Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volumes 6 No. 5 (2026)

ANALYSIS OF THE EFFECT OF WIND SPEED AND CONIDIUM DENSITY ON EDAMAME LEAF SPOT (*Cercospora* sp.) IN IMMATURE OIL PALM AREAS

Muhammad Riyan Alparizi[1], Guntoro[2], Henry Budi Hasibuan[3]
Indonesian Palm Oil Technology Institute, Deli Serdang
E-mail: alfarizirian18@gmail.com[1], guntoro@itsi.ac.id[2], henry.budialfalah@gmail.com[3]

Received:04/07/2026 | **Revised** : 10/07/2026 | **Accepted:** 27/07/2026 | **Published** :25/08/2026

Abstract

This study aimed to analyze the effects of wind speed and the number of *Cercospora* sp. conidia on the severity of leaf spot disease in edamame cultivated in immature oil palm areas. This research used a quantitative approach through field observations, spore trap installation, conidial counting, wind speed measurement, and disease intensity observation. The data were analyzed using multiple linear regression with SPSS. The results showed that the regression model was significant simultaneously, with an F value of 6.218 and a significance value of 0.004. Partially, wind speed had a positive and significant effect on disease severity, with a t value of 3.238 and a significance value of 0.002. Meanwhile, the number of conidia had a positive effect but was not significant at the 5% level, with a significance value of 0.100. The R Square value of 0.228 indicates that 22.8% of the variation in disease severity can be explained by the number of conidia and wind speed. These findings emphasize the importance of environmental factors in the epidemiology of edamame leaf spot disease.

Keywords: Leaf Spot; *Cercospora* sp.; Edamame; Wind Speed; Conidia.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a strategic commodity that plays an important role in the Indonesian economy because it has high production value, foreign exchange contribution, and agribusiness prospects (Purwanto, 2024). During the immature plant phase (TBM), the inter-row space of oil palm plantations can still be used for cultivating intercrops. One approach that has been widely developed is intercropping, namely planting more than one crop species on the same land area to increase land-use efficiency and diversify farmers' income (Yuliani et al., 2021).

Edamame (*Glycine max* (L.) Merrill) is a high-value horticultural commodity with good nutritional content as a source of plant-based protein. Edamame has larger seeds, a sweeter taste, and a softer texture than ordinary soybean; therefore, it has potential for development in intensive farming systems (Ilhamiyah et al., 2026). Edamame cultivation in immature oil palm areas can increase land productivity, but the microclimatic conditions under oil palm stands may affect air circulation, humidity, light intensity, and the development of plant pathogens (Cameron et al., 2024).

One of the major constraints in edamame cultivation is leaf spot disease, which can be caused by the fungus *Cercospora* sp. This disease produces necrotic spots on leaves, reduces the effective leaf area, disrupts photosynthesis, and potentially decreases plant growth and yield (Millenia et al., 2021). Disease development is strongly influenced by the presence of inoculum and environmental factors. Wind speed is an important factor because it can assist the dispersal of conidia from infection sources to healthy plants (Tantawi, 2007).

In addition to wind speed, conidial density also determines the possibility of infection. The higher the number of conidia available in the air or on plant surfaces, the greater the potential for disease development when supported by suitable environmental conditions. Simanjuntak (2025) showed that wind speed plays a role in the development of leaf spot disease in oil palm because it can accelerate inoculum dispersal. Therefore, this study is important to determine the effect of wind speed and the number of conidia on the severity of leaf spot disease in edamame cultivated in immature oil palm areas.

LITERATURE REVIEW

Edamame as an intercrop

Edamame is a vegetable soybean from the species *Glycine max* (L.) Merrill that has potential to be developed as an intercrop because it has high economic value and nutritional content. In the immature oil palm intercropping system, edamame can utilize the inter-row space of the main crop. The success of an intercropping system is determined not only by plant growth but also by environmental management, fertilization, planting distance, and plant health (Gunawan et al., 2025).

Edamame growth is influenced by morphological characteristics and environmental conditions. Edamame roots can form nodules as sites of symbiosis with nitrogen-fixing bacteria, while the leaves play an important role in photosynthesis (Soverda et al., 2024; Firnandya et al., 2025). Changes in temperature, humidity, and light can affect both vegetative and generative development (Maulana et al., 2024; Napitupulu et al., 2025).

