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Cultivation system and attractiveness of onion leaves to thrips

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ABSTRACT

Onion (*Allium cepa*) is a vegetable of great economic significance, especially in southern Brazil, where most of the national production is concentrated. Although conservation systems (e.g., no-tillage vegetable system [NTVS]) benefit the soil, little is known about their effects on plant-insect interactions. This study evaluated the attractiveness and oviposition of *Frankliniella schultzei* (Thysanoptera: Tripidae) on onion leaves cultivated under organic (NTVS) and conventional crop systems. Free-choice bioassays with onion leaf discs arranged in arenas were performed in the laboratory. Eight adult thrips were released in each arena and monitored at 6, 12, and 48 hours; oviposition was evaluated after 48 hours of exposure by staining the leaf tissues. Organic cultivation showed a higher number of thrips at 12 and 48 hours, whereas the total number of eggs at the end of the experiment did not differ between systems. Correlation analysis indicated that organic leaves had more insects at the end of the experiment; in contrast, leaves from the conventional system had fewer insects. The organic system increases the attractiveness of leaves to thrips without increasing oviposition.

Keywords: *Allium cepa*, Conventional system, *Frankliniella schultzei*, Organic system, No-tillage vegetable system.

Sistema de cultivo e a atratividade das folhas de cebola para tripes

RESUMO

A cebola (*Allium cepa*) é uma hortaliça de grande importância econômica, especialmente no sul do Brasil, onde se concentra a maior parte da produção nacional. Embora os sistemas de conservação, como o sistema de cultivo direto de hortaliças (SPDH), proporcionem benefícios para o solo, pouco se sabe sobre seus efeitos nas interações entre plantas e insetos. Este estudo avaliou a atratividade e a oviposição de *Frankliniella schultzei* (Thysanoptera: Tripidae) em folhas de cebola cultivadas em sistema orgânico (em SPDH) e convencional. Foram realizados bioensaios de livre escolha em laboratório, com discos de folhas de cebola dispostos em arenas. Oito tripes adultos foram soltos em cada arena e monitorados às 6, 12 e 48 horas, após 48 horas, a oviposição também foi avaliada por meio de coloração diferencial dos tecidos foliares. O cultivo orgânico apresentou um número maior de tripes tanto as 12 quanto às 48 horas, enquanto o número total de ovos no final do experimento não diferiu entre os sistemas. A análise de correlação indicou um aumento no número de insetos até o final do experimento nas folhas orgânicas. Em contrapartida, as folhas do sistema convencional apresentaram menos insetos ao final do experimento. O sistema orgânico aumentou a atratividade das folhas para os tripes sem levar ao aumento da oviposição.

Palavras-chave: *Allium cepa*, Sistema convencional, *Frankliniella schultzei*, Sistema orgânico, Sistema de plantio direto de hortaliças.

1. Introduction

Onion (*Allium cepa*) is the third most produced vegetable worldwide (Hanci, 2018) and has economic importance in Brazil, especially in the southern states, which concentrate one-third of national production (Giehl et al., 2023).

However, the sustainability of onion crops remains a challenge, as they are primarily grown in a conventional system (CS) with intensive soil management and high dependence on chemical inputs. These factors make CS more susceptible to physical and biological degradation of the soil and phytosanitary imbalances, particularly arthropod pests (Antoneli et al., 2021). In this context, conservation systems, such as the no-tillage vegetable system (NTVS), emerged as promising alternatives to enhance soil health and promote agroecological management (Kuneski et al., 2023).

The adoption of NTVS in onions may improve physical, chemical, and biological attributes of the soil (Bortolini et al., 2025), primarily through greater root complexity of cover crops, increased organic matter, and diversification of the associated microbiota (Souza et al., 2020; Ventura et al., 2021). Nevertheless, little is known about the influence of NTVS on plant-insect interactions.

Frankliniella schultzei is one of the primary pests of onions, with increasing occurrence in the main producing centers of the country. This species acts as a vector for viruses, inflicts direct damage to leaf tissue, and compromises the development and final yield (Carvalho et al., 2020).

In CS, the selective pressure imposed by insecticides may result in more tolerant pest populations and affect resistance mechanisms (Gul et al., 2023). In organic systems, the biological diversity of the agroecosystem and reduction of synthetic inputs may favor the accumulation of compounds that act as attractants or repellents, influencing the behavior of pests at different stages (Conboy et al., 2020). However, the absence of studies comparing conventional and organic crops hampers understanding of the mechanisms underlying interactions between onions and thrips in these contexts.

