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Effects of undercropping *Allium tuberosum* Rottler ex Sprengel (Amaryllidaceae) on Tetranychus urticae Koch (Acari: Tetranychidae) populations in strawberry

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Abstract. The twospotted spider mite (TSSM), *Tetranychus urticae* Koch is one of the most important pests on greenhouses/high tunnels worldwide. We evaluated effects of Chinese chive grown under the wooden structure which supports the bags used of strawberry grown, in two high tunnels from November 2016 to January 2017. TSSM mobile forms and number of eggs were counted on strawberry leaves. Five plants were randomly chosen on each plot. TSSM populations on strawberry leaves were assessed with magnifying glass (10 ×). Reductions were observed on three of eight assessments on TSSM mobile forms. On one date was observed reductions on mean number of TSSM eggs. Cumulate mite days overall data of TSSM mobile forms from two high tunnels reveals a reduction with intercrop. On the other hand, number of eggs was not altered. Results suggest that Chinese chive intercropped can reduce TSSM populations on strawberry high tunnels.

Keywords: Chinese chive; Companion planting; *Fragaria* × *ananassa*; Twospotted spider mite; Suspended strawberry.

Efeito do cultivo consorciado de *Allium tuberosum* Rottler ex Sprengel (Amaryllidaceae) em populações de *Tetranychus urticae* Koch (Acari: Tetranychidae) em morangueiro

Resumo. O ácaro-rajado, *Tetranychus urticae* Koch, é uma das mais importantes pragas em casas de vegetação no mundo. Foi avaliado o efeito do consórcio de cebolinha chinesa, cultivada sob as estruturas de madeira que suportam as sacolas para o cultivo de morangueiro (sistema suspenso), em duas casas de vegetação, entre novembro de 2016 e janeiro de 2017. Formas móveis e ovos de ácaros foram contabilizados em folhas de morangueiro. Para as avaliações, cinco plantas foram aleatoriamente selecionadas em cada parcela. Populações de ácaro-rajado em folhas de morangueiro foram avaliadas com lupa de bolso, com 10 x de aumento. Reduções foram observadas em três de oito avaliações de formas móveis de ácaro-rajado. Foram observadas reduções no número de ovos em uma avaliação. Tomando em consideração os dados de ácaros acumulados por dia, foi observado que o consórcio reduziu em 54% a população de ácaros. Por outro lado, o número de ovos não foi alterado.

Palavras-chave: Ácaro-rajado; Cebolinha Chinesa; *Fragaria* × *ananassa*; Plantas companheiras; Sistema suspenso.

Strawberry (*Fragaria* × *ananassa*), a perennial plant belonging to Rosaceae, has high sensorial characteristics and is considered a functional fruit because of its high concentrations of bioactive compounds, such as phenols, flavonoids, and vitamin C (Cerezo *et al.* 2010; Basu *et al.* 2014). The Brazilian production is estimated at 128,000 tons, in an area of 3573 ha, and main producing States are Minas Gerais, Paraná, Rio Grande do Sul, São Paulo, and Espírito Santo (EMATER-MG 2012). In Parana State, strawberry production is around 20000 tons, in an area of 679 ha (Andrade 2015), and main producing municipalities are São José dos Pinhais, Jaboti, Araucária, and Pinhalão (SEAB/EMATER-PR 2012). Strawberry growers are increasing using cultivation in bags suspended by wooden structures in high tunnels.

The twospotted spider mite (TSSM), *Tetranychus urticae* Koch (Acari: Tetranychidae), is one of the most important pests in greenhouses/high tunnels and field-grown strawberries. Its development and population growth increase under higher temperatures and low moisture (Zhang 2003). Plants under high tunnel environment are partially protected from rain, therefore more susceptible to TSSM outbreaks, making its control even more difficult. Then, finding new approaches for TSSM control are a critical need.

An appropriate use of vegetation could lead to pest reductions as an alternative to chemical control. A successful example of its use is the push-pull system: desmodium, *Desmodium uncinatum* (Jacq.) DC (Fabaceae), planted between maize, *Zea mays* L. (Poaceae), crops, repels pests, and attracts natural enemies; on the other hand, napier grass, *Pennisetum purpureum* Schum. (Poaceae), planted around that intercropping (maize and desmodium) attracts adults of pests for lay their eggs (Khan

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et al. 2014). Therefore, studies on repelling plants are very important.

