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A Comparative Analysis of Performance and Environmental Variables between the Use of Organic and Inorganic Fertilizers in Palm Oil

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Abstract- Oil palm industrial waste has caused serious pollution to the environment, especially to the air environment, due to the release of Nitrogen oxide (N2O), methane (CH4) and carbon dioxide (CO2) gas. In addition to polluting the air, these three gases have caused global warming, which increased the average temperature of the earth's surface due to excessive concentrations of greenhouse gases. This study aims to analyze the effect of using Empty Fruit Bunches(EFB) compost on the cost of fertilizer use at PT Eastern Sumatra Indonesia, the effect of using EFB compost on productivity at PT Eastern Sumatra Indonesia and the effect of using EFB compost on GHG values at PT Eastern Sumatra Indonesia. This study uses secondary data. The data needed is the cost of using organic and inorganic fertilizers, oil palm productivity, GHG values from 2014-2019 per semester. The results showed that the use of EFB compost as organic fertilizer had a significant effect on the cost of using fertilizer at PT Eastern Sumatra Indonesia. However, it has no significant effect on productivity. Yet, the use of EFB compost as organic fertilizer has a significant effect on GHG values in PT Eastern Sumatra Indonesia.

Keywords: Oil palm, Performance, Environment, Organic Fertilizer, Inorganic Fertilizer

I. INTRODUCTION

Indonesian main plantation crop as an export commodity is palm oil so that the area of oil palm plantations and productionsincrease every year, either insmallholder, state, or national private plantation. Progress data on the number of oil palm productions, exports and plantation can be seen in Table 1.

Table 1.Progress on the number of Indonesian oil palm productions, exports and plantations in 2009-2017

Description	Year								
	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production (million tons CPO)	19,3	21.96	23,1	26,0	27,8	29,3	31,1	31,7	38,0
Export (million tons CPO)	16,8	16,3	16,4	18,9	20,6	22,9	26,5	22,8	27,4
Export (Million US Dollar)	10,4	13,5	17,3	17,6	15,8	17,5	15,4	14,4	18,5
Area (Million ha)	7,9	8,4	9	9,6	10,5	10,7	11,2	11,2	14,1

Source : Ditjenbun, 2018

From Table 1, it can be seen that in the period of 9 years, from 2009 – 2017, the production of national palm oil CPO has almost doubled, which was from 19.3 million tonnes in 2009 to 38.0 million tonnes in 2017. Its contribution to export value also increased from US $ 10.4 million in 2009 to US $ 18.5 million in 2007. Meanwhile, oil palm plantations increased from 7.9 million ha in 2009 to 14.8 million ha in 2017 (Directorate General of Plantation, 2018). Productions and plantations are predicted to continually increase in line with both of the high expansion of oil palm plantations and the number of people (farmers) who manage oil palm trees.

The increasing of palm oil productions has made serious consequences of an increase in industrial waste, not only solid and liquid waste but also gas waste. Palm oil industrial waste has caused serious environment pollution, especially to the air environment, due to the release of methane (CH4) and carbon dioxide (CO2) gas. Beside polluting the air, these two gases have caused global warming, which increase the average temperature of the earth's surface due to excessive concentrations of greenhouse gases (Environment, 2016). Therefore, it needs efforts to process and utilize palm oil industrial waste so there will no negative impacts on the environment, as well as to provide economic benefits. The negative impact resulted is the effect of green house gas (GHG). With the reduction in GHG value, companies can get ISCC (International Sustainability and Carbon Certification) certification. ISCC is the first international standard certification system, which is claimed to prove sustainability and traceability as well as savings from greenhouse gases, for all types of biomass production (second generation renewable energy). Through the ISCC scheme, certified CPO will receive a premium price incentive of US $ 20-US $ 30 / Ton in the global market. The existence of ISCC certification comes from the need for environmentally friendly bio energy. It is also needed to suppress the effects of GHG which will cause global warming. Therefore, the existence of ISCC certification can be applied to all types of vegetable oil (Info Sawit, 2018).

