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Leaf miner seasonality, predation level and temporal occurrence of rust correlated to abiotic factors

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Abstract. Leaf miner and rust are considered the main afflictions with capacity to reduce productivity in coffee crops. These agents are influenced by abiotic factors with oscillating frequency over the years. Therefore, the objective of this study was to assess the seasonal fluctuation of leaf miner as well as predation incidence and coffee rust, correlating them with abiotic factors. The study was conducted at IFSULDEMINAS – Campus Inconfidentes, using the cultivar Rubi coffee. The sampling for rust and leaf miner was done in the intermediate and superior thirds of the plant, respectively, totalizing 42 plants in the study area. Soil analysis was conducted to correlate soil nutrients to the studied variables. Pearson correlation was applied to the biotic variables with precipitation and fertility, at the levels of 1 and 5% probability. The cycle of rust incidence alternated for the same period in distinct years, and the leaf miner presented coinciding behavior after the driest periods of the year. The predation level presented no correlation with precipitation data or number of miners. These afflictions presented no significant correlation with fertility parameters. Leaf miner provided higher occurrence indexes in June and December of 2014. In conclusion, the percentage of leaf miner was higher during the months of lower rainfall indexes or during prolonged Indian summer periods; the predation level was superior to the non-action period, given that there might have been influence of the woods near the studied crop; rust altered the occurrence spikes for both evaluated autumn seasons when correlated with precipitation.
Keywords: Climate, fertility, social wasps, Pearson correlation.

Introduction

Leaf miner and rust are considered the main biotic agents capable of reducing the productivity of coffee crops by directly attacking the leaf, causing its fall and, consequently, compromising its productive capacity.

These biotic agents can occur all year round with variable incidence in several periods and geographical locations, changing its occurrence in function of environmental variables, crop management and nutrition, among other factors.

With short and long term climate changes, it is necessary to conduct periodic studies focusing on the behavior of biotic agents and the intensity of their effects on crops, which allows us to know the critical periods of occurrence and to identify the levels of economic loss along with the ideal moment for chemical control application (Vieira Junior et al., 2008).

The occurrence of these afflictions is associated to abiotic factors, which influence the growth and susceptibility of the host plant, multiplication, dissemination, survival and the activity of the biotic agents. In this sense, climate changes can cause significant alterations in the occurrence and severity of diseases and pests, generating severe economic, social and environmental consequences (Ghini et al., 2011).

Among the pests with environmentally influenced behavior, leaf miner (*Leucoptera coffeella* (Guérin-Menéville, 1842) (Lepidoptera: Lyonetiidae)) is highlighted. It presents a cycle of 19 to 87 days, varying in function of temperature and moisture, and occurs with higher frequency during dry periods with the possibility of yearlong infestations, causing damages that can reach up to 80% with drastic defoliation until July (Nasser et al., 2011). For pest management, predation is an effective strategy since the need for application of defensives is reduced, providing higher possibility of ecological balance for the coffee crop.

Hamada et al. (2006), when studying the biological model of the occurrence of leaf miner for future climate conditions, verified an increase in the probable number of cycles, also identifying a regional difference in the number of cycles.

Regarding rust (*Hemileia vastratrix* Berk. et Br. (Uredinales: Pucciniaceae)), under climate conditions favorable to severe epidemics, a loss of 35 to 50% was observed (Zambolim et al., 2002), through the reduction of blossoming and flower buds, causing branch dryness. The disease is favored by nutritional deficiencies or unbalance, inadequate management and reduced spacing between plants, which can cause auto shading of the culture (Vieira Junior et al., 2008). The incidence of rust occurs with great intensity especially during the months with little rainfall in function of deficient management practices associated to favorable climate conditions. In these terms, Paiva et al. (2009) verified greater incidence during the months of April and May of 2008.

Chalfoun, Pereira and Xavier (2009), when studying the historic data series on rust in São Sebastião do Paraíso, MG, Brazil, observed a delay in the rainy season and in the occurrence of high temperatures in the beginning of summer. This influenced the emergence of the pathogen, dislocating the inflection curve to the months of January and February, changing the occurrence of the disease, which was then designated as late rust.

Therefore, the objective of this study was to assess the seasonal fluctuation of leaf miner, predation incidence and coffee rust, correlating them to abiotic factors.

