Population fluctuation of thrips in Moericke traps of different colors in semi-hydroponic strawberry cultivation

Janaína Pereira dos Santos[1], Anderson Fernando Wamser[2], Janice Valmorbida[3], Juracy Caldeira Lins Junior[4] and Marcelo Mendes de Haro[5]

Abstract – Thrips are main strawberry insect pests and the use of traps is a practical and low-cost method to capture and monitor them. This study aimed to evaluate the population fluctuation and the efficiency of colored Moericke traps in capturing thrips in semi-hydroponic San Andreas strawberry cultivation in Caçador, Brazil. From October 2019 to October 2021, thrips were collected using Moericke traps made with white, yellow, and blue colored bowls. The traps were distributed randomly, with four replications per color, arranged at the same height as the cultivation bench. To count the thrips, 20mL water samples were collected weekly from the bottom of each bowl. The data were transformed into ln(x) and the means were compared using the Tukey test ($p \leq 0.05$). Count data and meteorological variables were submitted to Pearson's correlation analysis ($p \leq 0.01$ and 0.05) using Student's *t*-test. We found that the thrips population increases in early spring (September and October), with population peaks in summer (January, February, and March). In July, the population reduces due to the decreased temperatures. The blue colored trap was the most efficient in capturing thrips. Weekly monitoring of thrips with Moericke trap allows the observation of population peaks and helps in decision-making for pest control in semi-hydroponic strawberry cultivation.

Index terms: *Fragaria* × *ananassa*; Thysanoptera; Monitoring; Integrated pest management.

Flutuação populacional de tripes em armadilhas Moericke de diferentes cores em cultivo de morangueiro semi-hidropônico

Resumo – Os tripes são importantes insetos-praga do morangueiro e o uso de armadilhas para a captura e o monitoramento destes insetos é um método prático e de baixo custo. Este estudo objetivou avaliar a flutuação populacional e a eficiência de armadilhas coloridas do tipo Moericke na captura de tripes em cultivo semi-hidropônico de morangueiro San Andreas, em Caçador, SC. As coletas dos tripes ocorreram de outubro de 2019 a outubro de 2021, utilizando-se armadilhas Moericke feitas com bacias de coloração branca, amarela e azul. As armadilhas foram distribuídas completamente ao acaso, com quatro repetições por cor, dispostas na mesma altura da bancada de cultivo. Para a contagem dos tripes, amostras de 20mL de água foram coletadas semanalmente do fundo de cada bacia. Os dados foram transformados em ln(x) e as médias comparadas pelo teste de Tukey ($p \leq 0,05$). Os dados de contagem e as variáveis meteorológicas foram submetidos à análise de correlação de Pearson ($p \leq$ 0,01 e 0,05) pelo teste t de Student. A população de tripes aumenta no início da primavera (setembro e outubro), com picos populacionais no verão (janeiro, fevereiro e março). Em julho a população reduz em função da diminuição das temperaturas. A armadilha de coloração azul foi a mais eficiente na captura de tripes. O monitoramento semanal dos tripes com armadilha do tipo Moericke permite observar os picos populacionais e auxilia na tomada de decisão de controle da praga em cultivo de morangueiro semi-hidropônico.

Termos para indexação: *Fragaria* × *ananassa*; Thysanoptera; Mmonitoramento; Manejo integrado de pragas.

Introduction

In Santa Catarina state, thrips (Thysanoptera: Thripidae) are considered the main insect pests of the strawberry crop (*Fragaria* × *ananassa* Duch.) (SANTOS et al., 2018), simultaneously damaging flowers and fruits (BERNARDI et al., 2015). The damage is caused by nymphs and adults that, by feeding on flowers, cause the appearance of brownish stains and necrotic spots on the stamens and floral receptacle at the site of the bite, causing premature wilting of the flowers (NONDILLO et al., 2008; 2010). They can also cause tanning on the surface of green and ripe fruits (GONZALES-ZAMORA & GARCIA-MARÍ, 2003; NONDILLO et al., 2010; BERNARDI et al., 2015), reducing fruit production and quality and increasing perishability postharvest.

