



Effect of pigeon pea intercropping or shading with leucaena plants on the occurrence of the coffee leaf miner and on its predation by wasps in organic coffee plantings

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ABSTRACT: *The infestation of coffee leaf miner and its predation by wasps were assessed in commercial organic coffee plantings shaded with leucaena or intercropped with pigeon pea. Plantings in northern Paraná were assessed every two weeks from June 2011 to December 2012. The percent of infested leaves, number of mines per leaf and the percent of predation by wasps (indicated by lacerations) were determined. Fewer coffee leaf miners and fewer mines per leaf were found in pigeon pea intercropped plantings (28.4% and 0.3, respectively) than in shaded plantings with leucaena (48.1% and 0.8, respectively). More predation by wasps was found in the shaded (27.2%) than in the intercropped (13.2%) plantings. Suggestions for new studies are presented along with suggestions for managing the leaf miner in coffee plantings.*

Key words: *Leucoptera coffeella; coffee pests; organic farming; biological control.*

Efeito da consorciação com feijão-guandu ou sombreamento com plantas de leucena na Ocorrência do Bicho-mineiro e sua predação por vespas em lavouras de café orgânico

RESUMO: *A infestação de bicho-mineiro e a sua predação por vespas foram avaliadas em lavouras comerciais de café orgânico sombreadas com leucena ou consorciadas com feijão guandu. As lavouras situadas na região Norte do Paraná foram avaliadas a cada duas semanas de junho de 2011 a dezembro de 2012. Determinou-se o percentual de folhas infestadas, o número de minas por folha e a porcentagem de predação por vespas (indicada pela laceração das minas). Menor infestação do Bicho-mineiro e o menor número de minas por folha foi verificada na lavoura consorciada com feijão guandu (28,4% e 0,3; respectivamente) em relação a lavoura sombreada com leucena (48,1% e 0,8; respectivamente). Maior predação por vespas foi verificada na lavoura sombreada (27,2%) em relação a lavoura consorciada (13,18%). Sugestões de novas pesquisas e para o manejo do bicho-mineiro em lavouras de café são apresentadas.*

Palavras-chave: *Leucoptera coffeella; pragas do café; cultivo orgânico; controle biológico.*

INTRODUCTION

The coffee leaf miner (CLM) *Leucoptera coffeella* (Lepidoptera: Lyonetiidae) is one of the key pests of coffee plantings and is reported in coffee growing regions throughout the world (PEREIRA et al., 2007; SCALÓN et al., 2011; RIGHI et al., 2013). The CLM larva mines the palisade parenchyma, prevents photosynthesis (NEVES et al., 2006), and may result in yield losses of 50% if control measures are not adopted (REIS & SOUZA, 1996).

In conventional farming systems, synthetic chemical insecticides are ordinarily used. However, chemical insecticides may fail to control the target pests and can sometimes fostering other pests (CORDEIRO et al., 2013). For example, CLM populations resistant

to insecticides have been observed under field conditions (FRAGOSO et al., 2003; RIBEIRO et al., 2003). Furthermore, secondary pest outbreaks, mostly of the red mite *Oligonychus ilicis* McGregor (Acari: Tetranychidae), have also been reported after spraying of pyrethroid insecticides (COREDEIRO et al., 2013). Moreover, many insecticides used to control CLM have resulted in the death of predatory wasps or at least reduced wasp activity (FERNANDES et al., 2013), resulting in losses to the coffee agroecosystem, in which wasps are important natural enemies of CLM (TUELHER et al., 2003; PEREIRA et al., 2007; SCALÓN et al., 2011).

The search for cropping systems that avoid the use of insecticides is desirable, and in this sense,

the improvement of biodiversity could possibly serve to enhance agroecosystem resilience and reduce insect pests in field crops and forests (GURR et al., 2003; JACTEL et al., 2005; LIN, 2011). Trees for shading and green manures (cover crops) have been used in coffee plantings (RESENDE et al., 2007; AMARAL et al., 2010; LOMELÍ-FLORES et al., 2010; SOUZA et al., 2014; THEODORO et al., 2014). Proper usage and management of these plants could improve the sustainability and quality of coffee yields.

Studies have shown that coffee agroecosystem diversification increases the occurrence of CLM's natural enemies (DE LA MORA et al., 2008; REZENDE et al., 2014; PACK et al., 2015). However, a simple increase in agroecosystem diversity may not ensure an increase in biological control (TSCHARNTKE et al., 2016). AMARAL et al., 2010 reported that coffee intercropped with banana trees (*Musa* spp.) was not able to reduce CLM occurrence. Thus, effects of different coffee intercropping systems on CLM and wasp occurrence are still largely unknown.

