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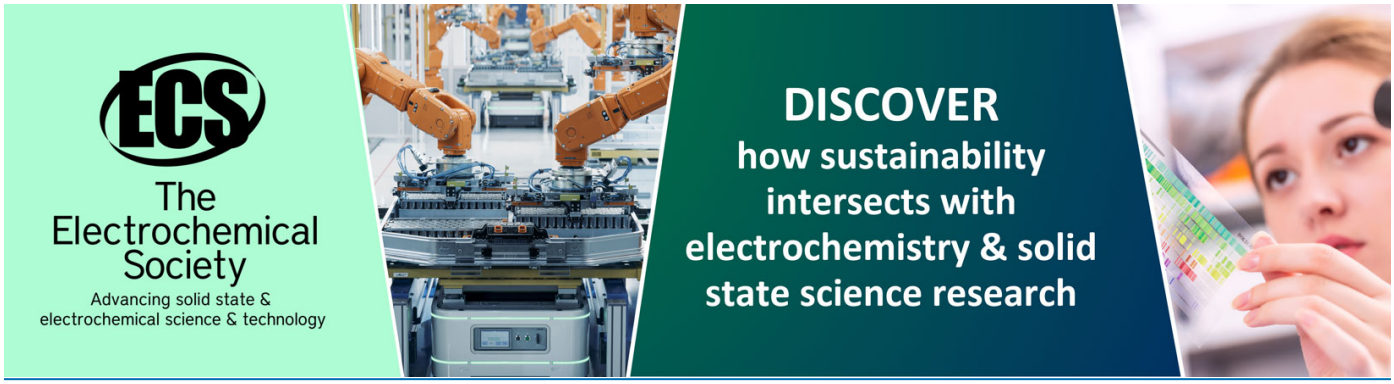

Incidence of basal stem rot disease of oil palm in converted planting areas and control treatments

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Abstract. The incidence of BSR was observed over years in 4 historically-different planting areas i.e. land converted from rubber, cacao and swamp, and continuous oil palm replanting area. In addition, we observed the effect of surgery-mounding to the lifetime of *Ganoderma*-infected palms and the effectiveness of different replanting techniques on the incidence of BSR disease. The infection rate of *Ganoderma* was faster in oil palm replanting area at 7.68% per yr, followed by land conversion from swamp, cacao, and rubber at 4.67%, 3.81%, and 1.06% per yr, respectively. Surgery-mounding of *Ganoderma*-infected palms can prolong the lifetime of the infected palms with number of death palm up to 4.45%. Meanwhile, removal of *Ganoderma* inoculum sources during replanting contributes to lower BSR incidence in the first nine years. The lowest incidence of BSR was observed following the complete removal of oil palm debris in combination with big-hole planting system with less than 5% infected palms. On the other hand, the incidence of BSR on the individual use of big-hole planting system during replanting was at 6.29% at 9 yr after planting. The result suggests the importance of inoculum removal during replanting to prevent Ganoderma infection in the early phase of oil palm development.

1. Introduction

Basal stem rot (BSR) disease caused by *Ganoderma boninense* remains as the most destructive disease of oil palm in Indonesia for decades [1-3]. The disease has caused a significant loss of fresh fruit bunches (FFB) production, up to 35%, in several plantations due to 50% declining of standing palms per ha area [1, 4]. Meanwhile, the economic losses due to BSR was estimated at USD 256 million for every 1% incidence in Indonesia [2] and approximately USD 500 million per year in Southeast Asia [5]. BSR is therefore classified as the most important disease on oil palm in Southeast Asia, particularly in Indonesia and Malaysia.

G. boninense was previously believed to only affected the old palm, but has recently found attacking immature palm of less than 1-yr-old [6]. The fungus also capable of spreading through wind using basidiospores and causes upper stem rot disease [7]. The incidence of BSR tends to increase following oil palm planting generation. Susanto and Sudharto [8] reported that BSR incidence of the old palm in the 1st, 2nd and 3rd planting generation was 17%, 18% and 75%, respectively. On the other hand, the disease incidence of immature palm in the 1st, 2nd, 3rd and 4th planting generation was 0%, 4%, 7%, and 11%, respectively.

