OPEN ACCESS

Global Journal of Research in Agriculture & Life Sciences
ISSN: 2583-4576 (Online)
Volume 05 | Issue 03 | May-June | 2025
Journal homepage: https://gjrpublication.com/gjrals/

Review Article

A Coming threatening disease for coffee production in southern Ethiopia: A case of coffee leaf spot disease

*Ano Wariyo[1] and Wondemagegnehu G/Tsedik

[1, 2] Plant Protection Department, Wondogenet Agricultural Research Center, Shashemane, Ethiopia.

DOI: 10.5281/zenodo.15738740 **Submission Date: 10 May 2025 | Published Date: 25 June 2025**

Corresponding author:** ***Ano Wariyo
Plant Protection Department, Wondogenet Agricultural Research Center, Shashemane, Ethiopia.

Abstract

Coffee (Coffea arabica L.) is an important crop in the Ethiopia's economy. However, among the main limiting factors, diseases are the major one that affects production of coffee in the country. In addition to major coffee diseases, coffee leaf spot (CLS) disease was become threatening coffee production in southern Ethiopia. Thus, survey was done to assess the current status and identify the real causal agent of the disease in the study areas. Disease prevalence, incidence and severity were recorded and analyzed. Present result showed that the real causal agent of the pathogen was identified and confirmed as Cercospora coffeicola. A total of ninety coffee farms from six districts were assessed and out of these, 72 (79.7%) were with disease, while the remaining 18 (20.3%) were disease free. The magnitude of the disease incidence and severity significantly varied among the study areas. The highest disease incidence (90.0%) and severity (36.8%) was recorded from Wonago, while the lowest (34.0 and 5.4%) was from Yirga Cheffe districts. The present report revealed that the main cause of the problems was CLS in addition to major coffee diseases in the study areas. Therefore, high attention should be needed in the future research works.

Keywords: *Culture, Identification, Isolation, Pathogen, Severity, Symptoms.*

Introduction

Coffee (*Coffea arabica* L.) is an important crop mainly grown in tropical and sub-tropical areas of the world. It is a major international traded agricultural commodity, next to oil in terms of economy (Dong et al., 2017). It is a vital crop for the Ethiopia's economy and development, comprising a significant portion of the national income and providing employment to millions (Divergences, 2023 & Maya Chacon, 2023). The crop is mainly grown in the eastern, southern, south western and western parts of Ethiopia (Emana, 2014). However, it is more important crop and highly significant in southern parts of the country than the other coffee growing parts, because it is one of the most valuable primary products in the country trade and most coffee producing areas fetch premium prices in the world market (Wolde et al., 2017).

Nowadays, climate change is believed to be the main limiting constraint in the agricultural sector because of the sensitivity of crops to increasing temperature and water shortages (Mendelsohn 2008 & Ramirez-Villegas and Challinor, 2012). Apparent negative effects include declines in crop yield and quality and increases in pest and disease infestation, leading to reductions in crop production worldwide (Pachauri et al., 2014). These pose significant challenges to smallholder farmers, many of whom are dependent on rain-fed cultivation and have limited access to financial and technical support (Cohn et al., 2017 & Holland et al., 2017) that could help them to respond to changing climatic conditions.

As a climate-sensitive plant, implications of climate change have altered coffee production, from decreasing crop yield and quality to increasing diseases and invasive pests (Pham et al., 2019). Frequencies of droughts, floods, winds, and disease incidences have negatively impacted on coffee production hence threatening to wipe away the valuable source of livelihoods for many beneficiaries (Jayathilaka et al., 2012 & Rahn et al., 2014). Diseases are the major factor that affects production of coffee in Ethiopia, resulting yield losses up to 57% (Cerda et al., 2017).

