Combined application of *Isaria fumosorosea* and beta-cyfluthrin in the control of coffee leaf miner[1]

William Oliveira do Lago[2], Paulo Henrique de Siqueira Sabino[2], Lucas Deleon Ramirio[3], Helaine Barros de Oliveira Venâncio[3]*

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ABSTRACT

The coffee leaf miner is responsible for significant decreases in coffee production. To mitigate the problems caused by this pest control strategies need to be applied. The combined application of chemical and biological insecticides is an alternative that can reduce the population of leaf miner in areas with high infestation and occurrence of resistant individuals. The objective of this study was to evaluate the combined application of *Isaria fumosorosea* and beta-cyfluthrin in the control of coffee leaf miner. A randomized block design was used, in a 4 x 2 factorial scheme, with four treatments: *I. fumosorosea*, beta-cyfluthrin, *I fumosorosea* + beta-cyfluthrin and control, besides two application levels, one and two applications. There was no significant effect on the interaction between treatments. The number of applications did not increase the control percentage of the leaf miner. However, the treatments *I. fumosorosea*, beta-cyfluthrin, *I fumosorosea* + beta-cyfluthrin showed a higher control percentage of the leaf miner, compared to the control treatment with both one and two applications. *I. fumosorosea*, beta-cyfluthrin, and the combination of *I fumosorosea* + beta-cyfluthrin are effective in controlling the leaf miner.

Keywords: biological control; coffee leaf miner; entomopathogens; *Leucoptera coffeella*.

INTRODUCTION

Among the main entomological problems of coffee plant, the leaf miner *Leucoptera coffeella* (Guérin-Méneville & Perrottet, 1842) (Lepidoptera: Lyonetiidae) is considered the most important coffee pest (Barrera, 2008). The damage caused by the leaf miner caterpillar leads to plant defoliation, especially in the driest seasons, reducing the photosynthetic rate and loss of crop yield (Costa *et al.*, 2015).

The leaf miner is predominantly controlled through chemical insecticides (Costa *et al.*, 2015). However, the indiscriminate use of these products can lead to the resurgence of secondary pests, side effects on natural enemies, pollinators and selection of resistant insects (Castellani *et al.*, 2016). One way to avoid this problem is the combined use of different control strategies. Therefore, diversifying control tactics becomes important for the management of the leaf miner in the coffee (Sabino *et al.*, 2018). The biological control using entomopathogenic fungi has been used as alternative to chemical for a wide range of pest insects (Barra-Bucarei *et al.*, 2019). One of them, *Isaria fumosorosea*, with potential to control of various pest insects (Silva *et al.*, 2012).

Thus, it is essential to investigate the effectiveness of combined application of *I. fumosorosea* and chemical insecticides and the possible application intervals, to provide a good plant health condition, avoiding the occurrence of economic losses. The objective of this study was to evaluate the combined application of *I. fumosorosea* and beta-cyfluthrin in the control of coffee leaf miner.

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[2] Universidade José do Rosário Vellano - UNIFENAS, Faculdade de Agronomia, Alfenas, Minas Gerais, Brazil. williamlago343@hotmail.com; paulo.sabino@unifenas.br
[3] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas, Muzambinho, Minas Gerais, Brazil. lucas.ramirio@muz.ifsuldeminas.edu.br; helaine.venancio@muz.ifsuldeminas.edu.br
* Corresponding author: williamlago343@hotmail.com

MATERIAL AND METHODS

The test was conducted at Sítio Córrego dos Laços, in the municipality of Areado - MG, Southern Minas Gerais. 'Catuaí IAC 144' coffee plants with 2 years of age, grown in 3.0 x 1.2 m spacing, under leaf miner infestation, were used for the test.

The chemical and biological insecticides used to comprise the treatments are described in table 1.

The experimental design used was in randomized blocks, in a 4x2 factorial, 1) *I. fumosorosea*, 2) beta-cyfluthrin, 3) *I. fumosorosea* + beta-cyfluthrin and 4) control treatment (water only), interacting with two application levels, one and two applications, with 4 replications, totaling 32 experimental plots, each consisting of 10 plants. The useful area of each plot consisted of the six central plants and, between the blocks, a coffee row was left as a border.