Cercospora sp. leaf spot disease

Cercospora sp. is a pathogen that causes leaf spot or leaf blight and can attack soybean and edamame plants. Initial symptoms appear as small yellow to light gray spots that later develop into necrosis. Under severe infection, leaves may become perforated, torn, dry, and fall prematurely (Millenia et al., 2021). This condition reduces the photosynthetic capacity of plants and may affect harvest quality.

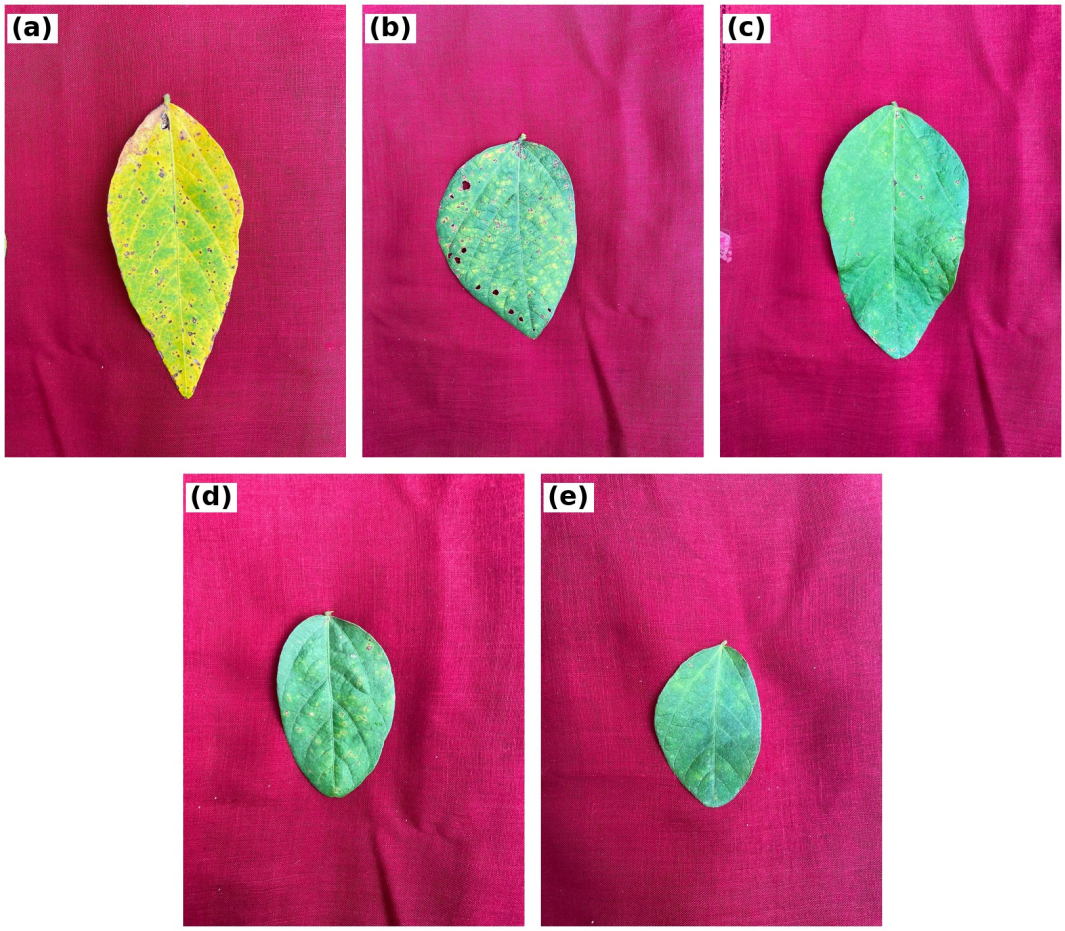

Figure 1. Variation of leaf spot symptoms on edamame leaf blades. *(a)* scale 4, *(b)* scale 3, *(c)* scale 2, *(d)* scale 1, *(e) scale 0*

Source: Research documentation, 2026.

The documentation shows variations in leaf spot symptoms on edamame, ranging from small brownish spots and chlorosis or yellow discoloration on the leaf surface to perforated leaf tissue and necrosis at more severe infection levels. These visual symptoms served as the basis for observing disease severity in this study.

At the field level, disease development is influenced not only by the presence of pathogens but also by host and environmental factors. Humidity, air circulation, sanitation, and inoculum intensity are factors that determine the possibility of infection (Cameron et al., 2024; Sahat et al., 2026).