Basil, *Ocimum minimum* L. (Lamiaceae), coriander, *Coriandrum sativum* L. (Apiaceae), or citronella grass, *Cymbopogon* sp. Spreng. (Poaceae) repels the hemipteran *Bemisia tabaci* (Gennadius) in olfactometer tests and on intercropping (citronella as mulching), on tomato, *Solanum lycopersicum* L. (Solanaceae), crops (Carvalho *et al.* 2017). In Botswana open field experiments, basil, garlic, *Allium sativum* L. (Amaryllidaceae), and marigold, *Tagetes patula* L. (Asteraceae), intercropping reduced *Brevicoryne brassicae* L. populations on kale (Tiroesele & Matshela, 2015). Studies reveal that intercropping also reduces mite populations on plants. Onion, *Allium cepa* L. (Amaryllidaceae) as intercrop plant reduces *Tetranychus evansi* Baker and Pritchard (Acari: Tetranychidae) populations on tomato leaves (Mtambo & Zeledon 2000). In study on field and greenhouse in Brazil, TSSM populations on strawberry leaves were reduced by garlic intercropping (Hata *et al.* 2016). In summary, these studies show that aromatic plants have potential to be included as intercropped plant for pest control.

Chinese chive, *Allium tuberosum* Rottler ex Sprengel (Amaryllidaceae), is a commonly used plant in Oriental (Chinese, Japanese and Korean) cuisine and their leaves and/or stalks are consumed raw or in cooked dishes (Pandey *et al.* 2014). Leaves of Chinese chive release a strong odor, develop well under shaded environments, and do not demand great management.

Our hypothesis is that Chinese chive volatile organic compounds released by its leaves reduce TSSM populations on strawberry leaves. Hence, we evaluated TSSM populations on strawberry leaves on two situations: spontaneous plants under the wooden structures of strawberry cultivation (control) and Chinese chive grown on the ground, under the structures "undercropping".

MATERIAL AND METHODS

Experiments were performed in Marialva County, Paraná State, Brazil, on two high tunnels: high tunnel one: 23° 29' 09.15" S, 51° 45' 57.45" W, 568 m a.s.l., and high tunnel two: 23°27'53.9"S 51°48'02.7"W, 614 m a.s.l.), distant 4.2 km between each other, in suspended strawberry system. Strawberry plants (Albion cv.) for both areas were planted in March 2015 and were grown on bags with 1.2 m length and 0.3 m width. Seven strawberry plants were cultivated per bag. Structures of the suspended system were made of wood, with 1.0 m of height above ground. Crops management was performed according to the standard technical recommendations, with adaptations to the cultivation in bags (Ronque 1998; Galina *et al.* 2013).

Treatments were control (spontaneous vegetation in the grown below the bags) and Chinese chive grown on the ground, below the structures (one row of Chinese chive grown under each two lines of cultivation) "undercropping" (Figure 1). Planting of Chinese chive was in March 2016. Plots consisted of two bags (14 strawberry plants per plot).

TSSM mobile forms (nymphs and adults) and number of eggs were counted on strawberry leaves. Five plants were randomly chosen in each plot. Observations were performed using a 10 × magnifying glass (1 cm^2). Three observations were made on the abaxial surface, in the central area of young leaflets, on each of five chosen plants. The same experimental design was set up in two high tunnels. Assessments were realized on November 21; December 13 and 27, 2016; and January 15, 2017.

Treatments were replicated eight times in completely randomized design. The cumulative effect of the mite feeding was evaluated by a cumulative number of mites per day (CMD) index. This formula is recommended to compare the accumulated treatment effects (Costello 2011). CMD index was calculated with the

Figure 1. Chinese chive cultivated as undercrop in a high-tunnel strawberry (Albion cv.) production.

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formula: $\sum\{[0.5 * (A_n + A_{n+1})]/D\}$ where, A n: Number of mites on sample "n"; A_{n+1}: Number of mites on next sample period (n+1); D: Number of days between sample "n" and sample "n+1".

To verify the assumptions for the analysis of variance, tests of the variance homogeneity and normality were performed. If assumptions were accepted, analysis of variance was performed and means were compared by Tukey's test ($\alpha = 0.05$). BioEstat 5.0 (Ayres 2007) and SASM-Agri (Canteri *et al.* 2001) software were used.

