Research Article

Biological parameters of *Tetranychus urticae* Koch (Acari: Tetranychidae) on strawberry cultivars in Ecuador

Parámetros biológicos de *Tetranychus urticae* Koch (Acari: Tetranychidae) en cultivares de fresa en Ecuador

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Abstract. The two-spotted spider mite (TSSM), *Tetranychus urticae* Koch, is considered to be the main pest to strawberry crops, and because of this, strategies to manage TSSM pest populations are necessary. Herbivore life history parameters are useful tools for evaluating resistance or susceptibility of host plants to pests. Under room environment conditions (18.0 ± 1.0 °C, 66.0 ± 10 % RH and 12:12 photoperiod), developmental times and reproductive parameters of *T. urticae* were evaluated on strawberry cultivars ('Monterrey' and 'Albión'). Total developmental time (egg- adult) did not show significant differences by effect of the strawberry cultivar; however differences referring only to duration of egg, larvae and protonymphal stages were detected. Conversely, longevity, oviposition and post-oviposition periods on 'Albión' were 17.9, 12.9 and 9.9% higher than on 'Monterrey'. Also, total number of eggs and daily oviposition rates were 55 and 58.7% higher on 'Albión' leaves. No differences were detected during the first oviposition days, but after day 5, significantly more eggs per day were observed on 'Albión'. The results indicate that 'Albión' is more suitable for *T. urticae* development. Based on performance of *T. urticae* on these two strawberry cultivars, planted in Ecuador, our results can be considered in the development of an integrated pest management program for this mite.

Key words: Albión, *Fragaria*, Monterrey, pest.

Resumen. El ácaro de dos manchas (TSSM), *Tetranychus urticae* Koch, es considerada la principal plaga del cultivo de fresas y debido a esto se requieren estrategias de manejo de las poblaciones del ácaro. Los parámetros de la historia de vida son herramientas útiles para evaluar la adaptabilidad de un cultivar a una plaga. El tiempo de desarrollo y los parámetros reproductivos de *T. urticae* fueron evaluados sobre dos cultivares de fresa ('Monterrey' y 'Albión') bajo condiciones de laboratorio (18,0 ± 1,0 °C, 66,0 ± 10 % RH y 12:12 fotoperíodo). El tiempo total de desarrollo (huevo-adulto) no mostró diferencias significativas por efecto del cultivar de fresa, sin embargo, fueron detectadas diferencias en cuanto al tiempo de incubación del huevo, larva y protoninfa. Contrariamente, la longevidad y los períodos de oviposición y post-oviposición fueron 17,9; 12,9 y 9,9% mayores en 'Albión' que en 'Monterrey'. También, el número total de huevos y la tasa diaria de oviposición fueron 55 y 58,7% mayor en hojas de 'Albión'. No se detectaron diferencias durante los primeros días de oviposición, pero después del día 5, un número significativamente mayor fue observado en 'Albión'. Estos resultados indican que 'Albión' es más adecuado para el desarrollo de *T. urticae*. Basados en el desarrollo de *T. urticae* sobre estos dos cultivares de fresa cultivados en Ecuador, nuestros resultados

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podrían ser considerados en el desarrollo de un programa de manejo integrado de plagas para esta especie de ácaro.

Key words: Albión, *Fragaria*, Monterrey, plaga.

Introduction

Strawberries are grown as a crop in over 60 countries around the world, with the United States being the largest producer and accounting for 29% of the world's strawberry production (FAO 2017). In Ecuador, this crop is mainly grown in the provinces of Pichincha and Tungurahua. In these provinces, strawberry production occurs between 1,300 and 3,200 m. above sea level, at an average temperature of 15 °C. Most Ecuadorian strawberry production is destined for domestic consumption, with the remainder being exported to the United States, the Netherlands, and Spain (FAO 2017).

