`The 10th Asian Academic Society International Conference (AASIC)
GMPI Conference Series
Vol. 3, May 2024, pp. 91-97
ISSN: 2829-0747. DOI: 10.53889/gmpics.v3.424

Analysis of The Relationship of Wind Speed and Rainfall on the Development of Coffee Leaf Rust (*Hemileia Vastatrix* B. & Br.) on Sipirok Arabica Coffee Plants in South Tapanuli District, Indonesia

Guntoro Guntoro[1], Lisnawita Lisnawita[2], A. Rafiqi Tantawi [3], Irda Safni[2]
[1] Doctoral Program in Agricultural Sciences, Universitas Sumatera Utara, Indonesia
[2] Faculty of Agriculture, Universitas Sumatera Utara, Indonesia
[3] Faculty of Agriculture, Universitas Medan Area, Indonesia

ARTICLE INFO

Article history:

Received January 10, 2024
Revised February 20, 2024
Published May 15, 2024

Keywords:

H.*vastatrix*;
Arabica coffee;
Sipirok;
weather;
disease severity;

ABSTRACT

Coffee is one of the agricultural commodities that is a priority for development by the Indonesian government because it has high economic value. Sipirok coffee is a mainstay Arabica coffee from the Highlands, South Tapanuli dictrict, Sumatera Utara - Indonesia. During its cultivation in the field, many problems were discovered, including coffee leaf rust disease caused by the fungus *Hemileia vastatrix*. This research aims to analysis the relationship between wind speed and rainfall on the development of coffee leaf rust disease (*H.vastatrix*) on Arabica coffee plants in South Tapanuli Regency, North Sumatere Province. The research was carried out at the community coffee planting center in the Sipirok Highlands, in Sampean Village, Sipirok District, South Tapanuli Regency with coordinates 1.64'N99.26'E with an altitude of 900 meters above sea level. The research was carried out by observing weather elements with a portable weather measuring device, capturing *H. vastatrix* fungal spores with a modified Kyosawa type spore capture device, and observing the severity of *H. vastatrix* coffee leaf rust disease. The collected data was analysed using correlation and regression analysis with SPSS Version 25. The results showed that wind speed and rainfall had a very positive effect on conidium capture and disease severity. Accordingly, there is a relationship between the elements of wind speed and rainfall on the development of coffee leaf rust disease (*Hemileia broadatrix* B. & Br.).

Corresponding Author:

Coresponding Author
Lisnawita, Faculty of Agriculture, Universitas Sumatera Utara, Indonesia
Email: itamuis@yahoo.com

1. INTRODUCTION

Coffee is an important crop and beverage in the world, providing income for more than 125 million people. Coffee is a tropical plant that is mostly grown in South America, Africa, Asia and parts of Oceania mainly by small farmers. In Africa, coffee is produced in East, Central, and West Africa, with Ethiopia being the largest producer. This is also the origin of Arabica coffee which is the main species produced in the world [1,2].

Coffee is Indonesia's leading commodity and the third-largest coffee producer globally after Brazil and Vietnam [4]. Coffee in Indonesia and several other countries is cultivated in various regions ranging from lowlands to highlands [5]. The emergence of pathogenic fungi in coffee plants [6] in both lowlands and highlands is a significant concern for coffee farmers as it leads to decreased production [3,7], one of which is coffee leaf rust caused by *H. vastatrix*. The reproduction of the *H. vastarix* fungus can be transmitted through wind movement, temperature, humidity, sunlight intensity, and rainfall [8,9]. Various efforts are made to control this disease.

The Arabica coffee (*Coffea arabica* L.) cultivation system is managed in various ways throughout the world [10] and in its management there are often several obstacles, including attacks by leaf rust disease caused

by the fungus *H.vastatrix* [11,12]. The main concern for Arabica coffee plants is several fungal diseases [13] which are often found together in the same location or on the same coffee plant. Arabica coffee is susceptible to the leaf rust fungus *H. broadatrix* Berk. and Br. On a global scale, coffee production has decreased over the last two decades compared to consumption which has continued to increase over the same period [9].The latest data on this disease was found in Saudi Arabia's Fyla district in August 2023 [6]. In Indonesia, in one province, namely North Sumatra, this disease is also found.