In this context, investigations on how agricultural management directly influences pest behavior at the leaf level are important. Moreover, studies evaluating the feeding preference and oviposition of *F. schultzei* on onion leaves across different cultivation systems are limited, although it is clear that soil and plant management influence the population dynamics of thrips (Carvalho et al., 2020). Analyzing the presence of individuals and oviposition over time may provide crucial evidence on the potential for resistance due to antixenosis conferred by agricultural management. Additionally, free-choice assays using standardized leaf discs enable the isolation of the cultivation system by eliminating confounding variables related to plant size or architecture (Egger et al., 2016).

This study aimed to evaluate the preference and oviposition of *F. schultzei* on onion leaves grown under two distinct management systems: organic (NTVS) and conventional.

2. Material and Methods

The experiment was conducted in a laboratory under controlled temperature (25 ± 2 °C), relative humidity (65% ± 5%), and a 12-hour photoperiod. The rearing of thrips and tests were performed in entomological cages, free from contamination by other insects, with constant monitoring of environmental conditions.

Adults of *F. schultzei* were collected from onion crops with a history of infestation and transferred to a laboratory breeding facility. Insects were kept on chive (*Allium schoenoprasum*) leaves inside entomological cages and covered with fine-mesh fabric. Food was provided regularly, and the population was monitored to ensure individuals had suitable conditions for bioassays. The population was maintained for three generations before the start of the experiment.

Onion leaves from two systems (treatments), cultivated at the Experimental Station of the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI, Ituporanga, southern Brazil, 27º24'52“S, 49º36'9”W, 475 m), were used: conventional tillage and organic (NTVS).

Conventional tillage was implemented in 2007 and includes one plowing and two harrowings annually before onion (*A. cepa*) cultivation in spring, followed by corn (*Zea mays*) in summer, and fallow (weeds) in winter. Phytosanitary control includes herbicides (ioxynil, pendimethalin, and fenoxaprop-p-ethyl + clethodim), insecticides (lambda-cyhalothrin and imidacloprid), and fungicides (metalaxyl + chlorothalonil, metalaxyl + mancozeb, iprodione, and tebuconazole + trifloxystrobin), according to recommendations of the manufacturers. A. cepa was fertilized until 2010 using 75, 120, and 60 kg ha^{-1} of N, P_2O_5, and K_2O, respectively. From 2010 onwards, the P_2O_5 dose was adjusted to 80 kg ha^{-1}. For Z. mays, 90 kg ha^{-1} of N is applied annually.

NTVS has been used for conventional onion cultivation for approximately 20 years. In 1996, the system was shifted with the application of limestone to raise water pH to 6 and implementation of a minimum cultivation system with crop rotation. This system was maintained until 2009, when the NTVS was established with the introduction of cover crops for winter (black-oats [*Avena strigosa*], rye [*Secale cereale*], oilseed-radish [*Raphanus sativus*], and fallow) and summer (velvet-bean [*Mucuna pruriens*]). In the same year, weeds were desiccated with Glyphosate®, and no more agrochemicals have been applied since then. Annually, cover crops are broadcast 1.5 times the standard recommendation (Monegat, 1991), maintained until full bloom, knocked down, and laid on the ground with a knife roller. Until 2011, 96 kg of P_2O_5 ha^{-1}, 125 kg of K_2O ha^{-1}, and 100 kg of N ha^{-1} (poultry litter) were applied annually. From 2012 onwards, only organic fertilization was applied in the area: 6 Mg ha^{-1} year^{-1} of poultry litter (193 g kg^{-1} of organic carbon and 20 g kg^{-1} of N) at onion transplanting and at bulb formation.

The seedlings (cv. Bola precoce) of both systems were grown using conventional methods and transplanted at a spacing of 0.1 x 0.4 meters between plants and rows, respectively.

Leaves from plants with uniform age (16 weeks after onion transplant) and at the same phenological stage (onion harvest) were collected in November 2024, stored in perforated bags, and kept under refrigeration (10 °C). Only leaves free of mechanical damage, insect attack, and disease were used in the assay.

The experiment with two treatments (conventional tillage and NTVS), each with 12 replicates, was conducted in a completely randomized design. Each arena (11 cm diameter Petri dishes) represented an experimental unit composed of two onion leaf discs of 0.785 cm^3 (one from each cultivation system), arranged in a free-choice test. The free-choice allowed the thrips to simultaneously access the leaves of both cultivation systems.

For infestation and evaluation, eight adult thrips were released in the center of the arena. Then, the insects on each leaf were counted at 6, 12, and 48 hours after exposure using a stereoscopic magnifying glass. To evaluate oviposition, the leaves were removed at the end of the experiment (i.e., 48 hours), stained with lactic acid, and the eggs were counted under a stereomicroscope.

