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PREVALENCE OF BASAL STEM ROT DISEASE CAUSED BY *GANODERMA* SP. ON OIL PALM (*ELAEIS GUINEENSIS* JACQ) IN GHANA

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ABSTRACT

Oil palm (Elaeis guineensis Jacq.) is the most productive and highest yielding edible oil crop in the world, being 13 times more productive than soybean and other oil-bearing seeds. In 2020/2021, a survey was conducted to assess incidence and severity of Ganoderma Basal Stem Rot (BSR) disease on selected palm trees in Central, Eastern, and Western regions of Ghana. A follow-up survey was conducted in 2022 to determine the current prevalence of the infection. A Ganoderma disease census was done based on the single-point assessment following the Standard Operating Procedure (SOP), with disease severity scale of 0-4 based on number of Basidiocarps per infected plant. A total of 7,500 palm trees from fifteen plantations were assessed. The number of fruiting bodies/basidiocarps per plant ranged from 2 to 291. Out of 15 plantations, 73% showed Ganoderma infection. Current study showed eight infected palms identified in Western region against two palms in 2020/2021. In Central region, one of the heavily infected palms identified on plot (B37-1) in 2021, was completely destroyed by the pathogen. Eastern region showed maximum presence of inoculum loads of Ganoderma pathogen with total number of 52 infected palms. Although, the disease incidence per selected plantations was low, (<10 %), the rate at which the disease was spreading and the ability of the fungus to attack younger palms 11 years, was of real concern. The study revealed increased disease incidence and severity, there is therefore the need for urgent management and constant monitoring for early detection and prevention.

Keywords: *Ganoderma* infection, Elaeis guineensis, Basidiocarps, disease prevalence

INTRODUCTION

Oil palm is the most important oil crop worldwide in terms of edible oil production and has thus attracted the attention of many developing countries, including Malaysia and Indonesia. The crop can contribute significantly to food security and improvement in foreign exchange standing. It also serves as a raw-material for oleochemicals and biodiesel fuel with total estimate of $24.66 billion export revenues (Parveez *et al*., 2022).

An estimated production of palm oil globally was about 78 million metric tons in 2022/2023 advancing from an estimated metric tons of 73 million in 2021/2022 marketing year. Oil palm is considered one of the important cash crops in Ghana, boosting rural economy with estimated total production of 2.5 million metric tons in 2021 (Sasu, 2023). Although this production remained stable since 2014, there is a potential for greater investment in the oil palm sector in Ghana. From 2005 to 2010, Ghana produced a total of 120,000 tonnes of palm oil (Angelucci, 2009). As at 2021, Ghana's production of crude palm oil had increased to 375,000 tonnes (Index Mundi, 2022). Despite the increased between 2000 to 2021, Ghana recorded a palm oil production deficit around 30,000 metric tonnes. It is projected that this could reach about 127,000 tonnes by 2024 (Commodafrica, 2018). Even though, this production is not consistent, there is a potential for greater investment in the oil palm sector in Ghana.

Unfortunately, efforts to increase oil palm production are hampered by diseases, pests, and environmental factors. One factor limiting the attainment of food security in Africa aside climate change is high crop loss through insect pests and diseases. The oil palm industry is thus threatened by these biological factors. Among the oil palm diseases that occur in oil palm plantations, is Basal stem rot (BSR). It is a disease that causes loss of yield and most often causes death of the trees. It is the most devastating and destructive disease of oil palm in tropical regions including Malaysia, Indonesia, Thailand, India, Papua New Guinea, and Africa (Khoo and Chong, 2023).

In Malaysia, BSR can cause economic losses between RM1.1 billion to RM3.0 billion (up to USD 933 million) a year (Hushiarian *et al*., 2013; Ommel *et al*., 2012). BSR causes loss of yield and most often causes 80% of the death of the infected palms (Hushiarian *et al*., 2013). It is believed to be caused by fungus *Ganoderma* sp. which is a white rot fungus and that devastates thousands of hectares of oil palm plantings in Southeast Asia every year (Khoo and Chong, 2023). It is estimated that, this *Ganoderma* fungi can wreak havoc on Malaysia's oil palms by 2040, wiping out 860,610 ha of mature oil palm trees (Olaniyi and Szulczyk, 2020). Khoo and Chong (2023) also reported similar scenario and indicated that, BSR disease can cause a significant economic loss of 43% to oil palm plantation in Indonesia within six months if appropriate management interventions are not implemented.

