Basal Stem Rot Disease Eradication and Improving Production with Ganoderma Vaccine/Biofungicide CHIPS in Flooded Area of Oil Palm Plantation

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Abstract: Ganoderma has always been the main cause of basal stem rot (BSR) in many countries including Indonesia. Many approaches have been made, such as physical, chemical, and biology approaches using endophytic microorganisms. This study uses Ganoderma vaccine/ Biofungicide CHIPS to control Ganoderma and MOAF fertilizer as a nutrition source in oil palms that are severely infected by Ganoderma. Experiment is conducted in an oil palm plantation at Kecamatan Bilah Hilir, Kabupaten Labuhan Batu, Sumatera Utara, Indonesia. This plantation is a sandy mineral soil, which is a former swamp area. Because of the low contour of the land, the areas are often inundated by floods for more than 1 month from the end of the year to the beginning of the year. This study aims to eradicate basal stem rot (BSR) disease in the areas. Because of the flooded area, the soil is quite damp and equal dispersion of Ganoderma spores occurs massively throughout the whole area. We conducted the study for 4 years (2017 to 2020), using Ganoderma vaccine/Biofungicide CHIPS in 3 blocks: D4, D5, and C3 as study area and block C6 as control block (without CHIPS). Results of this study showed the productivity reached 79,12 to 94,02% of the PPKS (Indonesia Oil Palm Research Centre) standard production. Although in unfavorable environmental conditions, these numbers show a very satisfying result as it compensates for healthy normal oil palm production, while experiment blocks using inorganic fungicides and Trichoderma, the productivity decreased from year to year. The combined application of Organic fertilizer MOAF for nutrient sources with Ganoderma vaccine /Biofungicide CHIPS is very effective against the spread of basal stem rot (BSR) diseases in oil palms even in unfavorable environments as in flooded areas.

Key-Words: Basal Stem Rot Diseases, Ganoderma Vaccine, Biofungicide, CHIPS, Trichoderma, Oil Palm, Flood, Swamp

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) comes from tropical forests in West Africa. Oil palm was brought to Indonesia in 1884 as four oil palm seeds (two from Bourbon and two from Amsterdam) and was first planted in the Bogor Botanical Gardens. In 1858, 146 seeds from the Bogor Botanical Gardens were distributed to Java, Sumatra, Kalimantan, Sulawesi, Maluku, and Nusa Tenggara [1].
Oil palm plantations in Indonesia cover 19 provinces with a total planted area of 5.45 million ha in 2004. The province which has the largest area in Riau, namely 1.37 million ha or constitutes 25.15% of the total national oil palm areas followed by North Sumatera (17, 53%) and South Sumatera (9,46%). The island with the largest area of oil palm plantations is in Sumatera with 76,93% of the total area of Indonesian oil palm plantations [2]. Following the origin of oil palm from Africa, basal stem rot (BSR) disease was first discovered in 1915 in Zaire (Congo) and is considered not to cause significant harm economically [3]. Then in 1920, it was also reported to appear in West Africa. Apart from these two countries, BSR diseases were also reported in Angola, Cameroon, Ghana, Nigeria, Zambia, San Tome, Principe, Tanzania, and Zimbabwe. In these African countries, BSR diseases usually attack wild coconut trees in forests and old oil palms that are about 25 years old. It has also been reported that BSR has attacked oil palm trees that are younger (15-19 years) even though the incidence of the disease is very low. It is estimated that in the coming years the incidence of this disease will increase [4].

In 1931 BSR disease was reported to attack 25-year-old oil palms in Malaysia and is still considered an economically insignificant disease. It was not long before it was reported that it was attacking oil palm in Indonesia. In these two countries, oil palm is cultivated on a large scale and its climate is suitable for *Ganoderma* so that the spread of BSR disease is very rapid. Thus one of the main obstacles to the cultivation of oil palm in Indonesia at the moment is their pathogens. Among the diseases present in oil palm, *Ganoderma boninense* Pat. cause BSR in oil palm in Indonesia [3][5]. In several oil palm plantations in Indonesia, BSR has caused the death of up to 80% or more of the entire population of oil palm, resulting in a decrease in oil palm production per unit area [6]. It is believed that *Ganoderma boninense* only attacked old oil palm, but recently *Ganoderma boninense is known* to attack the immature oil palm plantations aged ≤1 year. The incidence of disease increases with the generation of oil palm plantations. Symptoms of the disease will appear more quickly and more severely in the second or third generation of oil palms. Disease occurrence in immature oil palm is in the first, second, third, and fourth generation is at 0,4%; 7%; and 11% respectively. Meanwhile, the production plants in the first, second, and third generations respectively were 17; 18, and 75% [7]. Due to the high incidence of Ganoderma disease in the third generation of oil palm, many plantations have to accelerate replanting even though the plants are only 17 years old, which should be able to reach a productive age of 25 to 30 years. BSR disease also appears evenly both in coastal areas and in inland areas [8]. In Asia, in addition to these two countries, BSR disease is also found in India [9] and Thailand [10].

