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Current Status of Coffee Berry Disease in Java, Indonesia

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ABSTRACT

Coffee berry disease (CBD), caused by the fungus *Colletotrichum* spp., is one of the main obstacles to coffee cultivation and production globally. To date, no comprehensive research has been conducted on the incidence and severity of CBD in Indonesia. The study aimed to determine the current status of CBD and its correlation to agricultural practices. A planned investigation of coffee plantations was carried out in Central Java and West Java, Indonesia, from April to July 2024. Direct observation was conducted to evaluate the incidence and severity of CBD in 42 coffee plantations (*Coffea arabica* and *Coffea canephora*) in Bogor, Bandung, Sukabumi, Cianjur, Temanggung, Banjarnegara, and Wonosobo. Data on agricultural practices were collected through field observations and interviews with farmers. Climate data were obtained from the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG). In *C. arabica* plantations, the highest incidence of CBD was obtained in Bogor (West Java) and Temanggung (Central Java), with the maximum disease severity recorded in Bogor. In the *C. canephora* plantation, the incidence of CBD is relatively high, ranging from 86.67% to 100% across all study sites, with the highest disease severity also recorded in Bogor at 14.91%. The results of the correlation analysis showed that older plants and flat topography were associated with higher disease incidence, whereas shading was significantly correlated with increased CBD severity.

Keywords: *Colletotrichum*, disease severity, shade, topography

INTRODUCTION

Coffee is one of the most vital agricultural commodities globally, including in Indonesia. Currently, Indonesia ranks fourth as the largest producer after Brazil, Vietnam, and Colombia. Indonesia contributes approximately 7.21% of the world's total coffee production (Pusdatin 2022). In 2023, the total coffee plantation area in Indonesia was estimated at 1,266,850 hectares. This sector is predominantly sourced by smallholder plantations, which account for 99.56% of the total area, while government estates and private estates contribute 0.36% and 0.07%, respectively (STPHP 2024). The central production of coffee in Indonesia is mainly in South Sumatra, Lampung, Aceh, North Sumatra, Bengkulu, West Java, Central Java, East Java, South Sulawesi, and East Nusa Tenggara. This study focuses on coffee plantations located in the provinces of West Java and Central Java. West Java Province has a coffee plantation area of 54243 hectares, while Central Java encompasses approximately 50153 hectares (STPHP 2024).

Indonesian coffee production showed a declining trend between 2021 and 2023, with a 2.10% decrease recorded in 2022. One of the main constraints to productivity is the prevalence of phytopathogenic disease. Among these, coffee berry disease (CBD), caused by the fungal pathogen *Colletotrichum* spp., is one of the major constraints to global coffee production (Lu *et al.* 2025; Humphries *et al.* 2025). Furthermore, *Colletotrichum* spp. causing anthracnose disease is recognized as a significant pathogen on a diverse range of botanical hosts (Cao *et al.* 2019). This disease can infect leaves and branches, and it is particularly damaging to the coffee berries (Peralta-Ruiz *et al.* 2023).

Coffee berry disease (CBD) was first identified in Kenya in 1922 (Gimase *et al.* 2019; Adugna 2023). Subsequently, the disease spread to other African regions, such as Angola, Cameroon, Malawi, Tanzania, and Uganda (Weir *et al.* 2012; Belachew & Teferi 2015). To date, *Colletotrichum* species have been reported to infect coffee plantations globally, including in Vietnam (Nguyen *et al.* 2009), Thailand (Prihastuti *et al.* 2009), Brazil (Freitas *et al.* 2013), Mexico (Cristobal-Martinez *et al.* 2017), China (Cao *et al.* 2019), Saudi Arabia (Alhudaib *et al.* 2023), and Malaysia (Tang *et al.* 2025).