The two spotted spider mite (TSSM), *Tetranychus urticae* Koch, is considered a significant pest to strawberries in important production areas, such as Florida (USA) (Fraulo *et al*. 2008) and Brazil (Monteiro *et al*. 2014); however, information concerning the TSSM and Ecuadorian strawberries is still lacking. The TSSM prefers to feed on lower leaf surfaces, provoking leaves to turn a bronzed color (Tomczyk and Kropczynska 1985). High TSSM population densities can negatively affect leaf and flower development, diminishing strawberry quality and quantity (Fraulo *et al.* 2008; Afifi *et al.* 2010).

Differences in mite fitness are influenced by plant morphological and chemical characteristics, as well as plant defense mechanisms. These characteristics and mechanisms depend on plant genotype, pest species, and the interactions between both (Crooker 1985; De Ponti 1985; Dent 2000). Trichomes, foliar glands, and epidermis-cuticle strata thickness are morpho-anatomical features that can constitute physical barriers to tetranychid feeding. These features are also correlated to a negative incidence in the development and reproduction of TSSM (Bailey *et al*. 1978). Differences in phytophagous arthropod responses to host plant quality also depends on quantity and nature of primary and secondary metabolites (Awmack and Leather 2002; van den Boom *et al.* 2003). Effects of strawberry cultivars on tetranychid mite performances have varied. In one case, *T. urticae* showed greater population increases on the strawberry cultivars 'Hapil' and 'Pegasus', than on other cultivars (Sonneveld *et al.* 1997). In another case, although strawberry cultivars did not influence *T. urticae* developmental time (egg-adult), juvenile development, survivorship, and female fecundity were affected (Monteiro *et al.* 2014).

Considering the economic impact of *T. urticae* on strawberries in Province of Tungurahua, in Ecuador, mite performance in strawberry cultivars should be addressed in order to improve sustainable strategies which can contribute to the management of two-spotted spider mite populations. For this reason, in this article, biological parameters of *T. urticae* are evaluated in the two main strawberry cultivars used commercially in Ecuador.

Material and Methods

Biological aspects of *T. urticae*, were obtained and evaluated from commercial orchards of Albión' and 'Monterrey' in the Province of Tungurahua, Ecuador. Mites used for the evaluations were collected from *Solanum muricatum* leaves (sweet cucumber), grown at the Querochaca Faculty of Farm Sciences experimental campus, at the Universidad Técnica de Ambato (UTA) (01°22'47"S - 78°36'53"W). The stock-colony of these mites was maintained in sweet cucumber grown in 4.5 L pots in greenhouse during three months before the beginning of the experiments.

Two experiments were carried out at the Biotechnology Laboratory, Faculty of Agricultural Sciences (UTA), under the following environmental conditions: 18.0 ± 1.0 °C, 66.0 ± 10 % RH and 12 h photoperiod.

Experiment 1. Influence of cultivar on developmental time of *T. urticae*.

Each experimental unit consisted of a leaf disk (3 cm diameter) obtained from the center of the leaf that had been set aside for testing. The leaves were placed with the bottom surface facing up, onto a polyurethane layer, and continuously maintained wet through a daily addition of distilled water (Vásquez *et al*. 2015). Twenty units were used from each of the cultivars. A field-collected, *T. urticae,* adult female was transferred to each unit. At 12-h intervals, leaf disks were examined to determine when oviposition took place. The adult female and the excess eggs in each unit were then discarded, leaving only one egg per leaf disk.

The leaf disks were examined at 12-h intervals to determine the duration of each developmental stage. On each disk, soon after the female reached adulthood, a field-collected male was transferred to the respective experimental unit, and then maintained until its death. Dead males were replaced by new, field-collected males. Each 5 days, leaf disks were replaced with new disks to ensure a physiologically adequate rearing substrate throughout the experiment. Throughout each developmental stage, and the whole immature phase, differences in relation to mean durations between strawberry cultivars were compared.

Experiment 2. Reproductive parameters of *T. urticae* reared on two strawberry cultivars.