In North Sumatra, oil palm is so popular for it has been planted in historically-different planting areas due to land limitation. These includes replanting area from oil palm and

converted area from rubber, cacao or even wetland. However, there is lack of information on how these different planting areas contribute to the incidence of BSR disease.

Many efforts have been introduced to mitigate BSR disease in the field, including modification of replanting and cultural techniques, utilization of biocontrol agents, chemical control using fungicides [6, 9-12], and recently, utilization of *Ganoderma*-tolerant cultivars [13]. Chemical control using fungicide showed a promising result in laboratory testing but not in the field [11, 14, 15]. Meanwhile, biological control often showed an inconsistency result in the field [15, 16]. This seems to be related on the abundance of *Ganoderma* inoculum in the field, particularly in *Ganoderma*-endemic area.

Most of *Ganoderma* inoculum can only be removed during replanting. Thus, a modification in oil palm replanting protocols is required, particularly starting the 3rd-generation planting where *Ganoderma* inoculum are abundant. Meanwhile in living palms, approach to prolong the economic life of oil palm infected by *G. boninense* is also needed, aiming to harvest as many as FFBs before the palm collapsed.

This paper discusses the incidence of BSR in different planting areas, including conversion areas from other crops and abandoned land. We also demonstrated how surgery and mounding capable of prolonging the economic life of infected palms. In addition, we studied the effect of 3 different replanting techniques on the incidence of BSR disease in the field.

2. Methods

2.1. Incidence of BSR in conversion areas

The incidence of BSR in 4 different planting areas was observed in Bukit Sentang estate, North Sumatra. The area consists of oil palm replanting area (2nd generation planting of 12 to 15-yr-old), converted land from rubber tree (19 to 20-yr-old), cacao tree (20 to 23-yr-old), and wetland area (21 to 23-yr-old). The disease incidence was observed and calculated annually, started in 2013, from a 5 ha plot of each land type.

Figure 1. Surgery and mounding treatment on *Ganoderma*-infected palm. (a) removal of infected tissue following tar application; (b) *Trichoderma* application; (c) soil mounding at 150 cm radius from the palm; (d) soil compacting.

2.2. The effect of surgery and mounding on Ganoderma-infected palms

This study was conducted in the 2nd generation planting area (planting year 2003) in Bukit Sentang Estate. Fifty *Ganoderma*-infected palms with mild symptom were selected for surgery and mounding treatment (Fig. 1). On every palm, visually-infected bole tissue was axed and removed, leaving only the healthy-looking tissue. Following the surgery treatment, a thin layer of tar was applied on the surface of the healthy tissue. Subsequently, the bole was mounded with *Ganoderma*-free soil, mixed with 1 kg of *Trichoderma* product, of 60 cm in 8 with 150 cm radius circling over the stem. The number of collapsed palms was recorded for 4 yr after treatment.

2.3. The effect of replanting methods on BSR incidence

The study was conducted in the 4th generation planting area in Sei/Aek Pancur estate, North Sumatra where BSR incidence reached more than 80% in the previous generation. Three replanting methods were tested, consisted of standard replanting method [17], standard replanting method with big hole planting system [6], and combination of big hole planting system with root sanitation (Fig. 2). The incidence of BSR was observed annually in each area.

Figure 2. A preview of standard replanting method with big hole and root sanitation. (a-c) creation of big hole planting point following bole removal, (d) collection of root masses, (e) uprooting root masses of oil palm, (f) oil palm seedling planted in the centre of big hole, (g-h) big hole planting point made on sanitized area.

3. Result and discussion

3.1. Incidence of BSR in second-generation planting and conversion areas

Since 2013, the incidence of BSR is continuously increased within all planting areas (Fig. 3). As expected, the highest incidence of BSR was observed in the 2nd generation oil palm planting with disease incidence of 29.80% in 2019 higher than those in converted area from wetland, cacao, and rubber at 16.81%, 12.28%, and 10.15%, respectively. A dramatic increase of BSR incidence was observed in the period of 2014-2016 in the 2nd generation planting area. The higher incidence of BSR in the 2nd generation planting area was presumably due to the accumulation of *Ganoderma* inoculum. It has generally been accepted that available inoculum will increase over planting generations, resulting an increase in disease incidence in the newer generation [3, 18].

