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Impact of Moisture Stress on Coffee Blotch Miner, *Leucoptera caffeina* (Lepidoptera: Lyonetiidae) Incidence and Severity at Jimma

Tamiru Shimales[1], Desalegn Alemayehu[2], Minda Taddesse[3]

[1]Department of Plant Protection, Jimma Agricultural Research Center, Ethiopian Institute of Agricultural Research, Jimma, Ethiopia

[2]Department of Coffee Breeding and Genetics, Jimma Agricultural Research Center, Ethiopian Institute of Agricultural Research, Jimma, Ethiopia

[3]Department of Irrigation and Water Harvesting, Jimma Agricultural Research Center, Ethiopian Institute of Agricultural Research, Jimma, Ethiopia

Email address:

Stamiru8@gmail.com (T. Shimales)

Abstract: Sustainable agriculture relies on environmentally safe pest management methods such as proper irrigation that has impact on pest suppression. However, we lack information on the impact of moisture stress on coffee insect pest under Ethiopian condition. Thus, two irrigation level were evaluated on five Limmu coffee genotypes under rain shelter condition in 2016/2017. The trial was arranged in a factorial experiment in completely randomized block design with three replicates. Eight month old seedlings were grown on potted nursery media and subjected to either water deficit stress or well watered condition. The well watered treatments were irrigated at four days interval, while for moisture stressed irrigation was withhold for a month. Coffee blotch miner incidence and severity with relative to stress level were recorded. Coffee plants were less affected by coffee blotch miner under well watered than stressed ones. Irrigation reduces more than twice the incidence and severity of this pest. Cultural management that conserves soil moisture status, such as application of irrigation reduces pest damage to crop. This cultural pest management best fits integrated pest management which usually recommended for coffee producers in dry areas and during prolonged drought. Furthermore, studies are recommended on soil moisture conservation methods such as irrigation, cover crop and mulch with relation to coffee pests' dynamics.

Keywords: *Coffea arabica* L., Cultural, Genotypes, Irrigation, Intensities

1. Introduction

Irrigation plays a great role in increasing crop production in dry areas and during prolonged drought. Drought is a major environmental constraint affecting the growth and production of coffee [1]. Selection of drought tolerant Arabica coffee genotypes an important way to mitigate climate change impacts on coffee production [1]. In Ethiopia, different coffee genotypes have been evaluated for drought tolerance/moisture stress/ under rain shelter condition [1, 2]. During evaluation, the moisture requirement for the plant growth may altered and thereby increasing their susceptibility to insect pests, but not all coffee genotypes are alike, which is something we lack insight into. Severe

drought increases the damage by insect species in crops [3].

Arabica coffee is attacked by a diverse group of insect species [4]. In Ethiopia, over 49 coffee insect pest species has been identified, of which coffee blotch miner, *Leucoptera caffeina* (Washbourn) (Lepidoptera: Lyonetiidae) comes next to Antestia bugs in economic importance [5-7], both at field on young coffee plant and at seedling stage [8]. The study conducted at Agaro sub-centre indicated the percentage leaf damage by coffee blotch miner ranged from 2.2-55% with an average infestation of 13% [9], and at the same area the percentage of leaf damage estimated to 18.78-55.56% with an average infestation of 28.3% [8]. Long-term drought can result in reduced tree growth and health thereby increasing their susceptibility to insect pests. For example, the damage

and infestation of coffee by coffee thrips (*Diarthrothrips coffeae*) during prolonged drought was much higher than that of rainy season [10].

To reduce the damage caused by coffee pest/s, irrigation management can has an impact on pest suppression as cultural insect control method. For example, ensuring adequate moisture during the growing season assists in reducing stem-infesting insect densities of cultivated sunflower [11]. Likewise, study showed that incidence of irrigated coffee plants by the coffee leaf miner, *Leucoptera coffeella* was much lower than that of non-irrigated plant [12]. Such studies are important, as knowledge of cultural pest control may help to sustainably manage the crop from pest damage during moisture stress. Determining the effect of moisture stress on coffee pest intensities can be used as cultural pest management method. But low attention is given to the effect of moisture stress level on coffee pests. In this study, we investigated the impact of moisture stress on coffee blotch miner *Leucoptera caffeina* incidence and severity on five Limmu coffee genotypes with irrigation department under greenhouse condition.

2. Materials and Methods

2.1. Study Area

The experiment was conducted at Jimma Agricultural Research Center (JARC) (7°40'37''N and 36°49' 47''E, at 1753 altitude) in southwestern Ethiopia. JARC is found in Jimma zone, in Oromiya regional state, about 360 km southwest of Addis Ababa. The area receives mean annual rainfall of 1531 mm, with the main rainy season between June and September. Mean daily minimum and maximum temperatures are 11.5°C and 26.2°C, respectively.