Wind speed and number of conidia

Cercospora sp. conidia can spread with the assistance of wind. Tantawi (2007) explained that wind speed and air humidity are related to the dispersal of *Cercospora* nicotianae conidia in tobacco plants. This principle is relevant for understanding conidial dispersal in edamame fields because wind can carry pathogen propagules to healthy plant leaves.

The number of conidia describes the availability of infective propagules in the crop environment. The higher the number of conidia, the greater the chance of contact between pathogens and plant tissues. However, infection still requires suitable environmental conditions, such as humidity and temperature that support spore germination. Therefore, the relationship between the number of conidia and disease severity needs to be analyzed together with environmental factors such as wind speed (Simanjuntak, 2025; Sahat et al., 2026).

Table 1. Summary of previous studies

Researcher	Main Findings
Simanjuntak (2025)	Wind speed accelerates the dispersal of pathogenic inoculum in oil palm leaf spot disease.
Cameron et al. (2024)	Humidity, air circulation, and sanitation influence leaf spot attacks caused by Curvularia sp. in oil palm nurseries.
Tantawi (2007)	Wind speed and humidity are related to the dispersal of Cercospora nicotianae conidia.
Millenia et al. (2021)	Leaf spot disease is an important disease in soybean that can reduce plant growth and yield.

Source: Compiled from previous studies in the research manuscript.

METHODS

The study was conducted at the practice farm of the Indonesian Palm Oil Technology Institute (ITSI) in an immature oil palm area and at the ITSI Laboratory. The research site was located on Jalan Williem Iskandar, Kenangan Baru, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra Province, at an elevation of approximately 27 m above sea level. The research was carried out from April to May 2026.

The materials used included Ryoko edamame seeds, loose soil, rock phosphate fertilizer, fungicide, insecticide, water, plastic mulch, spore traps, object glasses, vaseline, lactophenol cotton blue, and labels. The tools used included an anemometer, compound microscope, cover glasses, tweezers, small brush, watering can, mobile phone camera, and SPSS software for data analysis.

Wind speed was measured daily at four observation times, namely 06.30, 12:00 and 18:00 WIB, using an anemometer placed around the plants. The number of conidia was counted using spore traps installed in the crop area. Object glasses attached to the spore traps were observed in the laboratory using a microscope to count the trapped conidia. The tool documentation in Figure 2 shows the position of the spore trap used to capture conidia in the crop area.

Figure 2. Spore trap equipment installed in the edamame cultivation area
Source: Research documentation, 2026.

The spore trap was installed around the crop area to capture conidia carried by air currents. Conidia that adhered to the object glass were then counted in the laboratory so that the number of conidia could be linked to wind speed and disease severity in edamame plants.

Disease severity was observed using a leaf damage scale. A score of 0 indicated no symptoms, while a score of 4 indicated symptoms covering more than 75% of the leaf area. The data obtained were analyzed quantitatively using multiple linear regression with the model Y = a + b1X2 + b2X4, where Y represents disease severity, X2 represents the number of conidia, and X4 represents wind speed.

Table 2. Leaf spot disease damage scale

Score	Criteria
0	No symptoms
1	Mild symptoms, 0-25%
2	Moderate symptoms, >25%
3	Moderately severe symptoms, >50%
4	Extensive symptoms, >75%

Source: Research methodology manuscript, 2026.

RESULTS AND DISCUSSION

Field conditions and disease symptoms

Field observations showed that edamame plants in the immature oil palm area displayed variations in growth conditions and disease symptoms on the leaves. Some plants showed yellowing leaves, the appearance of dark brown to blackish spots, and necrotic leaf parts. These conditions are relevant to the disease intensity or severity parameters used in the regression analysis.