Nowadays, over 14 types of diseases registered to affect coffee plant in Ethiopia. Among these, coffee berry disease (CBD) (*Colletotrichum kahawae)*, coffee wilt disease (CWD) (*Gibberella xylarioides)* and coffee leaf rust (CLR) (*Hemileia vastatrix)*, are major coffee diseases, however, the rest of diseases including coffee leaf spot (CLS) caused by *Cercospora coffeicola* (Berk and M.A. Curtis) considered to be minor (Derso et al., 2000 & Belachew et al., 2015). The coffee leaf spot is one of the oldest phytossanitary problems in coffee plantations; originally described by Berkeley and Cooke (Cook, 1881) on coffee leaves in Jamaica. Water and wind are responsible for disseminating the pathogen, and it is problematic mainly for Arabica coffee, especially in nurseries or in early stages at field, but the disease can affect coffee plants in all development stages (Amorim and Kuniyuki, 2005). The disease affects coffee plant growth, cherry yield and also bean quality (Martins et al., 2008 & Nelson, 2008).

The symptoms on leaves are circular spots with grey or white centres and lesions on berries and leaves which are initially brown in colour, sunken, oval in shape, with ashy centres (Martins et al., 2008). Cercospora leaf spot and berry blotch are also referred to as two phases of the same disease. Damage to leaves will lead to defoliation, reduced photosynthetic leaf area and loss of plant vigour (Surendra et al., 2015). Stressful environment predisposes the coffee trees to attack by *C. coffeicola* (McMahon, 2012). The bean quality is spoiled by a discoloration symptom which deteriorates the quality of the bean. Under field conditions, CLS is managed by routine copper based fungicide sprays; a contact fungicide which requires routine sprays which may lead to copper toxicity (Mwatsiya et al., 2023). Several management tactics have been employed to manage the disease which include growing coffee under shade, fertilization of coffee (Logan & Biscoe, 1987), green manuring in combination with urea treatment (Cardoso et al., 2013), were also found to be important in reducing the effects of the disease.

Historically, CLS of coffee has been considered a minor disease owing to its sporadic nature, confinement to nurseries and low severity ratings recorded in coffee plantations. The occurrence of this disease has also been associated with low management practices such as poor nutrition, water stress and high pest infestation levels (Logan & Biscoe, 1987). The disease is becoming even more severe with climate change; warm humid summers and the perennial nature of coffee, which can keep inoculum in the field for more than 30 years as a monoculture. Significant damages caused by CLS of coffee can be reflected in losses ranging from 15% to 30% in plantations, implying the devastating nature of the pathogen (Paiva et al., 2013). However, in recent years, the intensity of the disease has been increased dramatically in the southern parts of Ethiopia. Therefore, it was imperative to assess the current status of the disease distribution and intensity accompanied by infected coffee specimen's collections along with isolation and identification of the causal pathogen.

Materials and Methods

Description of the study areas and sampling procedures

A field survey was conducted in the major coffee-growing areas of southern Ethiopia during the 2023 and 2024 cropping seasons. Before field survey was started, brief discussion with team on how to prepare questionnaires and start survey, how many districts and Peasant Associations (PA) to be selected and on how to conduct laboratory works for isolation and identifications of the causal agents of the pathogen. Then, the team selected high coffee potential PA from three districts (Dale, Aleta Wondo and Wonsho) of Sidama and (Dilla Zuria, Wonago and Yirga Cheffe) from the Gedeo zone of South Ethiopia regions, in southern Ethiopia. From each district five representative PA and from each PA three different coffee farms were used for disease assessment at interval of about 3-5 km along the roads. A clustered sampling procedure was used, where five coffee trees were sampled at each farm by 50 m x 50 m plot size sampled in "W" manner.

The intensity of the disease was estimated as a percentage infected for each plant (%); standard diagrammatic scale with six classes of the proportion in the infected areas of the leaves affected by disease was used (Custódio et al., 2011). Class 1: 0.1-3.0, class 2: 3.1-6.0, class 3: 6.1-12.0, class 4: 12.1-18.0, class 5: 18.1-30.0, class 6: 30.1-50.0% (Figure 1). The disease incidence and severity were computed as follows (Sharma, 2021):

Disease incidence: It is the percentage of diseased plants or parts in the sample or population of plants in a field:

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected units x 100}}{\text{Total no. of units assessed}}$$