Periods of pre-oviposition, oviposition, post-oviposition, reproductive parameters (total fecundity, daily oviposition rate), and female longevity (measured from female's emergency until death) were determined on both strawberry cultivars. A newly emerged female and one adult male mite were placed together on leaf discs (3 cm diameter) from each of the strawberry cultivars as described above. Pre-oviposition periods were recorded at 12-h intervals; while other longevity and reproductive parameters were recorded every 24 h. Also, percent of survivorship was measured as number of alive individuals at each life mite stage. Leaf discs were removed and replaced by new ones at 4-day intervals. Ten replications were run.

Life table parameters, including intrinsic rate of natural increase (rm), net productive rate (R0), finite rate of increase (k) and mean generation time (T) as well as their standard errors were estimated by the jackknife method (Birch 1948) using the SAS System Software V6.12 (SAS Institute, 1989). Significance of differences between mean values of life table parameters was determined using Student's test (Maia et al. 2000).

Statistical analyses. Data were submitted to an analysis of variance and then compared by a t-Student test, with 5% probability. Survival percentage values were first transformed by arcosen√p and then submitted to a t-Student test.

Results and Discussion

Developmental rate

Although the total developmental time (egg-adult) did not show significant differences between strawberry cultivars, differences pertaining to duration of egg, larvae and protonymphal stages were detected (Table 1). Differences observed in the initial stages of *T. urticae* could be related to the presence of components in strawberry leaves that may have toxic or anti-digestive effects (Monteiro *et al*. 2014). In both cultivars, all eggs eclosed; however, some mortality was observed in subsequent stages (larvae, protonymph

and deutonymph) stages. Similar to our results, Monteiro *et al.* (2014) did not find that strawberry cultivars created differences in the total developmental period (egg to adult); however, they observed higher immature survivorship on some cultivars such as 'Aromas', 'Camarosa' and 'Seascape'. Some studies report differences in the egg incubation period when mites are reared on different substrates (Moro *et al.* 2012; Riahi *et al.* 2011; Vásquez *et al.* 2015). Differences in incubation period could be attributed to characteristics of the mother. The mother may have been affected by environmental conditions, e.g., age, rearing density, food quality, and food availability (Beckerman *et al.* 2006). However, this explanation is perhaps not appropriate for the differences observed, since in this study all mite mothers were collected from similar conditions (locality and host plant). Kuijper *et al.* (2014) stated that maternal effects should not be considered as a result of a single characteristic, but as the presence of a pool of interacting, though still poorly understood, traits. Most probably, JA-dependent direct defenses seem to have a role in enhancing egg mortality or increasing the time needed for embryonic development (Ament *et al*. 2004), however mechanisms involved are still unclear.

Previous studies have reported that the egg incubation time and duration of nymphal stage of *T. urticae* were affected by strawberry cultivars (Rezaie *et al.* 2013). Thus, *T. urticae* developmental time (egg-adult) varied from 12.5 to 18.8 days on 'Camarosa' and 'Festival' cultivars (Monteiro *et al.* 2014), and 7.0 to 9.9 days on 'Marak' and 'Chandler' (Rezaie *et al.* 2013). Also, El-Sawi *et al.* (2006) observed that the life cycle and immature stages of *T. urticae* were longer on 'Camarosa' and 'Sweet-Charlie' than on 'Gaviota' and 'Carts-bad' strawberry cultivars. These authors hypothesized that higher concentrations of total sugars, and lower concentrations of phenols and amino-acids in 'Gaviota' and 'Carts-bad', made these cultivars more preferable and susceptible to mite infestation. However, there is no information about leaf chemical composition in Albion and Monterey, hence it.

In general, differences were observed in survival levels in development stages of *T. urticae*, being significant higher in larvae and protonymphal stages on both strawberry cultivars; respectively; although, survival levels were slightly higher when mites were reared on 'Monterrey'. High mortality was observed during the deutonymph stage (Table 1). 'Albion' was the cultivar where the greatest number of *T. urticae* completed their life cycles. Conversely, Monteiro *et al.* (2014) observed low survival levels in *T. urticae* larvae, irrespective to the variety of strawberry cultivar; however, those the surviving larvae adapted to feed on strawberry disks and no significant differences were observed for the following instars, except for the teleiochrysalis.

