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Conference Paper

The Potency of Land Management to Minimize the Incidence of Basal Stem Rot (*Ganoderma boninense*) in The Next Generation of Oil Palm Plantation

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ABSTRACT

Ganoderma causes basal stem rot disease is a serious threat to the palm oil industry, especially in Malaysia and Indonesia. Field controlling with certain chemicals and biological agents have not been reported to be successful in reducing the *Ganoderma* incidence. This paper will be reporting about the potency of land management to minimize the incidence of basal stem rot disease in the next generation of oil palm plantations. Three methods of land management during the replanting process have been implemented, those are Windrowing the plant remnants (Windrow 1:1 & Windrow 2:1) as the main plot, Poisoning (No Poisoning and Poisoning) as a sub-plot and Fallowing (planting immediately and fallowing) as a sub-sub plot. The incidence of disease began to be observed two years after planting, by observing the canopy symptoms and the presence of *Ganoderma*'s fruiting bodies. Observations were made for 20 years, where at 5 years after planting, infections began to appear in the interaction treatment which belonged to windrow 1:1, non-poisoning and planting immediately. Meanwhile, at the end of the observation (20 years after planting), only the fallowing factor had a significant effect on the incidence of disease, where the percentage of disease incidence was half lower than without planting immediately (48.75%: 84.13%). This shows that the farther the plant is from the inoculum source (Windrow 2:1) will prevent the root contact of new plant to plant remnants and leaving the land not to be planted with oil palm for a certain period of time, reduced soil-borne disease agents, especially *Ganoderma* pathogens. Soil ploughing had been carried out exposing the soil to sunlight and exposing soil-borne disease organisms during the fallow process.

Keywords: Ganoderma, windrow, poisoning, fallowing, disease, incidence

Introduction

The oil palm industry is under threat of a prevailing incurable disease called Basal Root Stem (BSR), which is caused by a white rot fungus, known as *Ganoderma boninense*. With no current remedy at present, BSR is the major disease in oil palm plantations of SEA and therefore, of great economic importance to the world oil palm industry, especially to Malaysia and Indonesia, which are oil palm major producers and exporters. The disease is highly associated with the decay of lower stem, leading to severe symptoms such as unopened and flattening spear leaves (Chong et al., 2017).

Generally, initiation of BSR on oil palm by *G. boninense* established from infected debris that enters and gets in contact with roots and wounded part, which then progresses mainly through the inner, thin-walled cortex in plant (Chong et al., 2017). Until now, there is no one effective fungicide which belongs to chemical and or biological that have been reported, to suppress this disease in the field. Even though some antagonist microbes were effective in vitro and sometimes in screening test or nursery.

BSR is soil borne disease and it existed because infected debris so that, minimizing the Ganoderma's infection could be done by adopting good sanitation practices at replanting thus, reducing the amount of Ganoderma's inoculum within the soil (Chung, 2011; Virdiana et al., 2011).

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Currently, some estates in North Sumatra, Indonesia, had been practicing for removing all primary sources of its inoculum from soil. Like London Sumatra estate practices the new seedlings are planted in inter-rows at a recommended distance of at least 2 m from windrowed material (Flood et al., 2005).

Besides that, land management such fallowing can be implemented. Leaving land idle and clean through the growing season will reduce disease agents in the soil. Fallowing is especially helpful if done in the summer months when soil temperatures are high. Frequent ploughing will keep the soil dry and free of plant growth and expose soil-borne disease organisms. This experiment will investigate the potency of land management including windrowing, poisoning and fallowing to minimize the incidence of basal stem rot disease in the next generation of oil palm plantations.

