American Journal of Plant Biology
2025, Vol. 10, No. 2, pp. 41-45
https://doi.org/10.11648/j.ajpb.20251002.14

Research Article

Evaluating Lowland Coffee Genotypes Against Coffee Blotch Miner (*Leucoptera caffeina*) in Southwestern Ethiopia

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Abstract

Coffee is a vital crop in Ethiopia. The perennial and evergreen nature of the *Coffea arabica* favors attack by a number of insect pests. However, is lack of insights into the plant - pest interaction on Arabica coffee genotypes, which is important for the possibility of developing tolerant cultivar/s as management option. The aim of the current study was to investigate the reaction of coffee blotch miner *Leucoptera caffeina* against lowland coffee genotypes. Seven treatments were used in this experiment and arranged in randomized complete block design with three replications. On three branches, we counted the total number of leaves, as well as the number of leaves damaged. Severity was estimated by following the infested leaf area per total leaf area based on the leaf midrib recorded during data collection. In regard to the aim the reaction of lowland coffee genotypes to the insect were significantly different in damage level. The percentage of infested leaves by coffee blotch miner varied strongly among the genotypes at Agaro with 6.80% to 42.42% of the leaves attacked in 2021/22, 18.61% to 73.54% in 2022/23. The maximum severity (22%) was recorded from I_2 coffee genotypes in 2023. The pests also showed remarkable differences in their seasonal dynamics. From evaluated lowland coffee genotypes 42.86% resulted greater than 30% severity and 57.14% grouped under same group (<20% severity). Based upon the results, various infestation levels was observed among the evaluated coffee genotypes at Agaro, this indicated the existence of genetic variation in response to the pest damage. Therefore, future research works should be focused on characterizing and identify biochemical and secondary metabolites of low infested coffee genotypes against coffee pests. As breeding strategies recognizing coffee genotypes that exhibit tolerant to coffee pest is crucial for ensuring sustainable coffee production amid the evolving challenges posed by pests and climate change.

Keywords

Insect-plant Interaction, Severity, Infestation, Incidence, Ethiopia

1. Introduction

The perennial and evergreen nature of the *Coffea arabica* favors attack by a number of insects, diseases, mites, and some gastropods such as snails and slugs. All portions of the plants are susceptible to attack, and damage could appear at different crop growth stages. In Ethiopia, more than 59 arthropod pests have been identified and documented in coffee from 1966 till the present [1-5]. From identified Arabica coffee arthropods in the country around 30.51% are Hemip-

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Received: 19 April 2025; **Accepted:** 9 May 2025; **Published:** 18 June 2025

tera order whereas 28.81% is Lepidoptera order [5]. Among Lepidoptera order blotch miner is pest of coffee comes next to Antestia bugs in economic importance [1]. Blotch miner (*Leucoptera caffeina)* is the most economically important species attacking coffee leaves both at nursery and field condition [6]. The larvae create a distinct blotch mine while feeding gregariously in the upper side of the leaf [7-9]. However, the specific yield loss caused by the coffee blotch miner in Ethiopia has not been quantified yet. Nonetheless, considerable leaf damage from this insect has been documented in different coffee production system of Southwestern Ethiopia [10, 3, 11, 9]. When the larvae hatch it feeds inside a leaf just below the upper epidermis, resulting in leaf damage [8, 12]. Mined leaves by coffee blotch miner become dried and fallen, as result yield and coffee tree age could reduce [13].

As altitude is a proxy of climate change, coffee grown in low altitude severely affected by insect pest like blotch miner as compared to higher altitude [14, 9]. The intensity of management practices also influences the extent of damage caused by the coffee blotch miner [9]. A range of strategies aimed at enhancing crop tolerance to insect pests is emerging, particularly those that focus on plant secondary metabolism, immunity, and morphological characteristics. In response to herbivorous threats, plants allocate their energy towards the synthesis of various defensive compounds, including secondary metabolites [15]. From collected coffee germplasms, promising coffee accessions which express high yield, acceptable quality and other important trait is promoted to variety verification trial. So, these promoted genotypes should be evaluated for multiple pests (major diseases and insects) at naturally infested field at selected localities. Therefore, the aim of this research was to determine the reaction of coffee genotypes against coffee blotch miner on naturally infested field. Recognizing coffee genotypes that exhibit tolerant to coffee pest is crucial for ensuring sustainable coffee production amid the evolving challenges posed by pests and climate change.

2. Materials and Method

2.1. Description of Study Areas

The experiment was conducted at Agaro agricultural research sub-center from 2022-2023 cropping seasons. Agaro has an altitude of 1630 meters above sea level with the mean annual rainfall of the area being 1616 mm with an average maximum and minimum air temperature of 28.4 ℃ and 12.4 ℃, respectively. Seven coffee genotypes (Eb_1, 'I_1', I_2, K_1, K_2, 7454 and Dessu) were evaluated against coffee blotch miner. The verities 'Dessu' and '7454' considered as standard checks (checks for yield), released Arabica coffee verities. Spacing between coffee and experimental block was 2m and 3m, respectively. The design was completely randomized and evaluated in a block with three replicates.