Specifically, *Colletotrichum kahawae* subsp. Kahawae has been reported to infect green coffee berries, causing yield losses of approximately 60%–

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80% in Africa (Chen *et al.* 2005). The disease is a primary constraint to coffee cultivation in Ethiopia (Amare 2024). According to Silva *et al.* (2006), infection rates can reach 100% in highland areas characterized by high rainfall intensity and the absence of disease control measures. In Vietnam, *C. gloeosporioides* infestations on Catimor arabica cultivars result in yield losses ranging from 15% to 60% (Nguyen *et al.* 2009). Pathogen infection can occur both in the field and during post-harvest stages, resulting in berry deterioration and economic losses for coffee farmers (Ciofini *et al.* 2022).

The incidence and severity of CBD are heavily influenced by the microclimatic conditions within plantations and the agricultural practices applied by farmers. Several factors influence disease development, including rainfall patterns and altitude (Belachew & Teferi 2015; Ciofini *et al.* 2022), humidity, temperature, berry condition, and inoculum density (Zakaria 2021). Furthermore, the management of CBD is influenced by various agricultural practices, including the deployment of resistant cultivars (Ayalew *et al.* 2024), pruning intensity (McDonald *et al.* 2013), and the integration of agroforestry systems (Cerda *et al.* 2020), all of which play a critical role in CBD disease dynamics.

Therefore, understanding the interplay between disease metrics and management techniques is essential for developing sustainable cultivation strategies in changing environmental conditions. Currently, coffee berry disease (CBD) has been found in the fields in Indonesia. However, there has been no comprehensive research on the agricultural practices that affect the spread of coffee berry disease, as well as information on the incidence and severity of CBD. To support effective control measures for coffee berry disease, this research was conducted to assess the status of coffee berry disease in Indonesia and to determine the relationship between agricultural practices and the incidence and severity of CBD in Java, Indonesia.

METHODS

Field Survey

A survey of coffee plantations was conducted in several coffee-producing areas in West and Central Java from April to July 2024. The study sites were selected using a stratified random sampling design (Delp *et al.* 1986). Data on coffee-producing areas in West and Central Java were obtained from the statistical national leading estate crops commodity 2020–2022 (Ditjenbun 2021). Furthermore, the specific locations of Robusta and Arabica plantations were obtained from the Food Crops, Horticulture, and Plantation Office, as well as other relevant local government agencies. The coffee plantations examined were mature crops. A total of 42 coffee plantations were surveyed, covering West Java (Bogor, Bandung, Sukabumi, and Cianjur) and Central Java (Temanggung, Banjarnegara, and Wonosobo).

Disease Assessment

The incidence and severity of coffee berry disease (CBD) were assessed across 20 coffee trees per farm using a systematic sampling approach. The initial tree was selected at random, with subsequent trees sampled at two-tree intervals. Disease incidence was determined based on the presence or absence of symptoms on the sampled trees. The disease incidence was calculated as a percentage of diseased trees. To evaluate disease severity, four branches were selected from each tree, corresponding to the four cardinal directions (north, east, west, and south). On each branch, the total number of healthy berries and those exhibiting CBD symptoms was recorded.

The percentage of disease incidence and severity was calculated following the method described by Alemu *et al.* (2016) using the following formula:

$$\text{Incidence of coffee berry disease (\%)} = \frac{A}{B} \times 100$$

Where:
A = Number of diseased trees
B = Total number of observed trees

$$\text{Severity of coffee berry disease (\%)} = \frac{C}{D} \times 100$$

Where:
C = Number of diseased berries
D = Total number of assessed berries

Environmental and Agronomic Data Collection

Data on agricultural practices were collected through field observations and direct interviews with coffee farmers. These interviews were conducted using a standardized questionnaire designed to capture various agronomic parameters implemented on the farms (Table 1). Climatic data, including temperature, rainfall, and relative humidity, were obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) for both West Java and Central Java provinces.

Data Analysis

Data on disease incidence and severity percentages were processed using Microsoft Excel. Statistical analyses were performed using SPSS 22.0. One-way analysis of variance (ANOVA) followed by Duncan's test ($p < 0.05$) at a 95% confidence level was used to determine significant differences in average disease incidence and severity between groups.