One of the most types of solid waste produced by palm oil mills is empty fruit bunches (EFB), which can reach 22-23% of the total processed fresh fruit bunches (FFB) (Fauzi et al., 2012). So it is estimated that the amount of EFB waste throughout Indonesia in 2017 would have reached around 38.0 million tons. To make this enormous amount of EFB waste does not cause environmental problems, it is necessary to have good management to carry it out. One of the alternative ways of managing EFB is composting, so that the waste can be used as organic fertilizer (Fauzi et al., 2012).

PT Eastern Sumatra Indonesia (PTESI) is an oil palm plantation company located in Pematang Syahkuda Village, Gunung Malela District, Simalungun Regency, North Sumatra Province. The company

manages 3000 ha of oil palm plantation, and has a Palm Oil Mill (POM) unit to process fresh fruitbunches (FFB) into CPO and PK with a capacity of 30 tons / hour.

PT ESI has been producing compost from EFB using an aerobic system since 2016. The EFB compost has been applied to oil palm trees as a single or mixed fertilizer which will reducethe use of inorganic fertilizers directly. This compost can be produced and used continuously in the long term because the raw materials will always be available from POM. Therefore, it is necessary to know how far of which the economic and environmental impacts of using EFB compost on the company.So the writers are interested in conducting research with the title: **Comparative Analysis of Performance and Environmental Variables Between the Use of Organic and Inorganic Fertilizers at PT Eastern Sumatra Indonesia.**

II. METHODOLOGY

This research uses descriptive quantitative method.

It was conducted at PT Eastern Sumatra Indonesia, Pematang Syahkuda Village, Gunung Malela District, Simalungun Regency, North Sumatra Province from December 2019 to January 2020.

The type of data collected in this research consists of secondary data. These data were obtained from PT. Eastern Sumatra Indonesia with the documentation method. The requireddata in this reasearchare the costs of using organic and inorganic fertilizers, oil palm productivity and GHG values.

The data analysis technique used is by using linear regression method by analyzing data per semester from 2014-2019.

III. RESULT

The results obtained from this research are as follows:

The Use of Organic Fertilizer at PT. Eastern Sumatra Indonesia

PT. Eastern Sumatra Indonesia usesorganic fertilizers, i.e. EFB compost.It is processed into compost with a ratio of 1 ton EFB to produce 0.187 tonnes of compost (18.7%). The amount of organic fertilizer use in each month during 2014 - 2019 can be seen in Table 2.

Table 2.The amount of EFB compost organic fertilizer use at PT. Eastern Sumatra Indonesia, Per Semester in 2014 -2019

Year	Semester	Number of Applications (Tons)	Size Applications (Ha)	Dosage Application (tonnes / ha)
2014	I	10349.00	352.12	177.47
	II	9778.00	356.77	159.53
	Total	20127.00	708.89	337.00
2015	I	8707.00	312.70	166.22
	II	11145.00	387.86	172.05
	Total	19852.00	700.56	338.27
2016	I	7910.00	267.83	177.39
	II	8983.00	303.39	180.51
	Total	16893.00	571.22	357.89
2017	I	5872.00	198.40	181.14
	II	6489.00	202.30	194.95
	Total	12361.00	400.70	376.09
2018	I	6011.00	219.44	165.85
	II	11691.00	372.19	189.05

	Total	17702.00	591.63	354.91
2019	I	9721.00	305.18	191.50
	II	12504.00	386.16	196.39
	Total	22225.00	691.34	387.89
Average	Average	9096.67	305.36	179.34

For more details, the progress of EFB compost use from 2014 - 2019 can be seen in Figure 1.