The use of traps is one of the most practical and inexpensive methods for capturing and monitoring insects (MELO et al., 2001), especially those attracted by color (SANTANA et al., 2012), such as aphids, leafhoppers, chrysomelids, psyllids, whiteflies, leafminer flies, and thrips (SANTOS et al., 2021). In various types of cultivation, colored Moericke traps are widely used to monitor and control winged aphids (ROSSI, 1989; RESENDE et al., 2007) and thrips (SANTOS et al., 2018).

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[1] Agronomist, Dra., Epagri/Caçador Experimental Station (EECD), C.P. 591, 89501-032, Caçador, SC, phone: (49) 3561 6813, e-mail: janapereira@epagri.sc.gov.br.
[2] Agronomist, Dr., Epagri/Caçador Experimental Station (EECD), phone: (49) 3561 6828, e-mail: afwamser@epagri.sc.gov.br.
[3] Agronomist, Dra., Epagri/Caçador Experimental Station , phone: (49) 3561 6824, e-mail: janicevalmorbida@epagri.sc.gov.br.
[4] Agronomist, Dr., Epagri/Caçador Experimental Station , phone: (49) 3561 6814, e-mail: juracyjunior@epagri.sc.gov.br.
[5] Agronomist, Dr., Epagri/Itajaí Experimental Station (EEI), phone: (47) 3398 6321, e-mail: marceloharo@epagri.sc.gov.br.

Due to its effectiveness, practicality, and low cost, the Moericke trap is one of the most used in insect survey studies (CARMO, 2018). In this method, the insects are attracted by the trap's color; then, after falling into the water, they are trapped in the aqueous medium and die. These traps can be made with plastic material, such as rectangular or square trays (RESENDE et al., 2007) or round basins, both types with a volumetric capacity ranging from 2 to 2.5 L (SANTOS et al., 2018). The traps can be installed close to the ground when the cultivation is in the ground or on supports when the cultivation is suspended (SILVA et al., 2013).

The efficiency of using Moericke traps to detect the presence and quantify the population density of different species of thrips will depend on the color of the traps and the height at which they are placed in the crop (MUJICA et al., 2007). In this context, this study aimed to evaluate the population fluctuation and the efficiency of Moericke colored traps in capturing thrips to obtain information for pest management in semi-hydroponic strawberry cultivation.

Material and methods

This study was conducted in a greenhouse, at the Caçador Experimental Station (Epagri/ EECD) (26°49'03.1''S 50°59'24.9''W), with the strawberry cultivar San Andreas. The structure used in the semi-hydroponic cultivation was a simple bench, with slabs filled with 50L of a substrate composed of Sphagnum peat, roasted rice husks, expanded perlite, and vermiculite. In the fertigation, a hydraulic system was used, consisting of a deposit for the nutrient solution; non-draining and self-compensating drippers with a nominal flow rate of 8L h^{-1}; a manifold distributor with four outlets; four 4×6mm microtubes; and one dripper stake per plant. The experiment consisted of eight 6m long benches, spaced 90cm apart. Each bench consisted of two rows of slabs spaced 30cm apart. Planting density was 94,815 plants ha^{-1}.

Insects were collected weekly, and control was performed at population peaks with the following insecticides: Fitoneem® (Neem Oil) to control thrips and whiteflies; Delegate® (Spinetoram) for thrips; Thuricide® (*Bacillus thuringiensis*, var. *kurstaki*) for caterpillars; Actara® (Thiamethoxam) for aphids, and Boveril® (*Beauveria bassiana*) for whiteflies and spider mites. Figures 1 and 2 show the application times of the previously described insecticides.