Disease severity: Disease severity is the percentage of relevant host tissues or organ covered by symptom or lesion or damaged by the disease. It can be described by Percentage Disease Index/ Incidence and given by the formula:

$$\text{Disease Severity} = \frac{\text{Sum of total rating x} \qquad 100}{\text{Total no. of observation x highest grade in the scale}}$$

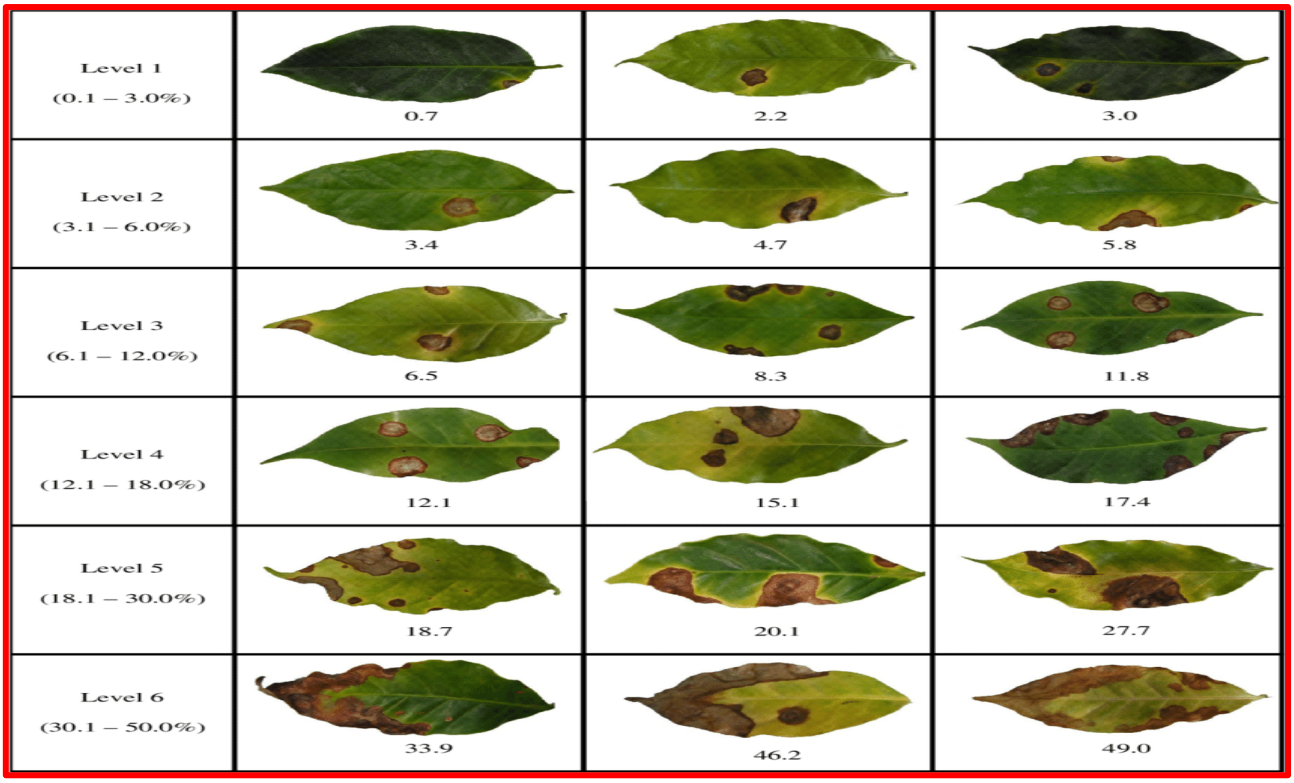


Figure 1: Diagrammatic scales used for the disease assessment (Custódio et al., 2011)

Sample collection, isolation and identification of the pathogen

Diseased samples of coffee leaves showing typical leaf spot symptoms of leaf spot were collected from the infected coffee trees to isolate and identify the kind of disease, and its causative agents properly under laboratory condition. The infected leaf samples were packed in paper packages and brought to the Plant Pathology Laboratory at Hawasa Agricultural Research Center and preserved at 4 ^{0}C for further identification of the pathogen. Laboratory works were done at Hawasa and Wondo genet Agricultural Research Center.