Data normality and homogeneity of variances were verified using the Shapiro-Wilk and Bartlett tests, respectively. Subsequently, analysis of variance (ANOVA) was performed, and means were compared using Student's t-test (6 and 12 hours) and Mann-Whitney test (48 hours). Spearman's correlation was conducted between the initial number of thrips and the number of eggs counted after 48 hours; the latter was also correlated with the final number of thrips in each assay using a Pearson’s correlation. Analyses were performed in Python (version 3.11), and significance was set at $p < 0.05$.

3. Results and Discussion

The permanence behavior of thrips varied with the cultivation system and elapsed time. Although no differences were observed between treatments at 6 hours ($p = 0.116$) (Figure 1), the NTVS had a higher number of individuals per leaf disc ($p = 0.018$) (5 insects vs. 3 in the CS) at 12 hours, and this behavior persisted after 48 hours ($p = 0.042$) (6 insects in the NTVS vs. 3 in the CS).

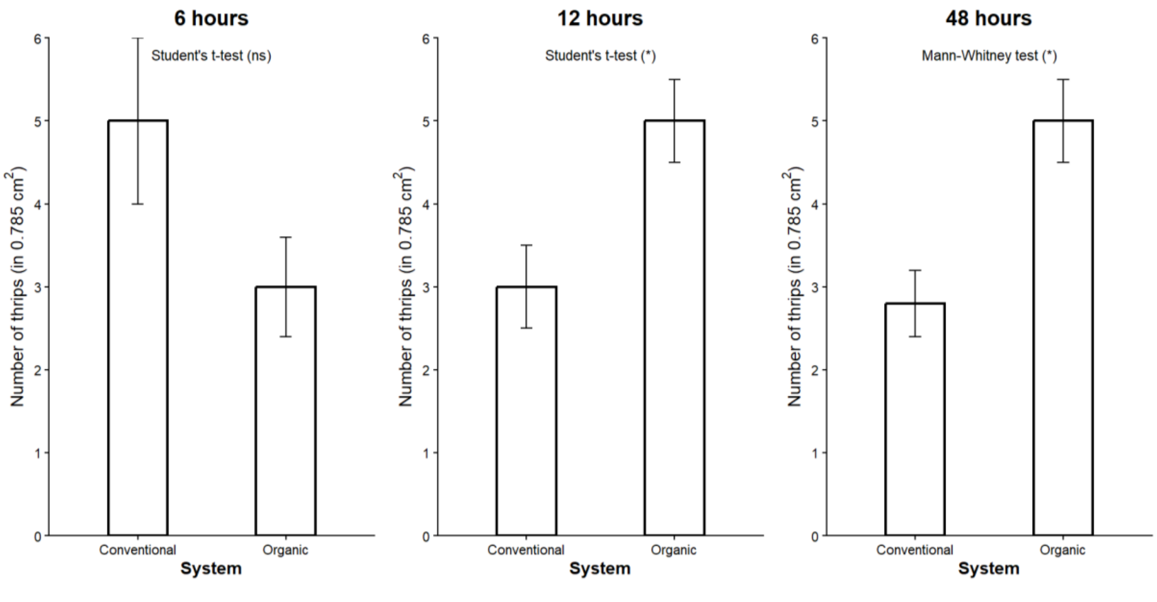

Figure 1. Number of thrips (*F. schultzei*) per onion leaf disc 6, 12, and 48 hours after release in the arena in the conventional tillage and organic (no-tillage vegetable system) crop systems. *significant difference ($p < 0.05$) between treatments; ns: not significant.

The greater permanence of thrips on leaf discs from the NTVS after 12 and 48 hours (Figure 1) may be associated with physiological and biochemical differences induced by cultivation practices. Organic management often results in leaves with distinct profiles of primary and secondary metabolites, including diverse volatile organic compounds, which may enhance host attractiveness or feeding stimulation (Ben-Mahmoud et al., 2018). Additionally, the absence of agrochemicals reduces potential repellency or lethal deterrent effects commonly reported for conventionally managed plants. This was observed after 12 hours of exposure, in which traces of agrochemicals in the CS (not evaluated in this study) may have caused repellency in the leaves of the CS (Jirata et al., 2025). Cultivation systems can also shape the phytosphere microbiota (Kumar et al., 2023) and influence the emission of microbial volatiles that modulate insect behavior.

The increased number of thrips on the leaves of organic systems indicated that, once established, thrips tended to remain on the selected substrate and prefer the leaves of the organic system (Figure 1). This behavior may reflect host recognition mechanisms mediated by volatile compounds or structural factors present in leaf tissues, which encourage prolonged attachment to more attractive substrates (Keshav et al., 2024).