Based on the results of research conducted by researchers in Sipirok District, South Tapanuli Regency, North Sumatra Province, it shows that this disease attacks almost all people's coffee plantations in Sipirok District.

2. METHODS

The research was carried out in October-November 2023 after previously conducting a survey of the locations where the research would be conducted. Five spore capture tools and one rainfall filter tool were placed at the coffee planting location for 24 hours during the research. Observations of the captured spores were carried out at 06.00 in the morning and 18.00 in the evening while observations of weather elements were carried out at 07.00 in the morning, 13.00 in the afternoon and 17.00. evening using a portable tool.

Observation of disease severity was carried out for each sample plant using the method [14]. Observation results using the formula:

$$I = \frac{\Sigma nv}{ZN} \; x \; 100\% \qquad (1)$$

Where *I* Disease intensity, *n* number of leaves for each attack category, *v* Scale value of each attack category. *Z* Highest scale value, *N* Number of leaves observed [13].

3. RESULTS AND DISCUSSION

The results of identification under a microscope showed that all samples observed were infected with coffee leaf rust disease caused by the fungus *H. vastatrix*. This fungus has urediospores which are initially round, but soon become elongated and have a shape similar to the rind of an orange fruit. The size of the uredospore ranges from about 14 µm in diameter to 23.5 µm in length. Severely affected leaves then fall and the plant becomes bare (**Fig. 1**). Such plants run out of starch reserves in their roots and branches, and eventually the plants die.

Fig. 1. (A). Bare plants due to *H.vastatrix* attack. (B) Attack symptoms visible on the leaves. (C) Uredospora *H.vastatrix* 400x magnification

To find out the relationship between wind speed and rainfall on conidium capture and disease severity, see: **Table 1**.

Table 1. Data on weather elements, conidium catch and severity of coffee disease in Sipirok month October and November 2023

Date	Wind velocity (m/sec)	Rainfall (mm)	Conidium capture	Disease Severity
October 21, 2023	0.53	6.7	16	8.88
October 22, 2023	0.60	0	25	9.17
October 23, 2023	0.77	0	20	9.46

Date	Wind velocity (m/sec)	Rainfall (mm)	Conidium capture	Disease Severity
October 24, 2023	0.67	18	17	9.76
October 25, 2023	0.20	2	13	10.05
October 26, 2023	1.47	0	18	10.35
October 27, 2023	1.40	6	16	10.64
October 28, 2023	1.43	0	21	10.93
October 29, 2023	0.40	0	16	11.23
October 30, 2023	1.07	5	23	11.52
November 11, 2023	1.60	14	42	12.88
November 12, 2023	1.03	0	26	13.27
November 13, 2023	0.90	0	21	13.66
November 14, 2023	1.07	4.1	27	14.05
November 15, 2023	1.03	6	32	14.44
November 16, 2023	1.60	0	31	14.83
November 17, 2023	0.77	20.6	18	15.22
November 18, 2023	0.87	0	23	15.61
November 19, 2023	1.13	7	28	20.70
November 20, 2023	1.07	35.2	28	21.13
Average	**0.98**	**6.13**	**23.05**	**12.89**

In a period of 1 month the average wind speed was 0.98, rainfall 6.13, conidium catch 23.05 and disease severity 12.89. From the first observation on 21 October 2023 to the last observation on 20 November 2023, the severity of the disease increased. This is because wind speed and rainfall numbers increase at the end of data collection.