Table 1. Developmental time (mean days ±SD) of *T. urticae* on 'Albión' and 'Monterrey' strawberry cultivars, at 18.0 ± 1.0 °C, 66 ± 10 % RH and 12 h photoperiod (numbers in parentheses represent % survivorship).

Cultivar	Egg	Larval	Protonymph	Deutonymph	Egg-adult
Albión	11.56±1.50a (100.0)a	4.42±0.61b (95.0)a	4.53±0.48a (85.0)ab	4.48±0.20a (77.5)b	24.57±0.29a (77.5)b
Monterrey	9.42±1.34b (100.0)a	4.80±0.70a (97.5)a	4.19±0.98b (92.5)a	5.00±0.25a (70.0)ab	23.83±0.36a (45.0)b

Mean in a column followed by the same letter did not show significant differences according to Student's
t test (two-tailed distribution), p-value <0.05.

Table 2. Performance of *T. urticae* females on two strawberry cultivars at 18 ± 1 °C, 66 ± 10 % RH and 12 h photoperiod (mean ± SD).

	Albión	Monterrey
Longevity	18.2 ± 3.22a	17.3 ± 4.83b
Pre-oviposition period (days)	2.1 ± 1.10b	2.8 ± 0.92a
Oviposition period (days)	8.8 ± 2.82a	7.8 ± 2.15b
Post-oviposition period (days)	7.3 ± 2.91a	6.7 ± 4.00b
Total oviposition (eggs)	578.0 ± 35.39a	260.0 ± 14.41b
Daily oviposition rate (eggs/day)	3.17 ± 0.56a	1.86 ± 0.43b

Mean in a column followed by the same letter did not show significant differences according to Student's
t test (two-tailed distribution), p-value <0.05.

Longevity and reproductive parameters

The longevity, oviposition and post-oviposition period differed significantly between cultivars, being 17.9, 12.9 and 9.9% higher on 'Albión' than on 'Monterrey', respectively (Table 2). Also, the total number of eggs and daily oviposition rates were 55 and 58.7% higher on 'Albión' leaves (Table 2). Differences on daily oviposition rate were detected only after day 5, when significantly more eggs per day were counted on Albión than in Monterrey (Fig. 1). Life table parameters also varied with the strawberry cultivar, being the values of net reproductive rate (Ro), mean time generation (T) and population doubling time (TD) higher in Albión, meanwhile intrinsic rate of increase (rm) and finite rate of increase (λ) higher in Monterrey (Table 3).

Monteiro *et al.* (2014) reported that cultivars influenced female longevity, which ranged from 7.4-11.8 days. Additionally, Giménez *et al.* (1993) found that strawberry cultivars can influence oviposition rates of *T. urticae* females; and cultivars with the highest levels of oviposition (6.2 eggs/day) were found to be highly susceptible to plague as compared to those with lower levels of oviposition (which were more resistant) (1.7 eggs/day). Conversely to our results, Karlec *et al.* (2017) reported that *T. urticae* performed better on 'Monterrey' than on 'Albión', suggesting that mite performance could be related to the chemical or nutritional characteristics of the host. Previous studies have demonstrated that cultivars from different plant species influence *T. urticae* life parameters i.e. rose (Golizadeh *et al.* 2017), papaya (Moro *et al.* 2012), soybean (Razmjou *et al.* 2009), and apple (Kasap 2004; Skorupska 2004). It is widely accepted that both chemical and morphological plant characteristics can affect their suitability as hosts, thus evoking

Table 3. Fertility life table of *Tetranychus urticae* females in Albion and Monterrey strawberry cultivars.

	Albion	Monterrey
Ro	65.0a	57.5b
T	29.92a	21.43b
rm	0.026b	0.036a
λ	1.011b	1.016a
TD	26.36a	19.45b

Mean values followed by the same letter in a row did not show statistic differences (Confidence interval 95%) after Jackknife test.
Net reproductive rate (Ro), mean generation time (T), intrinsic growth rate (rm), finite increase rate (λ), population doubling time (TD) in days.