The treatments were applied in intervals of 30 days, always in the late afternoon. The plants were sprayed using a manual costal sprayer, Jacto®, PJH 20, with a conical nozzle and an application volume of 400 $L.ha^{-1}$ was used. It was added to the adjuvant syrup Blend®, at a concentration of 0.5% (v/v), in all treatments. In the experimental area, there was no application of other insecticides and fungicides. Beta-cyfluthrin was chosen due to its action by contact and ingestion on the insect, can be applied in periods of low humidity.

For the assessments of the control of the leaf miner, four branches were marked, with the presence of mined leaves, in the middle-upper third of the plants by colored ribbons, two on each side, totaling 24 branches per useful plot. After each application, two branches per plant were evaluated, one on each side, all leaves of the branch being evaluated. Subsequently, the colored ribbons were removed from the branches so as not to be evaluated after the second application. Assessments of the number of leaves with mines by the leaf miner were carried out twelve days after each application, through the evaluation of leaves with at least one mine intact, that is, without signs of predation by wasps. Live and dead caterpillars in the mines were measured and the values were transformed into a percentage of mortality. Caterpillars that did not move when stimulated with a stylet were considered dead. Temperature and rainfall were recorded daily during the months of the experiment. The experiment was conducted for 42 days.

The data were submitted to analysis of variance using the R software, version 4.0.1 (R development core team, 2020). Subsequently, the residues were submitted to the Shapiro-Wilk normality test. For the analyzed variables that had a significant effect, the study of means was performed using the Scott-Knott test at 5% significance.

RESULTS AND DISCUSSION

There was no significant effect on the interaction between treatments and number of applications (gl = 3; F = 0.52; $p > 0.05$). The number of applications of the treatments did not increase the control percentage of the leaf miner (gl = 1; F = 0.28; $p > 0.05$). However, the treatments I. *fumosorosea*, beta-cyfluthrin and the combined *I. fumosorosea* and beta-cyfluthrin showed a higher control percentage of the leaf miner, compared to the control treatment with both one and two applications (gl = 3; F = 25.73; $p < 0.05$) (Table 2).

It was found that the number of applications had no influence on the mortality percentage of leaf miner caterpillars. Therefore, sequential applications without monitoring the population density of the pest become unnecessary.

Previous studies have shown that entomopathogenic fungi can occur naturally in coffee, showing action on leaf miner caterpillars (Reis & Souza, 2002). However, this is the first report showing the possibility of applying *I. fumosorosea* for the control of this pest insect.

Table 2: Percentage of mortality of the coffee leaf miner (± standard error) after the application of *I. fumosorosea* and beta-cyfluthrin under field conditions

Treatments	Number of applications	
	1	2
Control	14.23 ± 4.54 b A*	19.29 ± 4.08 b A
I. fumosorosea	55.19 ± 7.53 a A	62.34 ± 6.36 a A
Beta-cyfluthrin	66.66 ± 7.43 a A	68.12 ± 8.33 a A
I. fumosorosea + Beta-cyfluthrin	63.88 ± 8.06 a A	73.60 ± 7.29 a A

*Lowercase letters in the column and uppercase letters in the row do not differ by the Scott-Knott test at 5% significance.

Table 1: Insecticides used to conduct the experiment

Name		Formulation	Use [1]	Chemical group	Average concentration[2]
Technical	Commercial				
Beta-cyfluthrin	Bulldock®	125 SC	I	Pyrethroid	30 $mL.ha^{-1}$
Isaria fumosorosea	Octane®	SC	I	Not applicable	1 $L.ha^{-1}$

[1] I = Insecticide. [2] Recommended average concentration.