Analysis of Wind Speed and Rainfall on Conidium Capture

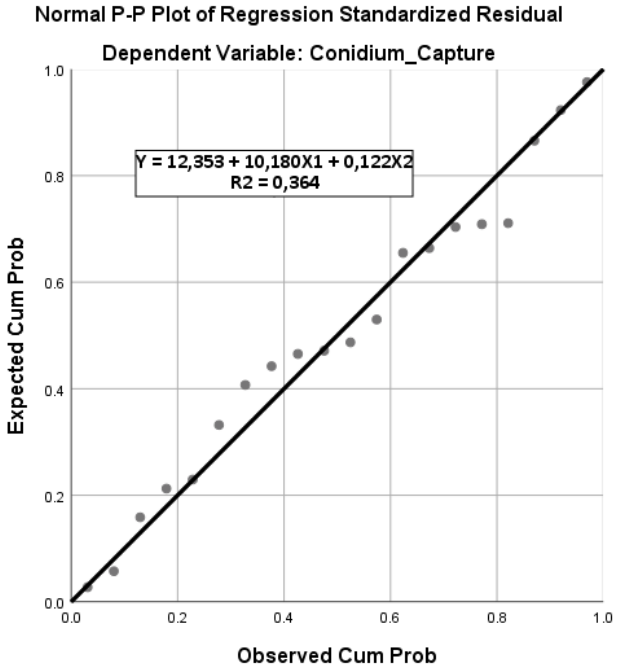

Fig. 2. Analysis of the Effect of Wind Speed and Rainfall on Conidium Capture in Sipirok

Table 2. Results of the Coefficient of Determination of Weather Elements on Conidium Catching

Model Summary b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.604a	,364	,290	5,912

a. Predictors: (Constant), Rainfall, Wind_Speed

b. Dependent Variable: Conidium_Capture

In **Fig. 2**, the multiple linear regression equation of wind speed and rainfall on conidium capture is Y=12.353 + 10.180X1 + 0.122X2, the constant value of 12.353 states that if there is no use of wind speed and rainfall or the value is 0, then the total conidium capture value is 12.353. And the multiple regression coefficient of wind speed and rainfall had a positive impact on conidium capture, with wind speed having the greatest impact on the number of conidium.

Based on **Table 2**, it shows that the R value is 0.604 or 60.4%, which means that the relationshipwind speed and rainfallto the number of conidia is closely related.The R square value shows a result of 0.363, meaning that the influence of wind speed and rainfall on the number of conidia is 36.3%, while the remaining 63.7% is influenced by external factors that are not included in the analysis model.

Table 3. Results of Simultaneous Regression Coefficients (F Test) of Weather Elements on Arrests Conidium

ANOVA [a]

Model		Sum of Squares	df	Mean Square	F	Ftable	Sig.
1	Regression	340,706	2	170,353	4,873	3,590	.021b
	Residual	594,244	17	34,956			
	Total	934,950	19				

a. Dependent Variable: Conidium_Capture

b. Predictors: (Constant), Rainfall, Wind_Speed

From the results of **Table 3**, data is obtained that wind speed and rainfall on conidium capture shows a significance figure < 0.05 and Fcount > Ftable. So from the analysis it can be concluded that there is an influence/relationshipwind speed and rainfall on conidium capture. In other words, Ha is accepted, meaning variablewind speed and rainfalltogether have a significant effectagainst conidium capture. Forwind speed and rainfallprovide a positive influence onconidium capture.

Analysis of Wind Speed and Rainfall on Disease Severity

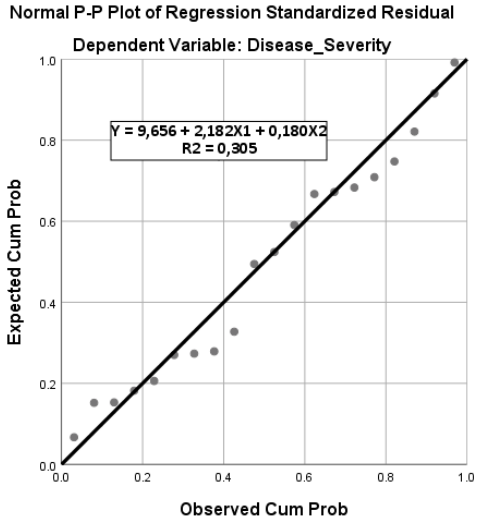

Fig. 3. Analysis of the Effect of Wind Speed and Rainfall on Disease Severity in Sipirok

Table 4. Results of Determination Coefficient of Weather Elements on Disease Severity

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.553a	,305	,224	3.06225

a. Predictors: (Constant), Rainfall, Wind_Speed

b. Dependent Variable: Disease_Severity

In **Fig. 3**, the multiple linear regression equation of wind speed and rainfall on the severity of coffee leaf disease is Y=9.656 + 2.182x1 + 0.180x2, the constant value of 9.656 states that if there is no use of wind speed and rainfall or the value is 0, then the severity of coffee leaf disease is 9.656. And the multiple regression coefficient of wind speed and rainfall had a positive impact on the severity of coffee leaf disease, with wind speed having the greatest impact on the number of conidia.