2.2. Seedling Preparation and Coffee Nursery Management

All recommended seed bed and seedling managements were carried out according to Shimbir *et al.* [13]. Seven month seedlings were transplanted to experimental pots (for treatment application) with capacity of five (5) liter pot, a month after establishment period; seedlings were subjected to the respective watering treatments (moisture stress level) in 2016/17 growing season.

2.3. Treatments and Design

The experiment was conducted in a Randomized Complete Block Design (RCBD) in a factorial combination with three replications. The five Limmu coffee genotypes (L3, L4, L45, L54 and L55) were evaluated for coffee blotch leaf miner incidence and severity and two watering regimes (well-watered and water-stressed). For well-watered treatments each genotypes were received 100% Etc full irrigation at four days intervals (maintained at field capacity), whereas, for stressed pots water was withheld for 30 days.

2.4. Coffee Blotch Miner Incidence and Severity Estimation

A total of four hundred eighty (480) seedlings were used for this experiment. From each pot, six coffee seedlings were selected for both incidence and severity data. For this, total number of leaves and infested leaves were counted per 6 pots in each treatment. On these selected pots, we counted the total number of leaves, as well as the number of leaves damaged by the coffee blotch miner. The mean number of leaves inspected for incidence was 1563.05±23.6. Finally, incidence was determined as the proportion of infected coffee leaf out of the total number of leaf counted**.**

For coffee blotch miner severity; six coffee seedlings was randomly selected out of 16 coffee seedlings per a single treatment, and 10 numbers of leaves were randomly selected and severity was estimated on naturally infested coffee at greenhouse condition. The mean number of leaves inspected for severity was 1171.68±22.2. On these, selected leaves were scaled to quantify the severity of coffee blotch miner. Finally, severity was estimated by following the infested leaf area per total coffee leaf based on the leaf midrib recorded during data collection (Figure 1).
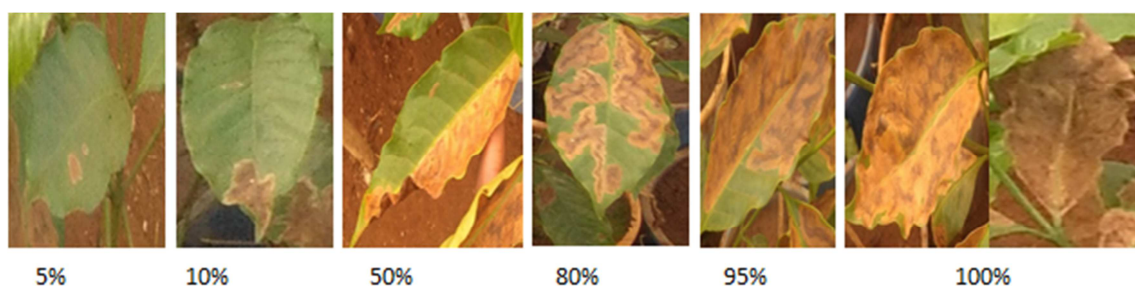

Figure 1. *Scale used to quantify the severity of coffee blotch miner Leucoptera caffeina. Photo credits: Tamiru Shimales.*

2.5. Data Analysis

The statistical data were subjected to the analysis of variance (ANOVA). The ANOVA model used for the analysis was:

$$Yikj = \mu + Vi + PSj + (VPS)ij + Rk + \varepsilon ijk$$

Where, $Yikj$=the mean value of the response variable of the ith genotype at the jth water stress level in k[th] blocks, μ =the overall mean, Vi =effect of genotype, PSj =effect of water stress, $(VPS)ij$, interaction effect of genotype and water stress, Rk, effect of block and εijk is a random error term due to those uncontrolled factors. The data were subjected to Analysis of variance (ANOVA) using S A S

(version 9.3) Statistical Analysis Software. All pairs of treatment means were compared using Least Significant Difference (LSD) test at 5% level of significant. Significant treatment means were separated using t test at $P < 0.05$.

3. Results

3.1. Moisture Stress Level and Coffee Blotch Miner Incidence and Severity

The percentage of infested leaves by the coffee blotch miner varied among the stress level, with 33.14% and 71.07% on watered and water-stressed coffee seedling, respectively (Table 1). A particularly high level of coffee blotch miner intensities (incidence and severity) was recorded on water-stressed coffee genotypes (Table 1). This might be due to the low moisture status of a stressed coffee plant (with hold for water for a month) was increase the pest infestation by increasing the susceptibility of the coffee plant. Thus, well-watered Limmu coffee genotypes had an incidence and severity of intact mines 2.14 and 2.43 times lower than that of moisture-stressed ones, respectively.