The specific susceptible or tolerant genotypes used (checks) for the coffee blotch miner in Ethiopia has not been identified. Hence the resistance and tolerant level of coffee genotype evaluated based on response of coffee genotypes against insect (by comparison). All recommended agronomic practices like shade management (light shade used), fertilization and weed management were carried out as JARC's recommendation.

2.2. Coffee Insect Pests' Assessment Method

Four coffee trees per row were systematically selected. Furthermore, each tree was stratified in to three canopy layers (upper, middle and lower) and a pair of branch from each layer was selected for assessment of the insect. The total number of leaves, as well as the number of damaged leaves was counted on selected branches based up on damage symptom observed on the leaves. Incidence was determined as the proportion of infected coffee leaf out of the total number of leaf counted. The severity of coffee blotch miner was estimated by following the infested leaf area per total leaf following the leaf midrib (Figure 1). The maximum estimation (100%) was given when severe mined leaves covered by blotch and followed by drying and fallen leaf [16]. No damage (0%); or few blotch mines (<5%, when damage symptom <2mm); and 50% when half of leaf area mined by blotch miner and most leaves with long blotch and several mines (50 percent of leaf covered by blotch symptom) and 100% when all leaf area covered by coffee blotch damage (Figure 1).

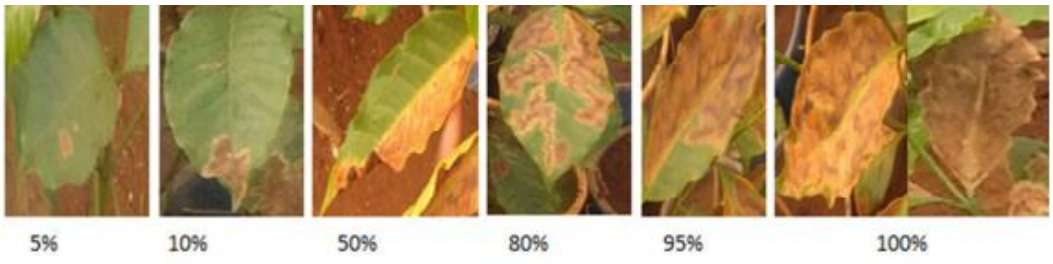

Figure 1. *Coffee blotch miner damage scale. Source: [16].*

Leaf area was calculated by measuring the leaf length (L) and leaf width (W) in centimeter, then after multiplied the measured leaf length and leaf width (L*W). Per plot twenty leaves were sampled and measured to see the relationship between coffee blotch miner and leaf area.

2.3. Statistical Analyses

Data were analysed using using R v 3.6.3 (R Core Team 2020) software. General Linear Model (GLM) procedure was employed for the analysis of the data. Least significant difference (5%) was used for mean separation.

2.4. Results and Discusion

The percentage of infested leaves by the coffee blotch miner varied among the evaluated lowland coffee genotypes, with 6.80% and 42.42% on Desu and I_2 coffee genotypes in 2022 growing season, respectively (Table 1). Similarly, high level of coffee blotch miner intensities (18.61 to 73.54%) was recorded on 'I_2' coffee genotype in 2023 growing season. However, damage proportion was different among different coffee varieties (Table 1 & Figure 1). Genotype I_2 coffee was the most damaged coffee variety among others. This result is consistent with other research in southern Ethiopia that found variable degrees of coffee blotch miner damage, ranging from 27.9 to 76.2% [17, 16, 6]. In southern Ethiopia, Shimales et al. [17] noted that coffee blotch miner had damaged I_2 coffee genotype up to 75% mean incidence and 50% of mean severity at Bebeka coffee farm. I_2 was the most susceptible and recorded with highest incidence and severity. More over the second and third high score was recorded for coffee genotype K_1 and I_1 in 2023. From assessed coffee verity lowest coffee leaf miner attack was recorded for Dessu and 7454 verities. Those two verities have small leaf area as compared to the other evaluated coffee genotypes. Those two varieties have lowest mean leaf area 70-83cm^2, whereas the leaf area of rest coffee genotypes (I and K group) estimated to 100-140cm^2 (Table 1).