Thrips were collected every seven days, from October 2019 to October 2021, totaling 104 sampling occasions. Thrips were captured in Moericke traps made with 2.5L round basins measuring 22cm in diameter, internally and externally colored in white (RBG: 255, 255, 255), 'gold' yellow (RBG: 255, 215, 0), and 'cobalt' blue hue (RBG: 0, 71, 171). The basins were randomly distributed, with four replications per color, and placed on a support mounted at the same height as the cultivation bench, 80cm from the ground. Each basin was filled with 2L of water mixed with 5mL of neutral detergent, aiming to break the surface tension of the water, thus avoiding the exit of captured insects. Every seven days the water was refilled, only adding up the amount evaporated and, every 14 days, the basins were washed, and the water and detergent were renewed. With a pipette, 20mL samples of water containing the insects were collected weekly from the bottom of each basin.

At the EECD Entomology Laboratory, the collected samples were inspected using a 6.4× magnification stereomicroscope to count thrips. The predominant species were identified following the routine slide assembly protocol for identifying thrips of any color (SILVEIRA & HARO, 2016). After assembly, the morphological characteristics of the specimens were identified using appropriate dichotomous keys for these species (MONTEIRO, 2001; MOUND & KIBBY, 1998).

Daily records of meteorological variables, from October 2019 to October 2021, referring to relative humidity (%) and air temperature (°C) (minimum, maximum, and average) were obtained from a meteorological station model H21-002 (Onset Computer Corporation, Bourne, MA, USA), installed inside the greenhouse at 1m from the cultivation. The records were obtained by sensors located at a height of 1.5m.

On each sampling occasion, the average number of thrips collected in traps of the same color was estimated to prepare annual graphs of population

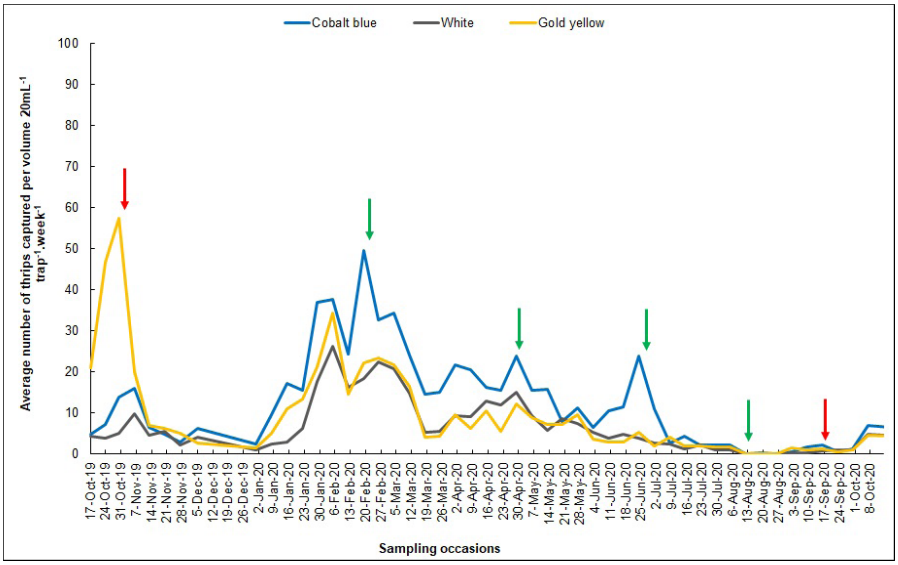

Figure 1. Average number of thrips captured.sampled volume $(20mL)^{-1}$.trap-1.week^{-1}, in semi-hydroponic San Andreas strawberry cultivation. The arrows indicate the application of insecticides for pest control, where: red (Espinetoram) and green (Neem Oil). Caçador, SC – October/2019 to October/2020

Figura 1. Número médio de tripes capturados.volume amostrado $(20mL)^{-1}$. armadilha^{-1}. semana^{-1}, em cultivo semi-hidropônico de morangueiro San Andreas. As setas indicam a aplicação de inseticidas para o controle de pragas, onde: vermelha (Espinetoram) e verde (Óleo de Neem). Caçador, SC – outubro/2019 a outubro/2020