Ganoderma is characterized by hard woody and brackets fruiting bodies (basidiocarps) and sometimes with stem. The basidiocarps mostly grow in a fan or hoof-like form on the stem (basal part) or sometimes at the upper part of the affected palms. BSR infection is associated with the decay of the stem, growth of basidiocarps and sometimes decay of the roots follows (Lim *et al*., 1992). Stem rotting restricts uptake of water and nutrients to the frond causing chlorosis and if not controlled leads to the collapse or the death of the entire plant (Rees *et al*., 2009).

Although the disease is less reported in West Africa including Ghana, recent preliminary investigation conducted by researchers from CSIR-Oil Palm Research Institute in 2019 and 2020 revealed incidence of BSR disease suspected in some selected oil palm plantations in Eastern, Central and

Western Regions of Ghana. Further to this development, the research team carried out a comprehensive study of the disease in 2021/2022 to validate its initial findings by determining the current incidence and severity of the disease and identify factors contributing to the incidence of the disease in order to develop appropriate management strategies, for the disease.

MATERIALS AND METHODS

This report involved preliminary investigation on prevalence and severity of BSR disease caused by *Ganoderma* sp. on oil palm in 2020/2021 and a follow-up survey conducted in 2022 to determine the current incidence and severity of *Ganoderma* situation in fifteen selected oil palm plantations in Ghana.

Location of study areas

The regions visited were Central, Eastern and Western regions. Fifteen (15) oil palm plantations were visited; five plantations per region. For the purpose of this study, the plantations visited were renamed with the initials of their respective regions and arranged in chronological manner. For-instance, the first plantation visited in Central region was named C1, the second one was C2 and so on. The communities visited in Central region were; Twifo Praso, Hemang, Gomoa-Ahubrasee and Nuamahkrom. These areas lie within latitudes 5˚3.209' N to 5˚7.891' N and longitudes 1˚23.200' W - 1˚ 54.360' W. They cover land area ranging from 1,160 to 4,231 km-2 of the region. The plantations visited in Eastern region were in Kusi-Kade, Kwae, Anyinam and Bunsu. These areas lie within latitudes 6°.10871N to 6˚.38431' N and longitudes 0°.35047' W - 0°.30' W and 0°10'E to 0° 30' E. They cover land an area ranging from 1200 to 1750 mm sq. of the region. Communities visited in Western region were Benso, Go slow, Trebuom and Adum Banso. These areas also lie within the range of latitudes 5˚ 02. 609' N to 5˚ 7.891' N and longitude 1˚53.021'W-1°54.099 W. They cover land area ranging between 1,160 and 6,231sq.km.

The climate of study areas

The study areas are within the wet semi-equatorial climatic zone, and moist semi-deciduous forest zones characterized by a double maxima rainfall pattern followed by a prolonged dry season. The mean minimum temperature ranged between 21 to 23˚C and a mean maximum varied between 26 and 31˚C. The relative humidity varied from 60% to 80% while average annual rainfall ranged from 1500 to 2000 mm.

Position of infected palm trees were taken with the aid of 3G GPS tracker (brand: VTO5F, Manufacturer: Protrack Service and country: China)

Infected palms identified were marked with red paint for easy identification and felling.

Field observation and assessment

Visual observations of the disease symptoms on oil palm and other suspected hosts (such as coconut and rubber tree) of the pathogen(s) were made across all the plantations visited. Plots maintenance, and various possible ways of the spread of the disease were also noted.

Fruiting bodies of the fungus and infected plant parts were carefully picked from each plot assessed and brought to CSIR-OPRI Plant Pathology laboratory for further clinical analysis.

