ASIAN JOURNAL OF AGRICULTURE
Volume 8, Number 1, June 2024
Pages: 41-49

E-ISSN: 2580-4537
DOI: 10.13057/asianjagric/g080106

Status of basal stem rot disease on areca nut palm plantations in Kubu Raya District, West Kalimantan, Indonesia

SUPRIYANTO♥, HENNY SULISTYOWATI, NUR ARIFIN
Department of Agriculture Cultivation, Faculty of Agriculture, Universitas Tanjungpura. Jl. Prof. Hadari Nawawi, Pontianak 78124, West Kalimantan, Indonesia. Tel./fax.: +62-0561-785342, ♥email: supriyantountan2013@gmail.com

Manuscript received: 29 February 2024. Revision accepted: 16 May 2024.

Abstract. *Supriyanto, Sulistyowati H, Arifin N. 2024. Status of basal stem rot disease on areca nut palm plantations in Kubu Raya District, West Kalimantan, Indonesia. Asian J Agric 8: 41-49.* Areca nut (*Areca catechu* L.) is one of the leading plantation commodities with high economic value in West Kalimantan Province, Indonesia. One of the problems that affects the productivity of areca nut plantations is the presence of pathogen attacks, especially attacks by the fungus *Ganoderma* sp. which is the main pathogen in Arecaceae (palmae) plants. *Ganoderma* cause basal stem rot disease which is still difficult to control. The objective of this research was to determine the incidence level of basal stem rot disease and the diversity of fungi which cause disease in areca nut plantations in Kubu Raya District. The experiments were conducted using plant census methods and the collection of fruiting bodies of pathogenic fungi. The collected fungi were isolated, morphologically identified, and then confirmed it pathogenicity by Koch's postulates. The results showed that the incidence of areca nut basal stem rot disease in Kubu Raya District was relatively low (1.99%). The incidence of disease was found to be higher (4%) in poorly maintained plantations. A total of 5 types of fungi were found associated with areca nut basal stem rot disease, namely 3 types of *Ganoderma* sp., and 2 types of *Trametes* sp. However, only the type of *Ganoderma* has proven capable of causing disease in areca nut palm plants.

Keywords: Areca nut**,** basal stem rot, *Ganoderma*, Kubu Raya, *Trametes*

Abbreviations: BPS: *Badan Pusat Statistik*, Kalbar: *Kalimantan Barat*, PDA: Potato Dectrose Agar

INTRODUCTION

The areca nut (*Areca catechu* L.) is one of the leading plantation commodities which has high economic value in West Kalimantan Province, Indonesia. The largest areca nut plantations in West Kalimantan Province are in Kubu Raya District with an area of 1,524 ha managed by around 3,875 farmers. In the last 5 years, areca nut production in Kubu Raya has increased rapidly, from 608 tonnes in 2017, to 1,849 tonnes in 2021 (67%). This is due to the ever-increasing demand and increasingly promising selling price offers. Currently, areca nut plants are the plantation commodity with the highest area and production in Kubu Raya District after oil palm, rubber, and coconut (BPS Kubu Raya 2022). Areca nuts are currently also a leading export commodity from West Kalimantan and are included as one of the five leading export commodities from West Kalimantan, and are widely export to India, Bangladesh, Iran, Afghanistan, China, and Myanmar with a total export volume of 3,643.21 tons (Ministry of Agriculture 2022).

Considering the high economic opportunities, the West Kalimantan Provincial Government tried increasing areca nut production. One of the programs that was being promoted was increasing the areca nut planting area in all districts in West Kalimantan. This program was contained in the West Kalimantan Provincial Government's Strategic Development Plan Document for 2019-2024, where it is targeted to realize new plantation crops covering an area of around 728,000 ha, including areca nut plants (Disbunnak Kalbar 2023). This program targets areca nut plants that can be developed in several districts, namely Kubu Raya, Mempawah, Sambas, Sanggau, Sekadau, Sintang, and Kapuas Hulu. For the province of West Kalimantan, the areca nut commodity was considered strategic because it could be an alternative income for plantation farmers. Apart from that, areca nut was also considered an alternative commodity when there was a decline in the prices of other plantation commodities such as palm oil, rubber, and coconut. This is because, in the last two decades, plantation commodity prices have always experienced relatively high fluctuations. Based on BPS records, the highest fluctuations in plantation commodity prices in West Kalimantan occurred in pepper, rubber, and palm oil (BPS West Kalimantan 2022). Thus, the development of areca nut commodities in West Kalimantan has strategic value to support the stability of the welfare of plantation farmers.

One of the factors that influences the yield and productivity of areca nut plantations is the presence of pathogen attacks, especially by the fungus *Ganoderma* sp. which is the main pathogen in palmae plants (Lim and Fong 2005; Paterson 2007; Flood et al. 2010; Prasetyo and Simanjutak 2017). As in other palmae plantations, such as oil palm and coconut, *Ganoderma* attacks which cause stem rot disease are a serious problem that is still difficult to control (Rakib et al. 2015; Supriyanto et al. 2022). In

addition, considering that areca nut plantations in West Kalimantan are generally converted the land from the secondary forest, usually, these pathogens are naturally present in the land, so the potential for areca nut plants to be attacked is also relatively high (Supriyanto et al. 2021).

In a cursory field observation, in areca nut plantations in Kubu Raya District, relatively many diseased plants were found, which were believed to be basal stem rot disease caused by *Ganoderma* sp. However, until now no in-depth observations have been carried out either to quantify the value of the losses or as an effort to find out how to control them. Even though there is a research report based on interviews that states that the areca nut plantations owned by farmers in Kubu Raya District have not yet shown any pest or disease attacks, this still requires further research to ensure the truth based on actual data in the field (Sulistyowati et al. 2023).