Leucaena plants (*Leucaena leucocephala* L.) have been used to protect crop plants against frost (VALENTINI et al., 2010) and to enrich soil organic matter (GUIMARÃES et al., 2014). Pigeon pea plants [*Cajanus cajan* (L. Millsp.)], in addition to being used for the protection of young plants against frost (CARAMORI et al., 1999), have also been used to improve soil quality and may be used to feed people and livestock (AZEVEDO et al., 2007). However, there is a lack of

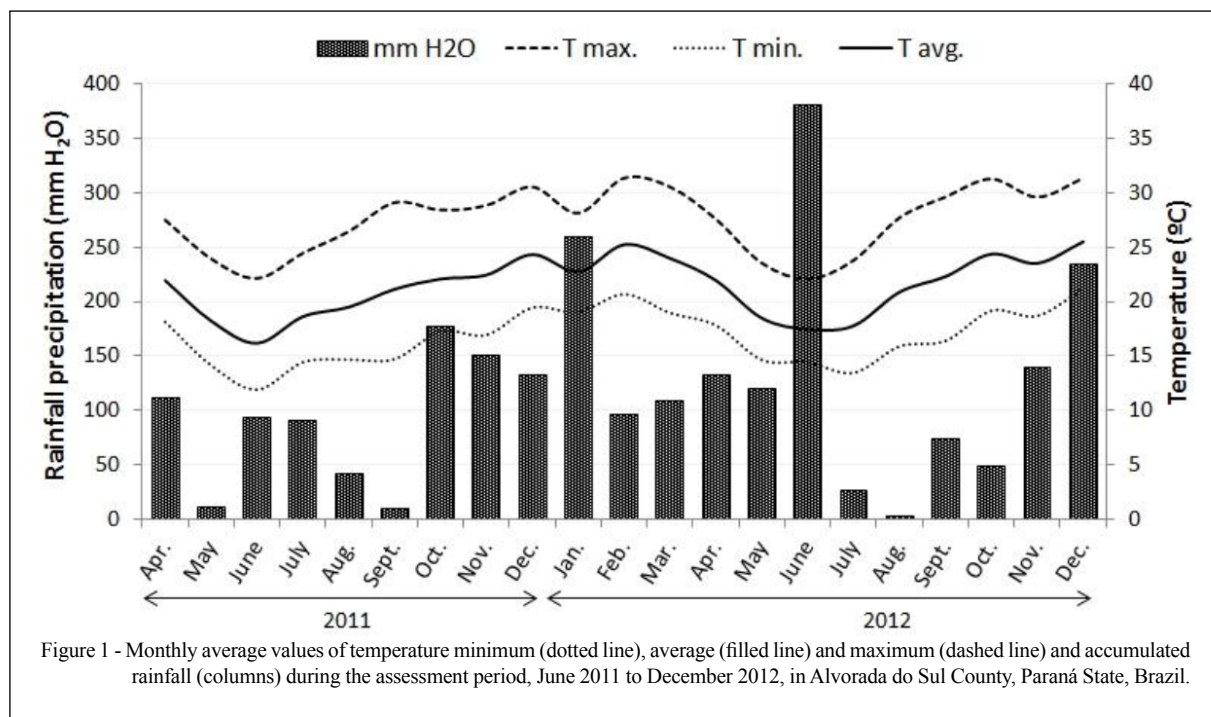
knowledge of how leucaena and pigeon pea plants affect CLM occurrence. Coffee plantings intercropped with these plants could affect microclimate conditions (mostly temperature, humidity and ventilation) and, consequently, CLM infestation and predation by wasps.

Therefore, prevalence of CLM infestation (percentage of leaves with mines and mines per leaf) and of predation by wasps over a year and a half were compared in two organic farming systems: one shaded with leucaena and the other intercropped with pigeon pea.

MATERIALS AND METHODS

Field surveys were conducted from June 2011 to December 2012 in two coffee plantings in Alvorada do Sul County, Brazil (22° 54' 50" S, 51° 13' 56" W; 532 m.a.s.l. and 22° 54' 38" S, 51° 13' 59" W; 530 m.a.s.l.). The two plantings were located only 400m apart. The regional climate is classified as humid subtropical with hot summers (Cfa). The mean temperature was 21.5°C, and accumulated rainfall was 2318 mm during the study period (data from IAPAR meteorological station; see figure 1).