Table 1. *Impact of moisture stress on coffee blotch miner incidence and severity.*

Moisture level	Incidence (%)	Severity (%)
Well-watered	33.14[b]	22.76[a] (4.63)
Water-stressed	71.07[a]	55.35[a] (7.34)
Mean	52.10	39.06
LSD (5%)	11.97**	12.38**
CV (%)	29.95	21.71

LSD=Least Significant Difference, CV=Coefficient of Variation. Values in the parenthesis were log transformed.

3.2. Response of Coffee Genotypes to Coffee Blotch Miner Intensities Under Stress Level

The analyses of variances table 2 indicate that there is highly significance differences between the well-watered and water-stressed Limmu coffee selections. The infested leaves by blotch miner on water-stressed coffee genotypes severely damaged as compared to watered coffee genotypes.

Of five Limmu coffee genotypes 27.9% to 42.0% and 66.6% to 72.8% mean percent incidence on well-watered and water-stressed were recorded, respectively. Similarly, the minimum and maximum severity of well-watered on L4 (16.0%) and water-stressed on L3 (66.4%) Limmu coffee genotypes under greenhouse were recorded (Table 2). As the coffee leaf area highly infested by this pest the photosynthesis processes disturbed and the infested leaf also shed (inadequate leaves left on branches). As result, plant growth and yield on young coffee significantly reduced due to insufficient leaves on branches bearing coffee berries.

Table 2. *Intensity of coffee blotch miner on well-watered and water-stressed coffee genotypes under greenhouse, 2016/2017.*

Coffee genotypes	Incidence (%)		Severity (%)	
	Well-watered	Water- stressed	Water-stressed	Water-stressed
L3	32.9[c]	66.6[ab]	23.7[cd]	66.6[ab]
L4	27.9[c]	67.3[ab]	16.0[d]	55.7[ab]
L45	42.0[bc]	72.4[a]	32.5[bcd]	52.8[ab]
L54	33.1[c]	76.2[a]	23.8[cd]	66.4[a]
L55	29.7[c]	72.8[a]	17.7[d]	54.7[ab]
LSD	26.7		17.7	
P<0.05	0.0015		0.007	
CV (%)	18.55%		21.70%	

LSD=Least Significant Difference, CV=Coefficient of Variation. Means followed by the same letters within the column are not significantly different at 5% level of probability.

4. Discussion

The aim of the current study was to investigate the impact of moisture stress level on coffee blotch miner incidence and severity under greenhouse condition. In regard to the aim well-watered coffee genotypes were found to decreases the coffee blotch miner damaged level (incidence and severity), and stressed coffee genotypes was highly damaged by the pest. This could mean that coffee plants are less likely to be affected by pest under optimum / required / moisture level than stressed ones. This could be because there was sufficient moisture level in the irrigated (watered) coffee plant, meaning that stressed coffee genotypes probably exposed to pest attack. This because of plants under stresses (drought) increase in nitrogen levels and the reduction in the plant's defense chemicals [14].

On water-stressed coffee genotypes the incidence and severity of coffee blotch miner increased with moisture stress. Our observation of increased the damage level of coffee seedling by coffee blotch miner on moisture stressed genotypes matches that of Huberty and Denno [15] on herbivorous insects, possibly due to osmotic stress associated with changes to leaf physiological and chemical traits [16]. Similarly, Harrington *et al.* [17] reported that sugar concentrations in foliage can increase under drought conditions, making it more palatable to herbivores. Well-

watered treatment had positive effect in pest reduction. The decrease of pest damage on well-watered coffee genotypes is in agreement with the findings of Assis *et al.* [12] on coffee, who observed that irrigated coffee plants showed lower *Leucoptera coffeella* infestation than non-irrigated coffee plants. This result suggests that cultural management that conserves soil moisture status, such as application of irrigation (availability of soil moisture) reduce pest damage.

5. Conclusion and Recommendation

The present study shows that well-watered treatment reduces twice the incidence and severity of coffee blotch miner as compared to water-stressed ones. Cultural management that conserves soil moisture status, such as application of irrigation (availability of soil moisture) reduces pest damage to crop. This cultural pest management best fits integrated pest management which usually recommended for coffee producers in dry areas and during prolonged drought. Field evaluation of different coffee genotypes with response to different moisture stress in different dry areas are important points for the feasibility of such results. Further studies are recommended to strengthen more the findings of the current study especially on soil moisture conservation methods such as irrigation, cover crop and mulch with relation to coffee pests' dynamics.