In the laboratory, 1 cm sections containing half diseased and half health leaf tissue were cut and surface sterilized in 30% sodium hypochlorite solution for about 30 seconds before rinsing 3 times in distilled water to remove some opportunistic pathogens. The sample was dried on damp filter paper chamber on the laminar airflow. The diseased portions were then transferred to 3 Petri dishes containing Potato Dextrose Agar (PDA). The inoculated Petri dishes were incubated for about 48 hours at a temperature of 25 °C in the constant temperature room, and transferred to the laboratory benches after two days. Cercospora colonies that developed were characterized, selected and isolated after 4-5 days. The procedure of isolation from PDA, incubation and re-isolation was repeated 3 times until a pure culture of Cercospora remains in the Petri dishes.

Data analysis

Analysis of variance (ANOVA) was done using single stage nested design (tree was nested/clustered under each farm). The data analysis was performed using SAS version 9.4 software package (Soloviev et al., 2017). Mean comparison tests were applied using the Fisher significant difference test (LSD) at a probability level of 5%.

Results and Discussion

Disease identification under field condition

The typical disease symptoms were observed on the leaves of the coffee trees (Figure 2a). These symptoms were circular spots with tan, gray, or white centers in both upper and lower leaves; lesions irregular in shape and cause leaf blight which is the typical symptom of CLS caused by *C. coffeicola* (Berk and M.A. Curtis) (Figure 2a, b and c). Lesions started as small, chlorotic spots that expand to become deep brown on the upper leaf surface (Figure 2b). The margins of the lesions are dark brown to reddish brown or purplish to black in color (Figure 2a and b). Lesions were also surrounded by bright yellowish "halo," which is more visibly apparent on the upper leaf surface (Figure 2a, b and c). Dark-colored and silvery-colored sporulations of the pathogen within the grayish-white centers of lesions were observed (Figure 2a and b). It also observed the affected leaves were defoliated prematurely which may reduce photosynthetic leaf areas and loss of plant vigour (Figure 3e).

Similarly, Ventura et al. (2007); Souza et al. (2011) & Bhandari et al. (2022) were noted that the disease affects both the leaves and fruits of the crop but more common on the leaves. The authors also observed that the symptoms of the disease are necrotic spots, consisting of a light-coloured centre surrounded by a purplish brown ring with yellowish (chlorotic) edges (halo), on the leaves and dark spots, with a dry aspect on the berries, the premature fall of leaves and fruits may occur.

Figure 2: Symptoms of the coffee leaf spot disease on the coffee trees leaves in southern Ethiopia

Isolation and identification of the pathogen under laboratory condition

In addition to disease identification under field's condition, laboratory works was conducted to isolate and identify the real causal agents of the pathogen affecting the coffee tree leaves for further confirmation. The morphological and microscopic features of the grown colonies of the pathogen on PDA were visually observed and identified using light (compound) and digital microscope. All cultures showed different colony morphology and three representatives fungal isolates were selected for microscopic identification (Figure 3). Colonies on PDA, showed reddish-purple surrounded by white (Figure 3a), white with brownish (Figure 3c) and pale pinkish (Figure 3e), while their reverse sides showed that dark purple (Figure 3a), pale brown (Figure 3b) and dark pinkish (Figure 3c) pigments, respectively. Microscopic observation showed that conidiophores were fasciculate, pale brown, simple, unbranched, septate and arises through the stomata, conidia were solitary, acicular to obclavate, straight to slightly curved, thin walled, multi septate (Figure 3d and e). On the basis of morphological and microscopic observation, the pathogen was identified and confirmed as *Cercospora* spp. as described by (Deighton, 1979). Thus, the pathogen was the causal agent of *C. coffeicola* (Berk and M.A. Curtis) causing coffee leaf spot disease.