The two organic plantings utilized different coffee cultivation systems. In the first system, coffee plants cv. IAPAR 59 with four years of age were spaced 2m (lines) X 1m (plants within the lines) and were intercropped (shaded) with *L. leucocephala*



trees of the same age planted with 2.5m X 5m spacing. In the second system, coffee plants (same cv. and spacing) were intercropped with pigeon pea plants (*Cajanus cajan* L.) (cultivar PPI 832), which were placed between coffee lines 0.5m apart. Fertilization varied according to cultivation systems. Shaded coffee received compost from poultry litter. Pigeon pea-intercropped coffee received compost from cattle manure plus crop residues. Compost (2kg/plant) was applied in both systems during the flowering period. Standard phytosanitary measures were not achieved during the study period.

Assessments of CLM infestation and wasp predation were conducted by establishing five sample points in each planting, each at least 10m apart. Each point included 10 coffee plants and sampled four random leaves per plant (N=40). The third pair of leaves (from the apex of the reproductive branch) was collected from the middle third of the plants (VILLACORTA & WILSON, 1994); if the third pair was absent, the fourth pair was used.

Pest infestation was assessed by counting the number of leaves containing injuries (mines) and without predation traces (intact mines). The number of mines exhibiting signs of predation (mines lacerated by wasp mandibles) was also counted. Assessments were conducted from 09:00 to 12:00 every 15 days, for a total of 33 assessments.

Tests for normality and homogeneity of variance were performed to verify the assumptions

for analysis of variance. Thereafter, groups were compared using a *t* test ($P < 0.01$). The BioEstat 5.0 (Ayres 2007) software package was used.

RESULTS AND DISCUSSION

We could not verify a relationship between CLM infestation and weather conditions recorded by the IAPAR meteorological station nearest the study areas. Although, weather conditions (at the regional level) were the same for the two areas, the occurrence of CLM was markedly different (Figure 1 and 2), probably due to the microclimatic effects that the intercropped plants (MORAIS et al., 2006) or shaded trees (ARAÚJO et al., 2016) caused in each coffee planting.

Pigeon pea-intercropped coffee presented fewer CLM infestations and number of mines per leaf than the leucaena-shaded coffee (Figure 3A and 3B). Evidence of predation of the CLM by wasps was more common in leucaena-shaded coffee than pigeon pea-intercropped coffee (Figure 3C).

CLM infestation in pigeon pea-intercropped coffee was above the action level (AL) of 30% (see REIS & SOUZA, 1996) at the beginning of the assessments; however, during all of 2012, infestation was below the AL (Figure. 3). In leucaena-shaded coffee, infestation was below AL only during November 2011 and remained above it for all other assessments. This is typical of the pest in the conventional plantings close to the experimental