In this 2nd generation planting area, the incidence of BSR increases following an exponential pattern in the first 14 yr of oil palm age. Following the formula described by Oka [19], the infection rate of *Ganoderma* in the 2nd generation planting area in Bukit Sentang was 7.68% per yr, faster than in the converted area from wetland, cacao and rubber at 4.67%, 3.81%, and 1.06% per year, respectively. Following this pattern, the FFB yield loss at age of 10-yr-old is predicted at 2.29 tonnes/ha/year, assuming that each infected palm produced 0.16 ton FFB/year less than the normal palm. Flood, Hasan, Turner and O'Grady [18] has previously mentioned that the economic loss due to BSR disease may begin to occur within 10 yr and severe loss at 15 yr. However, this may come earlier in the 3rd oil palm generation onward as *Ganoderma* infection tends to start earlier, even worst, in the immature stage.

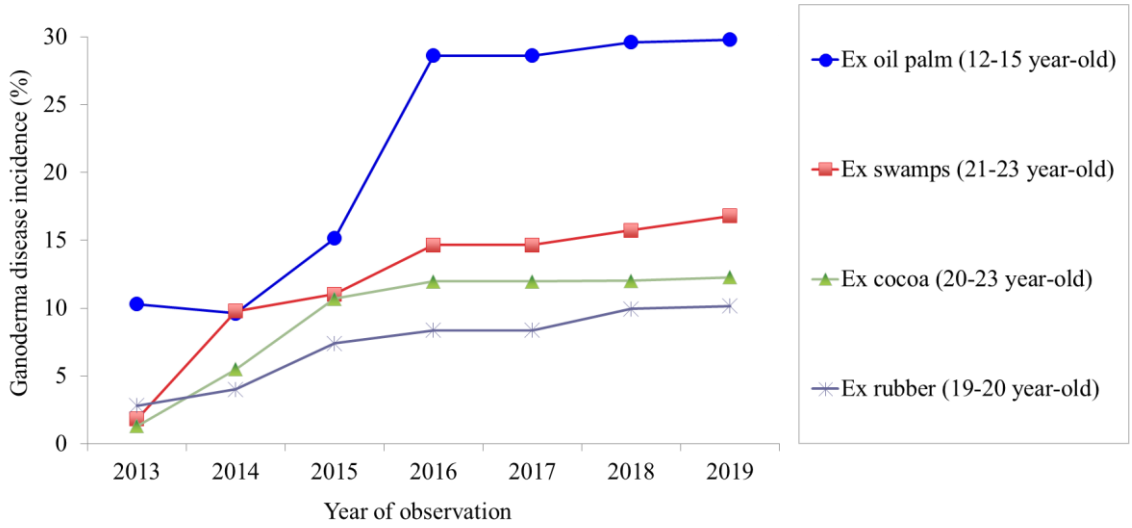

Figure 3. Growth of basal stem rot disease incidence over years in different planting areas.

