *Frankliniella occidentalis* to *Thrips palmi*. *Phytoparasitica 33*: 436-440.

Snyder GH, Rich DW, Elliott CL, Barbosa Filho MP (2005) Evaluation of candidate silicon fertilizers. *Soil Crop Sci. Soc. Fla. Proc. 64*: 52-54.

Zhao E, Xu X, Dong M, Jiang S, Zhou Z, Han L (2007) Dissipation and residues of spinosad in eggplant and soil. *B. Environ. Contam. Tox. 78*: 222-225.