Material and Methods

The experiment was conducted in London Sumatra Plantation, Dolok Estate, Lima Puluh Regency, North Sumatera Province, Indonesia. The oil palm trees were planted in 2000 and its field was ex-oil palm or the second generation of oil palm. As ex-oil palm, it had very serious Ganoderma incidence in the field. The observation of this experiment was conducted in 1999-2020. It used Split split plot design with 2 main plots, 2 sub plots and 2 sub-sub plots:

Table 1. Tested treatments of the experiment

Main Plot Windrow	Sub Plot Poisoning	Sub-sub Plot Fallowing
Windrow 1:1	Non-poisoning	Fallowing Planting immediately
	Poisoning	Fallowing Planting immediately
Windrow 2:1	Non-poisoning	Fallowing Planting immediately
	Poisoning	Fallowing Planting immediately

Plot size: 50 palms/plot, 4 replicates per treatment. Up-keep and field maintenance will follow the estate practice. Sub plots consists of factorial combination between fallowing and poisoning treatment where both of them treated in same precision. BL1 commercial seedlings were planted in this experiment. There was no special material was used in this experiment. Applying fertilizers and Trichoderma was conducted standardly of estate practice. In this experiment, soil mechanization was conducted like ripping, ploughing and harrowing. For sub plot 1, poisoning was done at one month before felling. Trees were poisoning by using 40 ml of glyphosate (Round up), it was applied by using trunk injection. Parameters which will be observed are percentage of Ganoderma incidence and Ganoderma score. Incidence is decided by seeing the score symptom and it is completed by fruiting body's existence and also basal rot special for infection which appears in young age. Because in young age, infection mostly does not cause fruiting body appears.

Results and Discussion

All data of observation for 20 years had been analyzed with ANOVA ($\alpha<0.05$), significance only happened in 2005, 2009, 2010, 2011, 2012, 2014 and 2015. In those years, the interaction of windrowing, poisoning and fallowing gave significant effect to reduce Ganoderma incidence (Table 2 and 3).

Table 2. The percentage of Ganoderma infection (%) of interaction treatment at 5-12 years (2005-2012)

Windrow	Poisoning	Fallowing	Year of Observation							
			2005	2006	2007	2008	2009	2010	2011	2012
Windrow 1:1	Non poisoning	Fallowing	**0.00a**	0.00	3.00	5.50	**10.00a**	**16.50a**	**19.50a**	**25.00a**
		Planting immediately	**0.00a**	0.50	16.00	28.00	**41.00c**	**53.50c**	**58.00c**	**61.50c**
	Poisoning	Fallowing	**0.00a**	0.00	2.00	5.00	**9.00a**	**13.50a**	**16.50a**	**20.00a**
		Planting immediately	**0.00a**	0.50	5.50	13.50	**28.50b**	**36.50b**	**42.50b**	**46.00b**
Windrow 2:1	Non poisoning	Fallowing	**0.00a**	0.00	1.00	2.50	**6.00a**	**9.50a**	**13.00a**	**17.00a**
		Planting immediately	**1.50b**	2.50	11.50	19.50	**28.00b**	**35.50b**	**40.50b**	**47.00b**
	Poisoning	Fallowing	**0.00a**	0.00	0.00	1.50	**3.00a**	**7.00a**	**9.50a**	**12.50a**
		Planting immediately	**0.00a**	1.00	13.00	21.50	**32.50b**	**41.50b**	**47.50bc**	**50.00bc**
LSD			0.01	0.01	0.05	0.09	0.07	0.11	0.13	0.14
CV(%)			0.00	130.80	40.50	47.90	22.30	16.50	17.10	16.80

Note: Means value followed by the same letter in the same column is not significantly different from level of 5% according to the duncan multiple distance test.