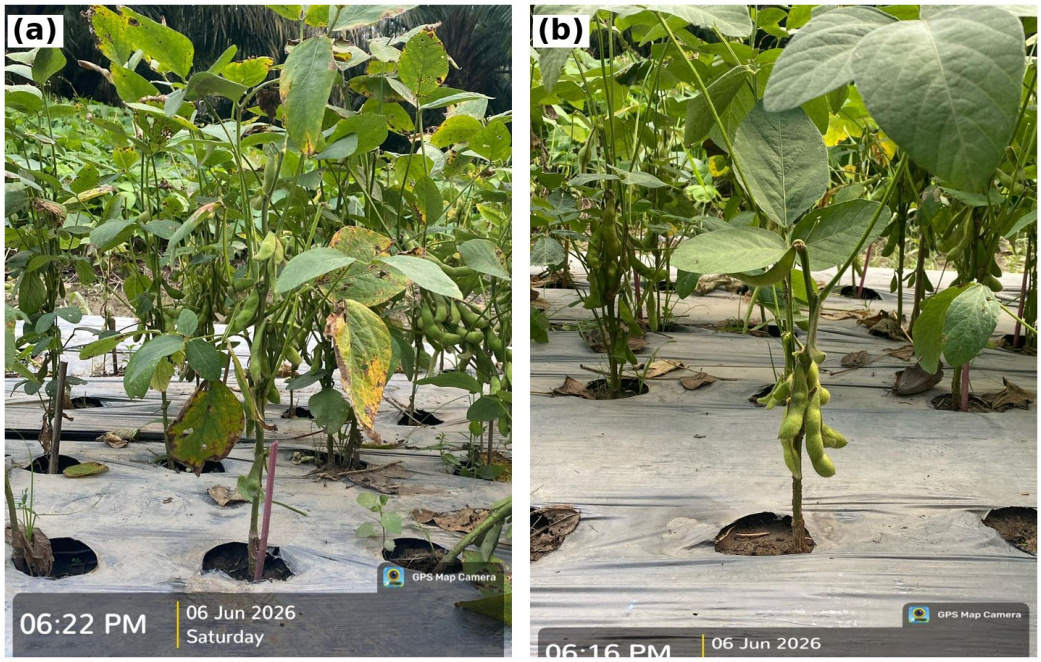

Figure 3. Edamame crop conditions and leaf spot symptoms in the field
Source: Research documentation, 2026.

The presence of symptoms in the field indicates that environmental factors, especially air circulation and wind movement, need attention because they may help disperse pathogen conidia. Therefore, wind speed and the number of conidia were analyzed to explain variation in the severity of leaf spot disease in edamame.

Classical assumption tests

Classical assumption tests were carried out to ensure that the regression model met the requirements for analysis. The normality test was performed on standardized residuals using the Kolmogorov-Smirnov test. The test results showed a significance value of 0.055, which is greater than 0.05; therefore, the residuals were declared normally distributed.

Table 3. Results of the residual normality test

Indicator	Value
N	45
Mean standardized residual	-0.000
Std. deviation of standardized residual	0.977
Kolmogorov-Smirnov Statistic	0.196
Asymp. Sig. (2-tailed)	0.055
Decision	Normal because Sig. > 0.05

Source: SPSS data processing, 2026.

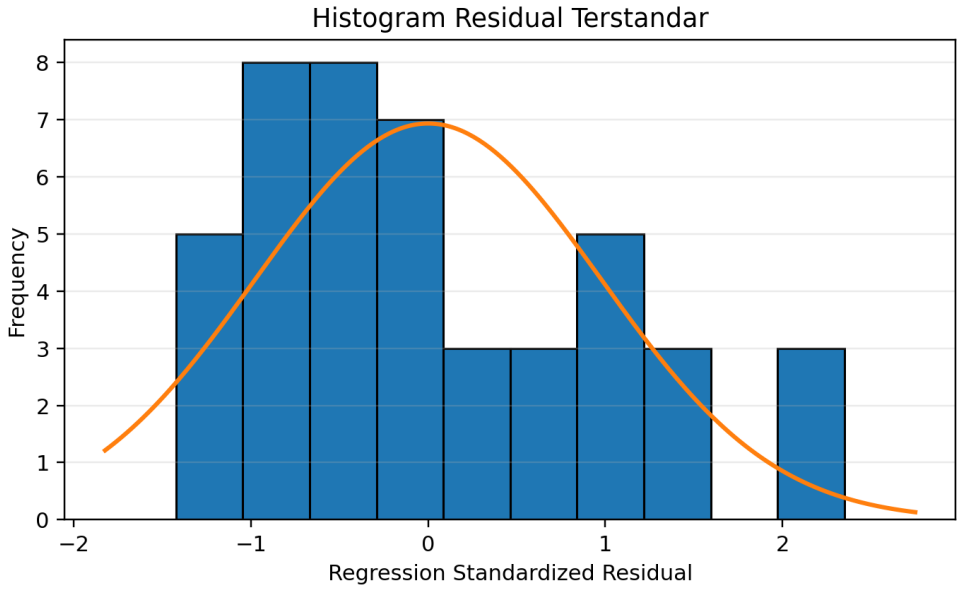

Figure 4. Standardized residual histogram

Source: SPSS data processing, 2026.