Considering the growing interest of the people of Kubu Raya District and the support of the West Kalimantan provincial government in areca nut cultivation, potential losses and yield losses that may arise in the future need to be anticipated early on. One of them is the need for further observation regarding suspected symptoms of *Ganoderma* sp. attacks, by observing the plantation in more detail. The aim of this research was to find out the status of *Ganoderma* attack which causes basal stem rot disease on areca nut plants in Kubu Raya District, and collecting the basic data relating to the diversity of disease-causing pathogens, patterns of disease spread, and environmental factors that influence it. This is very important basic data, especially in relation to disease control and management efforts in areca nut plantations.

MATERIALS AND METHODS

Study area

The research was conducted in May-November 2023. The research covered the entire administrative area of Kubu Raya District (108° 35'-109° 58' East Longitude, 0° 44' N-1° 01' South Latitude), West Kalimantan Province, Indonesia. The study covered 9 sub-districts, namely Batu Ampar, Terentang, Kubu, Teluk Pakedai, Sungai Kakap, Rasau Jaya, Sungai Raya, Sungai Ambawang, and Kuala Mandor B (Figure 1).

Determination of areca nut plantation samples

The plantation site samples were determined based on the representativeness of the sub-district area. The number of samples for each sub-district was determined based on the proportion of plantation area based on BPS data from Kubu Raya District. Plantation site samples were taken randomly based on the proportion of garden area in each sub-district. The initial database used is the latest plantation area data released by the BPS Kubu Raya District (2022). The sample population taken was around 2.5% of the population based on the officially recorded plantation area. The population sample distribution was carried out based on data on the area of the plantation area in each sub-district. The site of areca nut palm plants was categorized as plantations if they are planted in one area of at least 0.5 ha, or consist of at least 200 plants.

Areca nut plants census

The research included two stages, namely plant census stage and collecting samples of fungal fruiting bodies infected with stem rot disease in the field. Data collection on diseased plants was carried out using the plant population census method. A population census was carried out on a sample site selected in a structured random manner. The plant population census was carried out using the cruise method in which, the population was counted for each sample garden and the number of plants experiencing stem rot disease was counted. Quantification of disease incidence was carried out by comparing diseased plants with the total number of plants in the plantation in each sample site. Diseased plants were determined based on morphological symptoms on the plant and the presence of signs of disease in the form of fungal fruiting bodies.

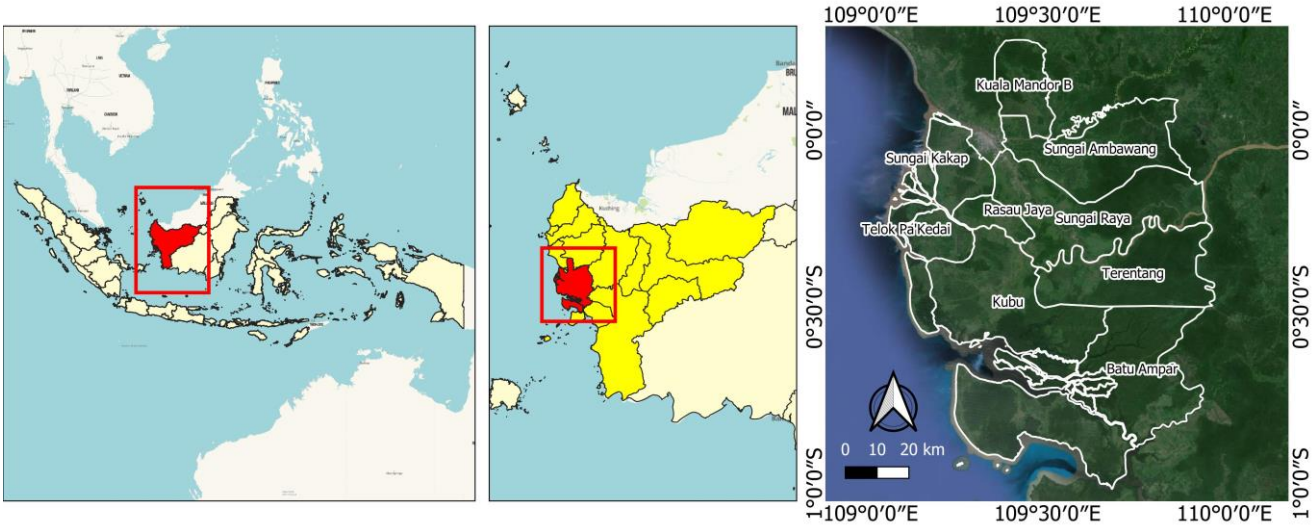

Figure 1. The map of study site in Kubu Raya District, West Kalimantan Province, Indonesia

Table 1. Criteria for scoring disease symptoms on areca nut seedling leaves

Score	Symptoms
0	Healthy seedlings, green leaves, no visible fungal mass on the seedlings.
1	1-3 chlorotic leaves without showing any fungal masses on the seedlings
2	Seedlings show a mass of fungus anywhere
3	More than 3 chlorotic leaves, necrotic leaves with or without fungal masses on seedlings
4	At least 50% of leaves had chlorosis or necrosis with or without fungal masses on seedlings
5	Seedlings die with or without the appearance of fungal masses on the seedlings

Collecting samples of fruiting bodies of disease-causing fungi

Samples of pathogenic fungi were collected from the field by taking fungal fruit bodies found on the stems of diseased arecanut palm plants. Three samples of macroscopic fruiting bodies were taken from each diseased plant, placed in a plastic bag, and taken to the laboratory for isolation and identification. Identification of pathogenic fungus was carried out by observing the morphology, such as shape, color, size, and special characteristics of the fruiting body and matching them with the characteristics in guidebooks (Alexopoulos et al. 1996; Minarsih et al. 2011).