The correlation between agricultural practices and disease variables was analyzed using the chi-square

Table 1 Cultivation variables and category class grouping

Cultivation variables	Class Category
Plant age	1–5 years
	6–10 years
	> 11 years
Topography	Flat (0–8%)
	Sloping (9–16%)
	Steep (25–40%)
Cropping pattern	Monoculture
	Polyculture
Coffee type	*C. arabica*
	C. canephora
Planting spacing	Dense (<2x2,5 m)
	Standard (2 x 2,5m) (2 x 3m)
	Wider spacing (> 2x3 m)
Pruning coffee plants	Routinely pruned
	Not pruned
Shade tree	Pruned
	Not pruned
Chemical Fertilizer	High
	Standard
	Low
Organic fertilizer	Not used
	Used
Using fungicides	Not used
	Used
Altitude	≥1000 m asl
	<1000 m asl

(χ^2) test. For this, cultivation variables were categorized into classes and organized into contingency tables, with disease incidence and severity classes as columns and cultivation variables as rows. A significant identification if the p-value was ($P \leq 0.05$). Microsoft Excel was used to calculate the percentage of coffee plantations categorized by disease incidence (< 30% and ≥ 30%) and disease severity (< 10% and ≥ 10%) across different cultivation variables.

RESULTS AND DISCUSSION

The field data were obtained from robusta and arabica coffee plantations with varying altitudes, from the lowest of around 449 m above sea level (m asl) in Sukabumi to the highest of 1,590 m asl in Cianjur (Table 2). The age of the coffee trees is the object of study, approximately 2 to 40 years old (Table 2).

Incidence and Severity of Coffee Berry Disease

The results showed that the incidence and severity of coffee berry disease (CBD) varied across the study regions. For *C. arabica*, the highest incidence of disease reached 100% in the Temanggung and Bogor areas, followed by Sukabumi at 90.63%. Similarly, Robusta coffee also showed the highest disease incidence of 100% in Bogor. It was not significantly different from the rates observed in other regencies, namely Temanggung (98%), Wonosobo (95%), and Sukabumi (87.5%) (Table 3).

The severity of CBD in Arabica coffee was highest in Bogor, reaching 28.14%, followed by Temanggung (14.05%) and Sukabumi at 10.56%. Meanwhile, the lowest disease severity was obtained in Banjarnegara (2.98%) and Bandung (3.15%). For Robusta coffee, the highest disease severity was observed in Bogor (14.91%), while the lowest was in Wonosobo at 5.02% (Table 3).

Colletotrichum spp. can infect coffee plants at all growth stages, including the berry, leaves, stems, branches, and flowers (Salotti *et al.* 2023). Pathogen infection typically initiates on green coffee cherries, approximately 8 to 16 weeks after flowering (Ayalew *et al.* 2024). The results of this study showed that the highest incidence and severity of the disease occurred in the Arabica coffee in Bogor Regency, West Java province (Table 3). The coffee plantation was cultivated at an altitude of 613 m asl, which is below the recommended threshold (Table 3). *C. arabica* typically requires an altitude between 1000 and 1600 m asl for optimal growth (Abubakar *et al.* 2024). According to the regulation of the Minister of Agriculture of the Republic of Indonesia (No. 128 / Permentan / OT.140 / 11/2014), parent plantations of Arabica varieties such as Andungsari 1 (AS1), Sigarar Utang, Gayo 1, Gayo 2, and Komasti are recommended for altitudes > 1000 for climate type A or B. While environmental factors, particularly altitude, site suitability, and climatic types, are critical factors that must be carefully considered (Supriadi *et al.* 2018). Although this disease can manifest across various altitudes, it is highly aggressive

Table 2 The number of plantations, varieties, altitude, and age of coffee plants were observed in the field