Soil is one of the basic components in the development of oil palm plantations. An understanding of soil characteristics in oil palm plantations is needed as a basis for determining technical culture actions to be taken to ensure the sustainability of land productivity [11]. Sandy soils which are classified as sub-optimal soils are generally poor in nutrients and are not widely used as a medium for agricultural activities. However, from a chemical point of view, sand soil contains enough elements of potassium and phosphorus which are not ready to be absorbed by plants so this needs to be assisted by the fertilization process [12]. Sandy soil has a coarse texture and looks single grain which has a specific surface area (m2 / g) ranging from 0.0001 to 0.005 m2 / g [13]. Sandy soil has good drainage but poor water retention capacity besides sand soil does not have plasticity properties [13].

Mineral soils are formed by changes in chemical energy in systems that contain a liquid or gas phase. In terms of the mineral content structure consisting of stone, glass sand, cement rock, clay, and ashpaltum and mineral fertility contain phosphate, potassium carbonate (potash) [14].

Whether or not a business runs profitable depends on the costs incurred, production costs to support all crop activities and profits for farmers, besides that the costs cultivated must also be taken into account, because the costs incurred will affect the income that will be received by farmers [15].

2. Materials and Methods

2.1 Research Materials

Experiments were carried out on oil palm plants with the planting year 2011 which is located in oil palm plantations in the district. Bilah Hilir, Kab. Labuhan Batu, Sumatera Utara.

The research was conducted for 4 years, from 2017 to 2020, with the following treatments:

Table 1. Treatment of the blocks used in the study

Block	Area (Ha)	Population	Planting Year	Treatment	
				Fertilizer	Fungicide
E1	34,71	4.784	2011	NPK, Dolomite	Biofungicide Trichoderma
D4	32,64	4.562	2011	MOAF	Biofungicide CHIPS
D5	38,29	5.385	2011	MOAF	Biofungicide CHIPS
C3	51,00	7.185	2011	MOAF	Biofungicide CHIPS
C6 (K*)	31,40	4.157	2011	Inorganic	Inorganic Fungicide

Fertilization in block E1 is carried out by sprinkling fertilizer evenly on the plate, after 10 days of fertilization followed by the application of Trichoderma Biofungicide, with the following dosage:

Table 2. Dosage of NPK Fertilizer and Trichoderma Biopesticide

No	Type of Fertilizer and Biofungicide	Dose	Rotation /Year
1	NPK 13-6-27	2,50 Kg/Tree	2
2	Dolomite	1,00 Kg/Tree	2
3	Trichoderma	0,40 Kg/Tree	2

The application of the Ganoderma / Biofungicide Vaccine CHIPS was carried out on all trees in blocks C3, D4, and D5, not only on plants with Ganoderma fruit bodies. For plants that contain Ganoderma bodies, first, clean them at the base of the stem, then attach the Ganoderma Vaccine / Biofungicide CHIPS to the base of the stem and cover with a little soil. Before the application of biofungicide CHIPS, it is necessary to ensure the condition of the disc is already in a clean state, with no midrib rot, root rot, and no basidiocarp that grows at the base of the palm tree trunk.

The Ganoderma Vaccine / Biofungicide CHIPS application is carried out once a year, the application is carried out in early January. The use of biofungicide CHIPS combined with the use of organic fertilizers MOAF as a source of nutrients and nutrients to oil palm. Fertilization is carried out twice a year, at the beginning of the rainy season (September-November) and at the end of the rainy season (March-April). With fertilizers and bio pesticides such as in Table 3.

Table 3. Dosage of MOAF Fertilizer and Ganoderma Vaccine / Biopesticide CHIPS

No	Type of Fertilizer and Biofungicide	Dose	Rotation /Year
1	MOAF 1	2,00 Kg/Tree	1
2	MOAF 2	2,00 Kg/Tree	1
3	MOAF 3	2,00 Kg/Tree	1
4	CHIPS	2,00 Kg/Tree	1

Meanwhile, the application of inorganic fertilizers and chemical pesticides in block C6 is carried out twice a year, at the beginning of the rainy season (September-November) and at the end of the rainy season (March-April) with doses of fertilizers and pesticides as in table 4.