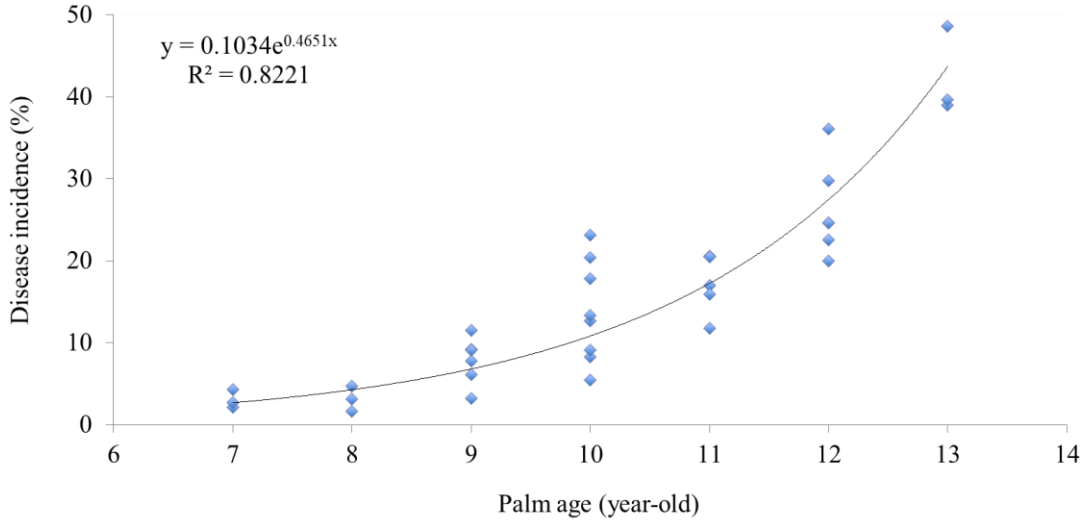

Figure 4. Correlation between basal stem rot disease incidence and palm age in the 2nd generation planting area in Bukit Sentang estate.

3.2. Surgery and mounding prolong the life of infected palms

The number of collapse palm is continously increased in treated and untreated palms (Fig. 5). The percentage of collapse palm in surgery and mounding increased from 0% in the 1st year after treatment (YAT) to 4.45% at 4 YAT, lower than untreated palm which increased from 2.72% to 14.14% at the end of observation. In surgery and mounding, palms begin to collapse in the 2nd year onward and at the lower rate than the untreated palms. The number of collapse palm in surgery and mounding plot increase at higher rate in the 4th yr. This indicates that surgery and mounding treatment is capable of prolonging the economic life of infecfected palms. Similar result was previously reported by Ho and Hashim [20] followed by Marshall, Hunt and Pilotti [21].

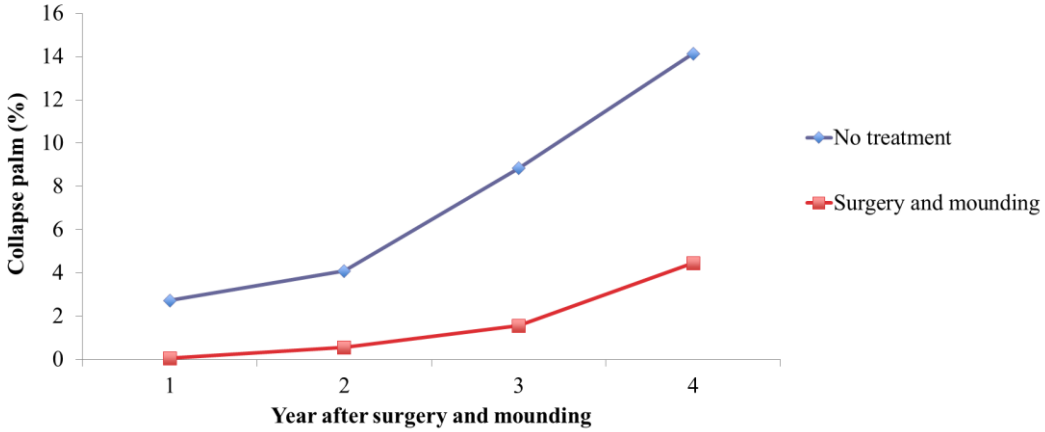

Figure 5. Percentage of collapse palms in surgery and mounding treatment.

Collapse palms in surgery and mounding treatment showed that *Ganoderma* infection is still developing, possibly from the root base that cannot be removed during the surgery activities. Despite *Ganoderma* infection cannot be stopped, the economic life of infected palms can be prolonged for 2 to 3 yr during which FFB can still be produced and harvested [10, 14, 20]. The success of surgery and mounding depends on the accuracy of infected stem tissue removal. If the infected tissue is not completely removed, generally the palm will collapse in the 1st yr after treatment.