Regency	Number of plantations	Coffee varieties	Altitude (m asl)	Age of plants (years)
Banjarnegara (Central Java)	7	*C. arabica*	1.087	5–7
Temanggung (Central Java)	7	*C. arabica*	1.400	24
		C. canephora	699	31–40
Wonosobo (Central Java)	7	*C. arabica*	1.300	6–14
		C. canephora	734	12
Bandung (West Java)	6	*C. arabica*	1.508	6–12
Bogor (West Java)	2	*C. arabica*	613	5
		C. canephora	701	7
Sukabumi (West Java)	4	*C. arabica*	475	7–10
		C. canephora	449	5–7
Cianjur (West Java)	9	*C. arabica*	1590	2–10
Total	42			

Table 3 Incidence and severity of coffee berry disease (CBD) in several coffee-producing areas in Java, Indonesia

Regency	*C. arabica*		*C. canepora*	
	DI (%)	DS (%)	DI (%)	DS (%)
Banjarnegara	37.86[a]	2.93[a]		
Temanggung	100.00[b]	14.05[b]	98.00[a]	8.43[a]
Wonosobo	62.5[ab]	7.62[ab]	86.67[a]	5.02[a]
Bandung	57.5[ab]	3.15[a]		
Bogor	100.00[b]	28.14[c]	100.00[a]	14.91[b]
Sukabumi	90.63[b]	10.57[ab]	87.50[a]	6.74[a]
Cianjur	71.66[ab]	8.24[ab]		

Note: DI = disease incidence, DS = disease severity; values followed by the same letter in the same column are not significantly different based on Duncan's Multiple Range Test (DMRT) at a 5% significance level.

in tropical and low to mid-altitude regions where temperatures consistently remain within its ideal range.

Bogor Regency is characterized by warmer ambient temperatures, ranging from 24.2°C to 28.8°C, alongside an average relative humidity of 83% (Table 4). These findings are consistent with research by Morkeliunas *et al.* (2021), which found that anthracnose disease requires temperatures ranging from 15°C to 30°C, with an optimum at 25°C. Fluctuations in temperature can induce higher disease incidence, as elevated temperature conditions frequently accelerate the severity of plant diseases (Cohen & Leach 2020; Ayalew *et al.* 2023).

The excessive rainfall observed in Bogor Regency appears to be a major driver behind the high incidence and severity of the disease. Throughout 2024, the region experienced no dry months with annual rainfall reaching approximately 4863.2 mm/ year (Table 5). Frequent or prolonged precipitation fosters the development of antracnose during the cropping season (Ahmed 2022; Salotti *et al.* 2023). This high rainfall increases ambient humidity, thereby creating an optimal microclimate for Colletotrichum proliferation (Torrez *et al.* 2023). Furthermore, rainfall is the main cause for the dispersal of *Colletotrichum* spp. conidia. (Bedimo *et al.* 2007). The physical action of rainfall operates via splash and wash-off mechanisms, resulting in the localized dispersal of conidia from the initial inoculum source (Rajasab & Chawda 1994).

Temanggung Regency in Central Java is an area with a relatively high incidence and severity of CBD, especially in Arabica coffee. In Temanggung, Arabica coffee is cultivated at an altitude of 1400 m asl, within a 24-year-old polyculture system intercropped with tobacco and without shade trees. Farmers in this region cultivate multiple Arabica varieties, including Sigarar Utang, Kartika, Andung Sari, Lini S, and Komasti. Our observations revealed a disease incidence of 100% and a severity of 14.05% (Table 3). The high prevalence of CBD is suspected to be linked to the region's substantial annual rainfall, which totals 4025 mm/year (Table 4). Notably, from January to April 2024 (the period immediately preceding the observations), monthly rainfall was consistently above average, ranging between 456 mm and 684 mm/month (Table 4).