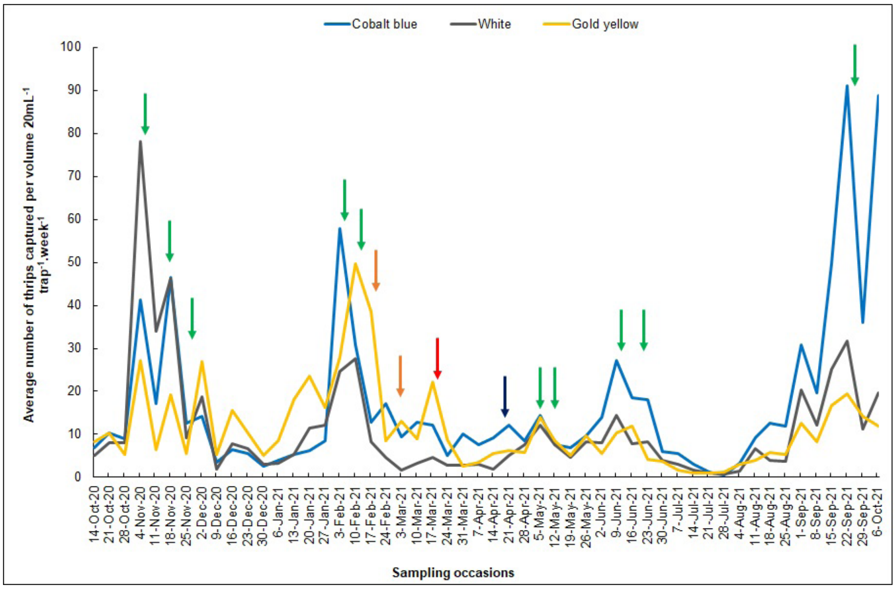

Figure 2. Average number of thrips captured.sampled volume (20mL)$^{-1}$.trap-1.week^{-1}, in semi-hydroponic San Andreas strawberry cultivation. The arrows indicate the application of insecticides for pest control, where: green (Neem Oil); orange (Bacillus thuringiensis, var. kurstaki); red (Thiamethoxam); and black (Beauveria bassiana). Caçador, SC – October/2020 to October/2021

Figura 2. Número médio de tripes capturados.volume amostrado (20mL)$^{-1}$. armadilha^{-1}. semana^{-1}, em cultivo semi-hidropônico de morangueiro San Andreas. As setas indicam a aplicação de inseticidas para o controle de pragas, onde: verde (Óleo de Neem); laranja (*Bacillus thuringiensis*, var. kurstaki); vermelha (Tiametoxam) e preta (*Beauveria bassiana*). Caçador, SC – outubro/2020 a outubro/2021

fluctuation. Statistical analyzes were performed using the SISVAR software (FERREIRA, 2019) and the thrips count data were transformed into ln(x); then, means were compared using the Tukey's test (p≤0.05). Counting data and meteorological variables recorded inside the greenhouse were subjected to Pearson's correlation analysis (p≤0.01 and 0.05) using Student's *t*-test. The obtained correlations were interpreted as proposed by Mukaka (2012). The values used in these analyses were relative to daily averages of relative humidity and air temperature (minimum, maximum, and average), recorded in the seven days preceding each thrips sampling occasion.

Results and discussion

Capture efficiency

The predominant species of thrips in semi-hydroponic San Andreas strawberry cultivation was *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), representing 95% of the collected specimens. This result corroborates data from the literature, which reports this species as the most frequent and abundant in the southern region of Brazil in strawberry crops (NONDILLO, et al., 2008; 2010; PINENT et al., 2011). Another three Thripidae species were collected: *Haplothrips gowdeyi* (Franklin) (0.3%); *Caliothrips phaseoli* (Hood) (0.7%), and *Thrips tabaci* Lind. (4%). The four species occurred throughout the study period.