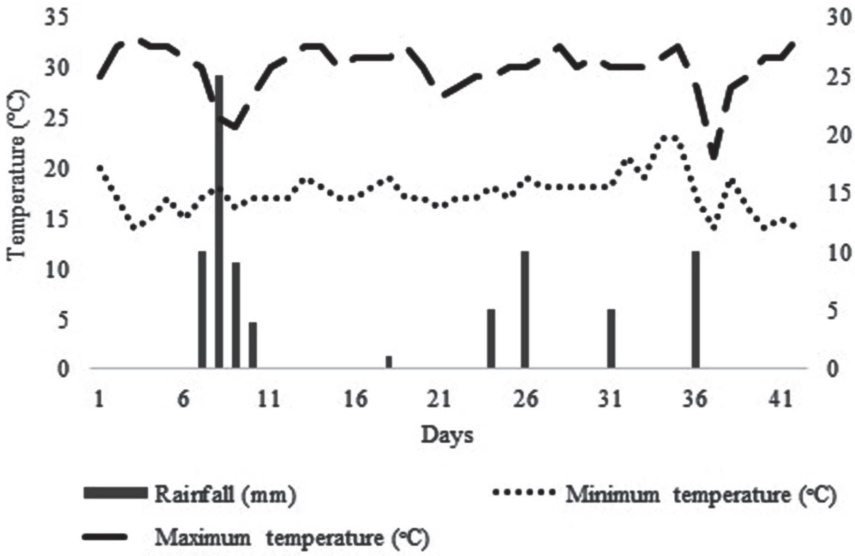

Figure 1: Variation of temperature and rainfall in August and September, 2019.

The effectiveness of *I. fumosorosea* on miner leaf larvae can be explained by the transfer mechanism of the spores that are present on the leaf surface after spraying, coming into contact with the larvae after hatching to start the mine formation process (Hesketh *et al.*, 2010). The same can happen to beta-cyfluthrin, which has a transfer mechanism to the insect by contact and ingestion, and has a residual effect on the adaxial epidermis of the leaves. Thus, after hatching, the caterpillars feed on the leaf surface to form the mines, at which time they can ingest the insecticide, causing their death (Melo *et al.*, 2019).

The combined application of chemical and biological insecticides can enhance the control of pest insects and is a strategy used within Integrated Pest Management (IPM) programs (Silva & Neves, 2005). In addition, studies show the potential of mixing *I. fumosorosea* with chemical insecticides to reduce the population of *Plutella xylostella* L. (Lepidoptera: Plutellidae) and *Bemisia tabaci* (Hemiptera: Aleyrodidae) (Nian *et al.*, 2015; Zou *et al.*, 2014). Our study suggests that the combined use of *I. fumosorosea* and beta-cyfluthrin did not increase the control percentage of the leaf miner in relation to the isolated application of each treatment. However, in areas with high leaf miner infestations, over 30% mined leaves and the presence of resistant individuals, the combined application of two control methods, which act differently on insects, can increase control effectiveness (Sabino *et al.*, 2018).

In general, rainfall in the evaluated months was low, not influencing the occurrence and natural mortality of the leaf miner, confirming the effectiveness of treatments on the pest insect (Figure 1). In addition, the low relative humidity (RH) (Figure 1) during the test period shows that *I. fumosorosea* has the ability to control pest insects in the dry period of the year and these conditions are favorable to the occurrence of the leaf miner, making this fungus one more tool to be used for the control of this pest. It is important to emphasize that the microclimate that occurs in the coffee plant, due to the leaf area, can favor the colonization of the entomopathogenic fungus, even in conditions of low humidity, enhancing the action of *I. fumosorosea* on *L. coffeella*.

CONCLUSIONS

It is concluded that the number of insecticide applications did not increase the control percentage of the leaf miner. The combined application, as well as the isolated application of *I. fumosorosea* and beta-cyfluthrin, is effective in controlling the leaf miner.

Our study suggests that combined and isolated applications of *I. fumosorosea* and beta-cyfluthrin can be used against the leaf miner. The modality of application will be chosen according to the infestation of the leaf miner and occurrence of resistant individuals.

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