The lowest incidence and severity of CBD in *C. arabica* were obtained in Banjarnegara, Central Java. The average disease incidence was 37.86%, with a disease severity of 2.93% (Table 3). In the Kalibening district of Banjarnegara, the cultivated Arabica varieties include Gayo 3, Sigarar Utang, Kartika, and Yellow Bourbon. These plantations consist of plants aged 5–7 years, situated at an altitude of 1087 m asl. The Cropping systems are generally monoculture, and integrated systems (such as polyculture with tea plants, and agroforestry with pine trees) are also practiced, typically incorporating shade.

Table 4 Average temperature levels across Bogor, Cianjur, and Sukabumi Regencies (℃)

Month	Regency								
	Bogor			Cianjur			Sukabumi		
	T_{min}	T_{max}	T_{avg}	T_{min}	T_{max}	T_{avg}	T_{min}	T_{max}	T_{avg}
January	24.5	27.5	26.2	20.5	22.8	21.8	24.6	27.6	26.8
February	24.2	27.9	26.4	20.6	22.9	21.6	24.1	28.3	27.1
March	25.2	27.7	26.3	20.1	23.0	21.7	25.6	27.5	26.8
April	26.1	28.5	27.3	21.8	23.7	22.6	26.6	29.7	27.4
May	25.5	28.1	27.4	21.5	23.3	22.3	25.7	30.3	27.0
June	26.1	27.9	26.9	21.3	22.6	21.9	25.7	27.8	26.8
July	24.7	27.5	26.3	18.9	22.7	20.9	25.0	27.9	26.1
August	24.9	27.7	26.8	20.4	22.9	21.5	24.7	27.4	26.1
September	25.8	27.8	26.8	20.7	23.7	22.0	25.7	28.8	27.1
October	25.6	28.8	27.2	20.7	23.0	22.6	26.1	29.3	27.9
November	25.4	27.6	26.7	21.3	23.7	22.5	25.9	27.9	26.9
December	28.1	24.8	26.2	20.4	22.9	21.5	24.0	28.5	26.4

Note: T_{min}= minimum temperature, T_{max}=maximum temperature, T_{avg}= average temperature. Source: Meteorology, Climatology, and Geophysics Agency (BMKG) of West Java and Central Java (2025)

Table 5 Rainfall levels in Banjarnegara, Bogor, Cianjur, Sukabumi, Temanggung, and Wonosobo regencies (mm)

Month	Regency						
	Banjarnegara	Temanggung	Wonosobo	Bandung	Bogor	Sukabumi	Cianjur
January	517.4	684	918	335	393.8	393.6	538.6
February	361.2	474	714	264	232.8	174	318.6
March	107	456	753	272	723	534.7	430.9
April	191.5	513	902	215	619.5	197.8	363
May	178.8	144	204	71	550,.6	52.7	174.2
June	137	105	298	156	224.1	147.7	134.6
July	6.2	9	132	30	139.8	19.5	77
August	9.9	0	5	53	122.5	2.5	151
September	206	240	421	135.5	402	19.5	356.7
October	134.9	44	44	80.8	493.6	2.5	115.9
November	675.4	522	849	512.3	730.1	65.5	631.7
December	513.9	834	698	90.2	231.4	41.5	234
Total	3039.2	4025	5938	2214.8	4863.2	1651.5	3526.2

Source: Meteorology, Climatology, and Geophysics Agency (BMKG) of West Java and Central Java (2025).

This study area experienced low to moderate rainfall intensity, with an annual total of approximately 3039.2 mm in 2024. High rainfall occurred early in the year (January and February), transitioning into a relatively dry period between March and August (Table 4). Disease incidence and severity were observed in July, during the regional coffee harvest season in Central Java, which typically spans from April to August. Consequently, this limited rainfall is suspected to have suppressed the incidence of *Colletotrichum* pathogens in Banjarnegara Regency. Additionally, microclimatic data recorded temperatures between 19.42°C and 29.33°C, with an average relative humidity of 83.26% (Table 6; Table 7).