Acknowledgements

Appendix

Figure 2. Coffee blotch miner infestation on well-watered and water- stressed Limmu coffee genotypes under greenhouse. Photo credits: Tamiru Shimales.

References

[1] Mohammed, M., Shimbir, T. and Meskelu, E., 2021. Evaluation of Coffee Genotypes for Drought Tolerance in South Ethiopia.

[2] Shimbir, T., Admasu, R. and Tadesse, M., 2018. Response of Hararghe Coffee Variety to Soil Moisture Stress at Seedling Stage. In: Atlabachew W., Mohammed M. and Abegaz F. eds. *Irrigation and Watershed Management*, 39-48p.

[3] Sharma, H. C., Dhillon, M. K., Kibuka, J. and Mukura, S. Z., 2005. Plant defense responses to sorghum spotted stem borer, Chilo partellus under irrigated and drought conditions. *International Sorghum and Millets Newsletter*, *46*, pp. 49-52.

[4] Le Pelley, R. H. 1973. Coffee insects. Annual Review of Entomology 18: 121–142.

[5] Million, A. and B. Murmane. 1986. A review of coffee insects and their control in Ethiopia. *In*: Proceeding of the first Ethiopian crop protection symposium, 4-7 February 1985, (Tsedeke, A., ed.). Addis Ababa, Ethiopia: 163-174.

[6] Million, A. 1987. Insect pests of coffee with special emphasis on Antestia, *Antestiopsis intricata* in Ethiopia. *Insect Science and its Application* 8: 977-980.

[7] Million, A. 2000. Significance of arthropod pests of coffee in Ethiopia *In*: Proceedings of Workshop on the Control of CBD in Ethiopia, 13-15 August 1999. Addis Ababa: IAR: 66–71.

[8] Shimales T., Kidanu S., Abate B. and Tefari. 2017b. Survey on Status of Key Coffee Insect Pests in Major Coffee Growing Areas of Ethiopia, *International Journal of Research Studies in Science, Engineering and Technology* volume 4 (9): 17-21.

[9] IAR (Institute of Agricultural Research). 1987. Jimma Research Center Progress Report for the Period 1984-85. IAR, Jimma.

[10] Shimales T. and Alemayehu D. 2018. Occurrence and Evaluation of Insecticides for Control of Coffee Thrips (*Diarthrothrips coffeae*) at Cheleleki, Southwest Ethiopia, *International Journal of Research Studies in Agricultural Sciences* (IJRSAS), 4 (11), pp. 18-22.

[11] Charlet, L. D., Aiken, R. M., Meyer, R. F. and Gebre-Amlak, A. 2014. Impact of irrigation on larval density of stem-infesting pests of cultivated sunflower in Kansas. *Journal of economic entomology*, *100* (5), pp. 1555-1559.

[12] Assis, G. A., Assis, F. A., Scalco, M. S., Parolin, F. J. T., Fidelis, I., Moraes, J. C. and Guimarães, R. J., 2012. Leaf miner incidence in coffee plants under different drip irrigation regimes and planting densities. *Pesquisa Agropecuária Brasileira*, *47*, pp. 157-162.

[13] Shimbir T., Alemseged Y., Taye K., Endale T. and Anteneh N. 2005. "Coffee seedlings management and production." Amharic version, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia. 17pp.

[14] Fernandes, F. L., Mantovani, E. C., Bonfim Neto, H. and Nunes, V. D. V. 2009. Efeitos de variáveis ambientais, irrigação e vespas predadoras sobre Leucoptera coffeella (Guérin-Méneville) (Lepidoptera: Lyonetiidae) no cafeeiro. *Neotrop. entomol*, pp. 410-417.

[15] Huberty, A. F. and Denno, R. F., 2004. Plant water stress and its consequences for herbivorous insects: a new synthesis. *Ecology*, *85* (5), pp. 1383-1398.

[16] Vandegeer, R. K., Cibils-Stewart, X., Wuhrer, R., Hartley, S. E., Tissue, D. T. and Johnson, S. N., 2021. Leaf silicification provides herbivore defence regardless of the extensive impacts of water stress. *Functional Ecology*.

[17] Harrington, R., Fleming, R. A. and Woiwod, I. P. 2001. Climate change impacts on insect management and conservation in temperate regions: can they be predicted?. *Agricultural and Forest Entomology*, *3* (4), pp. 233-240.