RESULTS AND DISCUSSION

Reductions of mobile forms of TSSM were observed on three of eight assessments: on November 21 (high tunnel one: $F = 6.77$; $p < 0.05$; high tunnel two: $F = 5.60$; $p < 0.05$), and on December 27 (high tunnel two: $F = 11.12$; $p < 0.05$) and one of eight observations reductions on mean number of TSSM eggs were observed on November 21 (high tunnel two: $F = 5.86$; $p < 0.05$) (Table 1 and 2).

Reductions in TSSM mobile forms populations were observed in both areas. In high tunnel one, significant reductions of mobile forms were observed in one assessment (74.80%, on Nov 21). In high tunnel two, significant reductions of mobile forms were observed in two assessments (reductions of 100 and 89.60% on November 21 and December 27, respectively). Reductions of the number of eggs were observed only on November 21 (100%). The CMD data shows that undercrop reduced TSSM population in high tunnel two (80% reduction).

The overall CMD data from two high tunnels reveals a significant reduction ($F = 7.85$; $p < 0.05$) of 54.23% (Figure 2). Analysis of the overall number of eggs data from the two high tunnels reveals that treatments did not differ between each other.

Previous studies included Chinese chive as intercropping plants for plant diseases and nematode control, obtaining promising results. Intercropping of this plant has been tested against *Pseudomonas solanacearum* on tomatoes (Yu 1999), *Fusarium oxysporum* f. sp. *cubense* on banana *Musa* spp. (Musaceae) (Zhang *et al.* 2013), and root-knot nematode on tomatoes (Huang *et al.* 2016). The use of garlic, other Amaryllidaceae plant, as intercropping plant reduced TSSM populations by 65% in strawberry leaves in a previous study in field (Hata *et al.* 2016).

Chinese chive main volatile organic compounds (VOCs) were identified as dimethyl disulfide (DMDS) and dimethyl trisulfide (DMTS) (Yabuki *et al.* 2010), which probably caused TSSM reductions in our study. However, TSSM mobile forms populations were reduced on 38% of observations in the present study. This suggests that insufficient VOCs concentrations were released by Chinese chive plants. Hence, before widespread recommendation of Chinese chive undercropping approach

Table 1. Mean numbers (±SD) of *Tetranychus urticae* mobile forms per cm² on leaves of strawberry (Albion cv.) planted in high tunnels, in undercropping with Chinese chive, 2016/17. Marialva, Paraná, Brazil, from November, 2016 to January, 2017.

High tunnel one					
Treatments	Nov 21	Dec 13	Dec 27	Jan 15	CMD
Control	2.50 ± 1.76 a	0.38 ± 0.52 a	0.25 ± 0.51 a	0.00 ± 0.00 a	0.57 ± 0.44 a
Undercrop	0.63 ± 0.92 b	0.88 ± 0.64 a	0.00 ± 0.00 a	0.00 ± 0.00 a	0.41 ± 0.38 a
C.V. (%)	93.42	93.20	261.86	0.00	80.85
F value	6.77	2.97	2.33	0.00	0.66
High tunnel two					
Treatments	Nov 21	Dec 13	Dec 27	Jan 15	CMD
Control	1.00 ± 1.20 a	0.00 ± 0.00 a	1.25 ± 0.89 a	0.13 ± 0.35 a	0.60 ± 0.40 a
Undercrop	0.00 ± 0.00 b	0.00 ± 0.00 a	0.13 ± 0.35 b	0.50 ± 0.76 a	0.12 ± 0.23 b
C.V. (%)	169.03	0.00	98.15	188.83	67.83
F value	5.60	0.00	11.12	1.62	14.97

Means ± SD within a column followed by the same letter are not significantly different by Tukey test: P>0.05. C.V.= Coefficient of Variation

Table 2. Mean numbers (±SD) of *Tetranychus urticae* eggs per cm² on leaves of strawberry (Albion cv.) planted in high tunnels, in undercropping with Chinese chive, 2016/17. Marialva, Paraná, Brazil, from November, 2016 to January, 2017.