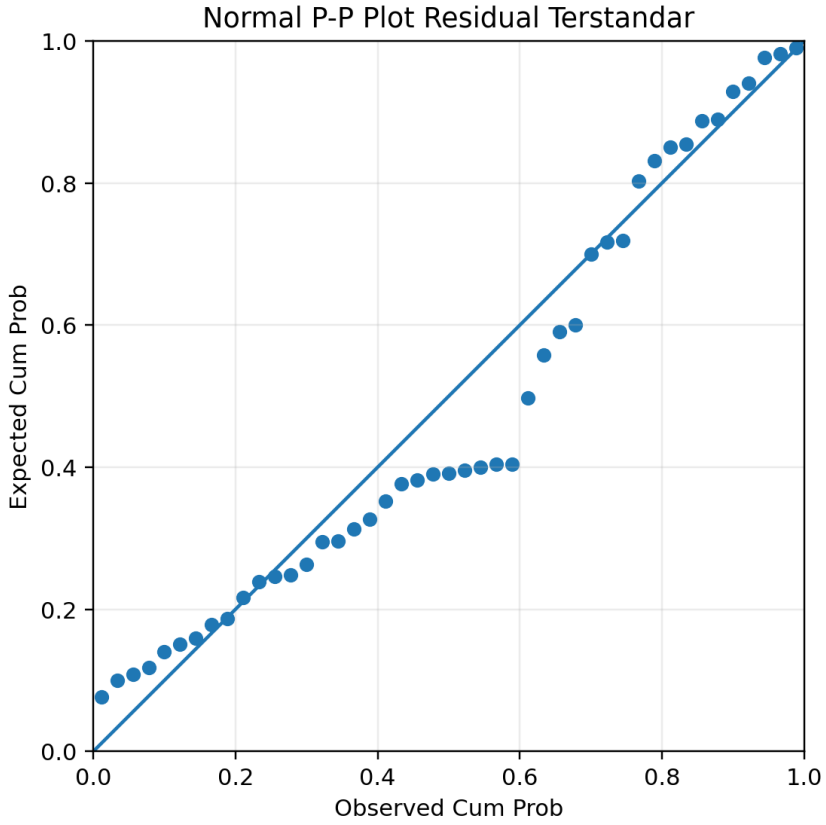

Figure 5. Normal P-P Plot of standardized residuals

Source: SPSS data processing, 2026.

The residual histogram shows a pattern approaching a normal curve, while the Normal P-P Plot shows residual points that tend to follow the diagonal line. This strengthens the conclusion that the normality assumption of the regression model was fulfilled.

Table 4. Multicollinearity test results

Independent Variable	Tolerance	VIF	Decision
Number of Conidia (X2)	0.992	1.008	No multicollinearity
Wind Speed (X4)	0.992	1.008	No multicollinearity

Source: SPSS data processing, 2026.

The Tolerance values for the number of conidia and wind speed were both 0.992, while the VIF values were both 1.008. These values indicate that the model did not experience multicollinearity because Tolerance was greater than 0.10 and VIF was less than 10.

Table 5. Summary of the heteroscedasticity test

Assessment Aspect	Observation Result
Residual point distribution	Points are distributed above and below the zero line
Specific pattern	No clear funneling, widening, or wave pattern formed
Decision	No visual symptoms of heteroscedasticity

Source: SPSS data processing, 2026.