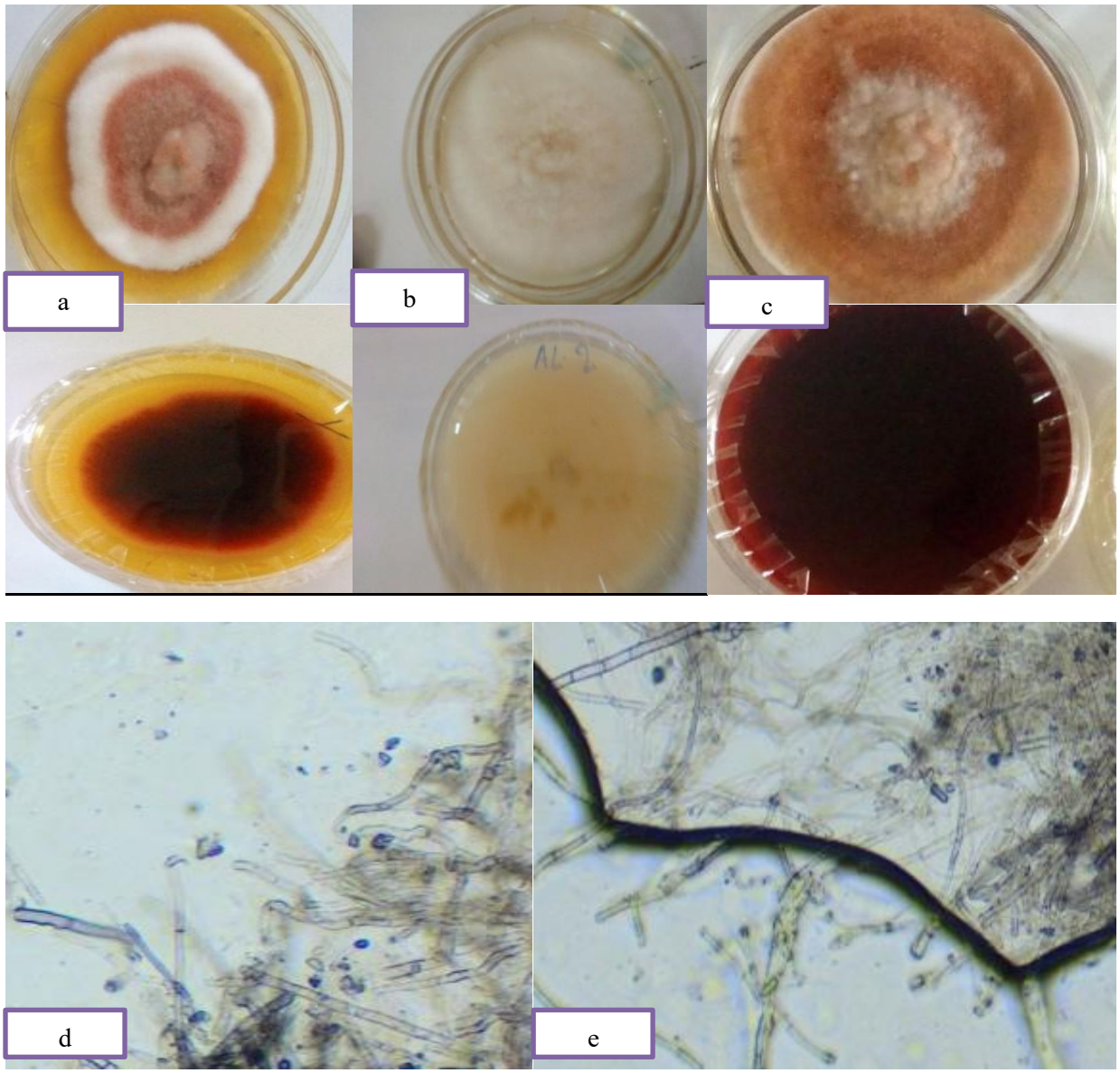


Figure 3: Morphological and microscopic features *C. coffeicola* causing CLS in southern Ethiopia.