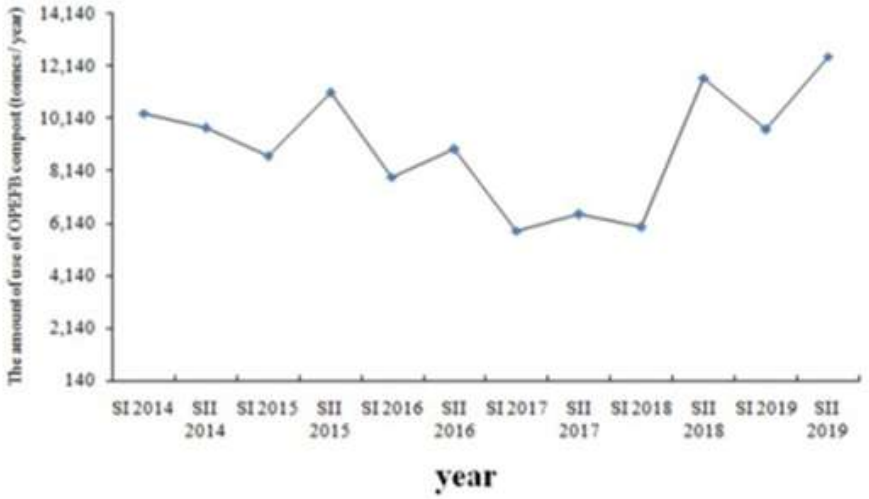

Figure 1. The Progress of EFB Compost Use at PT. Eastern Sumatra Indonesia, 2014-2019

Table 3.The Costs for using organic fertilizer EFB compost at PT. Eastern Sumatra Indonesia, 2014– 2019

Year	Semester	OPEFB Compost Costs (Rp)	Large Application (ha)	Cost Per Hectare (Rp / ha)
2014	I	54,763,707.35	352.12	155,525.69
	II	36,568,825.88	356.77	102,499.72
	Total	91,332,533.23	708.89	128,838.79
2015	I	43,020,692.54	312.70	137,578.17
	II	46,118,089.71	387.86	118,903.96
	Total	89,138,782.25	700.56	127,239.33
2016	I	40,655,939.99	267.83	151,797.56
	II	33,486,959.43	303.39	110,375.95
	Total	74,142,899.42	571.22	129,797.45
2017	I	1,096,849,249.93	198.40	5,528,474.04
	II	1,221,118,693.62	202.30	6,036,177.43
	Total	2,317,967,943.55	400.70	5,784,796.47
2018	I	1,323,279,548.80	219.44	6,030,256.78
	II	2,745,347,795.84	372.19	7,376,199.78
	Total	4,068,627,344.64	591.63	6,876,979.44
2019	I	1,104,897,469.92	305.18	3,620,477.98

	II	1,413,641,685.92	386.16	3,660,766.74
	Total	2,518,539,155.84	691.34	3,642,981.97
	Average	763,312,388.24	305.36	1,390,886.12

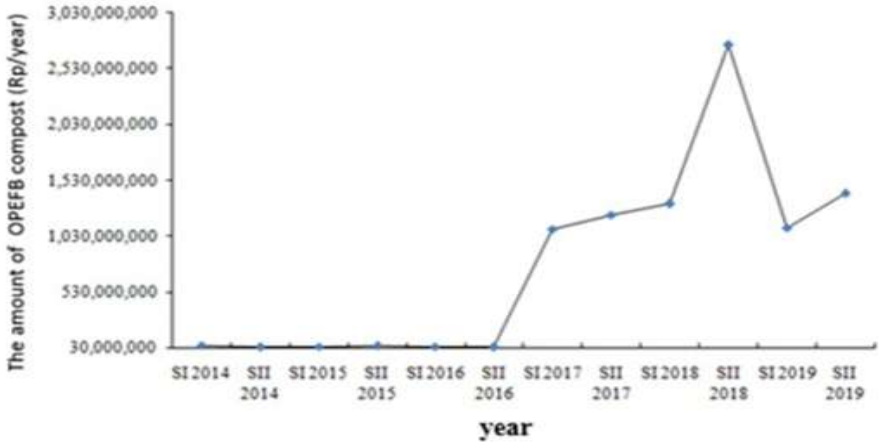

Figure 2. The Progress of EFB Compost Application Cost at PT. Eastern Sumatra Indonesia.