Fungal isolation and inoculation test on areca nut seedlings

Isolation of fungus and transmission test on areca nut seedlings were performed according to the method of Supriyanto et al. (2023). After identification, each group of fungi was isolated on a Potato Dextrose Agar (PDA) medium. Isolation was carried out by using a sterile scalpel to take a 0.5 × 0.5 × 0.5 cm piece of the inside of the fungal fruiting body. Before cutting, the outer surface of fungal fruiting body was washed thoroughly in tap water, followed by wiping using cotton wool moistened with 96% alcohol, and left to dry. The sections were placed on the PDA surface in a Petri dish and incubated for 6 days. After the mycelium grew on the surface of the PDA, mycelium was transferred to a new PDA until a pure isolate was obtained. After obtaining a pure isolate, the fungus was grown on 6 × 6 × 6 cm rubber wood blocks. Before use, the rubber wood block was soaked overnight, washed thoroughly, wrapped in a heat-resistant plastic bag, and autoclaved for 45 minutes. After cooling, rubber wood was inoculated with a fungal mycelium culture previously grown in a corn-water medium (Supriyanto et al. 2011). The rubber wood was then incubated at room temperature for 4-8 weeks. Rubber wood blocks were ready for use when the entire surface of the wood was covered with fungal mycelium. The infection test on areca nut seedlings was carried out in polybags in the following way. Areca nut seedlings in the form of shoots were planted on rubber wood blocks in which pathogenic fungi were grown and then covered with soil. The seedlings were then cultivated for 6 months in 50% para net shade. Maintenance included watering to keep the media within field capacity and controlling weeds around the seedlings. To determine the success of disease transmission, disease symptoms were observed in the seedlings. Observation of disease symptoms was carried out by scoring following the method of Rakib et al. 2015 (Table 1), and was carried out once a month. Disease intensity was calculated using the formula of Arwiyanto et al. (1994):

$$DI = \frac{\sum_{i=1} k \times nk}{Z \times N} \times 100\%$$

Where:
DI : Disesase intensity
nk : Number of plants with a score of k (k:0,1,2,3,4)
k : Score used
Z : Highest score
N : Number of plants observed

Observation of disease spread patterns

Observation of disease spread patterns was carried out in the following way. In each plantation where there was more than one diseased plant, the distance between the diseased plants was measured. Based on this distance, the distribution pattern was determined using the nearest neighbor analysis method (Clark and Evans 1954; Kamu et al. 2015, 2016).

RESULTS AND DISCUSSION

Condition of areca nut plantations in Kubu Raya District

Based on observations, areca nut palm plants are spread throughout all sub-districts in Kubu Raya District. However, each sub-district had a different area of areca nut plantations. In Sungai Ambawang District, there are many areca nut palm plants, both in home gardens and in community gardens. In general, the characteristics of areca nut plantations in Kubu Raya District were relatively varied, both in distribution, area, cultivation methods, and plant conditions. In this study, each plantation site sample was categorized into two groups of characteristics, namely cultivation method (monoculture/mixed) and maintenance status (maintained: not/maintained). These characteristics were taken considering that environmental conditions greatly influence the level of emergence of basal stem rot disease.

Based on the method of cultivation, areca nut plantations in Kubu Raya District were generally cultivated using a polyculture or mixed method. Areca nut palm plants cultivated in polyculture are more than 78.12% higher than those planted in monoculture (21.88%). Generally, areca nut palm plants were planted together with other plants, both plantation crops and fruit crops such as coconut, oil palm, rubber, durian, sugar cane, langsat, cempedak, jackfruit, banana, coffee, cassava, lemongrass, jabon, etc. In Teluk Pakedai District and Sungai Raya District, it was almost planted in polyculture (Table 2).

Areca nut palm plants planted in polyculture were generally planted in rows between other plants, or planted in ditch embankments to strengthen the soil structure so that it did not collapse easily. In Sungai Kakap District, in several places, it was found that areca nut plants were also planted between rice plants.

The method of cultivating areca nut plants in Kubu Raya District, both polyculture and multiculture, was generally also related to plantation conditions. In areca nut plantations planted in monoculture, they were generally in a well-maintained condition. Meanwhile, areca nut plantations planted in polyculture were generally found to be in conditions that were poorly maintained. In general, based on the samples observed, almost half of the areca nut plantations in Kubu Raya District were in poor condition, up to 46.88% of the total sample plantations (Table 3). The unmaintained sample plantations studied were found to have uncontrolled weeds, plantation cleanliness was not maintained, never fertilized, and plant pest organisms were not controlled. Apart from that, in general, areca nuts, which were the main crop in some sample plantations, were not harvested and post-harvest processed properly. In some locations, areca nuts were even left unpicked for years. Generally, this may be related to fluctuations in the price of areca nut. If the price increases, the fruit could usually be harvested and processed properly.

These results indicate that the management of areca nut plantations in Kubu Raya District were not being carried out well. Especially in mixed plantations, maintaining for areca nut palm plants only depends on maintaining for the other plants around them. In Sungai Kakap District, the well-maintained areca nut plantations were mixed plantations with langsat and durian plants. When farmers maintain their durian trees and langsat trees, they also maintain other trees, including areca nut palm trees on the plantation. In contrast to areca nut plantations which were planted together with rubber plantations, when the price of rubber decreased, the plantations were generally not maintained, so the areca nut palm plants around them were also not maintained.