Methods

The study was conducted at the School Farm of the IFSULDEMINAS – Campus Inconfidentes, in Inconfidentes, MG, Brazil, using a 4.5-year-old cultivar Rubi coffee crop (0.864 ha^{-1}) , implanted with a spacing of 2.2 m x 1.3 m. The crop is situated 140 m from a forest reserve, with an approximate area of 2.70 ha^{-1}. The local climate is classified as high altitude tropical, with dry winter and hot and rainy summer, which, according to Köppen, is characterized as Cwa. The crop is situated in a relief with 25% declivity, facing north and located at 910 m of altitude.

The sampling process for rust and leaf miner was done in the intermediate and superior thirds of the plant, respectively. One pair of leaves from the third or fourth knots of the pleigiotropic branch, located at the four cardinal points, were assessed in a total of five plants per sampling point, one situated in the central plant and the others located in the direction of the cardinal points, totalizing 40 leaves per sampling point and 42 sampling points. Regarding rust sampling, the non-destructive method was used. However, for leaf miner, the leaves were detached from the plant. Subsequently, the mean and the percentage of the total incidence of miner leaves (with and without predation), intact mined leaves, predated mined leaves, and occurrence of rust were assessed. The evaluations for predated leaves were performed by an observation of the dilacerations caused by the social wasps. The rainfall index was also monitored. The assessments were conducted monthly, from June 2014 to May 2015.

Soil analysis was conducted for each sampling point, in June 2014, at the depths of 0 to 20 cm, in order to assess the contents of P, K, Ca, Mg, Al, as well as SB, CEC, V, O.M and P-rem. This crop received no phytossanitary treatment during the study period.

Pearson correlation analysis was conducted using the Genes software (Cruz, 2013), at the levels of 1 and 5% of probability, for the parameters of mined leaves (with or without predation), predated leaves, intact mined leaves, and fertility and rainfall. Rust was also correlated with rainfall and fertility parameter. The graphs for these assessments were elaborated on Excel.

Results and discussion

The non-action level of leaf miner, which is when the prediction assumes values lower than 40% (Reis; Souza, 1998), occurred during most months of the studied period (Figure 1), indicating that the chemical control must not be used, since the control by predator wasps is efficient. The non-action level was 35.14% only for the month of October as illustrated in Figure 1. The percentage of mined leaves with or without predation remained always below 16.19%. In this case, even without considering the action of the wasps, chemical control would not be recommended, because the result it is below the level of economic damage (Souza et al., 1998).

In the correlations of intact mined leaves/predated mined leaves and mined leaves/predated mined leaves, there was no significant correlation detected (Table 1). Therefore, the level of predation is not influenced by the number of mines, which does not support the findings of Fernandes et al. (2009), who emphasize the increase in the density of predated mines as dependent on the density of leaf miners.

Tuelher et al. (2003), when evaluating the number of intact mines and the level of predation, describe that the correlation between these parameters was low, even when considering a high predation index. Thus, the increase or decrease in number of leaf miners is not proportionally influenced by predation of social wasps.

It is necessary to consider that the level of predation must be influenced by other factors, such as the case of application of defensives, forest preservation, maintenance of nests, etc. Santos et al. (2009) stated that environments in which there are forested areas might favor wasp nidification and fixation, which is the case of the crop of this study.

There was no correlation between mined leaves/rainfall and intact mined leaves/rainfall (Table 1). Nevertheless, Fernandez et. al. (2009) verified a negative correlation between mined leaves and rainfall, since rain can limit the flight capacity and the encounter of partners for reproduction, affecting the viability of eggs, larvae and pupas.

For the percentage values of mined leaves (Figure 2), it was verified that its intensity was always higher from June to October 2014, during which the levels of rainfall were below 53 mm, coinciding with the driest period of the year.

This intensity of mined leaves gradually decreased until November due to defoliation, and, from November and December of the same year, new foliage occurred, reflecting in the increase of this index, which coincides with the observed Indian summers, favoring the recurrence of this pest. Even with monthly registrations of rainfall above 200 mm for November and December, rains were unevenly distributed, which promoted a higher index of leaf miner attack, considering the occurrence in an atypical season (Figure 2).