Total Amount of Inorganic Fertilizers Use

Inorganic fertilizers used at PT. Eastern Sumatra Indonesia consists of 5 types, i.e. Dolomite, Kieserit, MOP, Rock Phosphate, and Urea fertilizers. In this case, the use of inorganic fertilizers is still needed as a source of various types of nutrients because the number of nutrients from organic fertilizersbasically is not sufficient foroil palm trees'growth.

Table 4. Costs of Using Inorganic Fertilizers at PT. East Indonesia Sumatra, 2014 - 2019

Year	Semester	Total Inorganic Fertilizer Costs (Rp)	Inorganic Fertilizer Cost Per Hectare (Rp/ha)
2014	I	1.999.565.202,29	3.600.656,89
	II	2.506.273.065,17	9.528.613,30
	Total	4.505.838.267,46	13.129.270,19
2015	I	2.059.319.009,44	5.378.416,65
	II	3.206.386.664,94	6.312.167,58
	Total	5.265.705.674,38	11.690.584,23
2016	I	2.766.162.125,71	11.703.964,61
	II	2.870.734.167,56	7.067.577,50
	Total	5.636.896.293,27	18.771.542,11
2017	I	2.068.619.253,03	16.066.964,42
	II	2.581.376.197,33	30.061.959,37
	Total	4.649.995.450,36	46.128.923,79
2018	I	2.973.479.765,13	11.376.750,95
	II	2.479.361.959,31	10.643.583,76
	Total	5.452.841.724,44	22.020.334,70
2019	I	1.930.240.480,03	12.127.400,81
	II	2.241.396.249,86	9.605.393,66
	Total	4.171.636.729,89	21.732.794,47
	Average	2.473.576.178,32	11.122.787,46

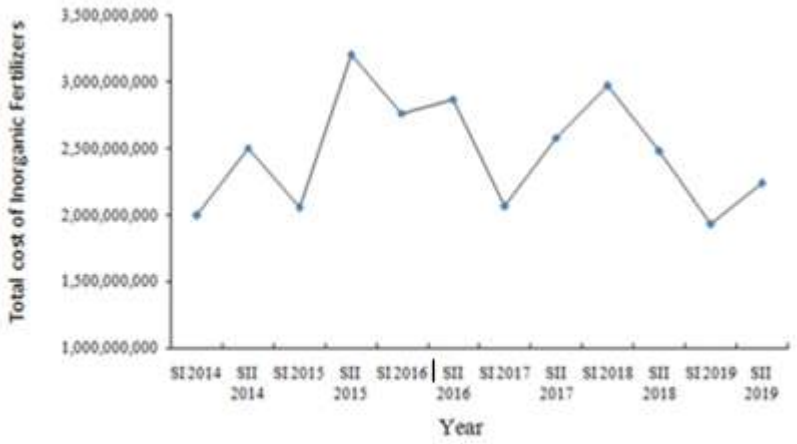

Figure 3. The Progress of Inorganic Fertilizer Costs at PT. Eastern Sumatera Indonesia, 2014-2019

Total Cost of Fertilizers

Thetotal cost of using fertilizers is the overall cost of using organic and inorganic fertilizer application. The total cost of using fertilizer every month during 2014 - 2019 can be seen in Table 5.

Table 5. The Total Cost of Using Fertilizer at PT. Eastern Sumatra Indonesia, 2014 - 2019