High tunnel one				
Treatments	Nov 21	Dec 13	Dec 27	Jan 15
Control	4.75 ± 5.77 a	0.00 ± 0.00 a	0.63 ± 1.19 a	0.00 ± 0.00 a
Undercrop	1.75 ± 2.19 a	0.75 ± 1.04 a	0.50 ± 0.93 a	0.00 ± 0.00 a
C.V. (%)	134.37	195.18	189.31	0.00
F value	1.89	4.20	0.05	0.00
High tunnel two				
Treatments	Nov 21	Dec 13	Dec 27	Jan 15
Control	2.38 ± 2.77 a	0.38 ± 0.74 a	0.88 ± 1.13 a	0.00 ± 0.00 a
Undercrop	0.00 ± 0.00 b	1.00 ± 1.52 a	1.38 ± 1.85 a	1.00 ± 2.07 a
C.V. (%)	165.19	173.31	135.95	292.77
F value	5.86	1.10	0.43	1.87

Means ± SD within a column followed by the same letter are not significantly different by Tukey test: P>0.05. C.V.= Coefficient of Variation

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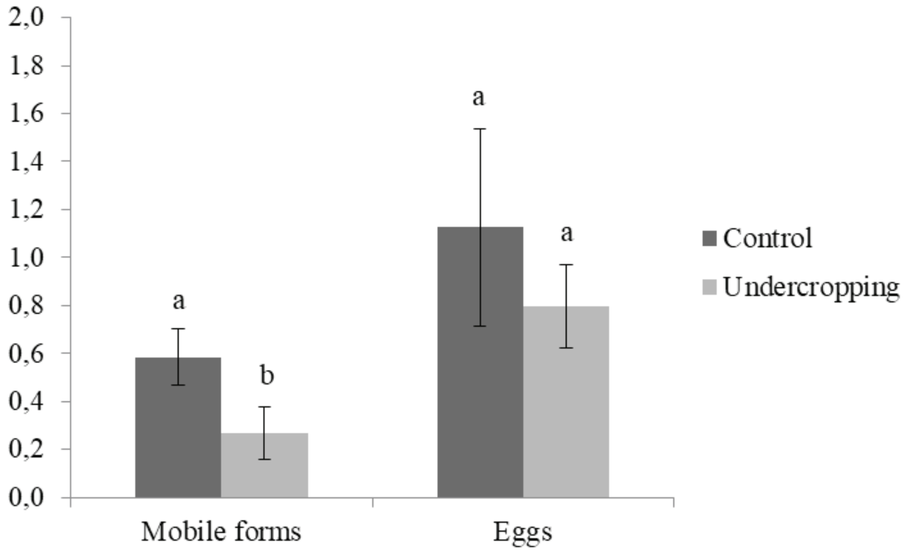

Figure 2. Mean number (± SEM) of *Tetranychus urticae* mobile forms and number of eggs per cm² on leaves of strawberry (Albion cv.) in control or undercropped with Chinese chive, with overall data from two high tunnels. Marialva, Paraná, Brazil, 2017.

we recommend that future studies could investigate if a higher Chinese chive planting density would provide more consistent TSSM reductions in strawberry leaves.

Farmers reported that Chinese chive is a perennial plant that supports shading and develops well below the structures that support the bags. In addition, Chinese chive leaves remain green through almost the entire period of a year in tropical conditions (Pandey *et al.* 2014). Then, those aromatic plants are continuously releasing VOCs by its leaves what may provide persistent protection for strawberry plants.

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REFERENCES

Andrade, P.F.S., 2015. Fruticultura. SEAB/DERAL – Secretaria de Estado da Agricultura e do Abastecimento – Departamento de Economia Rural. Available on: <http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/fruticultura_2014_15.pdf> [Access in: 18.iv.2017].

Ayres, M., 2007. BioEstat 5.0: Aplicações estatísticas nas áreas das Ciências biológicas e médicas. Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brasília.

Basu, A., A. Nguyen, N.M. Betts & T.J. Lyons, 2014. Strawberry as a functional food: an evidence-based review. Critical Reviews in Food Science and Nutrition, 54: 790-806. DOI: http://dx.doi.org/10.1080/10408398.2011.608174.

Canteri, M.G., R.A. Althaus, J.S.V. Filho, E.A. Giglioti & C.V. Godoy, 2001. SASM – Agri: Sistema para análise e separação de médias em experimentos agrícolas pelos métodos Scott – Knott, Tukey e Duncan. Revista Brasileira de Agrocomputação, 1: 18-24.

Carvalho, M.G., O.C. Bortolotto & M.U. Ventura, 2017. Aromatic plants affect the selection of host tomato plants by *Bemisia tabaci* biotype B. Entomologia Experimentalis et Applicata, 162: 86-92. DOI: https://doi.org/10.1111/eea.12534.