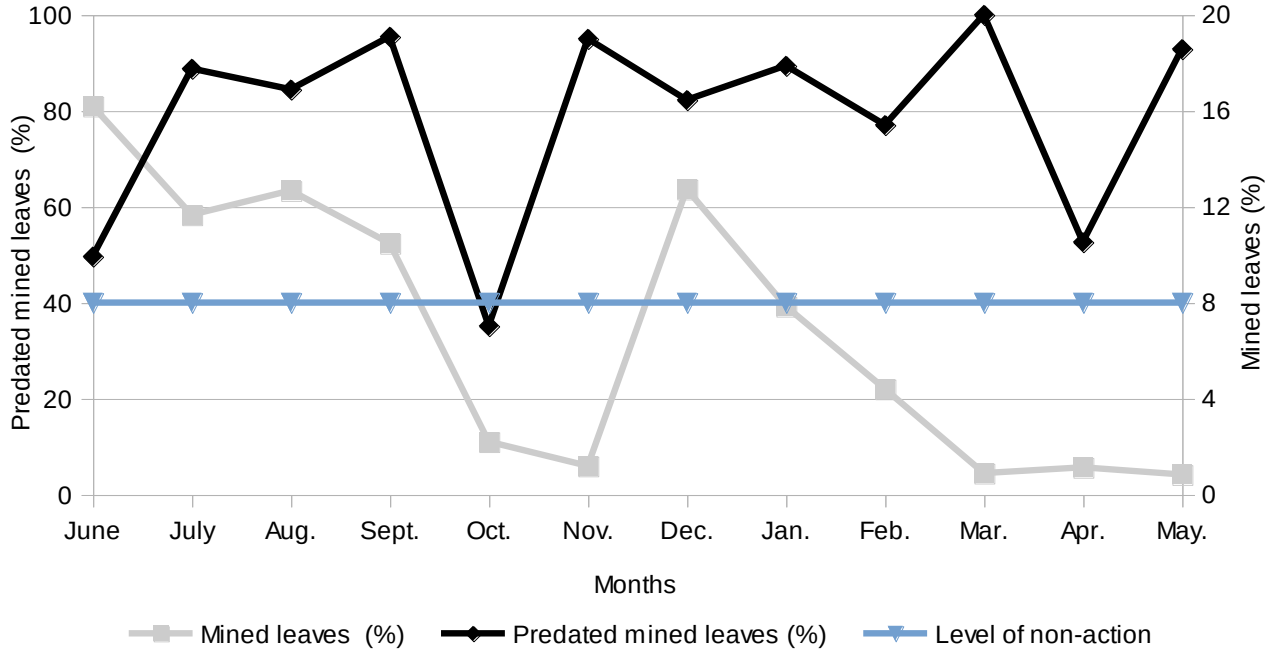

Figure 1. Occurrence of mined leaves with or without predation, predated mined leaves, and level of non-action, during the period from June of 2014 to May of 2015.

Table 1. Pearson correlation coefficients between mined leaves, predated mined leaves, intact mined leaves and rainfall. Inconfidentes, 2015.

Parameters	Correlation
Intact mined leaves/Predated mined leaves	- 0.03
Mined leaves (%)/Predated mined leaves (%)	- 0.50
Mined leaves (%)/Rainfall	- 0.35
Intact mined leaves (%)/Rainfall	- 0.33

*Significant at 5% probability

There was no correlation for the percentage of predated mined leaves correlated to rainfall (Table 2) in Figure 1, it is indicated that predation was always high, reaching levels superior to 35%, even during the driest periods of the year. This intense occurrence of predation is related to the non-application of defensives and with the proximity of a forest reservation, favoring a balanced environment with no relation to seasonal period or water regime. Costa et al. (2015) verified that the number of predated mined leaves was higher during the rainy period, which does not corroborate to our results, and can be associated to the need for rainfall as a water source, reducing the population during the dry period.

There was a significant correlation of -0.66 between rainfall/rust (Table 2). This was expected, given that, for sporulation and infection, two conditions are necessary: leaf wetness and adequate temperature conditions (Vale et al., 2000), since periods with higher rainfall remove part of the pathogenic spores from the leaf surface.

Figure 3 shows spikes of the occurrence of the pathogen in June 2014, with incidence of 80% and

gradually decreasing in function of the reduction of favorable climate conditions and of the defoliation that occurred during the post-harvest period. Chalfoun et al. (2001) found higher levels of rust at the end of the agricultural year, which indicates the use of better control strategies beyond the conventional months that occur, generally, between October and January of the next year.