There was a significant difference in the capture of thrips for the three trap colors. The blue-colored trap was the most efficient in capturing thrips, followed by the yellow. The white trap provided lower capture of thrips (Table 1). However, in November 2020, it was verified that the white trap provided a superior capture of insects than the blue and yellow. This can be explained by color fading on the inside of the blue and yellow bowls. Due to this, all basins of the experiment were replaced by new ones.

The mean number of thrips captured/sampled per volume/trap/week was 14.6; 10.3; and 8.7 in the blue, yellow, and white-colored traps, respectively (Table 1). In the tomato crop, Santos (2009) verified that for the capture of *Frankliniella schutzei* (Trybom) (Thysanoptera: Thripidae) thrips, the blue trap was more efficient than the yellow. Sampson & Kirk (2013) found that the use of blue traps in large quantities, aimed at the massive capture of *F. occidentalis* in semi-protected cultivation of strawberry cultivar Camarillo, reduced the number of adult thrips per flower by 61% and fruit tanning by 55%.

Population fluctuation

According to Parchen et al. (2010), to avoid damages to the crop, knowledge of the time of greatest occurrence of *F. occidentalis* related to local climatic conditions is an important tool for strawberry producers. The thrips population fluctuation determined by periodic samplings with Moericke traps proved to be seasonal, varying between months and between years of study (Figures 1 and 2). The thrips population tended to increase in early spring, in September and October, due to rising daily temperatures (Figures 1 and 2).

In the first year of the study, a population peak was recorded on October 30, 2019, which was followed by a drastic population reduction due to the application of insecticide (Spinetoram) (Figure 1). From January to February 2020, there was another population increase; then, in early July 2020, the population of thrips reduced drastically due to the decreased temperatures (Figure 1), increasing again in early November 2020 (Figure 2).

The following year exhibited the same trend as the first, in which the thrips population decreased in July and increased again in early September 2021, with the highest population peak in September 2021 (Figure 2). In Paraná state, Parchen et al. (2010) also found thrips population peaks in January and February, in 'Aromas' and 'Albion' strawberries cultivated in the soil in protected tunnels. In Rio Grande do Sul state, Nondillo et al. (2008) recorded larger populations of *F. occidentalis* from December to March, with a population decline after April. According to these authors, this occurred due to the high reproductive capacity of *F. occidentalis*, which presents 10 to 18 generations per year in strawberry producing regions of southern Brazil.

According to MUKAKA (2012), Pearson's correlation analysis revealed a weak positive correlation between the quantity of thrips count in the yellow trap and the meteorological variables, specifically air temperature (Table 2). The correlation was found to be stronger with average temperatures and minimum temperatures (Table 2). Although correlations were positive and significant for thrips count in the blue basin and air temperatures (Table 2), these can be considered negligible, as indicated by Mukaka (2012). Thus, air temperature is more positively correlated with thrips population fluctuation, and this correlation is better observed with the use of yellow traps. Probably the blue trap, by attracting more thrips (Table 1), tends to overestimate the population of this pest in the environment. No correlation was observed between relative humidity of the air and population fluctuation of thrips (Table 2). We highlight that the low correlation of thrips population fluctuation with meteorological variables may have occurred due to the application of insecticides at population peaks of the pest.

In southern Brazil, to control thrips in strawberry crops, the application of insecticides has been the main strategy adopted by producers. In many cases, these applications are made without technical criteria, which may increase production costs and presence of residues in the fruits, increasing the risks of environmental and human intoxication. According to Santos (2016), due to the environmental awareness of Brazilian producers and consumers demand for food without pesticide residues, pest management must be improved, requiring the use of strategies based on Integrated Pest Management (IPM). In this sense, monitoring thrips using sampling analysis with Moericke blue traps will allow monitoring the increase and decrease of pest populations in the cultivation area to verify the periods of most remarkable occurrence and population peaks.