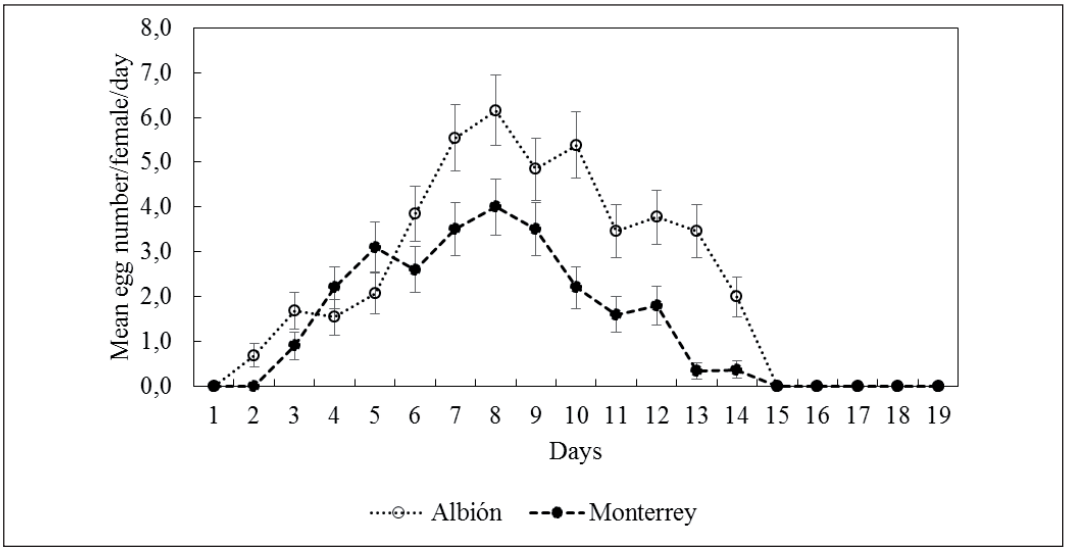

Figure 1. Mean number of eggs laid daily by *T. urticae* females reared on 'Albión' or 'Monterrey' strawberry leaves (Error bars represent standard deviation SD).

differences in herbivore performance (Awmack and Leather 2002; Golizadeh *et al.* 2016). According to Price *et al.* (1980), host plant quality influences life history parameters of herbivores, affecting growth, mortality, and fecundity rate. *Tetranychus urticae* has shown a preference and better life history parameters regarding performance on strawberry leaves (Greco *et al.* 2006); however, as previously mentioned, cultivars may have an influence on physiological conditions (fecundity, longevity and life cycle) (Dabrowski and Bielak 1978; Karlec *et al.* 2017; van de Vrie *et al.* 1972).

Separate from plant phenology, environmental conditions such as photoperiod can affect susceptibility to phytophagous mite feeding. Strawberry plant resistance to *T. urticae* has been shown to vary according to photoperiod, with plants under short days being more susceptible; and plants switched from short to long days, after harvest, showing a marked increase in resistance (Patterson *et al.* 1994). Finally, da Costa *et al.* (2016) stated that cultivars considered as neutral-day can exhibit different physiological behaviors depending on temperature and photoperiod conditions; however, the performance of such cultivars are little known, especially in sub-tropical regions of South America. Since the strawberry cultivars commercially used in Ecuador ('Albion' and 'Monterrey') are classified as neutral to day length, studies researching the effect of photoperiod on inducing plant resistance to phytophagous mites should be addressed in the Andean environment, in order to offer more sustainable strategies for management of two spotted spider mite populations.

Based on the performance of *T. urticae* on 'Albion' and 'Monterey' (cultivars generally used in Ecuador), our results may be considered for the development of strategies in the mite integrated management since they could be serve as a base for the development of more resistant cultivars. Besides this information is useful for strawberry growers since it could be used as an alternative control method aiming the reduction of use of pesticides in the control of *T. urticae* in strawberry crops.

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Literature Cited

Afifi, A., El-Laithy, A., Shehata, A. and El-Saiedy, E. (2010) Resistance of strawberry plants against the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *In*: 12th International Congress of Acarology, 2010, Amsterdam, Holland. pp. 505-507.