Table 4. Dosage of Inorganic Fertilizers and Fungicides

No	Type of Fertilizer and Fungicide	Dose	Rotation/ Year
1	Urea	2,80 Kg/Tree	2
2	KCL/MOP	2,75 Kg/Tree	2
3	Boron	0,08 Kg/Tree	1
4	Rock Phosphate	1,58 Kg/Tree	1
5	Kieserit	0,33 Kg/Tree	2
6	Inorganic Fungicide	0,40 Kg/Tree	2

Observations were made on the productivity of oil palm plantations every year from 2017 to 2020. Growth and generative development of oil palm was observed and accumulated at the end of the year. Other observations were made by observing the vegetative growth of oil palm, such as the condition and color of the leaves, the condition of the midrib, the development of the spear leaves, the roots of the plants since the first month after application. In this study, Ganoderma control was carried out in an integrated manner by removing the propagule source, suppressing the development and activity of Ganoderma, increasing immunity and plant health, especially roots thus increasing plant productivity. This approach is expected to be able to reduce the mortality rate of plants and extend the life span of the plants, to maintain and increase the productivity of oil palm that is infected by Ganoderma.

2.2 Research methods

2.2.1 Method of collecting data

In this study, the data required are primary and secondary. Primary data obtained directly through observation and direct interviews. Secondary data were obtained from several instances.

2.2.2 Data analysis method

Data were analyzed using the method of Revenue Cost Ratio (R / C), to test the feasibility of using the Ganoderma vaccine / Biofungicide CHIPS through income earned from the crop each year (2017 to 2020).

According to Hermanto, to find out the R / C ratio using the formula:

$$R/C\ ratio = \frac{TR}{TC}$$

Remarks:

R/C ratio	= Revenue Cost R ratio
TR	= Total Revenue
TC	= Total Cost

R / C ratio assessment criteria:
R / C <1, means that the business has suffered a loss / is not worth running
R / C> 1, it means that the business is profitable /worth working on
R / C = 1, which means that the business breaks even [16].

3. Results and Discussion

The experimental plantation area is a former swamp with wavy, low land contours, and sandy mineral soils. BSR caused by Ganoderma has been infecting this plantation for a long time. However, it still produces fruit, mostly male inflorescences are more than the female inflorescences. Previously, Ganoderma control was carried out chemically. Based on field observations, significant differences are seen in the productivity of the oil palm plantations and the condition of the plants using CHIPS and inorganic fungicides.
Soils with sandy soil textures tend to have a higher incidence of basal stem rot disease. This is greatly influenced by the nature of the soil matrix [17]. The rate of Ganoderma infection rate in sandy soil is due to the physical properties of loose sandy soil or high porosity so that the plant roots will move more quickly to the source of the Ganoderma inoculum. Soil chemical properties that affect the rate of Ganoderma infection in the soil is pH. Apart from soil conditions, climate can also affect the spread of Ganoderma.

The results of vegetative and generative growth after the application of CHIPS to oil palms are significant compared to oil palms that are not given CHIPS. Experiments were observed for 4 consecutive years. BSR is a major problem in Indonesian palm oil production. BSR disease first appeared in Indonesia in 1931 and has caused 50% of deaths in oil palm plantations in North Sumatera [18]. Common approaches for BSR disease are extraction, land clearing by burning, and the use of synthetic fungicides. A recent approach is to use biological agents as antagonistic endophytic microbes of *G. boninense* [19].
Based on rainfall data for 4 years (2017 to 2020), the number of wet months, dry months, and humid months are calculated by using calculations according to the theory of Schmidt & Ferguson. The Schmidt-Ferguson climate classification is based on the relationship between wet months and dry months [20]. This relationship is given the symbol Q.

$$Q = \frac{Total\ dry\ month}{Total\ wet\ month}\ x\ 100\%$$

Table 5. Rainfall from year 2017 to 2020

MONTH	**YEAR (mm/month)**			
	2017	**2018**	**2019**	**2020**
Jan	105	295	216	187
Feb	64	123	87	102
Mar	93	75	66	96
Apr	195	125	238	174
May	75	252	98	79
Jun	6	150	138	101
Jul	38	142	82	65
August	102	119	109	100
Sept	197	323	261	201
Oct	194	319	302	241
Nov	274	368	280	328
Dec	100	267	198	206
Average	120,3	213,2	172,9	156,7

Table 6. Climate Type according to Schmidt & Ferguson

Zone	**Dry Month**	**Q value**	**Climate Condition**
A	<1,5	<0,14	Very Wet
B	1,5 - 3,0	0,14 - 0,33	Wet
C	3,0 - 4,5	0,33 - 0,60	Rather Wet
D	4,5 - 6,0	0,60 - 1,00	Medium
E	6,0 - 7,5	1,00 - 1,67	Rather Dry
F	7,5 - 9,0	1,67 - 3,00	Dry
G	9,0 - 10,5	3,00 - 7,00	Very Dry
H	>10,5	>7,00	Extraordinarily Dry

(Source: Lakitan, 1997:40-41)

Based on Table 5, the calculation of the value of Q = 0,091- 0,5, shows that the climate in the experiment area belongs to zone Cto A that is rather wet to very wet.