Based on **Table 4**, it shows that the R value is 0.553 or 55.3%, which means that the relationshipwind speed and rainfallto the number of conidia is closely related.The R square value shows a result of 0.363, meaning that the influence of wind speed and rainfall on the number of conidia is 36.3%, while the remaining 63.7% is influenced by external factors that are not included in the analysis model. The R square value shows a result of 0.305, meaning that the influence of wind speed and rainfall on the number of conidia is 30.5%, while the remaining 69.5% is influenced by external factors that are not included in the analysis model.

Table 5. Results of Simultaneous Regression Coefficients (F Test) of Weather Elements on Disease Severity

ANOVA [a]

Model		Sum of Squares	df	Mean Square	F	Ftable	Sig.
1	Regression	70,089	2	35,045	3,737	3,590	.045b
	Residual	159,415	17	9,377			
	Total	229,504	19				

a. Dependent Variable: Disease_Severity

b. Predictors: (Constant), Rainfall, Wind_Speed

From the results of **Table 5**, data is obtained that wind speed and rainfall on the severity of coffee rust diseaseshows a significance figure < 0.05 and Fcount > Ftable. So from the analysis it can be concluded that there is an influence/relationship of wind speed and rainfall on the severity of coffee rust disease.

In other words, Ha is accepted, meaning variablewind speed and rainfall together have a significant effect on the severity of coffee rust disease. Forwind speed and rainfall provide a positive influence on severity of coffee rust disease.

In this research, we have conducted a survey in several areas in people's coffee growing centers in South Tapanuli Regency. The survey results showed that there was an attack by *H.vastatrix* leaf rust disease. We have interviewed several farmers and most of the farmers do not know about this disease. In this paper we only explain how the relationship between wind speed and rainfall can cause increased disease severity in the Sipirok area. Wind speed from the research results showed significant results on the number of conidium catches and disease severity. Likewise, the results of rainfall data showed significant results on the number of conidium catches and disease severity. Article written by[15] states that small dew droplets will jump from one leaf to another both on one plant and on neighboring plants with the help of even a small amount of wind, which can cause this disease to spread. Other articles [12] also stated that splashing rainwater can cause uredospores to move from one leaf to another, causing transmission of this pathogen.

If this disease is not controlled immediately, it will result in attacks becoming more widespread, even throughout coffee growing areas in Indonesia. Of course, this will threaten the economy of both farmers as business actors and the Indonesian economy globally. As previously reported by [12], stated that since 1861-2020 leaf rust disease has spread almost throughout the world. Early detection needs to be done so that this disease does not spread widely [16]. The use of wise and environmentally friendly chemicals, namely organic fungicides, can be used as a final alternative to control this disease.

4. CONCLUSION

Based on the conducted research, it can be concluded that wind speed and rainfall have a positive impact on conidium capture and disease severity in community coffee plantations in Sipirok. It is imperative to enhance education for farmers regarding understanding of this disease, and early monitoring along with the implementation of appropriate control techniques for managing *H. vastatrix* are necessary.

REFERENCES

[1]. International Coffee Organization. Assessing the economic sustainability of coffee growing. 2016.
[2]. Gichuru E, Alwora G, Gimase J, Kathurima C. Coffee Leaf Rust (Hemileia vastatrix) in Kenya—A Review. Vol. 11, Agronomy. MDPI; 2021.