Ament, K., Kant, M.R., Sabelis, M.W., Haring, M.A. and Schuurink, R.C. (2004) Jasmonic acid is a key regulator of spider mite-induced volatile terpenoid and methyl salicylate emission in tomato. *Plant Physiology, 135*(4): 2025-2037.

Awmack, C.S. and Leather, S.R. (2002) Host plant quality and fecundity in herbivorous insects. *Annual Review of Entomology, 47*: 817-844.

Bailey, J., Furr, R., Hanny, B. and Meredith, W. (1978) Field populations of two-spotted spider mites on sixteen genotypes at Stoneville. *Journal of Economic Entomology, 71*: 911-912.

Beckerman, A.P., Benton, T.G., Lapsley, C.T. and Koesters, N. (2006) How effective are maternal effects at having effects?. *Proceedings of the Royal Society B: Biological Sciences, 273*: 485-493.

Birch, L.C. (1948) The intrinsic rate of natural increase of an insect population. *Journal of Animal Ecology, 17*: 15-26.

Crooker, A. (1985) Embryonic and juvenile development. *Spider mites: their biology, natural enemies and control, vol 1A.* (ed. Helle, W. & Sabelis M.W.), p. 149-163. Elsevier Science Publishers B.V. Amsterdam.

Da Costa, R.C., Calvete, E.O., Mendonça, H.F.C., Campagnolo, A. and Chiomento, J.L.T. (2016) Performance of day-neutral strawberry cultivars in soilless culture. *Australian Journal of Crop Science, 10*(1): 94-100.

Dabrowski, Z.T. and Bielak, B. (1978) Effect of some plant chemical compounds on the behaviour and reproduction of spider mites (Acarina: Tetranychidae). *Entomologia Experimentalis et Applicata, 24*: 117-126.

De Ponti, O. (1985) Host plant resistance and its manipulation through plant breeding. *Spider mites: their biology, natural enemies and control, vol 1A.* (ed. Helle, W. & Sabelis M.W.), p. 395-403. Elsevier Science Publishers B.V. Amsterdam.

Dent, D. (2000) *Insect Pest Management*. Second ed. CABI Biosciences, Ascot.

El-Sawi, S.A. (2006) Effect of different strawberry cultivars on the development and fecundity of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), with special reference to their chemical contents. *Annals of Agricultural Sciences, 51*(1): 295-302.

FAO (2017) Faostat. Consulted 20 May 2016. Available in: http://www.fao.org/faostat/es/#data/QCg.

Fraulo, A.B., Mcsorley, R. and Liburd, O.E. (2008) Effect of the biological control agent *Neoseiulus californicus* (Acari: Phytoseiidae) on arthropod community structure in North Florida strawberry fields. *Florida Entomologist, 91*: 436-445.

Giménez, R.M., Scheerens, J.C. and Erb, W.A. (1993) In vitro screening of 76 strawberry cultivars for twospotted spider mite resistance. *Horticultural Science, 28*(8): 841-844.

Golizadeh, A., Ghavidel, S., Razmjou, J., Fathi, S.A.A. and Hassanpour, M (2017) Comparative life table analysis of *Tetranychus urticae* Koch (Acari: Tetranychidae) on ten rose cultivars. *Acarologia, 57*(3): 607-616.

Golizadeh, A., Jafari-Behi, V., Razmjou, J., Naseri, B. and Hassanpour, M. (2016) Population growth parameters of rose aphid, *Macrosiphum rosae* (Hemiptera: Aphididae) on different rose cultivars. *Neotropical Entomology, 46*(1): 100-106.

Greco, N.M., Pereyra, P.C. and Guillade, A. (2006) Host-plant acceptance and performance of *Tetranychus urticae* (Acari, Tetranychidae). *Journal of Applied Entomology, 130*(1): 32-36.

Karlec, F., Fonseca, A.D., Oliveira, A.C.B. and Cunha, U.S. (2017) Development of *Tetranychus urticae* Koch (Acari: Tetranychidae) in different strawberry cultivars. *Revista Brasileira de Fruticultura, 39*(1): 1-8.