Figure 1. The condition of the garden was flooded

Based on rainfall data from 2017 to 2020, it can be seen that this research area often rains which causes this area to be inundated with water for up to 1 full month from the end of the year to the beginning of the year. Several factors affect the productivity of oil palm: climate, area shape, soil conditions, planting material, and cultivation technique [21]. Furthermore, Risza states that plant age, total plant population per hectare, soil preservation systems, pollination systems, harvest-transport coordination systems, production security systems, and harvest wages systems also affect oil palm productivity [22].

Based on the factors that affect the productivity of oil palm plantations, experiment with the use of biofungicide CHIPS combined with organic fertilizer MOAF still work optimally for oil palm that is infected by Ganoderma severely, moreover, the condition of the soil, climate, and the shape of the region that is in unfavorable circumstances compared to the area that uses inorganic fungicide and inorganic fertilizers. If a significant decrease in production occurs simultaneously and continuously on the plantation area, it can cause a huge loss economically. Inorganic fungicide use in the long term will give a negative impact on the environment such as harmful to non-pathogenic organisms, toxicity in humans, animals, and resistance to pathogens [23].

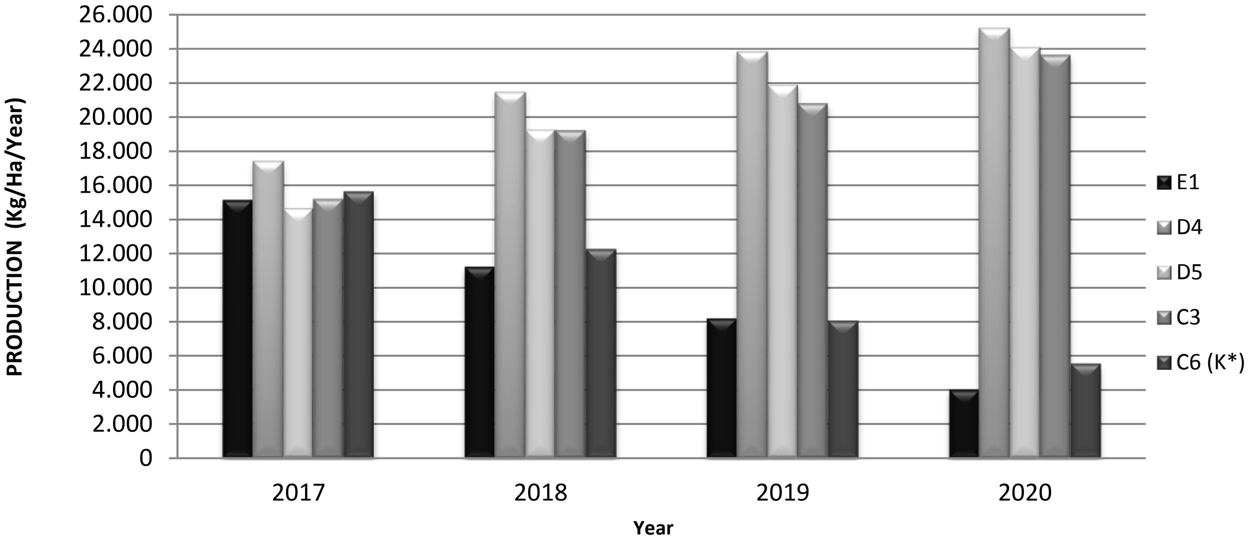
Production results from 2017 to 2020 can be seen in table 6. The table shows a high increase in productivity on land using the biofungicide CHIPS

Table 7. Production Results (Fresh Fruit Bunch) 2017 to 2020

No	Area	Block	Area (Ha)	TT	Type of Seed	Fresh Fruit Bunch (Kg/Ha/Year)							
						2017		2018		2019		2020	
						P	R	P	R	P	R	P	R
1	Kec. Bilah Hilir, Sumatera Utara	E1	34,71	2011	DxP Sucofindo	18.500	15.115	23.000	11.206	25.500	8.185	28.000	4.021
2		D4	32,64				17.393		21.478		23.848		25.215
3		D5	38,29				14.638		19.236		21.853		24.059
4		C3	51.00				15.238		19.847		20.804		23.630
5		C6 (K*)	31,40				15.634		12.272		8.076		5.556

Information :
*K * : Control*
P : PPKS (Indonesia Palm Oil Research Centre) Production Standards
R : Production Result
TT : Year of Planting

In table 7, we can see the comparison of the number of oil palm plantations applied by CHIPS, Trichoderma, and control blocks (inorganic fungicide applications). In the research block that was previously attacked by Ganoderma, it was severe enough to damage plants and affect the productivity of oil palm plants, but it gradually improved after the application of CHIPS, this can be seen from the vegetative and generative development of oil palm plants. From 2017 to 2020, the production of research blocks (D4, D5, and C3) experienced a higher increase compared to the production of control blocks & Trichoderma application blocks. For more details, see the comparison chart of production results for 4 years.