The oviposition of *F. schultzei* after 48 hours of exposure ranged from 14 to 18 insects and did not vary between cultivation systems (p = 0.177) (Figure 2). Similarly, the number of eggs after 48 hours was not significantly correlated with the number of thrips in the times and treatments evaluated (r = 0.08, p = 0.66).

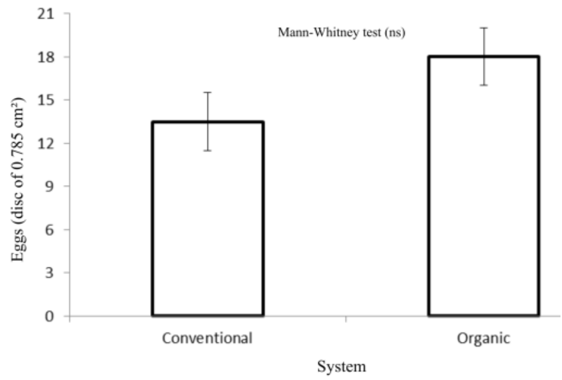

Figure 2. Number of *F. schultzei* eggs after 48 hours in onion leaf discs from conventional tillage and organic (no-tillage vegetable system) crop systems. ns: not significant ($p < 0.05$).

Spearman's correlation indicated a shift in the behavior of thrips on leaf discs over time. The permanence in onion leaf disks of the CS significantly reduced over time throughout the experiment (r = -0.28, p = 0.031).Conversely, the correlation was positive in onion leaves of the NTVS, suggesting that the number of insects increased throughout the experiment (r = 0.29, p = 0.030) (Figures 1 and 2). The lack of correlation between the number of thrips at each time and the number of eggs supports the hypothesis that oviposition is influenced by factors other than permanence on the substrate alone. Although the higher density of thrips on organic leaves suggested a preference, this did not necessarily translate into higher oviposition. Females may have explored the leaves without encountering adequate stimuli for oviposition, or self-limiting mechanisms (e.g., critical population density or the recognition of marking pheromones) may have played a role (Ben-Mahmoud et al., 2018).

These results suggest that leaves from the organic system are more attractive to thrips, with implications for the integrated management of this insect pest. In crops managed organically, phytosanitary monitoring should be intensified, especially during the early stages of the crop cycle when colonization is highly possible (Smith et al., 2017). Conversely, the lower permanence observed in leaves of the conventional system may be associated with the use of chemical pesticides, which may alter the acceptability of these leaves even at sublethal levels. Repellent compounds, changes in biochemical composition, or altered leaf surface texture may create sensory or physiological barriers, making it challenging for insects to attach (Gill et al., 2015). Nonetheless, the exclusive use of these substances does not eliminate the risk of oviposition, which highlights the need for complementary control strategies, regardless of the cultivation system adopted (Wondimagegn, 2022).

Using free-choice arenas and uniform leaf discs enabled isolating the cultivation system on insect behavior while minimizing interference from structural factors, such as leaf area, roughness, and plant architecture. The standardization of plant material and the prior breeding of insects in a controlled environment also enhanced the robustness of the inference that the observed differences were attributed to the cultivation system (Mundinger et al., 2025).

The main limitation of this study was the lack of chemical or structural analyses of the leaves, which could help clarify the compounds or properties underlying differences in the attraction of thrips; thus, these insights could guide the development of pest monitoring protocols that consider the increased attractiveness of organic systems. Future research should combine antixenosis assays with metabolomic and leaf-microscopy analyses to deepen understanding of the mechanisms regulating the preference and oviposition of *F. schultzei* in onions.

4. Conclusions

The type of cultivation system affects the permanence behavior of *F. schultzei* on onion leaves. Organic management increased attractiveness to thrips for prolonged periods, while oviposition did not differ between cultivation systems. These findings indicate that cultivation practices influence plant-insect interactions in distinct ways. Future research may include chemical and structural analyses of leaves to better understand the behavior of thrips.

Authors' Contribution

Contextualization: Zeist, A.R.; Giovanetti, L.K., Kurtz, C., Comin, J.J.

Formal analysis: Zeist, A.R.; Alcântara, C.O., Giovanetti, L.K., Gonzales, J.A.B., Kurtz, C.

Research: Zeist, A.R.; Alcântara, C.O., Giovanetti, L.K., Gonzales, J.A.B.

Validation: Zeist, A.R.; Alcântara, C.O., Giovanetti, L.K., Gonzales, J.A.B., Kurtz, C., Comin, J.J.

Supervision: Zeist, A.R., Kurtz, C., Comin, J.J.

Review and editing: Zeist, A.R.; Alcântara, C.O., Giovanetti, L.K., Gonzales, J.A.B., Kurtz, C., Comin, J.J.

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