Status of areca nut basal stem rot disease in Kubu Raya District

Basal stem rot disease on areca nut can be identified by the presence of symptoms that appear on the leaves, such as paleness, wilting, yellowing, drooping of the leaf, and the appearance of spear leaves (young leaves that did not open). Apart from that, it can also be seen by the appearance of signs of disease in the form of fruiting bodies of pathogenic fungi at the base of the areca nut stem or trunk (Figure 2). These symptoms were very similar to the symptoms of basal stem rot disease in oil palm (Idris et al. 2000; Rakib et al. 2015; Supriyanto et al. 2020). Every plant that showed these symptoms were considered a diseased plant. Plants that die and showed signs of disease were also considered as diseased plants.

Based on the population census and basal stem rot disease census conducted in each sample site, data were obtained that basal stem rot disease occured evenly in almost all sample sites and was the main cause of areca nut plant death. Basal stem rot disease occurs both in areca nut plants grown in monoculture, polyculture and both in well-maintained and unmaintained plants . In monoculture plantations, basal stem rot disease was not found only in Teluk Pakedai District and Sungai Raya District. However, this may be because the plants were young and not yet fully grown. Generally, basal stem rot disease is found in old plants because it is associated with the development of pathogenic fungi that are relatively slow to develop (Naher et al. 2015; Lisnawita and Tantawi 2016; Muniroh et al. 2019). These results indicate that all areca nut plantation locations in Kubu Raya District have the potential to be infected with basal stem rot disease so the future development of areca nut plantations requires more serious attention.

Table 2. The cultivation methods of areca nut palm in Kubu Raya District, West Kalimantan Province, Indonesia

Sub-districts	Cultivation methods				Number of sample sites
	Monoculture	Percent	Policulture	Percent	
Kubu	1	33.3	2	66.7	3
Teluk Pakedai	0	0	3	100	3
Sungai Kakap	2	16.67	10	83.3	12
Rasau Jaya	1	50	1	50	2
Sungai Raya	0	0	2	100	2
Kuala Mandor B	3	30	7	70	10
Kubu Raya	7	21.88	25	78.12	32

Table 3. Conditions of areca nut plantations in Kubu Raya District, West Kalimantan Province, Indonesia

Sub-districts	Plantation conditions				Number of sample sites
	Well-maintained	Percent	Poorly-maintained	Percent	
Kubu	2	66.67	1	33.3	3
Teluk Pakedai	2	66.67	1	33.33	3
Sungai Kakap	7	58.33	5	41.67	12
Rasau Jaya	1	50	1	50	2
Sungai Raya	1	50	1	50	2
Kuala Mandor B	4	40	6	60	10
Kubu Raya	17	53.12	15	46.88	32

Table 4. The incidence of basal stem rot disease in areca nut based on cultivation methods in Kubu Raya District, West Kalimantan Province, Indonesia

Sub-districts	Disease Incidence				Average (%)
	Monoculture	Percent	Polyculture	Percent	
Kubu	2/274	0.73	12/513	2.34	1.54
Teluk Pakedai	0	0	24/780	3.08	1.54
Sungai Kakap	34/671	5.07	187/3960	4.72	4.90
Rasau Jaya	5/344	1,45	0/260	0	0.73
Sungai Raya	0	0	9/681	1.32	1.32
Kuala Mandor B	8/688	1.16	56/2121	2.64	1.90
Kubu Raya	49/1977	1.40	288/8315	2.35	1.99

Table 5. The incidence of basal stem rot disease in areca nut based on plantation conditions in Kubu Raya District, West Kalimantan Province, Indonesia

Sub-districts	Disease incidence				Average (%)
	Well-maintained	Percent	Poorly-maintained	Percent	
Kubu	2/274	0.73	12/513	2.34	1.535
Teluk Pakedai	4/572	0.69	20/208	9.62	5.155
Sungai Kakap	57/2472	2.31	164/2159	7.59	4.95
Rasau Jaya	5/344	1.45	0/260	0	0.725
Sungai Raya	2/301	0.66	7/380	1.84	1.25
Kuala Mandor B	10/971	1.029	54/1838	2.94	1.98
Kubu Raya	80/4934	1.14	257/3524	4.06	2.59

Table 6. The incidence of basal stem rot disease in areca nut based on plantation conditions in Kubu Raya District, West Kalimantan Province, Indonesia

Sub-districts	Isolated species									
	Ganoderma sp. 1		*Ganoderma* sp. 2		*Ganoderma* sp. 3		*Trametes* sp. 1		*Trametes* sp 2.	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Kubu	1	0.29	3	0.87	9	2.62	1	0.29	0	0
Teluk Pakedai	1	0.29	20	5.81	2	0.58	1	0.29	0	0
Sungai Kakap	4	1.16	214	62.20	3	0.87	4	1.16	1	0.29
Rasau Jaya	1	0.29	4	1.16	0	0	0	0	1	0.29
Sungai Raya	0	0	7	2.03	0	0	1	0.29	2	0.58
Kuala Mandor B	5	1.45	58	16.86	1	0.29	0	0	0	0
Kubu Raya	12	3.49	306	88.95	15	4.36	7	2.03	4	1.16

Figure 2. Disease symptoms of areca nut basal stem rot disease

Based on the cultivation method, the intensity of basal stem rot disease in areca nut was higher in polyculture than in monoculture plantations (Table 4). On average, disease intensity in polyculture was 2.35%, while in monoculture it was only 1.4%. This result is likely related to the origin of the areca nut plantations in Kubu Raya District, which were generally former forests, so the pathogen was already in the land before the plantations were built. As was already known, the pathogenic fungus that causes basal stem rot generally comes from *Ganoderma* sp., a fungi inhabiting tropical rainforest habitats (Paterson 2007). This is also related to the wide host range of *Ganoderma* (Hasan et al. 2005; Hushiarian et al. 2013). Coconut, rubber, langsat, durian, jackfruit, and cempedak, are also hosts for *Ganoderma* sp. that cause stem rot disease (Susanto 2009).