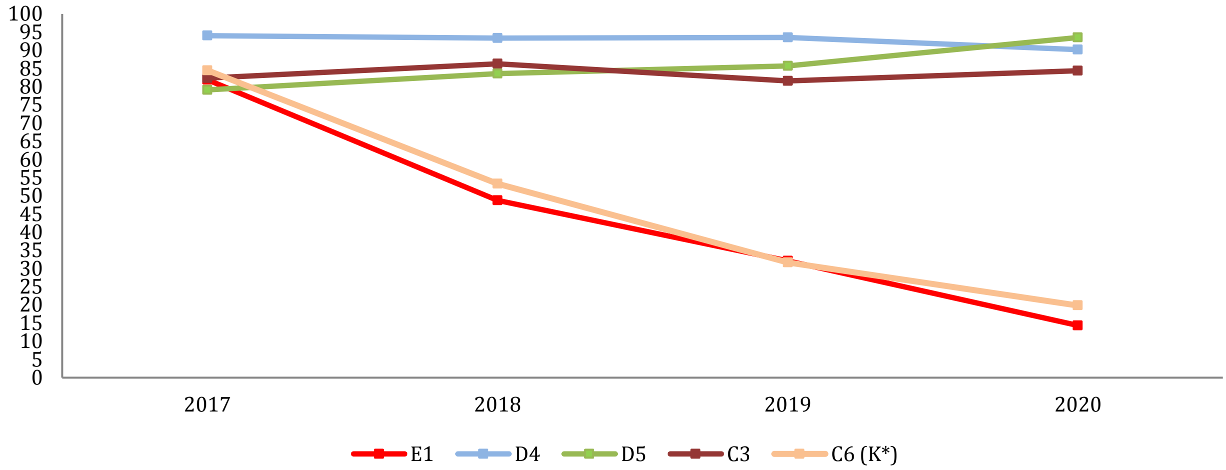
Graph 1. Comparison of production output for 4 years

In the graph above, it can be seen that the number of oil palm plantations applied with Trichoderma and Inorganic Fungicides has decreased productivity every year, while the blocks that have been applied with the Ganoderma CHIPS vaccine have increased production.

Table 8. Percentage of Experiment Production with PPKS (Indonesia Palm Oil Research Centre) Production Standard

Block	**Percentage (%) PPKS Production Standard**			
	2017	**2018**	**2019**	**2020**
E1	81,92	48,72	32,10	14,36
D4	94,02	93,38	93,52	90,18
D5	79,12	83,63	85,70	93,52
C3	82,37	86,29	81,58	84,39
C6 (K*)	84,51	53,36	31,67	19,84

The table above shows that after the application of the biofungicide CHIPS (2017 - 2020) to oil palm that is infected by Ganoderma severely with unfavorable environmental conditions, the less profitable areas are still able to produce production close to the production standards set by PPKS (Indonesia Palm Oil Research Centre) for healthy normal oil palms. The experiment production percentages are from 79,12 % to 94,02%. Application of biofungicide CHIPS can maintain and increase productivity, whereas the control block has decreased production with PPKS standard from year to year. For more details, it can be seen in graph 2.



Graph 2. Comparison of 2017 to 2020 production yields against PPKS standards

The graph shows that there is a decrease in the percentage of increased production in the experiment block and it occurred in block C3, this was because oil palm in block C3 experienced the most severe Ganoderma infection compared to the other two experiment blocks. Meanwhile, when compared to the control block and the Trichoderma application block, the three research blocks had a higher Ganoderma infection rate, as seen in table 9. A decrease in production can occur due to the lack of nutrients and nutrients needed for productivity, especially in plants that are infected by Ganoderma, nutrient deficiency can also be caused by environmental conditions that are often rainy and inundated by water so that fertilizers are carried away by water and application of inorganic and Trichoderma to control Ganoderma also washed away by the water, this can occur because of the conditions of plantation land is sandy mineral soil. In addition, the decline in oil palm productivity could be due to a reduced plant population due to fallen trees being infected by Ganoderma. In the observation results, there are several fallen trees, it can be seen in Figure 2. If basidiocarp grows around the base of the trunk or palm tree, the xylem and phloem tissue at the roots and stems are dead and not functioning thus within 6-12 months the plants will completely fall and die [24].

However, the application of biofungicide CHIPS can maintain and even increase production. It can occur due to improving conditions in Ganoderma infected oil palm by having sufficient nutrients sources.