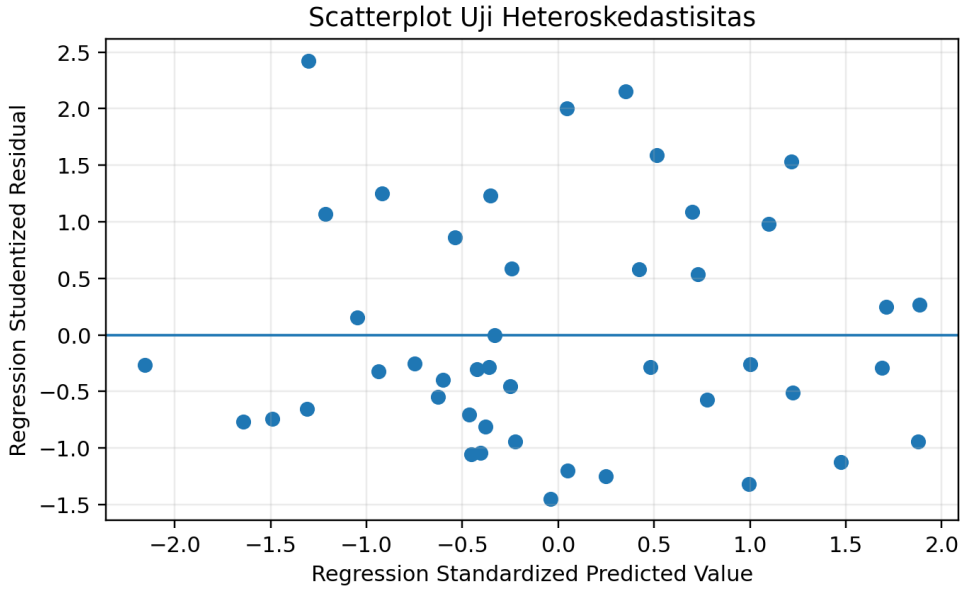

Figure 6. Scatterplot for the heteroscedasticity test

Source: SPSS data processing, 2026.

The scatterplot shows that the residual points were distributed around the zero line and did not form a specific pattern. Therefore, the regression model did not show visual symptoms of heteroscedasticity.

Multiple linear regression results

The multiple linear regression results showed that the number of conidia and wind speed together had a relationship with the severity of leaf spot disease in edamame. The model summary is presented in Table 6.

Table 6. Model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.478	0.228	0.192	0.174

Source: SPSS data processing, 2026.

The R Square value of 0.228 indicates that the number of conidia and wind speed were able to explain 22.8% of the variation in disease severity. The remaining 77.2% was influenced by other factors outside the model, such as humidity, temperature, rainfall, plant condition, field sanitation, and other microclimatic factors.

Table 7. F test / ANOVA results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.377	2	0.188	6.218	0.004
Residual	1.272	42	0.030		
Total	1.649	44			

Source: SPSS data processing, 2026.

The F value of 6.218 with a significance value of 0.004 indicates that the number of conidia and wind speed simultaneously had a significant effect on the severity of leaf spot disease. Thus, the regression model is suitable for explaining the relationship between the independent variables and disease severity.

Table 8. t-test results and regression coefficients

Variable	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	-0.293	0.195		-1.504	0.140		
Number of Conidia (X2)	0.009	0.005	0.229	1.680	0.100	0.992	1.008
Wind Speed (X4)	0.269	0.083	0.441	3.238	0.002	0.992	1.008

Source: SPSS data processing, 2026.

Based on Table 8, the multiple linear regression equation obtained is:

$$Y = -0.293 + 0.009X2 + 0.269X4$$

The coefficient of the number of conidia was 0.009, indicating that every one-unit increase in the number of conidia tended to increase disease severity by 0.009 units, assuming wind speed remained constant. However, the significance value of 0.100 was greater than 0.05, so the number of conidia did not yet have a significant partial effect at the 5% level. The wind speed coefficient was 0.269, indicating that every one-unit increase in wind speed tended to increase disease severity by 0.269 units, assuming the number of conidia remained constant. The significance value of 0.002 was smaller than 0.05, so wind speed had a positive and significant effect on leaf spot disease severity.

Discussion

The results showed that wind speed was a significant factor affecting the severity of leaf spot disease in edamame. This finding supports the concept that wind can help disperse pathogen conidia from infection sources to healthy plant parts (Tantawi, 2007). Under crop conditions in immature oil palm areas, air movement can carry *Cercospora sp.* propagules to edamame leaves, thereby increasing the possibility of infection.

The number of conidia had a positive direction of effect but was not partially significant. This indicates that inoculum availability alone is not sufficient to determine disease severity if it is not supported by suitable environmental conditions. Other factors, such as humidity, rainfall, temperature, leaf wetness duration, plant age, and crop sanitation conditions, may strengthen or weaken the relationship between the number of conidia and disease infection (Cameron et al., 2024; Sahat et al., 2026).

Simultaneously, the number of conidia and wind speed significantly affected disease severity. This condition shows that the epidemiology of leaf spot disease should be understood as an interaction among pathogen, host, and environment. Disease management in the edamame intercropping system in immature oil palm areas needs to consider field sanitation, conidial monitoring, air circulation, and crop microclimate conditions.