Infected samples were collected from all the plantations visited. Samples collected were put into sterile envelopes, labeled, and brought to the laboratory for pathological analysis.

Disease sampling

Both purposive and random sampling techniques were used. Purposive sampling was used to select three oil palm growing

regions in Ghana. A simple random sampling technique was used to select both the farming communities and the fifteen (15) oil palm plantations. Five hundred (500) oil palm plants per plantation/an area were assessed.

Intensive *Ganoderma* disease scouting was carried out based on the single-point disease assessment using the standard operating procedure (SOP) of the *Ganoderma* census published by the Malaysian Palm Oil Board (MPOB, 2014). The process was done by counting the number of infected plants using a block of one hundred (100) trees along a diagonal on each farm for proper disease representation. This assessment was once adopted in a similar preliminary study carried out in the Eastern region where the disease was first detected and two other (Central and Western) regions where BSR was later recorded. Data collected were recorded on the disease assessment index sheet.

Disease incidence

Disease incidence per plantation was done using method described by Lekete (2014) with slight modification. This was computed as:

$$\%\ \text{BSR Disease Incidence (DI)on the field} = \frac{Number\ of\ infected\ oil\ palm\ per\ Plantation}{Total\ number\ of\ selected\ oil\ palm\ per\ Plantation} \times 100 \quad \mathbf{1}$$

Disease severity score

Disease severity was scored using a scale of 0 to 4 (Lekete *et al*., 2019; CSIR-OPRI, 2019)

where:

0: no fruiting body/no foliar symptoms

1: 1-3 number of fruiting body / foliar symptoms on two fronds

2: 4-6 fruiting bodies / foliar symptoms on three fronds

3: 7-9 fruiting bodies / foliar symptoms on four fronds

4: > 9 Maximum number of fruiting bodies / foliar symptoms > 4 fronds

Disease management

Although, Lim *et al*. (2012) stated that there is still no effective disease control currently against *Ganoderma*/BSR infections, we employed the techniques proposed by Chung (2011) to control the disease on the affected site. These include removing and destroying the infected palms to prevent further spread of the disease, minimize the economic loss, and to prevent healthy plant from reinfection. Infected palms identified were marked with red paint for easy identification and felling. Other heavily infected palms were tagged for uprooting and burning; palms showing foliar symptoms were tagged and placed under observation.

Data collection and analysis

Data collected were based on: plant age, percentage infection (Disease incidence), % number of fruiting bodies /plant, severity score and mode of spread, and was analysed using descriptive statistics and R- Core Statistical Software (2021). LSD at 0.5 % was used to separate the means.

RESULTS AND DISCUSSION

Field observation and assessment

Basal stem rot disease observed on the fields depicted the signs of *Ganoderma* mushroom (basidiocarps) also known as "*Ganoderma* fruiting bodies". The mushrooms first appeared as small white buttons of tissue (Plate1A) on the stem and later developed into bracket shape. It is mostly located at the base of the affected palm tree (Plate1B)

and sometimes on the upper side of the infected palm (Plate 2). According to Chong *et al*. (2017a), the Basal stem rot pathogen, *Ganoderma* sp is characterized with pin-head fruiting bodies which later developed into fan-shaped woody basidiocarps and double-walled with inner layers that range in colours from white, brown to deep-brown as observed in this study.

Symptoms and signs of *Ganoderma* basal stem rot disease observed on the field

Plate 1 A and B: Developmental stage of *Ganoderma* mushroom on oil palm

Plate

(A) *Mushroom pinhead depicting the initial appearance of the* *Ganoderma* *mushroom*

Plate

(B) *The bracket-shaped size of* *Ganoderma* *mushroom*

It is believed that the *Ganoderma* basal stem rot disease incidence was first observed in Denkyembour district in Eastern region by early scientists in 2010/2011 and as at that time, only two (2) palms were infected. In 2017, the total number of infected palms increased to Nine (9) with two which were formerly infected and overwhelmed with the disease symptoms (*Ganoderma* basidiocarps) fell and left to rot on the field. These rotten stumps are most contagious and served as source of inoculum for disease spread.