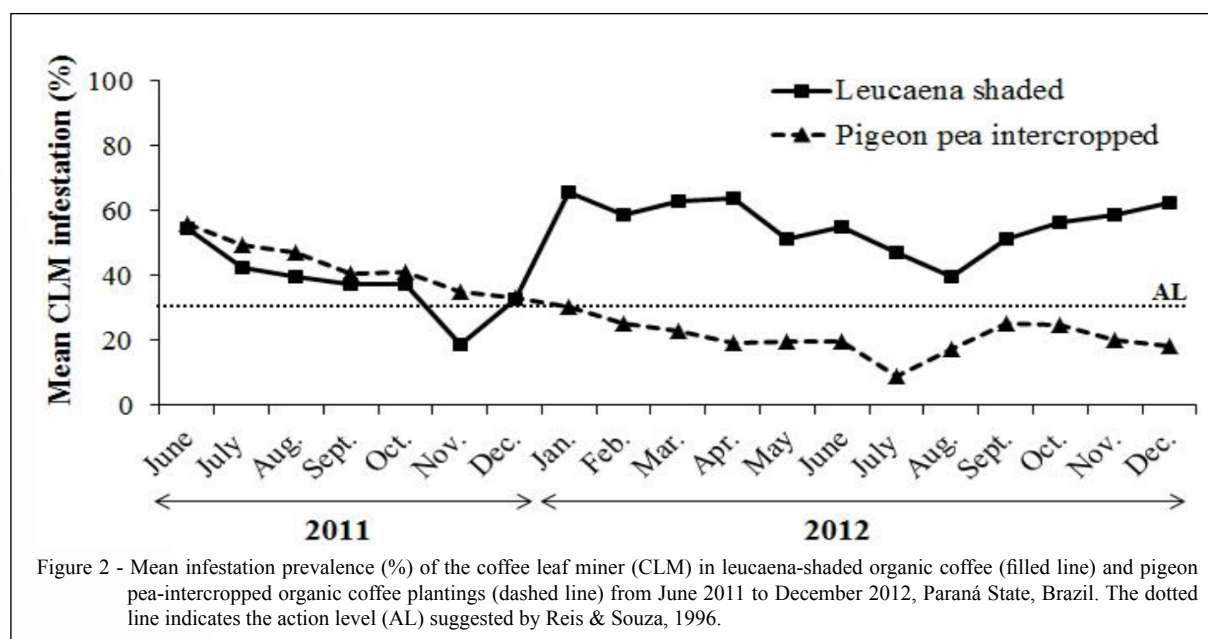
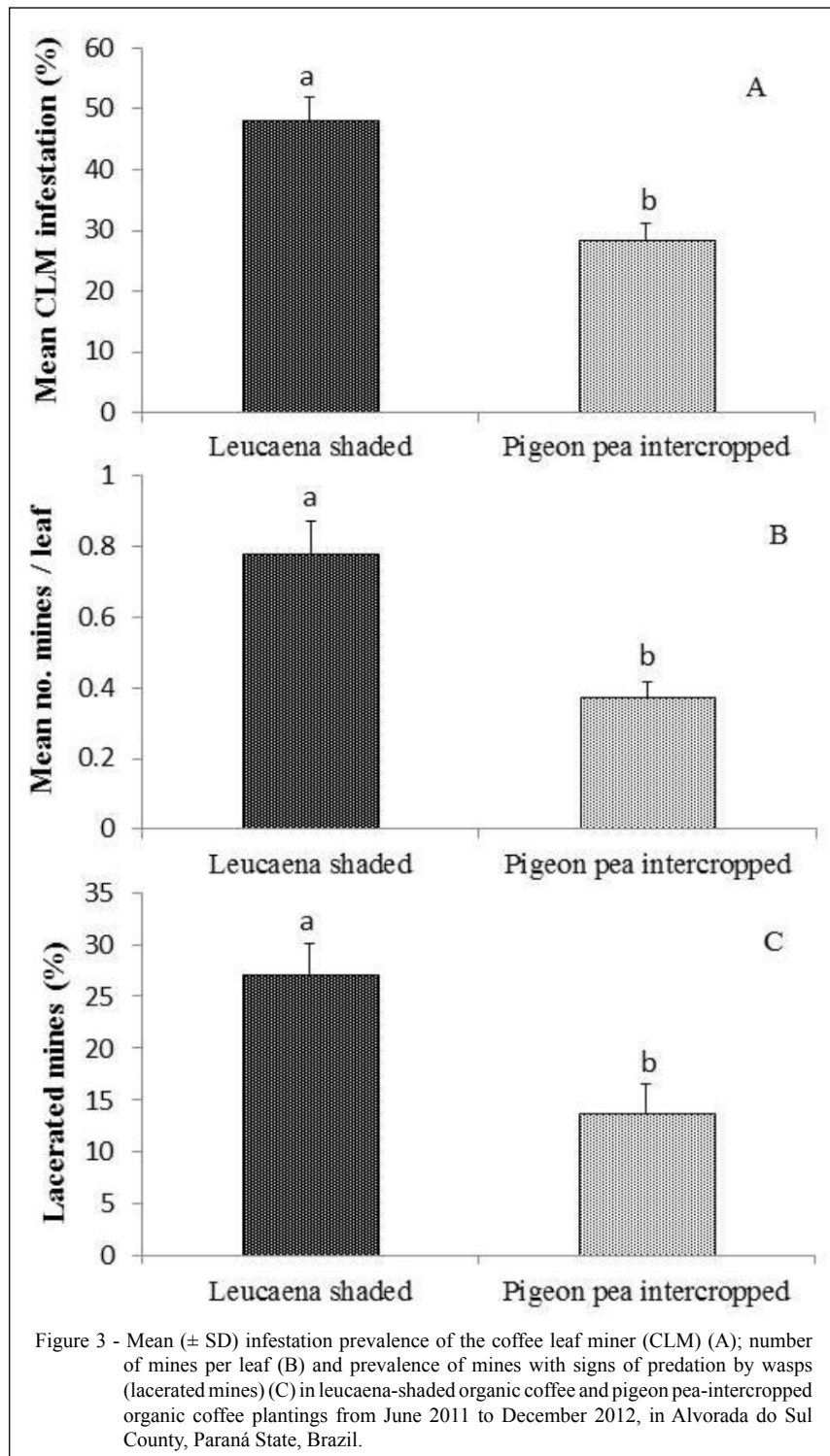


Figure 2 - Mean infestation prevalence (%) of the coffee leaf miner (CLM) in leucaena-shaded organic coffee (filled line) and pigeon pea-intercropped organic coffee plantings (dashed line) from June 2011 to December 2012, Paraná State, Brazil. The dotted line indicates the action level (AL) suggested by Reis & Souza, 1996.



areas, in which farmers must spray several times during the production cycle.