3.3. Incidence of BSR following different replanting methods

The incidence of BSR varies within different replanting methods (Fig. 6). The incidence is higher in the standard replanting method since the 1st yr compare to the big hole and its combination with root sanitation method. BSR incidence increased from 2.10% in the 1st yr to 52.35% in the 9th yr after planting. Meanwhile the incidence of BSR in big hole and combination with root sanitation begins in the 3rd and 7th yr after planting, respectively. BSR incidence was successfully maintained under 5% for 7 and 9 yr in big hole and combination with root sanitation method, respectively. This result demonstrated that the removal of *Ganoderma* inoculum sources such as trunks, boles, and roots are essential to avoid infection in the early phase of oil palm development in the 3rd generation planting onward.

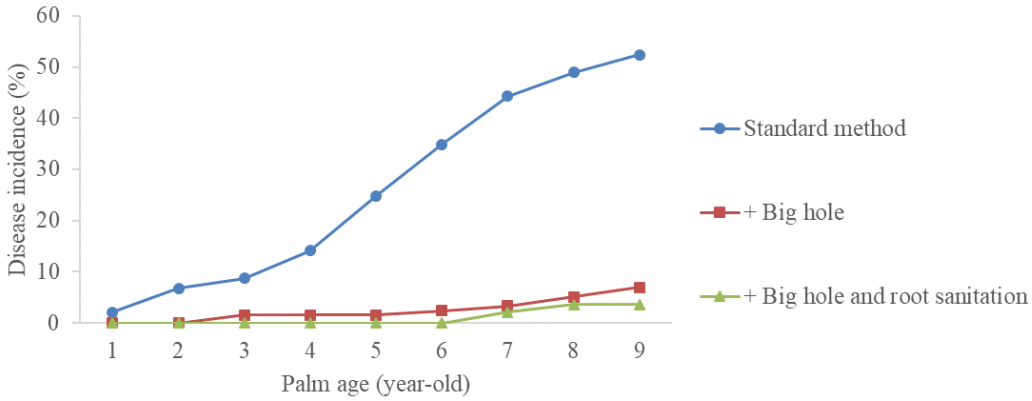

Figure 6. The incidence of basal stem rot within 3 different replanting methods.

Disease avoidance through inoculum removal during replanting is one of the success keys in *Ganoderma* disease management [22]. However, the total removal of all inoculum sources from an old stand in a *Ganoderma* endemic area is practically imposible. Thus, the modification in

replanting method aiming at removing as many of the larger tissue sections as possible. Stump tissue, consisted of bole and thick crust of roots immediately surrounding it, is the most important inoculum source of BSR disease [18]. Most of this part can be removed by excavating the soil using a big hole of 3x3 m at 1.5 m depth. In this study, the infection of *Ganoderma* in big hole system was observed starting the 3rd yr. This is probably because the roots of the palm have a lower chances of get in contact with *Ganoderma* inoculum in the first 2 yr after planting. Prasetyo, Susanto and Utomo [23] previously reported that roots of oil palm in a big hole planting system will only spread laterally within the hole in the first 3 yr and thus avoiding contact with *Ganoderma* inoculum outside the hole.

Infected roots, on the other hand, play a significant role in BSR disease infection in replanting area. Current replanting methods are directed largely to reduce the amounts of large oil palm remnant such as stumps and trunks [12, 17, 24] but most of the root debris stays untouched inside the area. Thus, adopting the replanting method in rubber plantation, we removed as much root debris as possible, more than 1.5 tonnes roots/ha area, in combination with stumps removal via big hole planting system. This replanting method resulted in smaller disease incidence compare to standard replanting procedure and big hole planting system. Palms showing BSR symptoms were observed starting in the 7th yr after planting, suggesting that the removal of roots remnant will greatly suppress *Ganoderma* infection in the beginning phase of oil palm development.

4. Conclusion

The infection rate of *Ganoderma* was faster in oil palm replanting area at 7.68% per yr, followed by land conversion from wetland, cacao, and rubber at 4.67%, 3.81%, and 1.06% per year, respectively. Surgery-mounding of Ganoderma-infected palms can prolong the lifetime of the infected palms for 2 to 3 YAT. Meanwhile, removal of *Ganoderma* inoculum sources during replanting contributes to lower BSR incidence on oil palm in the first 9 yr after planting whereas the incidence of BSR was keep maintained under 5%.

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