Table 9. Levels of Ganoderma Stadium

Block	Area (Ha)	Population	Planting Year	Ganoderma Stadium
E1	34,71	4.784	2011	2
D4	32,64	4.562	2011	2-3
D5	38,29	5.385	2011	2
C3	51,00	7.185	2011	3-4
C6 (K*)	31,40	4.157	2011	2-3

Figure 2. Fallen tree due to Ganoderma attack on the control block

Leaf and midrib conditions

The leaf color showed that there was a striking difference in the color between before and after the application of CHIPS. From the observations made on the color of the leaves before the application of CHIPS, they are pale green to yellowish, but after application, the color of the leaves changes to a bright green color. Apart from leaf color, there are 1-3 spear leaves and broken midribs on each oil palm that is attacked by Ganoderma. The use of CHIPS has proven to have improved the condition of oil palm by opening the spear leaves and reducing broken fronds. Differences show in figure 3. Symptoms of Ganoderma infection in juvenile plants are indicated by yellowing of all the fronds, while in older plants that are infected by Ganoderma, the fronds will hang or get stuck. Based on the severity of the attack in Figure 3, BSR disease is more difficult to observe externally in the early stage than in the severe stage. This is due to the slow progression of the disease. External symptoms are difficult to observe in an early stage because it shows similar characteristics with the condition of the palm oil with water deficit, nutrient deficits, stagnant or termite attack symptoms. External symptoms are more easily observed in adult plants through dry midrib and spear leaf that does not open [24] .

Figure 3. Comparison of Plant Conditions

Figure 4. Ganoderma Fruit Body

Ganoderma fruit bodies were found at the base of several plant stems, as *shown in Figure 4*. This shows that Ganoderma infection on the oil palm is quite severe. By the time the crown symptoms appear and can be observed, half of the tissue in the base of the stem has died as a result of Ganoderma infection. In the rotten tissue, it will be light brown followed by a dark area like a ribbon shadow or marked by the appearance of the fruiting body [24].
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Root conditions

In the observations made in 2018, the growth of the roots of oil palm has progressed quite well, as evidenced by the growth of new roots, as can be seen in *Figure 5*. The growth of new roots helps plants to absorb water and soil nutrients to meet plant needs. The growth of new roots also gives the plant the possibility to survive for a longer time.

Figure 5. New Roots Growth

Oil palm plant care

Table 10. Estimated Cost of Maintenance

A. Cost of MOAF and CHIPS

No	Activites	Tree/Ha	Norm		Rotation	Amount	Unit Price	Total cost
1	**Fertilization**	128						
	M1		2	Kg/Tree	1	256,00	Rp 7.200,00	Rp 1.843.200,00
	Labor		0,54	WD/Ha	1	0,54	Rp 81.500,00	Rp 44.010,00
	M2		2	Kg/Tree	1	256,00	Rp 7.200,00	Rp 1.843.200,00
	Labor		0,54	WD/Ha	1	0,54	Rp 81.500,00	Rp 44.010,00
	M3		2	Kg/Tree	1	256,00	Rp 7.700,00	Rp 1.971.200,00
	Labor		0,54	WD/Ha	1	0,54	Rp 81.500,00	Rp 44.010,00
	CHIPS		2	Kg/Tree	1	256,00	Rp	Rp

							12.500,00	3.200.000,00
	Labor (piled up at the base of the stem)		6	WD/Ha	1	6,00	Rp 81.500,00	Rp 489.000,00
2	**Raking**		3,2	WD/Ha	2	6,40	Rp 81.500,00	Rp 521.600,00
3	**Production Path**							
	Labor		0,33	WD/Ha	3	0,99	Rp 81.500,00	Rp 80.685,00
	Herbicide Roundup Power Max		0,25	Liter/Ha	3	0,75	Rp 70.000,00	Rp 52.500,00
	Herbicide Metafuron		6,25	Liter/Ha	3	18,75	Rp 165,00	Rp 3.093,75
4	**Inter-Row Mow**							
	Labor		2,17	WD/Ha	3	6,51	Rp 81.500,00	Rp 530.565,00
5	***Pruning***							
	Labor		128	Tree/WD	1	128,00	Rp 1.400,00	Rp 179.200,00
6	**Harvest**							
	Labor		-	-	-	17.393,00	Rp 205,00	Rp 3.565.565,00
	Transport FFB		-	-	-	17.393,00	Rp 95,50	Rp 1.661.031,50
							TOTAL COST	**Rp 16.072.870,25**