Year	Semester	Organic Fertilizer Cost (Rp)	Inorganic Fertilizer Cost (Rp)	Total Fertilizer Cost (Rp)
Per Total:				
2014	I	54.763.707,35	1.999.565.202,29	2.054.328.909,64
	II	36.568.825,88	2.506.273.065,17	2.542.841.891,05
	Total	91.332.533,23	4.505.838.267,46	4.597.170.800,69
2015	I	43.020.692,54	2.059.319.009,44	2.102.339.701,98
	II	46.118.089,71	3.206.386.664,94	3.252.504.754,65
	Total	89.138.782,25	5.265.705.674,38	5.354.844.456,63
2016	I	40.655.939,99	2.766.162.125,71	2.806.818.065,70
	II	33.486.959,43	2.870.734.167,56	2.904.221.126,99
	Total	74.142.899,42	5.636.896.293,27	5.711.039.192,69
2017	I	1.096.849.249,93	2.068.619.253,03	3.165.468.502,96
	II	1.221.118.693,62	2.581.376.197,33	3.802.494.890,95
	Total	2.317.967.943,55	4.649.995.450,36	6.967.963.393,91
2018	I	1.323.279.548,80	2.973.479.765,13	4.296.759.313,93
	II	2.745.347.795,84	2.479.361.959,31	5.224.709.755,15
	Total	4.068.627.344,64	5.452.841.724,44	9.521.469.069,08
2019	I	1.104.897.469,92	1.930.240.480,03	3.035.137.949,95
	II	1.413.641.685,92	2.241.396.249,86	3.655.037.935,78
	Total	2.518.539.155,84	4.171.636.729,89	6.690.175.885,73
	Average	763.312.388,24	2.473.576.178,32	3.236.888.566,56
Per Hectar:				
2014	I	155.525,69	3.600.656,89	3.756.182,58
	II	102.499,72	9.528.613,30	9.631.113,02
	Total	128.838,79	13.129.270,19	13.387.295,60
2015	I	137.578,17	5.378.416,65	5.515.994,82
	II	118.903,96	6.312.167,58	6.431.071,54
	Total	127.239,33	11.690.584,23	11.947.066,36
2016	I	151.797,56	11.703.964,61	11.855.762,17
	II	110.375,95	7.067.577,50	7.177.953,45
	Total	129.797,45	18.771.542,11	19.033.715,62
2017	I	5.528.474,04	16.066.964,42	21.595.438,46
	II	6.036.177,43	30.061.959,37	36.098.136,80
	Total	5.784.796,47	46.128.923,79	57.693.575,26
2018	I	6.030.256,78	11.376.750,95	17.407.007,73
	II	7.376.199,78	10.643.583,76	18.019.783,54
	Total	6.876.979,44	22.020.334,70	35.426.791,27
2019	I	3.620.477,98	12.127.400,81	15.747.878,79
	II	3.660.766,74	9.605.393,66	13.266.160,40
	Total	3.642.981,97	21.732.794,47	29.014.039,19
	Average	2.499.713,09	11.122.787,46	13.875.206,94

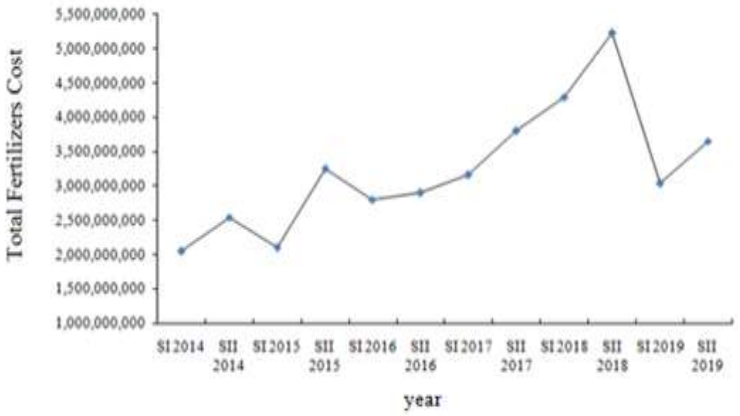

Figure 4. The Progress of Total Fertilizer Costs at PT. Eastern Sumatra Indonesia, 2014-2019

Production and Productivity

Productionis the results obtained from the entire plantations, while productivity is the result obtained from each hectare of plantation. The production and productivity produced by the company in each month during 2014 - 2019 can be seen in Table 6.