Table 3. The percentage of Ganoderma infection (%) of interaction treatment at 13-20 years after planting (2013-2020)

Windrow	Poisoning	Fallowing	Year of Observation							
			2013	2014	2015	2016	2017	2018	2019	2020
Windrow 1:1	Non poisoning	Fallowing	27.50	**28.50a**	**30.50a**	35.00	40.50	47.50	51.00	57.00
		Planting immediately	64.50	**71.00c**	**74.50b**	77.50	83.50	86.00	87.50	88.50
	Poisoning	Fallowing	21.50	**24.50a**	**29.00a**	34.00	40.00	43.00	45.00	48.50
		Planting immediately	51.50	**54.50b**	**63.00b**	68.50	76.00	81.50	82.50	82.50
Windrow 2:1	Non poisoning	Fallowing	19.00	**23.50a**	**27.50a**	31.00	37.50	45.50	49.00	52.00
		Planting immediately	52.00	**59.00bc**	**65.00b**	69.50	72.50	77.50	82.00	83.00
	Poisoning	Fallowing	13.50	**16.00a**	**19.00a**	22.00	26.50	27.50	32.00	37.50
		Planting immediately	55.00	**60.00bc**	**66.50b**	70.50	75.50	79.50	81.00	82.50
LSD			0.14	0.15	0.14	0.13	0.13	0.13	0.14	0.13
CV(%)			19.00	16.20	10.70	12.00	12.60	12.10	11.00	13.00

Note: Means value followed by the same letter in the same column is not significantly different from level of 5% according to the duncan multiple distance test

Based on table 2 and 3, the infection started to appear in 2005 (5 years after planting), where it happened in interaction of windrow 2:1, non-poisoning and planting immediately (1.5%) and in the next year (2006), the infection started to appear in other treatment, and it happened in all sub-sub plot "planting immediately". In 2015 (15 years after planting), the combination of windrow 2:1, poisoning and fallow gave the best performance where its infection was about 19%. This condition was keep going until the last of observation and or at 20 years after planting.

Even though, at the last of observation, the ANOVA showed insignificance in all interaction treatment (Table 3). It showed that 20 years after planting, the best treatment was the combination of windrow 2:1, poisoning and fallowing with infection was about 37.50%. The worst combination was windrow 1:1, non-poisoning and planting immediately with infection was about 89%. It indicated that by using windrow 2:1 made seedlings had more distance from trunk/ inoculum source and poisoning trees could accelerate the decomposition so that the existence of inoculum source could be faster to disappear from the field. Accelerating decomposition by using poisoning, it relates to Paterson's investigation. Conversely, an oil palm trunk enriched with all the required nutrients is considered recyclable for fertilizing the field, although a small proportion of nutrients are released despite the fast degradation. The decomposition pattern shows that higher parts of the trunk have less lignin than basal segments. Using specific methods to pulverize and spread debris to accelerate degradation, waste can be managed along with *Ganoderma,* and other pests can be reduced but unfortunately this whole process tends to be uneconomic (Paterson, 2007).

In this experiment, for getting best performance, implementing windrow 2:1, poisoning and fallowing was not enough, because the replanting process must be conducted rightly. For example, all remnant's palms must be sanitized completely. According to Chung's (2011) reported that Ganoderma infection could be minimized by doing good sanitation at replanting thus, reducing the amount of Ganoderma inoculum within soil. Virdiana et al. (2011) said that poisoning the old stand of palms by injecting herbicides to increase the rate of decay and facilitate felling. After the felling process is conducted, then boles from all palms (whether infected or symptomless) are dug out and the boles and trunk materials are placed/stacked in windrows.

Table 4. F probability and LSD from Analysis of Variance at 20 years after planting

Source of variation	**F pr.**	**LSD**
Windrowing	0.12	0.08
Poisoning	0.10	0.09
Fallowing	<.001	0.07
Windrowing.Poisoning	0.98	0.10
Windrowing.Fallowing	0.41	0.09
Poisoning.Fallowing	0.20	0.11
Windrowing.Poisoning.Fallowing	0.37	0.13

Based on analysis of variance above, it was determined that sub-sub plot (fallowing) is the only main factor showed significance, while main plot and sub plot 1 has no significant effect whatsoever. The results can be seen on Table 5 and 6.