Distribution and intensity of the disease

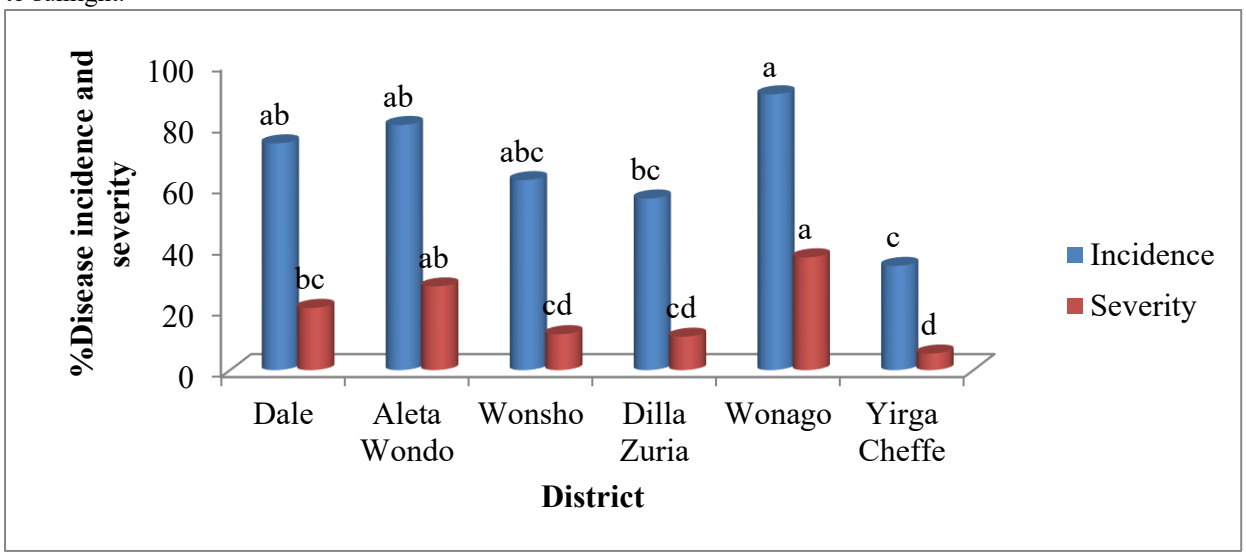
The survey result revealed that there was a wide distribution of CLS disease in all assessed districts of Sidama and South Ethiopia Regions, in southern Ethiopia (Table 1). A total of ninety (fifteen farms per district) coffee farms were assessed during the 2023 and 2024 cropping seasons (Table 1). Out of these, 72 (79.7%) farms were infected with disease, while the remaining 18 (20.3%) farms were free of the disease. Relatively, the highest (100.0%) disease prevalence was recorded in both Dale and Wonago, while the lowest (40.0%) was recorded in Yirga Cheffe districts (Table 1). Interestingly, Zambolim et al. (1997) noted that the disease can be the most important coffee disease, leading to losses of up to 30% depending on the seasons and regions in the country. The authors also reported that the disease occurrence can be varies from nursery-to-field plantings, and severe epidemics are recorded when management practices are not well conducted both at nurseries and orchards.

Table 1: Distributions of the assessed coffee farm and coffee leaf spot disease during the 2023 and 2024 cropping seasons in southern Ethiopia.

District	Number of assessed farms	% of farms with disease	% of farms without disease
Dale	15	100.0	0.0
Wonsho	15	83.3	16.7
Aleta Wondo	15	80.0	20.0
Dilla Zuria	15	75.0	25.0
Wonago	15	100.0	0.0
Yirga Cheffe	15	40.0	60.0
Total	**90**	**72.0**	**18.0**
Mean	**15**	**79.7**	**20.3**

A present report also indicated that CLS incidence (P = 0.0148) and severity (P = 0.0005) significantly varied among districts (Figure 4). Consequently, the highest (90.0 and 36.8%) mean disease incidence and severity was computed from Wonago, followed by Aleta Wondo districts (80.0 and 27.3%). Likewise, the lowest (34.0 and 5.4%) was computed for Yirgacheffe district, respectively (Figure 4). Accordingly, the mean disease incidence and severity were 74.0 and 20.3, 80.0 and 27.3, 62.0 and 11.7, 56.0 and 10.9, 90.0 and 36.8, 34.0 and 5.4% in Dale, Aleta Wondo, Wonsho, Dilla Zuria Wonago and Yirga Cheffe, respectively, with mean disease incidence and severity of 66.0 and 18.7% for the six districts (Figure 4).