B. Cost of Inorganic Fertilizer and Fungicide Inorganic

No	Activites	Tree/Ha	Norm		Rotation	Amount	Unit Price	Total Cost
1	**Fertilizer**	128						
	Urea		2,8	Kg/Tree	2	716,80	Rp 5.400,00	Rp 3.870.720,00
	Labor		0,5	WD/Ha	2	1,00	Rp 81.500,00	Rp 81.500,00
	KCL/MOP		2,75	Kg/Tree	2	704,00	Rp 6.700,00	Rp 4.716.800,00
	Labor		0,5	WD/Ha	2	1,00	Rp 81.500,00	Rp 81.500,00
	Boron		0,08	Kg/Tree	1	10,24	Rp 12.000,00	Rp 122.880,00
	Labor		0,5	WD/Ha	1	0,50	Rp 81.500,00	Rp 40.750,00
	Rock Phosphate		1,58	Kg/Tree	1	202,24	Rp 3.000,00	Rp 606.720,00
	Labor		0,83	WD/Ha	1	0,83	Rp 81.500,00	Rp 67.645,00

	Kieserit		0,33	Kg/Tree	2	84,48	Rp 2.600,00	Rp 219.648,00
	Labor		0,5	WD/Ha	2	1,00	Rp 81.500,00	Rp 81.500,00
	Fungicide Inorganic		0,4	Kg/Tree	2	102,40	Rp 11.500,00	Rp 1.177.600,00
	Labor (piled up at the base of the stem)		6	WD/Ha	1	6,00	Rp 81.500,00	Rp 489.000,00
3	**Chemist Spray+ Production Path**							
	Labor		0,33	WD/Ha	3	0,99	Rp 81.500,00	Rp 80.685,00
	Herbicide Roundup Power Max		0,25	Liter/Ha	3	0,75	Rp 70.000,00	Rp 52.500,00
	Herbicide Metafuron		6,25	Liter/Ha	3	18,75	Rp 165,00	Rp 3.093,75
4	**Inter-row Mow**							
	Labor		2,17	WD/Ha	3	6,51	Rp 81.500,00	Rp 530.565,00
5	***Pruning***							
	Labor		128	Tree/WD	1	128,00	Rp 1.400,00	Rp 179.200,00
6	**Harvest**							
	Labor		-	-	-	15.634,00	Rp 205,00	Rp 3.204.970,00
	Transport FFB		-	-	-	15.634,00	Rp 95,50	Rp 1.493.047,00
							TOTAL COST	**Rp 17.100.323,75**

C. Cost of NPK fertilizer and Biofungicide Trichoderma

No	Activities	Tree/Ha	Norm		Rotation	Amount	Unit Price	Total Cost
1	**Fertilizer**	128						
	NPK 13-6-27		2,5	Kg/Tree	2	640,00	Rp 5.575,00	Rp 3.568.000,00
	Labor		0,5	WD/Ha	1	0,50	Rp 81.500,00	Rp 40.750,00
	Dolomite		1	Kg/Tree	2	256,00	Rp 850,00	Rp 217.600,00
	Labor		0,5	WD/Ha	1	0,50	Rp 81.500,00	Rp 40.750,00
	Trichoderma		0,4	Kg/Tree	2	102,40	Rp 11.000,00	Rp 1.126.400,00
	Tenaga Kerja (dilakukan		6	WD/Ha	1	6,00	Rp 81.500,00	Rp 489.000,00

	timbun di pangkal batang)							
2	**Chemist Spray +Production Path**							
	Labor		0,33	WD/Ha	3	0,99	Rp 81.500,00	Rp 80.685,00
	Herbicide Roundup Power Max		0,25	Liter/Ha	3	0,75	Rp 70.000,00	Rp 52.500,00
	Herbicide Metafuron		6,25	Liter/Ha	3	18,75	Rp 165,00	Rp 3.093,75
3	**Inter-row mow**							
	Labor		2,17	WD/Ha	3	6,51	Rp 81.500,00	Rp 530.565,00
4	***Pruning***							
	Labor		128	Tree/WD	1	128,00	Rp 1.400,00	Rp 179.200,00
5	**Harvest**							
	Labor		-	-	-	15.115,00	Rp 205,00	Rp 3.098.575,00
	Transport FFB		-	-	-	15.115,00	Rp 95,50	Rp 1.443.482,50
							TOTAL COST	**Rp 10.870.601,25**

*WD: Working Days
*FFB: Fresh Fruit Bunch

The table above shows the cost of maintaining 1 year of oil palm plantations for 1 ha of plantation land in the block applied CHIPS, inorganic fungicides, and Trichoderma. According to Antoni, the costs in producing oil palm include Plant maintenance costs, such as: eradicating weeds, fertilizing, eradicating pests and diseases, basic shoots, consolidating, maintaining teras and hooves, and maintaining infrastructure. Harvest costs or costs to accelerate all activities to release production (FFB) or crops from the field (area) to collectors or factories such as harvest labor costs, procurement costs, work tools, and transportation costs [25]. Maintenance costs for productive plants (TM) and harvest costs are components of production costs that determine the level of income received by farmers [26].