Table 5. The percentage of Ganoderma infection (%) of fallowing system treatment at 5-12 years after planting (2005-2012)

Fallowing	**Year of Observation**							
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Fallowing	**0.00a**	**0.00a**	**1.50a**	**3.63a**	**7.00a**	**11.60a**	**14.63a**	**18.63a**
Planting Immediately	**0.378b**	**1.13b**	**11.50b**	**20.63b**	**32.50b**	**41.75b**	**47.13b**	**51.13b**
LSD	0.00	0.01	0.02	0.04	0.02	0.03	0.04	0.05
CV(%)	66.70	55.09	5.40	17.30	14.90	15.20	15.30	15.20

Note: Means value followed by the same letter in the same column is not significantly different from level of 5% according to the duncan multiple distance test.

Table 5 showed that the Ganoderma infection started to appear at 7 years after planting (in 2007) and planting immediately was 2 years faster to show the infection. In the last of observation (20 years after planting) (Table 6), fallowing had been almost double lower than planting immediately. It indicated that he longer of fallow period will suppress the life cycle of Ganoderma in the soil, by giving space time during those time, there was no plant host and the field got sunlight exposure intensively. Fallowing gave space time for the field to be covered by weeds. Weeds which grew will encourage soil microbes to live with, especially for them which live in the surface of plant roots or rhizosphere. Fallowing was one of effort to help the field to get the soil condition be normal, where reducing the domination of Ganoderma appearance in the soil. Even though, it has not been proved properly but it could indicate that fallowing could cut the life cycle of Ganoderma. For completing the prove, the soil metagenomics needs to be conducted.

Table 6. The percentage of Ganoderma infection (%) of fallowing system treatment at 13-20 years after planting (2013-2020)

Fallowing	Year of Observation							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Fallowing	**20.38a**	**23.13a**	**26.50a**	**30.50a**	**36.13a**	**40.88a**	**44.25a**	**48.75a**
Planting Immediately	**55.75b**	**61.13b**	**67.25b**	**71.50b**	**76.88b**	**81.13b**	**83.25b**	**84.13b**
LSD	0.06	0.05	0.04	0.05	0.05	0.06	0.05	0.07
CV(%)	15.70	16.60	14.60	12.60	10.70	9.00	9.50	7.90

Note: Means value followed by the same letter in the same column is not significantly different from level of 5% according to the duncan multiple distance test.

Leaving fields fallow and promoting the establishment of biota unimpeded by tillage and other disruptive management practices not only results in drastic changes in plant communities, but also in soil quality and soil microbiomes. Levels of soil organic matter, nutrients, and microbial biomass increase in cultivated fields that are left fallow for extended lengths of time (Post et al., 2000; Howard et al., 2020) and these successional changes in soils may affect plant growth and resistance to herbivores (Howard & Kalske, 2018). The composition of soil microbiomes is also widely known to shift over ecological succession (Maharning et al., 2009), which is likely to affect the performance of the plants with which they interact. For example, the abundance of pathogenic fungi has been found to decrease over successional time in abandoned agricultural fields (Hannula et al., 2017), suggesting that these shifts are functional and may benefit plants over succession. Our recent work also suggests that these successional shifts in microbial communities may improve plants' resistance to herbivores (Howard et al., 2020).

Some aspects need to be concerned for implementing this method. First, the planting of seedlings will be late one year than normal and absolutely it affects the first harvesting time. Another risky is that operational must spend extra budget for controlling weeds which grow during fallowing time. For estate who has social issue, it will be more difficult to implement fallowing system, because letting the field without planting any kind of commodity will be very easy for people to claim it. So that, operational needs extra supervision to prevent it.

Conclusion

Combination of windrow 2:1 with poisoning and fallow promise new light on Ganoderma control, and its effect to be carefully observed for longer period. Treatment fallow only gave significant effect in 20 years of observation. Experiment to test fallow effect in poor drained soil to be conducted to learn whether fallow effect prevail in other condition. By the result of this experiment, fallowing is promising to be implemented into replanting procedure even though the first harvesting time will be late one year.

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