CONCLUSION

Based on the analysis, the number of conidia and wind speed simultaneously had a significant effect on the severity of leaf spot disease in edamame plants, with an F value of 6.218 and a significance value of 0.004. Partially, wind speed had a positive and significant effect on disease severity, with a t value of 3.238 and a significance value of 0.002. The number of conidia had a positive effect but was not significant at the 5% level, with a t value of 1.680 and a significance value of 0.100. The R Square value of 0.228 indicates that 22.8% of the variation in disease severity can be explained by the number of conidia and wind speed, while the remaining variation is influenced by other factors outside the model. Therefore, the control of leaf spot disease in edamame needs to consider wind conditions, the presence of conidia, and other microclimatic factors in the field.

REFERENCES

Cameron, R. R., Yusticia, S. R., & Febrianni, A. (2024). Analysis of oil palm nursery condition factors on leaf spot disease attacks caused by Curvularia sp. Planta Simbiosa Jurnal Tanaman Pangan dan Hortikultura, 6(2), 127-138.

Firnandya, F. S., Jumadi, R., & Redjeki, E. S. (2025). Growth and yield of edamame soybean (Glycine max L. Merril) under goat manure fertilizer treatment and different planting media in polybags. TROPICROPS, 8(1), 38.

Gunawan, H., Isra, M., Maisarah, M., Purjianto, P., & Febrianto, E. B. (2025). Intercropping growth response of edamame plants on oil palm land with the application of Biosaka. Journal of Agriculture, 4(1).

Ilhamiyah, A. J. K., Zuraida, A., Pangestu, R. F., & Gazali, A. (2026). Population study of edamame plant pests treated with duck eggshells. 51, 26-35.

Mahendra, A. Y., & Oktarina. (2017). Response of edamame soybean (Glycine max L. Merrill) to application time and concentration of gadung botanical pesticide. 15(1).

Maulana, A. J. Y., Fakuroji, M. M., Angga, S. D., Wardah, N. I., Ulfa, W., & Jumiatun. (2024). Growth response of edamame plants to the application of biofertilizer based on lemuru fish amino acids and edamame root PGPR. Tabela Jurnal Pertanian Berkelanjutan, 2(2), 44-52.

Millenia, H. T., Febrianty, A., Lussy, A. D., & Nurhasanah, I. (2021). Types of diseases in soybean plants (Glycine max) and their physical and chemical control. Prosiding SEMNAS BIO, 635-647.

Napitupulu, S. T. M., Sugiono, D., & Agustini, R. Y. (2025). Effect of golden apple snail egg extract and Growmore foliar fertilizer on soybean plant growth and production. 15(1), 10-17.

Purwanto, E. (2024). Effect of synthetic insecticides on the population of the oil palm flower-pollinating beetle Elaeidobius kamerunicus Faust. Undergraduate thesis, Sriwijaya University.

Sahat, B., Samosir, P., Herawati, N., Husni, K., & Shaleh, M. (2026). Literature review of symptom characteristics and attack intensity of leaf spot disease from pre-nursery seedlings to immature oil palm plants. 9(4), 3176-3181.

Simanjuntak, G. (2025). Analysis of the effect of wind speed on the development of leaf spot disease (Curvularia sp.) in oil palm plants (*Elaeis guineensis Jacq*.). Indonesian Palm Oil Technology Institute.

Soverda, N., Swari, E. I., Neliyati, Yuni Ratna, Pebrianti, H. D., & Wahyuni, D. (2024). Morphological characteristics and yield of edamame soybean treated with eco-enzyme and different weed control methods in tropical land. 9, 67-73.

Suprapto, A., Oktasari, W., & Firmansyah, A. R. (2023). Growth and yield of edamame plants (Glycine max (L.) Merr.) as affected by planting media types and the application of arbuscular mycorrhizal fungi (AMF). 8(1), 1-6.

Tantawi, A. R. (2007). Relationship between wind speed and air humidity on the dispersal of Cercospora nicotianae conidia in tobacco. 26(4), 160-167.

Vani, M. R., Rohmiyati, S. M., & Yuniasih, B. (2024). Effect of legume cover crop on soil physical properties in immature plants. 2, 640-647.

Yuliani, N., Sabur, A., & Napisah, K. (2021). Soybean as ground cover plant and intercrop in immature oil palm plantation. E3S Web of Conferences, 306, 5011.