Table 1. *Incidence and severity of coffee blotch miner against lowland coffee genotypes.*

Treatments	Bloch miner incidence (%) in 2022	Blotch miner severity (%) 2022	Bloch miner incidence (%) in 2023	Blotch miner severity (%) in 2023	Leaf area (cm^2)
Eb_1	10. 02^{cd}	2.47^{c}	29.56(5.1)^{cd}	11.39^{b}	88.35^{bcd}
I_1	32.82^{abc}	23.05^{ab}	51.79 (7.02)^{abc}	8.22^{b}	117.13^{ab}
I_2	42.42^{a}	28.11^{ab}	73.54(8.5)^{a}	22.77^{a}	111.63^{abc}
K_1	36.81^{ab}	33. 56^{a}	56.53(7.4)^{ab}	3.62^{b}	114.60^{ab}
K_2	23.22^{abcd}	14.86b^{c}	36.05(5.9)^{bcd}	5.40^{b}	137.95^{a}
7454	16.63^{bcd}	7.69^{c}	29.56(5.3)^{cd}	4.56^{b}	83.9^{cd}
Dessu	6.80^{d}	1.22^{c}	18.61(4.2)^{d}	5.13^{b}	70.49^{d}
CV (%)	14.46	27.92	17.3	36.33	15.89

BLM= Coffee blotch miner (Leucoptera caffeina); Means followed by the same letters within the column are not significantly different from each other at 5% level of probability. Values in the parenthesis were log_{10} transformed.

From evaluated coffee genotypes in 2022 the lowest mean incidence and severity was recorded from coffee genotype Dessu in 2022 and 2023 growing season (Table 2). Thus, in 2022, 'I_2' lowland genotype was 6.24 times more likely to be infested by blotch miner than 'Dessu' variety. In addition, by 2023 cropping season same coffee genotype (I_2) was infested by the blotch miner up to 3.23 times. The genotypes K_1, K_2, I_1 and I_2 was ≥3.4 times infested by coffee blotch miner than 'Desu' variety (Table 2), whereas Eb1 was 1.47 times infested by coffee blotch miner than Desu genotype.

In addition to insect damage leaf area of the genotypes were measured and four genotypes (I_1, I_2, K_1 and K_2) resulted above 100 cm^2 and three varieties resulted below 90cm^2. This lower leaf area had lowest blotch miner infestation (Table 2). Based on the below table as the coffee leaf area increased the blotch miner infestation increased, but the chemicals composition in the genotype and physiological characteristics may also affect the preference of the insect. Study indicated that the selection of host plants by monophagous insect is sometimes concentrated on the production of particular plant secondary metabolites [15]. As mined leaves by coffee blotch miner increased the coffee leaves mined by blotch dropped, this could directly related with yield and coffee quality. Mined leaves by coffee blotch miner become dried and fallen, as a result yield and life

span of coffee tree could be reduced [13]. A Rapid assessment of the coffee blotch miner on irrigated lowland coffee genotypes (I_1, I_2, K_1 and K_2) indicated that 75% mean incidence and 50% of mean severity was recorded on I_2 genotype at Bebeka coffee farm [17].

Our result indicate that from evaluated lowland coffee genotypes, 42.86% resulted greater than 30% severity and 57.14% grouped under same group (<20% severity). The insect showed remarkable differences in their seasonal dynamics (2022 and 2023). This indicated that various reactions of coffee genotypes to insect pests are mainly influenced by environmental factors and the interaction of Arthropod-genotype interaction. The reaction of lowland coffee genotypes to the coffee blotch miner was significantly different in damage level. This could mean that evaluated coffee genotypes have different response to the pest, and some coffee genotypes probably exposed to pest attack, whereas, other could tolerate pest infestation. Study indicated that, the varied responses of this particular varietal to insect pests may involve secondary compounds that inhibit insect growth and development by disrupting their developmental stages. These compounds can serve as feeding deterrents, diminish nutritional value, impair protein digestion, and lead to the production of toxic substances detrimental to the insects [15]. Thus, low level of coffee genotypes to insect pest has the potential to directly in coffee blotch miner management suggestions for farmers.

3. Conclusion and recommendation

Coffee blotch miner is one of economically important insect defoliating coffee leaf in different coffee growing regions of Ethiopia. Besides, leaf damage caused by blotch miner directly affects the photosynthesis and production. Based upon the results, various infestation levels was observed among the evaluated coffee genotypes, this indicated the existence of genetic variation among coffee genotypes in response to the pest. Therefore, future research works should be focused on characterizing and identify biochemical and secondary metabolites of low infested coffee genotypes against coffee pests. Further studies are recommended especially on identification of tolerant coffee genotypes as one component of integrated pest management options. As breeding strategies recognizing coffee genotypes that exhibit tolerant to coffee pest is crucial for ensuring sustainable coffee production amid the evolving challenges posed by pests and climate change.

Abbreviations

JARC	Jimma Agricultural Research Center
EIAR	Ethiopian Institute of Agricultural Research
BLM	Coffee Blotch Miner

Acknowledgments

This study was supported by Ethiopian Institute of Agricultural Research and EU-café project. The authors would like to thank Agaro Agricultural research sub center and coffee breeding department for their collaboration during the execution of the study.

Author Contributions

The author conceived the ideas and designed methodology. The author collected the data, analyzed the data and writing of the manuscript. Author contributed critically to the drafts and gave final approval for publication.

Conflicts of Interest

The author declares no conflicts of interest.

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