Cerezo, A.B., E. Cuevas, P. Winterhalter, M.C. Garcia-Parrilla & A.M. Troncoso, 2010. Isolation, identification, and antioxidant activity of anthocyanin compounds in Camarosa strawberry. Food Chemistry, 123: 574-582. DOI: https://doi.org/10.1016/j.foodchem.2010.04.073.

Costello, M., 2011. Insects and mites in organic vineyards systems, p. 111-144. *In*: McGourty, G.T., J., Ohmart & D. Chaney (Eds.). Organic winegrowing manual: A Step-by-Step Guide to Growing Your Own Grapes ANR Publications, Richmond, 188 p.

EMATER-MG (Empresa de Assistência Técnica e Extensão Rural do Estado de Minas Gerais) - Departamento técnico, 2012.

Galina, J., L. Ilha & J. Pagnoncelli, 2013. Cultivo orgânico do morangueiro em substrato. Cadernos de Agroecologia, 8: 1-4.

Hata, F.T., M.U. Ventura, M.G. Carvalho, A.L.A. Miguel, M.S.J. Souza & M.A.C. Zawadneak, 2016. Intercropping garlic plants reduces *Tetranychus urticae* in strawberry crop. Experimental and Applied Acarology, 69: 311-321. DOI: https://doi.org/10.1007/s10493-016-0044-3.

Huang, Y.H., Z.C. Mao & B.Y. Xie, 2016. Chinese leek (*Allium tuberosum* Rottler ex Sprengel) reduced disease symptom caused by root-knot nematode. Journal of Integrative Agriculture, 15: 364-372. DOI: https://doi.org/10.1016/S2095-3119(15)61032-2.

Khan, Z.R., C.A.O. Midega, J.O. Pittchar, A.W. Murage, M.A. Birkett, T.J.A. Bruce & J.A. Pickett, 2014. Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. Philosophical Transactions of the Royal Society B: Biological Sciences, 369, article: 20120284. DOI: https://doi.org/10.1098/rstb.2012.0284.

Mtambo, C.C. & I.H. Zeledon, 2000. The development of integrated control methods for the tomato red spider mite (*Tetranychus evansi*) in Malawi, p. 139-147. *In*: Phiri, I.M.G., A.R. Saka & E.H.C. Chilembwe (Eds.). Agricultural technologies for sustainable development in Malawi. Proceedings of the first annual scientific conference held at the Malawi Institute of Management. 343 p.

Pandey, A., K. Pradheep & R. Gupta. 2014. Chinese chive (*Allium tuberosum* Rottler ex Sprengel): a home garden species or a commercial crop in India. Genetic Resources and Crop Evolution 61: 1433-1440. DOI: https://doi.org/10.1007/s10722-014-0144-z.

Ronque, E.R.V., 1998. A Cultura do Morangueiro. Instituto Emater, Curitiba. 206 p.

e-ISSN 1983-0572

SEAB/EMATER - Secretaria da Agricultura e do Abastecimento do Paraná -– Secretaria do Estado e Abastecimento/Instituto Paranaense de Assistência Técnica e Extensão Rural, 2012.

Tiroesele, B. & A.O. Matshel, 2015.The effect of companion planting on the abundance of cabbage aphid, *Brevicoryne brassicae* L., on kale (*Brassica oleracea* var. acephala). Journal of Plant and Pest Science, 2: 57-65

Yabuki, Y., Y. Mukaida, Y. Saito, K. Oshima, T. Takahashi, E. Muroi, K. Hashimoto, Y. Uda, 2010. Characterisation of volatile sulphur-containing compounds generated in crushed leaves of Chinese chive (*Allium tuberosum* Rottler). Food Chemistry, 120: 343-348. DOI: https://doi.org/10.1016/j.foodchem.2009.11.028.

Yu, J.Q., 1999. Allelopathic suppression of *Pseudomonas solanacearum* infection of tomato (*Lycopersicon esculentum*) in a tomato-chinese chive (*Allium tuberosum*) intercropping system. Journal of Chemical Ecology, 25: 2409-2417. DOI: https://doi.org/10.1023/A:1020809805081.

Zhang, H., A. Mallik & R.S. Zeng, 2013. Control of Panama disease of banana by rotating and intercropping with Chinese chive (*Allium tuberosum* Rottler): Role of plant volatiles. Journal of Chemical Ecology, 39: 243-252. DOI: https://doi.org/10.1007/s10886-013-0243-x.

Zhang, Z-Q. 2003. Mites of greenhouses: identification, biology and control. CABI Publishing, Wallingford. 244 p.

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