In Robusta coffee, the highest disease incidence and severity were recorded in the Bogor regency. In this region, robusta coffee is cultivated as a monoculture at an altitude of 613 m asl, without shade trees. Conversely, the lowest disease severity was observed in Wonosobo (Table 3). Although it experienced the highest annual rainfall at approximately 5938 mm/year (the study location is Karangsari Village, Sapuran District, Wonosobo Regency), the incidence of Coffee Berry Disease (CBD) remained relatively low. This suppressed disease severity is likely attributed to the adoption of recommended cultivation practices by farmers. In Wonosobo, Robusta coffee is cultivated at an altitude of approximately 713 m asl, where the plantation employs balanced fertilization, regular pruning, and a polyculture system intercropped with *Annona muricata* and other perennial crops that effectively serve as shade.

Agricultural Practice Associated with the Incidence and Severity of CBD

The chi-square (χ^2) analysis results evaluating the association between agricultural practices and the incidence and severity of CBD are presented in Table 7. Two agricultural practices were found to be significantly associated with CBD incidence: plant age and topography. In contrast, other factors (including cropping pattern, pruning, plant spacing, altitude, the application of chemical fertilizers and organic fertilizers, fungicide use, varieties, and shade patterns) showed no significant correlation.

Analysis of disease severity showed that shade utilization patterns were significantly associated with coffee berry disease. Other factors, such as plant age,

Table 6 Average temperature levels across Banjarnegara and Bandung Regencies (℃)

Month	Regency					
	Banjarnegara			Bandung		
	T_{min}	T_{max}	T_{avg}	T_{min}	T_{max}	T_{avg}
January	21.63	28.96	25.10	22.6	26.6	24.3
February	21.53	29.33	25.54	22.9	25.3	24.4
March	21.72	29.28	25.43	22.5	25.5	24.4
April	21.88	28.81	25.57	23.3	26.5	25
May	21.30	28.60	25.19	24.2	26.4	25.3
June	20.70	28.26	24.96	23.3	25.5	24.3
July	19.43	27.10	22.70	22.1	25.3	23.8
August	19.42	27.47	22.92	23.5	25.4	24.5
September	20.17	28.57	23.64	23.1	26.4	24.9
October	20.90	29.10	24.79	24.3	26.8	25.6
November	21.49	29.08	24.26	23	25.2	23.9
December	21.97	29.12	24.37	22.3	26.3	24.6

Note: T_{min}= minimum temperature, T_{max}=maximum temperature, T_{avg}= average temperature. Source: Meteorology, Climatology, and Geophysics Agency (BMKG) of West Java and Central Java (2025).

Table 7 Average humidity levels across Banjarnegara, Bogor, Cianjur, Sukabumi, and Bandung Regencies (%)

Months	Regency				
	Banjarnegara	Bandung	Bogor	Sukabumi	Cianjur
January	84.13	76	87	89	83
February	81.63	81	87	87	82
March	82.65	80	87	88	82
April	86.14	81	85	88	83
May	83.32	75	84	87	80
June	82.93	77	83	85	80
July	82.67	73	79	81	80
August	80.42	69	77	79	76
September	81.70	72	79	77	75
October	80.42	73	79	78	75
November	87.17	88	84	87	83
December	85.90	82	85	87	87
Averange	83.26	77.25	83.00	84.42	80.50

Source: Meteorology, Climatology, and Geophysics Agency (BMKG) of West Java and Central Java (2025).

topography, cropping pattern, pruning, plant spacing, altitude, chemical fertilizers, and organic fertilizers, did not exhibit a significant relationship with disease severity.