Our observation of lower infestation of CLM in pigeon pea-intercropped plantings corroborates a

previous study performed by THEODORO et al., 2014. In general, when coffee seedlings are planted between pigeon pea lines (“tunnels”), fewer CLM are observed (CARAMORI, 2000). Microclimate is affected when

pigeon pea is intercropped between coffee seedlings, and adult planting protects the plants from frost and wind (MORAIS et al., 2006; CARAMORI et al., 1999). As a result, CLM population dynamics may also be affected. The lower daytime temperature in coffee intercropped with pigeon pea (MORAIS et al., 2006) may negatively influence CLM development (LOMELÍ-FLORES et al., 2010). Intercropping pigeon pea plants in coffee planting also alters nutrient dynamics in the soil and affects CLM indirectly. Total soluble sugars are also affected by organic fertilizers and thus may also affect CLM (THEODORO et al., 2014).

CLM infestations during the coldest months were previously reported under shaded conditions (LOMELÍ-FLORES et al., 2010), but this was not the case in our present study (Figure 3). A combination of factors may be associated with the differences in CLM populations among the farming systems. Although, poultry litter has been previously reported to reduce CLM damage (THEODORO et al., 2014), infestations in the leucaena-shaded coffee treatment (which was fertilized with poultry litter) were higher than in the treatment with pigeon pea intercropping (Figure 2A and B). In addition to leaf nutritional condition, the headspace volatiles in the planting may affect CLM dynamics because coffee volatiles can influence CLM mating behavior (FONSECA et al., 2013). Pigeon pea probably affected CLM behavior as well; this plant has been reported to have insect-repellent properties (ROMEIS et al., 1998, OBICO & RAGRARIO, 2014). Additional studies must be conducted to confirm CLM repellence by pigeon pea plants compared with coffee plants.

Predatory wasps are the principal natural enemies of CLM and regulate pest populations under field conditions (TUELHER et al., 2003; PEREIRA et al., 2007; SCALÓN et al., 2011). High abundances of natural enemies in organic farming systems have also been previously reported (ALTIERI & NICHOLLS, 2004), probably due to lower anthropogenic disturbance and higher plant diversity (BIANCHI et al. 2006).

Higher predation of CLM mines in the leucaena-shaded coffee than pigeon pea-intercropped coffee (Figure 2C) may be associated with a density-dependent relationship due to differences in the availability of the prey (Figures. 2 and 3). The density-dependent relationship between predatory wasps and CLM has been previously described (FERNANDES et al. 2009). This hypothesis is supported by the fact that predatory wasps are attracted to volatiles emitted by coffee plants damaged by CLM (FERNANDES et al., 2010). Leucaena plants also have extrafloral nectaries (FREITAS et al., 2001), which may also attract wasps

to the coffee planting. Furthermore, leucaena plants may serve as a suitable shelter for establishing wasp nests, since the wasps prefer tree like plants rather than shrubs or herbaceous plants (SOUZA et al., 2014).

The information obtained in our study may be used to design more resilient coffee-producing agroecosystems. One option to maximize the beneficial effects of both leucaena and pigeon pea plants in coffee plantings to reduce CLM would be the inclusion of both plant species, for example, intercropping pigeon pea and using leucaena as a windbreak. If beneficial additive effects of these species on CLM infestations could be achieved, it seems likely that the action level would not be reached. However, for wide spread utilization by farmers to be effective, additional studies must be conducted to determine optimal management of these plants (densities, spacing, cultivars, pruning, etc.) and their multifunctional effects (yields, weed suppression, frost protection, reduced erosion, soil fertility improvement, etc.) and constraints on their use in coffee plantings (labor, interference with cultivation practices, excessive shading, etc.).

CONCLUSION

We observed fewer CLM mines on leaves of coffee plants in the pigeon pea-intercropped planting than in the leucaena-shaded planting. More signs of CLM predation by wasps were observed in the leucaena-shaded than the pigeon pea-intercropped planting.

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