Surveys have shown that the disease occurs in all the three regions of oil palm plantations visited but the incidence and type of mushroom identified from each region varied greatly among the localities. The shape of the basidiocarps observed on the field slightly differed from one palm to the other (Plate 2). Those with characteristic bracket(s) arising at the end of stalk/stipe (Plate 2) were quite common.

Plate 2 *Ganoderma* ***mushroom growing at the upper part of the oil palm (Upper stem rot disease)***

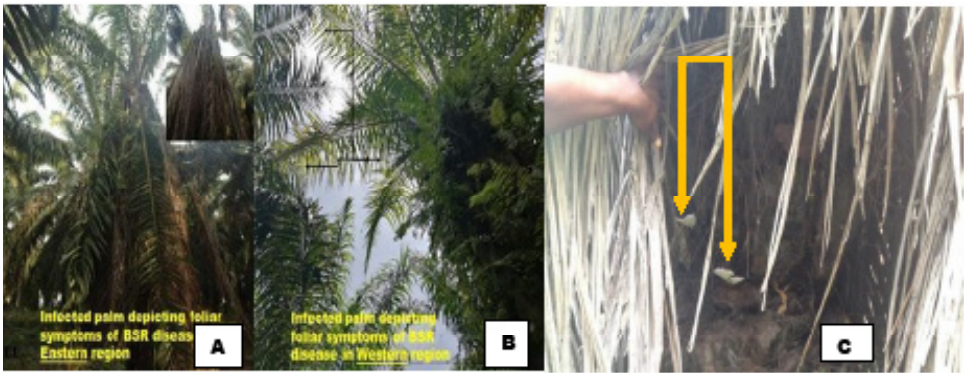

Plate 3. ***Infected oil palms showing foliar symptoms of BSR***

A denotes Dropping/falling of infected fronds, B denotes Infected palms depicting chlorosis of foliar symptoms, and C denotes Revealed suspected *Ganoderma* mushroom (arrowed).

The pathogen was found to exhibit foliar descriptive symptoms such as yellowing (Chlorosis) (Plate 3B) and falling of the palm fronds on the infected palm alongside the presence of basidiocarps which showed evidence that the causal agent could be the *Ganoderma* sp.

The first indication of chlorosis in mild cases, is a paling of the green colour of the palm fronds (Plate 3B), followed by general yellowing of the leaf tissue but leaf veins /broom remain green. In severe cases, dropping/falling of the palm fronds occurred. Some of these fallen palm fronds were several feet long to the ground (Plate 3A). They do not decompose easily, and with careful search underneath and opening of the sluggish fronds (at the basal part of the affected palm) showed suspected *Ganoderma* mushrooms (Plate 3C).

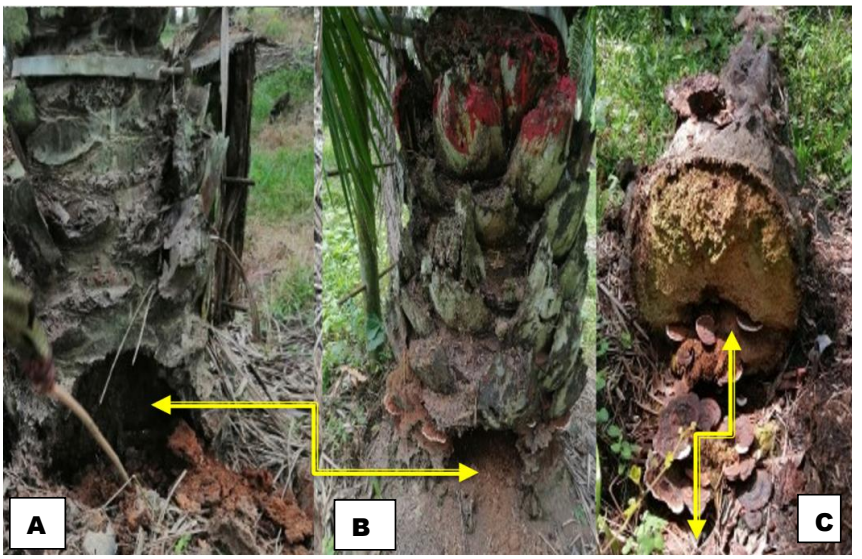

Plate 4. ***Devastating effect of BSR disease on oil palm as observed on the field (arrowed)***