Plant age is significantly associated with the incidence of CBD, with prevalence increasing as coffee plants mature (Table 8). *Colletotrichum* pathogens typically infect coffee berries from the onset of flowering and fruit set (Peralta-Ruiz *et al.* 2023). These fungi exhibit a polycyclic developmental type (De Silva *et al.* 2017; Salotti *et al.* 2023). Polycyclic pathogens can produce conidia continuously throughout the growing season. This leads to repeated infection cycles in perennial hosts such as coffee crops. Our observations confirm this trend: plants aged 2–5 years showed a disease incidence of approximately 60%, which increased to > 90% in plants aged 6 years and older. Furthermore, in plantation coffee where trees exceeded 10 years of age, the incidence of the disease reached 100% (Table 9). In the Temanggung regency, where coffee crops are 24–40 years old, the disease incidence peaked at 98-100%. As coffee plants mature, their nutrient requirements increase significantly. However, field observations revealed that most Indonesian coffee farmers apply fertilizers at rates well below the recommended dosage. This nutritional deficit exacerbates the susceptibility of aging coffee crops to pathogen infection. This finding aligns with Byrareddy *et al.* (2019), who noted that fertilization practices among coffee farmers in Indonesia remain substantially lower than the required standards.

Topography is another agricultural practice significantly associated with the incidence of CBD. According to Manfarizah *et al.* (2025), flat land with a slope of 0–8% is ideal for Arabica coffee. While Whibowo *et al.* (2024) state that Robusta coffee is well-suited for flat to sloping land (0–16%). Flat land typically offers superior soil fertility and stability, often resulting in higher yields. However, this study found that coffee plantations on flat land exhibited a high disease incidence, reaching 100% (Table 8).

This high incidence is likely due to poor drainage conditions of flat land, which can lead to waterlogging. Such conditions induce physiological stress and create a highly humid microclimate conducive to fungal growth. Furthermore, canopy management is often suboptimal; farmers frequently prioritize the pruning of orthotropic branches while neglecting plagiotropic branches (productive site branches), leading to overly dense canopies. This selective pruning, combined with high planting densities in polyculture systems where standardized spacing is often ignored, results in excessive canopy density. There are crowded environments for pathogen proliferation. Therefore, effective drainage management, implementing systematic pruning of both orthotropic and plagiotropic branches, and optimizing plant spacing within polyculture systems are critical strategies for mitigating the incidence of CBD.

Table 8 Correlation between cultivation variables and the incidence and severity of coffee berry disease (CBD)

Cultivation variables	Incidence disease		Severity disease	
	Chi-square	P	Chi-square	P
Plant age	7.910*	0.019	1.268	0.530
Topography	6.525*	0.038	1.165	0.558
Cropping pattern	0.003	0.953	0.840	0.359
Pruning	0.731	0.393	0.041	0.838
Cropping spacing	3.006	0.222	2.577	0.275
Altitude	2.456	0.117	0.009	0.920
Chemical Fertilizer	0.138	0.710	0.467	0.494
Organic Fertilizer	3.006	0.083	0.161	0.687
Using Fungicide	0.221	0.638	1.412	0.235
Coffee type	1.569	0.210	0.012	0.911
Shade tree	0.966	0.326	7.291**	0.006

Note: * = Significant correlation <0.05; ** =Significant correlation <0.05

Table 9 Distribution of coffee plantations categorized by incidence and severity of disease across various cultivation variables

Cultivation variable	Percentage of Coffee plantations (%)			
	Disease Incidence		Disease Severity	
	<30%	≥30%	<10%	≥10%
Plant age				
a. 1–5 years	33.33	66.67	87.50	12.50
b. 6–10 years	6.25	93.75	68.75	31.25
c. > 10 years	0	100	66.67	33.33
Topography				
a. Flat	0	100	78.26	21.74
b. Sloping	27.27	72.73	63.64	36.36
c. Steep	12.50	87.50	62.50	37.50
Cropping pattern				
a. Monoculture	9.38	90.63	75	25.00
b. Polyculture	10.00	90	60	40
Pruning				
a. Routinely pruned	13.04	86.96	70.37	29.63
b. Not pruned	5.26	94.74	73.33	26. 67
Spacing				
a. Dense	0	100	50	50
b. Standard	16.00	84	72.73	27.27
c. Wider	0	100	100	0
Altitude				
a. > 1000 m asl	14.81	85.19	72	28.00
b. <1000 m asl	0	100	70.59	29.41
Chemical fertilizer				
a. Standard	7.14	92.86	66.67	33.33
b. Low	10.71	89.29	76.19	23.81
Organic fertilizer				
a. Used	16	84	69.23	30.77
b. Not used	0	100	75.00	25.00
Using fungicides				
a. Used	14.29	85.71	58.33	41.67
b. Not used	8.57	91.43	76.67	23.33
Coffee type				
a. Arabika	0	100	70.97	29.03
b. Robusta	12.90	87.10	72.73	27.27
Shade tree				
a. Pruned	8.70	91.30	83.33	16.67
b. Not pruned	10.53	89.47	41.67	58.33