Based on the condition of plantations, basal stem rot disease in areca nut was known to occur more often in areca nut plants that were not well maintained. In areca nut plantations that were not well maintained, the incidence of disease was much higher (4.06%) than in those that were well maintained (1.14%) (Table 5). Unmaintained

plantation conditions are very favorable for the development of the disease (Alizadeh et al. 2011; Kok et al. 2013; Widiastuti et al. 2018; Puspita et al. 2022). In plantations that are unmaintained, generally, the environmental conditions of the plants may be very humid because the weeds are not controlled, there is a lot of organic material available that can support the pathogen's survival, and the plants are less vigorous, so they are more susceptible to pathogen attacks. Meanwhile, in relatively well-maintained plantations, with relatively clean conditions, not a lot of organic material, and more vigorous plants, the disease will develop less, so the incidence is also low.

These results indicate that well-maintained plantations were able to prevent the development of basal stem rot disease, both on areca nuts planted in monoculture or planted in a mixture with other plants. Thus, plantation maintenance was one of the important factors that must be carried out in efforts to control this disease.

Fungal diversity associated with areca nuts basal stem rot disease in Kubu Raya District

Based on observations of the shape and color of the fruiting bodies of fungi collected from plantation samples, there were five different groups of fungi. The first group was fungi with stalkless, oyster-shaped fruiting bodies, thick and hard, rough and shiny upper surfaces, dark brown, with a diameter of 5-16 cm (Figures 3.C-D). The second group was fungi with oyster-shaped fruiting bodies with stalks, thick and tend to be soft, the upper surface was smooth and shiny, light brown, and 3-8 cm in width (Figure 3.A). The third group was fungi with fruiting bodies of indeterminate shape and mostly branched, tending to be thin and hard, the upper surface was rough and shiny, light brown to dark brown, with varying sizes (Figure 3.B). The fourth group was fungi with fruiting bodies shaped like oysters but in layers, thick and soft, with a rough, dull white upper surface with varying sizes (Figure 3.E). The fifth group was fungi with semicircular to oyster-shaped fruiting bodies, thin and tough, bright red rough upper surface, 2-7 cm in diameter (Figure 3.F). Based on the appearance of the fruiting bodies, the first to third groups were thought to belong to the *Ganoderma* genus which is characterized by the presence of shiny upper skin (Loyd et al. 2017), while the fourth and fifth groups were thought to belong to the *Trametes* genus (Olou et al. 2020).

Based on the collection of fungal fruiting bodies found on diseased areca nut palms, it was observed that in each sampling site, more than one type of fungus was found associated with basal stem rot disease. However, all types of fungi were not found in the same frequency. The most frequently found fungus was *Ganoderma* sp. 2nd type, where the percentage of occurrence was more than 88%. Meanwhile, other fungi were found with relatively low frequency, with below 5 percent. *Ganoderma* type 1 was 3.49%, *Ganoderma* type 3 was 4.36%, *Trametes* type 1 was 2.03%, and *Trametes* type 2 was 1.16%. Based on the percentage of presence of fungi that was collected, it can be assumed that the most likely cause of the main basal stem rot disease of areca nut in Kubu Raya District was the *Ganoderma* type 2 fungus (Table 6).

To ensure that the fungi associated with areca nut basal stem rot disease were the cause of disease or not, a disease transmission test was carried out. The test results showed that all the three types of *Ganoderma* tested were able to cause disease in areca nut seedlings by showing symptoms, such as leaves wilted and died, and the presence of *Ganoderma* fruiting bodies at the base of the stem, which were similar to the field symptoms. Based on observations, each fungus from the *Ganoderma* group was capable of causing disease in areca nut seedlings as indicated by the high intensity of the disease (Table 7). Meanwhile, two other types of fungus, namely *Trametes* sp., until the 6th month of observation, did not cause disease in test areca nut seedlings, as indicated by the zero intensity of disease. *Trametes* type 1, was even able to form fruiting bodies on the soil surface, but the plant showed no symptoms of disease (Figure 4). This means that the plant remains healthy even though pathogens also develop around the plant. Thus, this indicates that *Trametes* fungus tested in this study may be saprophytic and not a pathogen of areca nut plants. *Trametes* sp. known that it was not a pathogen (Hasan et al. 2005). This result was the same as previous studies, where the fungus that causes areca nut basal stem rot disease generally comes from the *Ganoderma* group, especially *G. boninense* (Surbakti et al. 2010; Goh et al. 2014; Wong et al. 2021; Castillo et al. 2022).

Table 7. Results of fungal transmission tests on areca nut seedlings

Fungi	Disease intensity (%)	Remark
Ganoerma sp. 1	91b*	Pathogenic
Ganoerma sp. 2	93b	Pathogenic
Ganoerma sp. 3	89b	Pathogenic
Trametes sp. 1	0a	Non Pathogenic
Trametes sp. 2	0a	Non Pathogenic

Note: *The same letters following the numbers in the same column indicate there is no significant difference in the 5% level DMRT test

Table 8. Distribution pattern of basal stem rot disease on areca nut.