Table 6. Production and Productivity at PT. Eastern Sumatra Indonesia, 2014 – 2019

Year	Semester	Production (ton)	Area (ha)	Productivity (ton/ha)
2014	I	19.239,95	1.578,41	12,19
	II	19.575,77	1.569,31	12,47
	Total	38.815,72	1.573,86	24,66
2015	I	18.388,97	1.632,34	11,27
	II	23.294,31	1.625,51	14,33
	Total	41.683,28	1.628,92	25,59
2016	I	16.204,75	1.647,28	9,84
	II	20.139,37	1.647,28	12,23
	Total	36.344,11	1.647,28	22,06
2017	I	17.211,83	1.581,93	10,88
	II	20.113,88	1.581,93	12,71
	Total	37.325,71	1.581,93	23,60
2018	I	15.349,51	1.581,93	9,70
	II	18.910,17	1.581,93	11,95
	Total	34.259,67	1.581,93	21,66
2019	I	15.320,63	1.581,70	9,69
	II	16.174,96	1.581,65	10,23
	Total	31.495,58	1.581,67	19,91
	Average	18.327,01	1.599,27	11,46

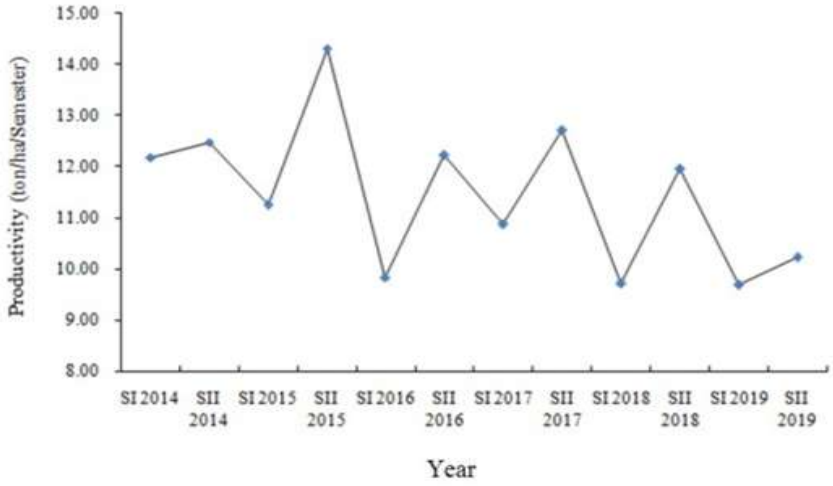

Figure 5. Productivity Progress at PT. Eastern Sumatera Indonesia, 2014-2019

Green House Gas (GHG)

GHG (Green House Gas) is gases that absorb solar heat (infrared radiation) when it is reflected back by the earth's surface. Among the GHGs are water vapor, carbon dioxide (CO2), nitrous oxide (N2O) and methane. The value of GHG in each month during 2014 - 2019 can be seen in Table 7.

Table 7. Value of Green House Gas at PT. Eastern Sumatra Indonesia, 2014–2019

Year	Semester	GHG Value (Kg CO2,eq/Ton FFB)
2014	I	391,83
	II	460,94
	Total	852,77
2015	I	249,08
	II	388,59
	Total	637,67
2016	I	349,52
	II	324,99
	Total	674,51
2017	I	339,19
	II	327,31
	Total	666,50
2018	I	391,21
	II	238,18
	Total	629,38
2019	I	241,23
	II	245,10
	Total	486,33
	Average	328,93