BSR disease is associated with decay of the lower stem or the upper part of the infected palms (Plate. 4C). Study revealed that *Ganoderma* sp. could invade different category of oil palm in-respective of the type of progeny and the age, thus making the pathogen very difficult to control/manage.

Assessing the age of oil palm trees

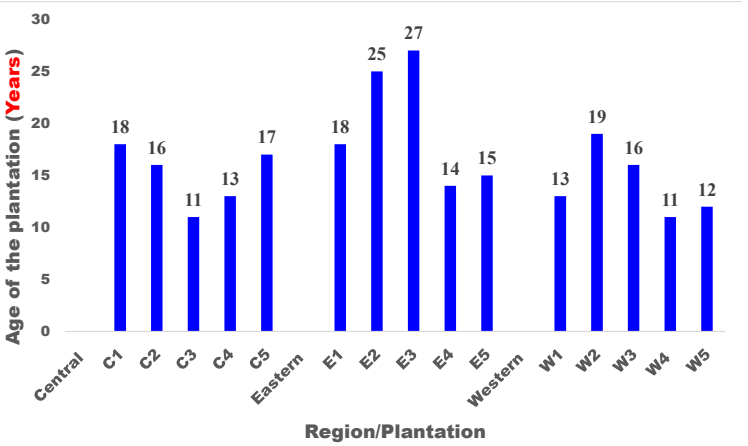

Fig. 1 ***Age of the palm trees accessed with respect to each region visited***

C1 – C5 denotes Central region, E1 – E5 denotes Eastern region, and W1 – W5 denotes Western region

The ages of the palm trees ranged between 11 and 27 years. Those at the age of 27 years were the majority, followed by 25, 19, and 18 years with the least being 11 years old. The Eastern region recorded the oldest plantation/ palm age (25 and 27 years) among all the

plantations assessed (see Fig. 1). Indicating one of the reasons, BSR (*Ganoderma* infection) was more pronounced in plantations with older palm plants, especially those in the Eastern region compared to those observed in the other regions. These observations were similar to a previous survey carried out by Turner and Bull (1981).

In the Central region, the oldest plantation recorded was 18 years old followed by 17 years with the youngest being 11 years old. On average, the Western region recorded the youngest palm age as compared to the average palm age in the Eastern and Central regions. Until recently, Basal stem rot disease was associated primarily, with older palm trees, of at least 30 years of age and was termed "malady of aging palm" (Turner *et al*., 1967). In this study, the disease appeared to have affected both young and old palm plants, a similar observation was made by Susanto *et al*. (2005), where it was observed that BSR disease manifested quickly and severely in younger seedlings.

Even though the disease incidence in the selected regions was low (< 10 %), the ability of the fungus to attack much younger palms at 11 years, as was observed in this study, calls for more attention to be paid to the disease.

Incidence of Basal Stem Rot disease in the selected oil palm growing regions of Ghana

The field survey revealed a limited number of oil palms showing the signs and symptoms of BSR disease in selected oil palm growing regions. Sixty-two (62) palm trees in all, were identified with *Ganoderma* mushrooms (Plate 4). There was a dramatic increase in the percentage of infection in Eastern and Western regions compared to the total infection in 2020 /2021 and that of 2022.

In 2020/2021 Eastern region, recorded 28 infected palms, however in 2022 the total palms infected rose close to double the number from previous years. The same scenario occurred in the Western region where five palms were recorded in 2020/2021 and 2022, total infections increased to eight.