In this study, the higher disease distribution and intensity was found in poorly managed (excessive weed competition, poor plant nutrition, open fields without shade trees leading to drought stress) coffee farms both in young and old coffee plantations and on seedlings stages at nursery sites. The emerging of this disease also might be due to climate change like increasing of temperature and erratic rainfall, presence of high insect pest (coffee leaf blotch minor) infestation levels and the persistence of the disease pathogen in the field due to the nature of coffee (perennial) as a monoculture for a long period of time. Similarly, da Costa et al. (1995); Ribeyre & Avelino (2012) reported that the disease seems more problematic in the newly established coffee orchard and is more susceptible to field with plant nutrition deficiency (high fruit load and the plants nutritional imbalance), particularly nitrogen and potassium, water deficiency and over-exposure to sunlight.



*Note = CV (%) for disease incidence (34.8), and severity (51.6).

Figure 4: The intensity of Cercospora leaf spot disease assessed during the 2023 and 2024 cropping seasons in southern Ethiopia.

Conclusions

Coffea arabica L. is a vital crop to the Ethiopian economy. Ethiopian coffee growers, however, are currently facing many challenges causing substantial yield losses due to emerging of serious coffee diseases associated with climate scenarios and low management practices. Among these of which CBD, CWD and CLR are the major ones, highly affecting coffee productions in the country. In addition to these diseases, CLS disease caused by *C. coffeicola* which has been considered as a minor in the past owing to its sporadic nature, confinement to nurseries and low severity ratings recorded under coffee fields was currently become threatening coffee production resulting in significant damage and defoliation of the coffee leaves in southern Ethiopia. In this study, significantly high CLS disease distribution and intensity was observed upon both local and improved coffee varieties associated with low management practices (nutritional deficiency, poor field sanitation, over-exposure to sunlight (insufficient shade trees leading to drought stress) and high insect pest infestation levels which predispose the plant to various diseases infection and development (i.e. coffee leaf spot). The disease is becoming serious with climate change/shift/ (warm humid summers) and the nature of coffee in the field as a monoculture which is a perennial crop. The present survey suggested that the root cause of the problems was CLS (*C. coffeicola*) as confirmed using field symptoms and laboratory identification in addition to major coffee diseases in the study areas. Therefore, high attention should be needed in the future research works as this disease might be become threatening coffee production. Furthermore, several problems such as low management practices (plant nutrition deficiency, insufficient shade trees, aged susceptible local coffee land races, and weedy) and high insect pests infestation in most coffee farms which were highly associated with the distribution and intensity of the CLS disease were noted. Thus, training should be given for the coffee growers and agricultural experts as high priority issues.

Acknowledgments

Authors would like to thank Wondo genet Agricultural Research Center and Awada Agricultural Research Sub-center for facilitating the vehicle, financial, information exchange and keen cooperation for the successful accomplishment of this study. We also would like to thank Hawasa Agricultural Research Center for facilitating and technical support for successful completion of the laboratory works. Our special thanks also go to Mr. Tegene Atlaw and Getachew Gudero from Wondo genet and Arbaminch Agricultural Research Centers for their vehement collaboration and encouragement until the accomplishment of the study, respectively.

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CITATION
Ano W., & W. G.Tsedik. (2025). A Coming threatening disease for coffee production in southern Ethiopia: A case of coffee leaf spot disease. In Global Journal of Research in Agriculture & Life Sciences (Vol. 5, Number 3, pp. 83–90). https://doi.org/10.5281/zenodo.15738740