Sub-districts	Distribution Patterns (Number of Plantations)		
	Random	Clustered	Random and Clustered
Kubu	2	0	0
Teluk Pakedai	2	0	1
Sungai Kakap	3	2	6
Rasau Jaya	1	0	0
Sungai Raya	1	1	0
Kuala Mandor B	4	0	4
Kubu Raya	13	3	11

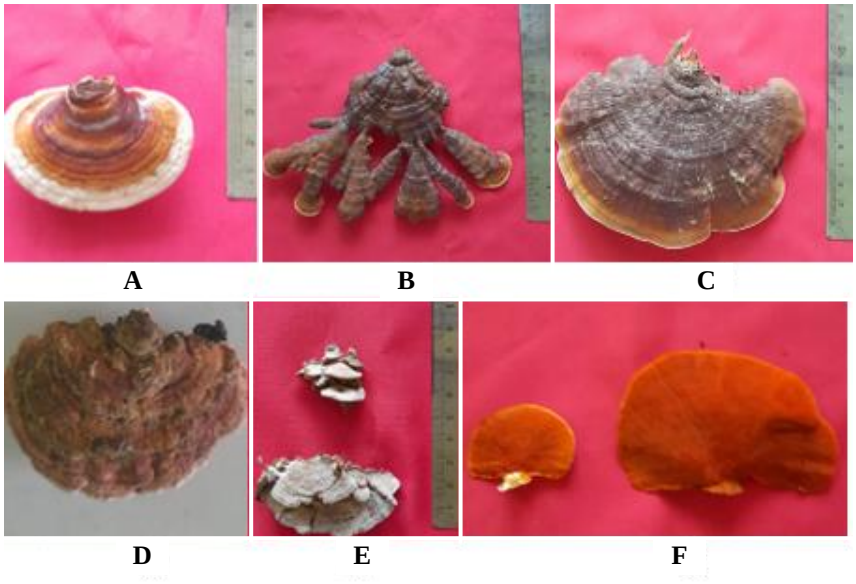

Figure 3. Five types of fungal fruiting bodies associated with areca nut basal stem rot disease. A-D. *Ganoderma* sp. groups, E-F. *Trametes* sp groups

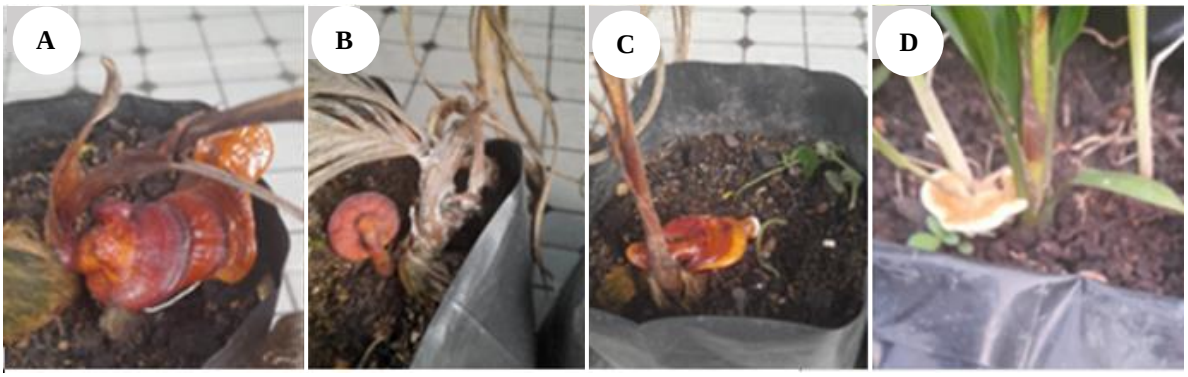

Figure 4. Test results of fungal inoculation on the areca nut seedling: A-C. All the three fungi *Ganoderma* genus were caused areca nut basal stem rot disease. D. 2 other types of fungi, namely *Trametes* sp. did not cause disease in areca nut seedlings

Pattern of distribution of areca nut basal stem rot disease in Kubu Raya District

Based on observations in the field, there were two types of distribution patterns of areca nut basal stem rot disease in Kubu Raya District, namely a random distribution pattern and a clustered pattern. Each pattern can be found in the observed sample site. In each sample site, some were found spreading randomly, in groups, but some were found spreading randomly and also in groups. Random distribution patterns were found in around 40.63% of the sample sites, while group distribution patterns were found in around 9.38% of samples. The random or group distribution patterns were found in around 34.38% of samples (Table 8). This result is different from the distribution pattern of basal stem rot disease in oil palms where it is generally found in groups (Sanderson 2005; Rakib et al. 2017; Hamzah et al. 2020). This may occur for several reasons. Most likely, it is related to the level of disease progression. In plantations where the disease was found to spread randomly, generally, the incidence was very low below 1%. Meanwhile, in plantations with a higher incidence, there is a pattern of disease spread that tends to be clustered. Thus, if the disease spreads further, it is also possible that it may spread into clusters.

In conclusion, the results of this research show that in Kubu Raya District, basal stem rot disease has been found on areca nut plantations caused by the fungus *Ganoderma* sp. In the future, even though the incidence is still low, the development of areca nut plantations in Kubu Raya District needs to be aware of the potential spread of this disease.

ACKNOWLEDGEMENTS

The author would like to thank Universitas Tanjungpura (Untan), Pontianak, West Kalimantan, Indonesia for funding this research through DIPA Untan 2023-2024 with contract No. 3012/UN22.3/PT.01.03/2023.

REFERENCES

Alexopoulos CJ, Mims CW, Blackwell M. 1996. Introductory Mycology. John Wiley & Sons Inc, New York.