Periodic sampling with blue traps associated with phytosanitary management can help in decision-making on thrips control and minimize pest damage and economic losses. This method can also be complemented by the monitoring of some plants at random using the beating method, which, according to Bernardi et al. (2015), consists of shaking the flowers on a plastic tray with a white background to verify the incidence of thrips. Adhesive traps can also be used for this purpose. Allied to this, the use of traps has several advantages such as: not being toxic to humans and environment, having no smell, being easy to handle, and being useful in open fields, greenhouses, and crops, where application of pesticides is restricted, which is the case with organic crops.

We highlight that the Moericke trap made with basins is more practical and cheaper compared to the adhesive trap. The blue-colored adhesive trap costs about 4.50 BRL per unit (amount obtained in September 2022 from three different suppliers) and, depending on the thrips infestation in the crop, these traps must be replaced weekly with new ones. Moericke traps made with bowls cost about 20.00 BRL per unit and must be replaced with new ones when the color fades, which can take up to 12 months, as observed in the present study. In this way, using Moericke traps becomes a low-cost option for strawberry producers, especially in small areas and in organic crops.

Even though the yellow color is not mentioned in the literature as a preferential attractiveness for thrips, we observed that these insects were captured by traps of this color, a fact also observed by Santana et al. (2012) in the cultivation of organic vegetables and by Mujica et al. (2007) in grapevine. In Uruguay, Mujica et al. (2007) verified that yellow traps were the most efficient method of monitoring thrips (*F. occidentalis*) compared to the beating method. Therefore, if other pests that are attracted by the yellow color in the crop are detected, such as aphids, whiteflies, and cows, it is recommended to install yellow traps interspersed with blue ones since the basins can be changed places according to the insect pest occurrence in each plot.

Table 1. Mean value (±SE) of thrips captured per Moericke traps^{-1}.week^{-1} in semi-hydroponic San Andreas strawberry cultivation (n=104). Caçador, SC - October 17, 2019 to October/2021

Tabela 1. Valor médio (±EP) de tripes capturados por armadilhas Moericke^{-1}.semana^{-1} em cultivo semi-hidropônico de morangueiro San Andreas (n=104). Caçador, SC - outubro/2019 a outubro/2021

Trap color	Number of thrips captured.sampled volume (20mL)$^{-1}$.trap^{-1}.week^{-1}
'Cobalt' blue	14.6 ± 1.56 a
'Gold' yellow	10.3 ± 1.04 b
White	8.7 ± 1.05 c

Means followed by the same letter do not differ from each other by Tukey's test at 5% probability of error.

Table 2. Pearson's correlation for thrips captured in Moericke traps and meteorological variables obtained inside of greenhouse, in semi-hydroponic San Andreas strawberry cultivation (n=104). Caçador, SC - October/2019 to October/2021

Tabela 2. Correlação de Pearson entre a captura de tripes em armadilhas Moericke com as variáveis meteorológicas obtidas no interior da casa de vegetação, em cultivo semi-hidropônico de morangueiro San Andreas (n=104). Caçador, SC - outubro/2019 outubro/2021

Trap color	Relative humidity	Air temperature		
		Minimum	Average	Maximum
'Cobalt' blue	-0,03ns	0.25*	0.24*	0.26**
'Gold' yellow	0,01ns	0.40**	0.39**	0.32**
White	-0,09ns	0.15ns	0.15ns	0.16ns

ns=Pearson's correlation coefficient not significant by the t test at 5% significance
* and **= Pearson's correlation coefficient significant by the *t*-test at 5 and 1% significance, respectively.
Weak positive correlation according to MUKAKA (2012).

Conclusions

- The population fluctuation of thrips is seasonal, varying between months and years of the study, and the number of insects captured in Moericke traps tends to increase in the warmer periods of the year.
- The blue Moericke trap is the most efficient trap for capturing thrips in semi-hydroponic San Andreas strawberry cultivation.

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