[3]. Gichuru E, Alwora G, Gimase J, Kathurima C. Coffee Leaf Rust (Hemileia vastatrix) in Kenya—A Review. Vol. 11, Agronomy. MDPI; 2021.
[4]. USDA. United States Departement of Agriculture. 2023.
[5]. Belachew K, Senbeta GA, Garedew W, Barreto RW, Del Ponte EM. Altitude is the main driver of coffee leaf rust epidemics: a large-scale survey in Ethiopia. Trop Plant Pathol. 2020 Oct 1;45(5):511–21.
[6]. Alhudaib K, Ismail AM. First Occurrence of Coffee Leaf Rust Caused by Hemileia vastatrix on Coffee in Saudi Arabia. Microbiol Res (Pavia). 2024 Jan 8;15(1):164–73.
[7]. Lazebnik T, Rosenfeld A, Alexi A, Shami L. Economical-Epidemiological Analysis of the Coffee Trees Rust Pandemic. 2023 Apr 25; Available from: http://arxiv.org/abs/2304.14515
[8]. De Melo E, Filho V, Domian CA. Prevention and control of coffee leaf rust Handbook of best practices for extension agents and facilitators. 2019.
[9]. Avelino J, Allinne C, Cerda R, Willocquet L, Savary S. Annual Review of Phytopathology Multiple-Disease System in Coffee: From Crop Loss Assessment to Sustainable Management. 2018; Available from: https://doi.org/10.1146/annurev-phyto-080417-
[10]. Zewdie B, Tack AJM, Adugna G, Nemomissa S, Hylander K. Patterns and drivers of fungal disease communities on Arabica coffee along a management gradient. Basic Appl Ecol. 2020 Sep 1;47:95–106.
[11]. Avelino J, Allinne C, Cerda R, Willocquet L, Savary S. Annual Review of Phytopathology Multiple-Disease System in Coffee: From Crop Loss Assessment to Sustainable Management. 2018; Available from: https://doi.org/10.1146/annurev-phyto-080417-
[12]. Garedew W, Lemessa F, Pinard F. Landscape context and plot features influence the epidemics of coffee leaf rust (Hemileia vastatrix) in southwest Ethiopia. Archives of Phytopathology and Plant Protection. 2019 Jan 20;52(1–2):71–89.
[13]. Li K, Hajian-Forooshani Z, Vandermeer J, Perfecto I. Coffee leaf rust (Hemileia vastatrix) is spread by rain splash from infected leaf litter in a semi-controlled experiment. Journal of Plant Pathology. 2023 Aug 1;105(3):667–72.
[14]. Merle I, Tixier P, De Melo E, Filho V, Cilas C, Avelino J. Forecast models of coffee leaf rust symptoms and signs based on identified microclimatic combinations in coffee-based agroforestry systems in Costa Rica 2 3. 2020.
[15]. Mukherjee P, Roy M, Mandal BP, Dey GK, Mukherjee PK, Ghatak J, et al. Green synthesis of highly stabilized nanocrystalline silver particles by a non-pathogenic and agriculturally important fungus T. asperellum. Nanotechnology. 2008;19(7).
[16]. Soares A da S, Vieira BS, Bezerra TA, Martins GD, Siquieroli ACS. Early Detection of Coffee Leaf Rust Caused by Hemileia vastatrix Using Multispectral Images. Agronomy. 2022 Dec 1;12(12).

BIOGRAPHY OF AUTHORS

Guntoro, Doctoral Program in Agricultural Sciences, Universitas Sumatera Utara, Indonesia
Email: guntorosukses@gmail.com

Lisnawita, commonly known as Ita, was born in Kualasimpang on October 5, 1969. She works as a lecturer specializing in Plant Pathology (Phytopathology) in the Agrotechnology Study Program at the Faculty of Agriculture, Universitas Sumatera Utara. Ita's expertise lies in the field of Plant Pathology (Phytopathology), particularly fungi/mycology and nematodes (Nematology). Email: itamuis@yahoo.com

Ahmad Rafiqi Tantawi, Professor at the Faculty of Agriculture, Medan Area University, Medan Indonesia. Works as a lecturer with a concentration in Plant Disease Science (Phytopathology) and Plant Epidemiology. Email ; ahmadtantawi@yahoo.com

"Irda Safni, born in Surabaya on March 22, 1971, is a lecturer in Agrotechnology at the University of North Sumatra. She obtained her Doctoral degree (Ph.D.) in Microbiology from The University of Queensland in 2014. Educational Profile: - Bachelor's degree from the University of North Sumatra - Master's degree from the University of Adelaide, Australia - Ph.D. from the University of Queensland, Australia with a broad educational background and expertise in plant pathology and plant bacteriology, Irda Safni provides valuable contributions to the development of agrotechnology. As a lecturer, she is dedicated to guiding students and contributing to research in the field of plant pathology, enhancing understanding and innovation in agriculture. Email: irdasafni@gmail.com"