Alizadeh F, Abdullah SNA, Khodavandi A, Abdullah F, Yusuf UK, Chong PP. 2011. Differential expression of oil palm pathology genes during interactions with *Ganoderma boninense* and *Trichoderma harzianum*. J Plant Physiol 168: 1106-1113. DOI: 10.1016/j.jplph.2010.12.007.

Arwiyanto T, Goto M, Tsuyumu S, Takikawa Y. 1994. Biological control of tomato bacterial wilt with the use of avirulent strain of *Pseudomonas solanacearum* isolated from *Sterilitzia reginae*. Annu Phytopath Soc 60: 421-430. DOI: 10.3186/jjphytopath.60.421.

Badan Pusat Statistik (BPS) West Kalimantan. 2022. Provinsi Kalimantan Barat Dalam Angka 2022. Badan Pusat Statistik, Pontianak. [Indonesian]

Badan Pusat Statistik Kabupaten Kubu Raya (BPS). 2022. Kabupaten Kubu Raya dalam Angka 2021. https://kuburayakab.bps.go.id/publication/2021/02/26/f4469ded4fcab4b95b651a58/kabupaten-kubu-raya-dalam-angka-2021.html [Indonesian]

Castillo SY, Rodríguez MC, González LF, Zúñiga LF, Mestizo YA, Medina HC, Montoya C, Morales A, Romero HM, Sarria GA. 2022. *Ganoderma zonatum* is the causal agent of basal stem rot in oil palm in Colombia. J Fungi 8: 230. DOI: 10.3390/jof8030230.

Clark PJ, Evans FC. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 35 (4): 445-453. DOI: 10.2307/1931034.

Dinas Perkebunan dan Peternakan Provinsi Kalimantan Barat (Disbunnak Kalbar). 2023. https://disbunnak.kalbarprov.go.id/. [Indonesian]

Flood J, Hasan Y, Rees R, Potter U, Cooper R. 2010. Some latest R & D on *Ganoderma* diseases in oil palm. Proceeding of the second international seminar oil palm diseases, advances in *Ganoderma* research and management.

Goh YK, Ng FW, Kok SM, Goh YK, Goh KJ. 2014. Aggressiveness of *Ganoderma boninense* isolates on the vegetative growth of oil palm (*Elaeis guineensis*) seedlings at different ages. Malays Appl Biol 43 (2): 9-16.

Hamzah A, Saputra R, Puspita F, Nasrul B, Irfandri, Depari NS. 2020. *Ganoderma* diversity from smallholder oil palm plantations in peatlands of Kampar District, Indonesia based on mycelia morphology and somatic incompatibility. Biodiversitas 22 (1): 16-22. DOI: 10.13057/biodiv/d220103.

Hasan Y, Foster HL, Flood J. 2005. Investigations on the causes of Upper Stem Rot (USR) on standing mature oil palms. Mycopathologia 159: 109-112. DOI: 10.1007/s11046-004-4431-7.

Hushiarian R, Yusof NA, Dutse SW. 2013. Detection and control of *Ganoderma boninense*: Strategies and perspective. SpringerPlus 2: 555. DOI: 10.1186/2193-1801-2-555.

Idris AS, Ariffin D, Swinburne TR, Watt TA. 2000. The identity of *Ganoderma* species responsible for BSR disease of oilpalm in Malaysia: Pathogenecity test. MPOB Information Series : 77b.

Kamu A, Chong KP, Idris AS, Ho CM. 2016. Economic loss due to *Ganoderma* Disease In Oil Palm. Intl J Soc Behav Educ Econ Bus Ind Eng 10(2): 604-608.

Kamu A, Phin CK, Idris AS, Mun HC. 2015. Distribution of infected oil palms with *Ganoderma* basal stems root disease. JSRD 2 (10): 49-55.

Kok SM, Goh YK, Tung HJ, Goh KJ, Wong WC, Goh YK. 2013. In vitro growth of *Ganoderma boninense* isolates on novel palm extract medium and virulence on oil palm (*Elaeis guineensis*) seedlings. Malays J Microbiol 9 (1): 33-42. DOI: 10.21161/MJM.45212.

Lim HP, Fong YK. 2005. Research on basal stem rot (BSR) of ornamental palms caused by basidiospores from *Ganoderma boninense*. Mycopathologia 159: 171-179. DOI: 10.1007/s11046-004-4440-6.

Lisnawita H, Tantawi AR. 2016. Survey of basal stem rot disease on oil palms (*Elaeis guineensis* Jacq.) in Kebun Bukit Kijang, North Sumatera, Indonesia. IOP Conf Ser: Earth Environ Sci 41: 012007. DOI: 10.1088/1755-1315/41/1/012007 .

Loyd AL, Smith JA, Richter BS, Blanchette RA, Smith ME. 2017. The laccate *Ganoderma* of the southeastern United States: A cosmopolitan and important genus of wood decay fungi. EDIS 2017: 333. DOI: 10.32473/edis-pp333-2017.

Minarsih H, NP DL, Darmono TW, Herliyana EN. 2011. Analisis keragaman genetik *Ganoderma* spp. yang berasosiasi dengan tanaman kakao dan tanaman pelindungnya menggunakan Random Amplified Polymorphic DNA (RAPD). Menara Perkebunan 79(1): 6-14.. DOI: 10.22302/ppbbi.jur.mp.v79i1.72. [Indonesian]

Ministry of Agriculture. 2022. Ekspor Biji Pinang Asal Kalbar Menggeliat, Kementan Dorong Ekspor dalam Bentuk Olahan. https://pertanian.go.id/home/?show=news&act=view&id=3873. [Indomesian]

Muniroh MS, Nusaibah SA, Vadamalai G, Siddique Y. 2019. Proficiency of biocontrol agents as plant growth promoters and hydrolytic enzyme producers in *Ganoderma boninense* infected oil palm seedlings. Curr Plant Biol 20: 100116. DOI: 10.1016/j.cpb.2019.100116.