Kasap, I. (2004) Effect of apple cultivar and of temperature on the biology and life table parameters of the two-spotted spider mite *Tetranychus urticae. Phytoparasitica, 32*(1): 73-82.

Kuijper, B., Johnstone, R.A. and Townley, S. (2014) The evolution of multivariate maternal effects. *PLoS Computational Biology, 10*(4): 1-11.

Maia, A., Luiz, A. and Campanhola, C. (2000) Statistical inference on associated fertility life table parameters using jackknife technique: computational aspects. *Journal of Economic Entomology, 93*(2): 511-518.

Monteiro, L.B., Kuhn, T.M.A., Mogor, A.F. and da Silva, E.D.B. (2014) Biology of the two-spotted spider mite on strawberry plants. *Neotropical Entomology, 43*: 183-188.

Moro, L.B., Polanczyk, R.A., Carvalho, J.R., Pratissoli, D. and Franco, C.R. (2012) Parâmetros biológicos e tabela de vida de *Tetranychus urticae* (Acari: Tetranychidae) em cultivares de mamão. *Ciência Rural, 42*(3): 487-493.

Patterson, C.G., Archbold, D.D., Rodriguez, J.G. and Hamilton-Kemp, T.R. (1994) Daylength and resistance of strawberry foliage to the twospotted spider mite. *Horticultural Science, 29*(11): 1329-1331.

Price, P.W., Bouton, C.E., Gross, P., Mcpheron, B.A., Thompson, J.N. and Weis, A.E. (1980) Interactions among three trophic levels: Influence of plants on interactions between insect herbivores and natural enemies. *Annual Review of Ecology, Evolution, and Systematics, 11*: 41-65.

Razmjou, J., Tavakkoli, H. and Fallahi, A. (2009) Effect of soybean cultivar on life history parameters of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Journal of Pest Science, 82*: 89-94.

Rezaie, M., Saboori, A., Baniamerie, V. and Allahyari, H. (2013) Susceptibility of *Tetranychus urticae* Koch (Acari: Tetranychidae) on seven strawberry cultivars. *International Research Journal of Applied and Basic Sciences, 4*(9): 2455-2463.

Riahi, E., Nemati, A., Shishehbor, P. and Saeidi, Z. (2011) Population growth parameters of the two-spotted spider mite, *Tetranychus urticae*, on three peach varieties in Iran. *Acarologia, 51*(4): 473-480.

Skorupska, A. (2004) Resistance of apple cultivars to spotted spider mite, *Tetranychus urticae* Koch (Acarina: Tetranychidae) Part II. Influence of leaf pubescence of selected apple cultivars on fecundity of two-spotted spider mite. *Journal of Plant Protection Research, 44*(1): 69-74.

Sonneveld, T., Wainwright, H. and Labuschagne, L. (1997) Two methods for determining the resistance of strawberry cultivars to two-spotted mite (Acari: Tetranychidae). *Acta Horticulturae, 439*: 199-204.

Tomcyk, A. and Kropczyńska, D. (1985) Effects on the host plant. *Spider mites: their biology, natural enemies and control, vol 1A.* (ed. Helle, W. & Sabelis M.W.), p. 317-329. Elsevier Science Publishers B.V. Amsterdam.

van De Vrie, M., Mcmurtry, J.A. and Huffaker, C.B. (1972) Ecology of tetranychid mites and their enemies - a review - III: biology, ecology, and pest status, and host-plant relations of tetranychids. *Hilgardia, 41*(13): 343-432.

van den Boom, E.M., Van Beek, T.A. and Dicke, M. (2003) Differences among plant species in acceptance by the spider mite *Tetranychus urticae* Koch. *Journal of Applied Entomology, 127*: 177-183.

Vásquez, C., Colmenárez, Y. and de Moraes, G.J. (2015) Life cycle of *Raoiella indica* (Acari: Tenuipalpidae) on ornamental plants, mostly Arecaceae. *Experimental and Applied Acarology, 65*(2): 227-235.