Coffee plants are evolutionarily indigenous to the African forest, where they naturally evolved beneath the canopies of primary forest trees. Consequently, Indonesian farmers generally incorporate shade trees in coffee cultivation to mitigate the effects of the tropical dry season. However, rising global demand has driven increased production, the expansion of planting areas, and the advancement in cultivation technology. These factors have facilitated a transition from traditional shaded systems to full sun exposure in monoculture plantations (Torrez *et al.* 2023). Although *C. arabica* historically evolved as a species requiring shade (DaMatta 2004; Avelino *et al.* 2018). Contemporary coffee is increasingly cultivated under an intensive monoculture system in full sunlight (Avelino *et al.* 2018).

This study found that 52.38% of the observed plantations utilized shade trees. These shaded plantations generally showed lower disease severity, with 83.33% of them maintaining severity levels below 10% (Table 8). These findings align with Bedimo *et al.* (2008), who reported that shaded coffee plants grown under shade exhibit a lower incidence of CBD compared to those cultivated in full sunlight.

The lowest disease severity (approximately 5.02%) was found in Robusta coffee plantations at Karangsari, Wonosobo Regency. These plantations implemented an agroforestry system at an elevation of 734 m asl, integrating cultivars BP 42, BP 358, and BP 409 with *Annona muricata* L. and *Albizia chinensis* as shade trees. Management practices involve routine pruning and biannual fertilization with a combination of NPK and organic manure.

According to Matovu *et al.* (2013), the utilization of shade in coffee plantations contributes to a lower incidence and severity of CBD. This reduction is attributed to the canopy's ability to mitigate rainwater splash, thereby limiting the dispersal of *Colletotrichum kahawae* conidia. During the dry season, shade trees play a crucial role in maintaining humidity and reducing evapotranspiration rates. However, Motisi *et al.* (2022) suggest that shade can have a dual effect: While it hinders the physical dispersal of the disease, it may simultaneously shorten the latent period of certain pathogens.

Therefore, maintaining an optimal shade percentage is critical, as both excessive and insufficient shade can negatively impact coffee growth and yield. Studies by Sarmiento-Soler *et al.* (2020) reported that a 30% shade cover can increase coffee yields in Uganda. It improves the quality of coffee berries (Torrez *et al.* 2023). Furthermore, DaMatta & Ramalho (2006) emphasized that shade serves to buffer climate fluctuations, creating a more stable and conducive microclimate for coffee cultivation.

CONCLUSION

In Arabica plantations, the highest disease incidence of CBD was obtained in Bogor (West Java) and Temanggung (Central Java), with the peak disease severity in Bogor. In Bogor Regency, the high incidence and severity of the disease in Arabica coffee are closely linked to its cultivation at low altitudes, characterized by warm temperatures (24.2°C–28.8°C) and high rainfall. In Robusta coffee plantations, disease incidence was notably high, ranging from 86.67% to 100% across all study sites, with the highest severity of the disease in Bogor at 14.91%. Correlation analysis results showed that older plants and flat topography were significantly associated with a high incidence of the disease, and heavy shading was significantly associated with increased CBD severity.

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