In the Central region, the incidence was on the reverse. It was noticed that two of the four infected palms identified in 2021 were removed using a clean clean-clearing method. Hence, only two infected palms were recorded in 2022. Chong *et al*.(2017b) noted that the best way to reduce the disease occurrence and maintain disease-free plantation was through proper field sanitation removal of infected palms and clean clearing.

This study revealed that the incidence of suspected *Ganoderma* infection (BSR disease) in 2022 from the selected oil palm plantations in Ghana was between 1 and 7 %. Across the three regions, the Eastern region recorded the highest percentage (7.2 %) of infection, this was followed by Western (2.4 %) and Central region (1.2 %).

Data revealed that the eastern region recorded the highest number (52) of infected palms followed by the Western region (8) with the Central region recording (2) the least (Fig. 2). This could be because the disease was first found in the Eastern region by the early researchers in 2009/2010 (personal communication, 2022), and at that time, the disease was regarded as not economically important hence, little study was done to curb its spread in the region. This study revealed a randomly distributed pattern of all infected palms examined across the three regions. This finding is contrary to the spatial distribution of *Ganoderma*-infected oil palm observed by Assis *et al*. (2015).

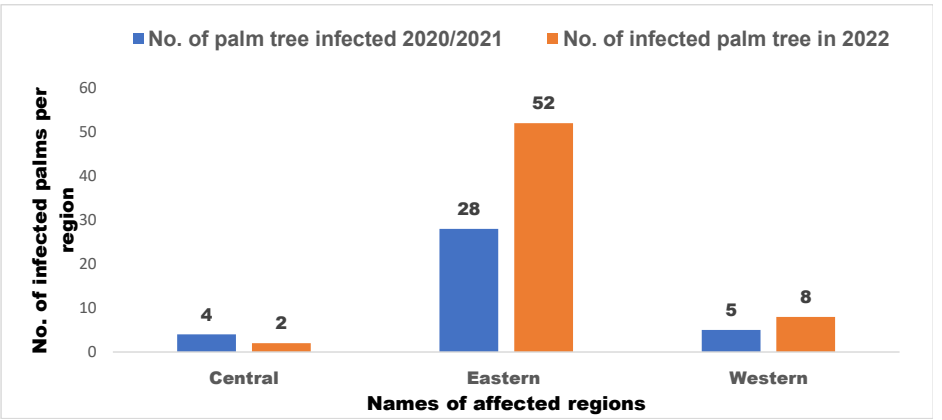

Fig. 2. Progress of incidence of BSR disease per region in a given year

The study showed the current percentage incidence of BSR disease in oil palm in Ghana. No *Ganoderma*-infected palm was identified in plantations C2, W2, and W5 (Table 1). BSR was known to affect seedlings (Susanto *et al*., 2005), however, in this study no symptom or sign of the suspected fungus, *Ganoderma*, was observed in the nursery palms.

Although the species name is yet to be confirmed, *Ganoderma* sp. is known to be a very dangerous fungal pathogen. Hushiarian *et al*. (2013) emphasized the economic importance of the fungus or disease when they noted that it could destroy more than 80 % of oil palm stands, especially in areas where plantations are planted with seedlings raised from materials from fields with previous disease history.

Mode of spread

It was revealed that, the disease occurred in patches and mostly attacked palm plants that were located close to the roadsides/footpaths and that some insects and human factors could probably helped in the spread of the disease. However, further investigations are needed to validate these findings. According to Pilotti *et al*. (2003), biological factors such as insect pests, and other animals, and environmental factors including water and wind aid with the spread of the BSR disease.

It was believed that a high incidence of BSR disease occurs in areas where new plantations are sited near old oil palm fields that are rotting away. The damage caused by the disease increases when oil palm is replanted after oil palm and these damages are more and more drastic through the successive replanting cycles (Singh, 1991; Ariffin *et al*., 2000). A similar situation was observed in the Western (W4) and Eastern (E5) regions where some of the infected severed trunks were left to rot. It also explained that such situations may lead to the production of a high number of basidiocarps which may result in a high inoculum load in the affected areas.