From November 2014 to May 2015, a significant increase of the pathogen was expected. However, this did not occur. According to Chalfoun et al. (2001), irregular rainfall make the progress of rust difficult, which becomes evident in Figure 3, with the monthly sum of rains and their respective oscillations for the period in question extending from October 2014 to April 2015.

Garçon et al. (2004) verified that the incidence of rust reached 84.5% in June 2000, corroborating the results found in this study. This indicates that rust has presented similar behavior over the years. However, in May 2015, a reduced incidence of the pathogen was observed, which reinforces the need for punctual management based on climatic conditions, warning stations and pathogen monitoring, demanding monitoring for a wider period, which can also change the form of pathogen control.

There were no significant correlations for the variables: leaf miner, mined leaves, predated leaves, intact predated leaves and fertility, with the same result for rust and fertility variables. This result is probably related to plant nutrient balance over isolated nutrient analysis, given that the nutritionally balanced plant is more resistant to biotic factors. Vasco (2016) verified that there was no significant interaction between the doses of K and B, and coffee rust, for the area under incidence progress curve (AUDPC). However, a positive correlation for the nutrients: K, B, Cu and Fe with (AUDPC), was verified during foliar analysis. Furthermore, the incidence of coffee rust increased with the increase in the content of these nutrients due to the nutritional unbalance of the higher doses of K and B. Vieira Junior et al. (2008) verified that, in the cultivation of *canephora* coffee, the severity of coffee rust was always superior under shading conditions, regardless the nutritional aspect or the management applied to the selected crops.

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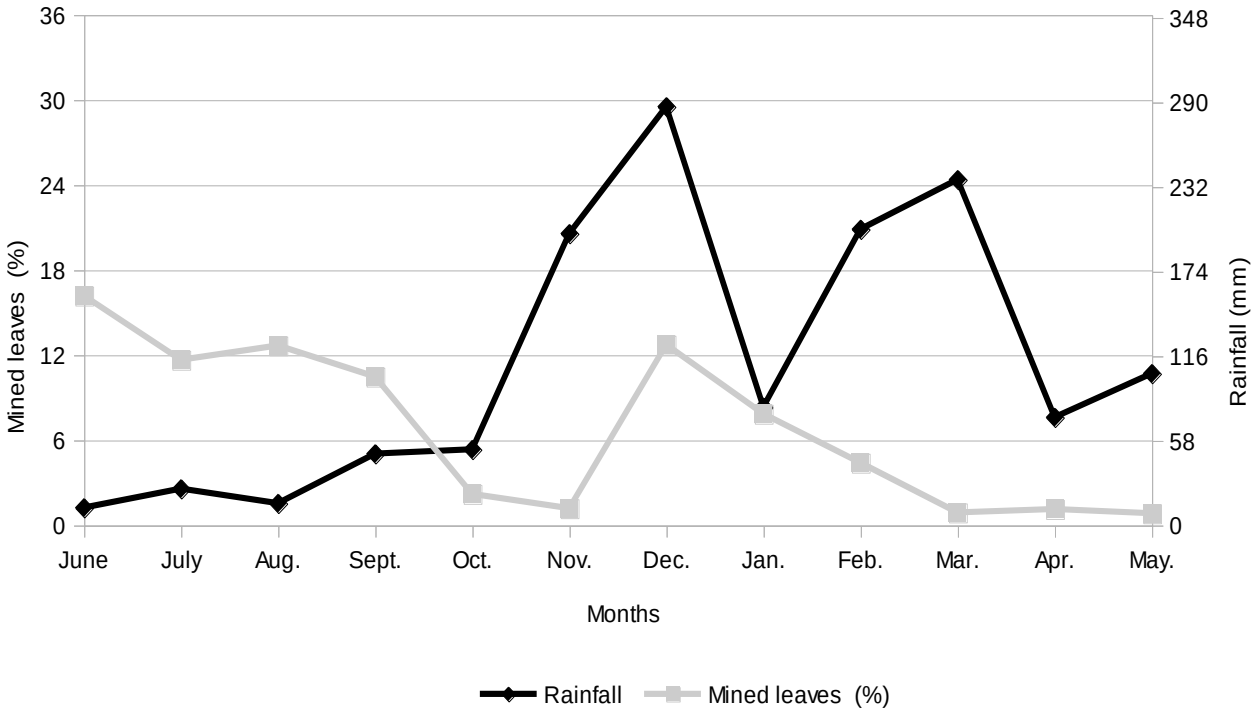

Figure 2. Occurrence of mined leaves with and rainfall, during the period from June of 2014 to May of 2015.