Naher L, Siddiquee S, Yusuf UK, Mondal MMA. 2015. Issues of *Ganoderma* spp. and basal stem rot disease management in oil palm. Am J Agric Sci 2(3): 103-107.

Olou BA, Krah FS, Piepenbring M, Yorou NS, Langer E. 2020. Diversity of *Trametes* (Polyporales, Basidiomycota) in tropical Benin and description of new species *Trametes parvispora*. MycoKeys 65: 25-47. DOI: 10.3897/mycokeys.65.47574 .

Paterson RRM. 2007. *Ganoderma* disease of oil palm—A white rot perspective necessary for integrated control. Crop Prot 26 : 1369-1376. DOI: 10.1016/j.cropro.2006.11.009.

Prasetyo AE, Simanjutak D. 2017. Kemunculan upper stem rot *Ganoderma* pada generasi tanam pertama kelapa sawit. Warta PPKS 22 (1): 15-20. [Indonesian]

Puspita F, Nugroho TT, Saputra R. 2022. Biological control agents potential and molecular identification of endophytic *Trichoderma* isolates originated from oil palm tissue against *Ganoderma boninense* Pat. Jurnal Ilmiah Pertanian 19 (2): 48-55. DOI: 10.31849/jip.v19i2.9402. [Indonesian]

Rakib MRM, Bong CFJ, Khairulmazmi A, Idris AS. 2015. Aggressiveness of *Ganoderma boninense* and *G. zonatum* isolated from upper- and basal stem rot of oil palm (*Elaeis guineensis*) in Malaysia. J Oil Palm Res 27(3): 229-240.

Rakib RM, Bong CJ, Khairulmazmi A, Idris AS, Jalloh MB, Ahmed OH. 2017. Association of copper and zinc levels in oil palm (*Elaeis guineensis*) to the spatial distribution of *Ganoderma* species in the plantations on peat. J Phytopathol 165: 276-282. DOI: 10.1111/jph.12559.

Sanderson FR. 2005. An insight into spore dispersal of *Ganoderma* boninense on oil palm. Mycopathologia 159: 139-141. DOI: 10.1007/s11046-004-4436-2.

Sulistyowati H, Ruliyansyah A, Pramulya M. 2023. Keragaan kebun dan karakteristik petani pinang di Kabupaten Kubu Raya, Kalimantan Barat. Jurnal Pertanian Agros 25 (1): 507-513. DOI: 10.37159/jpa.v25i1.2425. [Indonesian]

Supriyanto, Priyatmojo A, Arwiyanto T. 2011. Uji penggabungan PGPF dan Pseudomonas putida strain pf-20 dalam pengendalian hayati penyakit busuk lunak lidah buaya di tanah gambut. J Trop Plant Pests Dis 11: 11-21. DOI: 10.23960/j.hptt.11111-21.

Supriyanto, Purwanto, Poromarto SH, Supyani. 2020. The relationship of some caracteristic of peat with oil palm basal stem rot caused by *Ganoderma* in peatlands. IOP Conf Ser: Earth Environ Sci 423: 012064. DOI: 10.1088/1755-1315/423/1/012064.

Supriyanto, Purwanto, Poromarto SH, Supyani. 2021. Hubungan karakteristik biologis gambut dengan penyakit busuk batang yang disebabkan *Ganoderma* pada kelapa sawit. Perkebunan dan Lahan Tropika 11 (1): 1-8. DOI: 10.26418/plt.v11i1.53357. [Indonesian]

Supriyanto, Purwanto, Poromarto SH, Supyani. 2022. The effect of indigenous vegetation in the control of oil palm Basal Stem Rot (BSR) disease caused by *Ganoderma* on peat land. IOP Conf Ser: Earth Environ Sci 1016: 012059. DOI: 10.1088/1755-1315/1016/1/012059.

Supriyanto, Purwanto, Poromarto SH, Supyani. 2023. The effectiveness of acid-tolerant antagonists in the control of oil palms root necrotic caused by *Ganoderma* sp. in peat soils. E3S Web Conf 467: 01023. DOI: 10.1051/e3sconf/202346701023.

Surbakti R., Utomo C, Susanto A. 2010. Identifikasi molekuler dan uji patogenesitas *Ganoderma* asal tanaman pinang pada tanaman kelapa sawit. J Penelitian Kelapa Sawit 18 (1): 18-28. [Indonesian]

Susanto A. 2009. Basal stem rot in Indonesia: Biology, economic importance, epidemiology, detection, and control. Proceeding of The International Workshop on Awareness, Detection, and Control of Oil Palm Devastating Diseases.

Widiastuti H, Taniwiryono D, Hendarjanti H, Harjotedjo S, Sugeng MH. 2018. Chemical and biological characteristics of selected wet soil in oil palm plantation attack with *Ganoderma* sp. IOP Conf Ser: Earth Environ Sci 183: 012019. DOI :10.1088/1755-1315/183/1/012019.

Wong WC, Tung HJ, Fadhilah MN, Midot F, Lau SYL, Melling L, Astari S, Hadziabdic D, Trigiano RN, Goh KJ. 2021. Genetic diversity and gene flow amongst admixed populations of *Ganoderma boninense*, causal agent of basal stem rot in African oil palm (*Elaeis guineensis* Jacq.) in Sarawak (Malaysia), Peninsular Malaysia, and Sumatra (Indonesia). Mycologia 113 (5): 902-917. DOI: 10.1080/00275514.2021.1884815.