From the table above, we can see that the cost of maintaining oil palm plants using Trichoderma is cheaper than using CHIPS and inorganic fungicides. However, this is not good news, because, with the low cost of controlling Ganoderma using Trichoderma, the yield of oil palm also low, the reason is that it decreases every year, while the cost of controlling Ganoderma using inorganic fungicides is higher than the CHIPS application. but the production yield is lower than that of the CHIPS application.

To determine the success of controlling Ganoderma by using the biofungicide CHIPS, Trichoderma, and inorganic fungicides, it can be seen from the benefits given. The selling price of oil palm FFB based on market price data for Sumatra's plantation commodities can be seen in table 10. The obstacle faced by farmers is uncertainty in FFB prices due to unstable world oil prices. The decline in oil prices affects the income of farmers.

Table 11. Cost estimation of FFB Price from 2017 to 2020

Year	2017	2018	2019	2020
FFB Price	Rp 1.718	Rp 1.385	Rp 1.523	Rp 2.008

Source : info sawit

From the estimated FFB price in 2017 to 2020, a comparison of the R/C for the application of Ganoderma/ CHIPS Vaccines, Trichoderma and inorganic fungicides is obtained as shown in table 15. Analysis of the CHIPS in farming busines generally provides large profits, which is reflected in the R/C>1 (Revenue Cost Ratio), where income from the harvest is greater than maintenance costs in 1 year.

Table 12. Revenue & Cost of Trichoderma application for 4 years

Blok	2017		2018		2019		2020	
	R	C	R	C	R	C	R	C
E1	Rp 25.967.570	Rp 10.870.601,25	Rp 15.520.310	Rp 9.695.946,75	Rp 12.465.755	Rp 8.788.136,25	Rp 8.074.168	Rp 7.536.854,25

Table 13. Revenue & Cost of CHIPS application for 4 years

Blok	2017		2018		2019		2020	
	R	C	R	C	R	C	R	C
D4	Rp 29.881.174	Rp 16.072.870,25	Rp 29.747.030	Rp 17.300.412,75	Rp 36.320.504	Rp 18.012.597,75	Rp 50.631.720	Rp 18.423.381,25
D5	Rp 25.148.084	Rp 15.244.992,75	Rp 26.641.860	Rp 16.626.691,75	Rp 33.282.119	Rp 17.413.100,25	Rp 48.310.472	Rp 18.076.003,25
C3	Rp 26.178.884	Rp 15.425.292,75	Rp 27.488.095	Rp 16.810.297,75	Rp 31.684.492	Rp 17.097.875,75	Rp 47.449.040	Rp 17.947.088,75

Table 14. Revenue & Cost Trichoderma application for 4 years

Blok	2017		2018		2019		2020	
	R	C	R	C	R	C	R	C
C6	Rp 26.859.212	Rp 17.100.323,75	Rp 16.996.720	Rp 16.090.042,75	Rp 12.299.748	Rp 14.829.144,75	Rp 11.156.448	Rp 14.071.884,75

Table 15. Ratio R/C

Block	**2017**	**2018**	**2019**	**2020**
E1	2,39	1,60	1,42	1,07
D4	1,86	1,72	2,02	2,75
D5	1,65	1,60	1,91	2,67
C3	1,70	1,64	1,85	2,64
C6	1,57	1,05	0,83	0,79

Based on the R/C comparison above, the feasibility test for the application of CHIPS as a Ganoderma controller shows a number above 1 in all blocks that are applied to CHIPS, even up to 2.75, this shows that the application of CHIPS can provide considerable benefits. When compared with blocks that use inorganic fungicides R/C, the number is above 1 but continues to decrease every year, while blocks that are applied to Trichoderma only meet eligibility in 2017 of 1.57 and 2018 of 1.05 while in 2019 and 2020 R/C of Trichoderma application below 1 can be seen in table 15, this shows that the application of Trichoderma has suffered losses. This can also occur in the application of inorganic fungicides as it also decreases every year. Farming is said to be successful if it at least can generate enough income to pay for the costs of all equipment treated, capital interest, wages for the work of farmers and their families that are used for farming properly and can maintain farming conditions at least in their original state [27].

4. Conclusion

The study was conducted from 2017 to 2020 in a 188.04 Ha oil palm plantation located in the District of Bilah Hilir, Labuhan Batu Regency, Sumatera Utara, Indonesia. The results of the application of Ganoderma Vaccine/Biofungicide CHIPS are very effective and efficient in eradicating Ganoderma in sandy mineral soils which are former swamp areas and are flooded for up to 1 full month from the end of the year to the beginning of the year And when combined with MOAF fertilizer, it can increase the productivity of oil palm plants.

It can be seen from the amount of productivity of oil palm plants produced every year that can cover the cost of plant maintenance and provides a large profit every year with the Ganoderma Vaccine /CHIPS Vaccine compared to the application of inorganic fungicides and Trichoderma.

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