Table 2. Pearson correlation coefficients between predated mined leaves, precipitation and rust. Inconfidentes, 2015.

Parameters	Correlation
Predated mined leaves (%)/Rainfall	0.37
Rainfall/Rust (%)	- 0.66*

*Significant at 5% probability

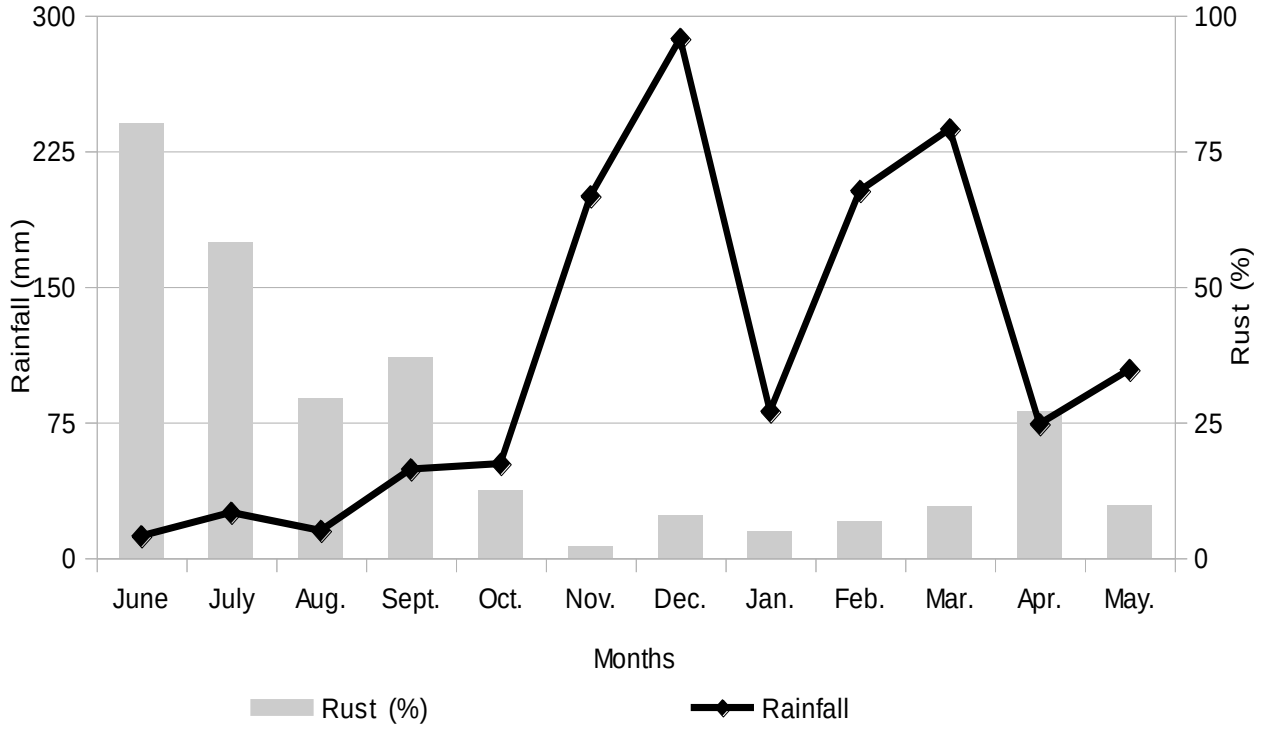

Figure 3. Monthly occurrence of rust and rainfall from June 2014 to May 2015.

Conclusion

The percentage of leaf miner was higher during the months with lower rainfall or during the long Indian summers.

The predation level was superior to the non-action level, which can be related to the influence of the forest near the studied crop, given that it was not influenced by abiotic factors.

The rust presented alternate occurrence spikes for both autumns evaluated and was correlated to rainfall.

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