Prevalence and severity of BSR in three selected oil palm growing regions in Ghana

The number of fruiting bodies counted on each infected palm varied between 2 and 291 with severity scores between 2 and 4, with 4 being the highest (Table 1). On average, the Eastern region recorded the highest disease intensity and severity compared to the two other regions (Western and Central regions) visited. However, there was a variation in total fruiting bodies recorded across the individual

plantations in the region. For instance, in 2020/2021 plantation E4 in Denkyembour District recorded 58 fruiting bodies as the highest with a severity score of 4. This was followed by E1=21, E2 = 19, E3 = 14, and E5 =12 with a severity score of 3 as the least. In 2022, plantation E5 recorded 67 fruiting bodies as the highest with a severity score of 4, followed by E2 with 54 fruiting bodies, E1 = 43, E3 = 37, and E4 = 33 as the least (Table 1).

Table 1. Severity score of *Ganoderma* infection in selected oil palm plots in Ghana

Region/ Plantation	No. of fruiting bodies		Severity score range		Classification	
Central	2021	2022	2021	2022	2021	2022
C1	12	4	3	1	moderate	Mild
C2	0	0	0	0	Nil	Nil
C3	6	18	2	4	Moderate	very Severe
C4	13	20	3	4	Severe	Very severe
C5	0	16	0	4	Nil	Very severe
LSD @ 5 %	**10.16**		**1.57**			
Eastern						
E1	21	43	4	4	Very Severe	Very Severe
E2	19	54	4	4	Very severe	Very severe
E3	14	37	3	4	Severe	very Severe
E4	58	33	4	4	Very severe	Very severe
E5	17	67	4	4	Very Severe	Very severe
LSD @ 5 %	**4.74**		**0.62**			
Western						
W1	12	27	3	4	Severe	Very severe
W2	0	8	0	2	Nil	Moderate
W3	0	4	0	1	Nil	Mild
W4	134	9	4	2	Very severe	Moderate
W5	0	0	0	0	Nil	Nil
LSD @ 5 %	**6.44**		**1.24**			

In the Central region, there was a steady increase in disease severity as a result of the increase in fruiting bodies formation on the infected palm trees across the years, except in plantation C1 which recorded 12 fruiting bodies in 2020/2021and 4 fruiting bodies in 2022 as a result of two infected palms that were uprooted before the second visit.

Western region also recorded a decrease in average fruiting bodies in 2020/2021 and 2022 disease assessment years as a result of the felling of some of the heavily infected palms on the affected plots. However, plantations W1 and W3 saw an increment in the total number of fruiting bodies counted in 2020/2021 (W1=12, W3=0) and in 2022 (W1=27, and W3=9) respectively. Plantation C3 recorded

only one infected palm with 8 small to medium pinheads (Plate 1A) of *Ganoderma* mushroom.

Generally, the disease incidence in the selected regions was low but the disease severity varied based on the number of basidiocarps present on each infected palm. The high severity score of the disease in Western (W3), Central (C5), and Eastern (E5, E4, and E2) regions in 2022 was unexpected. This is because the total number of infections recorded in 2020/2021 from those plots was very low and do not expect a sudden increase in infection within a one-year interval. However, Chong *et al*. (2017a) reported that initially most of the *Ganoderma*-infected palms appeared asymptomatic, however, chlorosis, as well as mushroom pin-heads, appear when an infection reaches 60–70%, this could explain the sudden increase in the percentage of infection in Eastern and Western regions as many of the palms assessed in 2020/2021 might have been asymptomatic.

Furthermore, some of these infected palm plants were spotted in the vicinity of healthy palm plants suggesting that the disease occurred randomly at the time of observation. A random pattern of infected palm plants is an indication that the pathogen was not spreading from plant-to-plant contrary to the clustered pattern of infection reported by Campbell and Madden (1990) and Assis *et al*.(2015).

It must be noted that knowledge of the infection pattern is important to the understanding of the epidemiology of infection by soil-borne pathogens (Gilligan, 1983).

According to Kamu *et al*. (2015), identification of the type of disease pattern and spread in a field is critical in epidemiological investigations, as this can help stakeholders select the best management strategy to combat the disease outbreak.

Field sanitation and disease management

Field sanitation and a few cultural practices recommended by Corley and Tinker (2003) were employed to control the disease at the study site. These included removing and destroying some of the heavily infected palms to prevent further spread of the disease (Fig. 3).

Although Lim *et al*. (2012) reported of no effective control currently against BSR caused by *Ganoderma* sp., Chung (2011) rather proposed that sanitation, including clean clearing and proper cultural practices could help reduce inoculum and disease spread. Hence, removing and destroying the infected palms will help prevent further spread of the disease, minimize economic loss, and prevent healthy palm plants from reinfection. Khoo and Chong (2023) observed that to stop the spread of BSR disease and provide short-term relief to the oil palm, cultural methods and field sanitation are necessary. Research has shown that sanitation if properly done could drastically reduce the incidence of BSR disease in oil palm plantations by 13% (Ahmad *et al*., 2012).

Plate 3. Heavily *Ganodera*-infected oil palm removed and destroyed

Other problems observed on the field

Table 2. Percentage of other problems identified on the field

Problems observed	Percentage of other problems identified (%)
Minor diseases (Dieback, leaf spots, *Marasmius* bunch rot)	12.0
Minor insect pests (Such as black ants, Aphids and palm weevil)	9.0
Parasitic plants	15.0
Flooding (too much rainfall)	38.0
Weeds	18.0
Others	8.0

Few factors were observed on the field that could influence the occurrence of the disease including poor drainage, flooding, nutritional imbalances, and deficiencies (see Table 2). Turner and Bull (1967) made similar observations and cited poor drainage, flooding, nutritional deficiencies, poor maintenance, and heavy weed growth among a few factors that influence the incidence of *Ganoderma* Basal Stem Rot (BSR) disease.

The survey team observed the following as minor areas of interest; i) some unidentified insect(s) from Lepidoptera feeding directly on the Basidiocarps (Fruiting bodies) of suspected *Ganoderma* sp. as shown in (Plate 3); ii) die-back disease on some of the young and old oil palm trees causing necrosis in the leaves, however, the initial stage of the disease development was not much noticed. The team also observed an incidence of *Pestaloptiopsis* leaf spots alongside other leaf spots in the nursery but the incidence was low.

CONCLUSION AND RECOMMENDATION

Conclusion

1. This study has shown that the "suspected *Ganoderma* Basal Stem Rot" disease is emerging as one of the major diseases of oil palm in Ghana. Although the species name of the causal agent is yet to be confirmed clinically, field analytical evidence strongly suggests that the disease is *Ganoderma* infection.
2. Plantations with poor cultural and sanitary farming practices are likely to be infected with the disease. The study revealed the presence of upper stem rot disease on oil palms caused by the same *Ganoderma* species.
3. It also showed a random distribution of all infected palms which was contrary to the findings by Campbell *et al*. (1990) and Assis *et al*. (2015). Although there could be the possibility that in the future the spread of the disease could be from tree to tree through root contact, however, this present study revealed that the spatial distribution of the infected palms in the studied site is random, not clustered.
4. The study showed the current level of incidence/percentage infection of *Ganoderma* basal stem rot disease of oil palm plants in Ghana. The pathogen was found to exhibit foliar descriptive symptoms in some of the infected palm plants and the presence of basidiocarps is evident that the causal agent could be the *Ganoderma*. However, further clinical analysis is needed to confirm it.

Recommendations

This study suggests that BSR disease can be prevented mainly through regular monitoring and effective farm management practices. It is recommended that regular monitoring should be carried out for early detection and control of new infections. All infected palms should be removed and treated immediately after the disease is noticed to reduce the inoculum load in the affected areas. There should be extensive education about the dangers posed by BSR disease on oil palm production among farmers and stakeholders.

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CONFLICTS OF INTEREST:

There is no conflict of interest regarding the submission of this manuscript

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