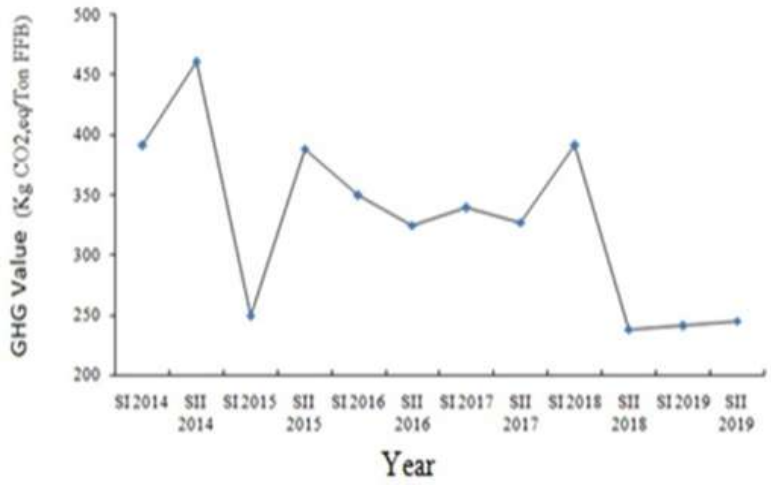

Figure 6. Progress of GHG Value, 2014-2019

IV. DISCUSSION

The use of EFB compost can increase the total cost of fertilizer and oil palm productivity, as well as reduce the GHG value. The effect of using EFB compost ontotal costs offertilizer, productivity and GHG values can be seen in Table 8.

Table 8. The Effect of Using EFB Compost on Total Cost of Fertilizers, Productivity anf GHG Value at PT. Eastern Sumatra Indonesia, 2013-2019

Variable	Y		
X	The Sum of The Fertilizer Cost (Y1)	Productivity (Y2)	GHG Value (V3)
OPEFB compost fertilizer	1,983*	-0,531^{ts}	-2,791^{ts}

Note* : = Significantly Effective
tn = Not Significantly Effective

Source: Data processed by SPSS

The first hypothesis proposed in this study is: the use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on the cost of using fertilizer. This hypothesis was tested statistically using simple linear regression, where the amount of EFB compost use as *variable X* and total cost of fertilizer (cost of organic + inorganic fertilizers) as *variable Y*.

The general equation between the use of EPOFB compost and fertilizer costs is as follows:

Y = - 57,101,623,3+ 395,766,9 X

From the above equation it can be seen that the regression coefficient of using EFB compost as organic fertilizer is 395,766.9, which means that each ton of EFB compost use per hectare will increase fertilizer cost for Rp. 395,766.9 per hectare per semester. The *t*-value is 1.983 and it shows a probability value (P-value) with a significance level of 0.035 <0.05, which means that H0 is rejected and H1 is accepted. The hypothesis which states that the use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on the cost of using fertilizer is acceptable at a 95% confidence level. This significant effect may be due to organic fertilizers. Since organic fertilizers contain a small number of nutrients,they will make slower results when compared to inorganic fertilizers. So that to provide an equal number of nutrients between the two types of fertilizers, organic ones must be applied a lot more than inorganic ones. (Rinsema, 2010). Since the effect of these organic fertilizers as available nutrients for plants will take a long time, inorganic fertilizers are also needed which resulted an increase in the total cost of fertilizers. As in the response curve of the effect of the amount of EFB compost on the total cost of fertilizer can be seen in Figure 7.

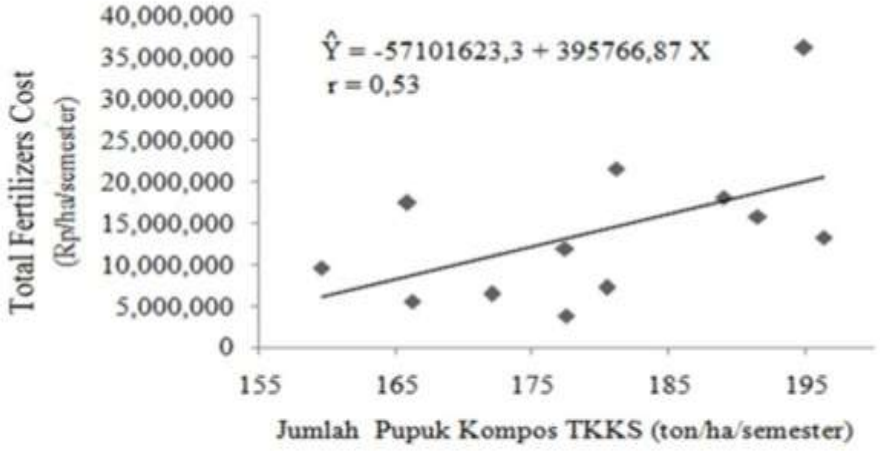

Figure 7. The Response Curve of The Amount of EFB Compost on Fertilizer Cost

The second hypothesis proposed in this study is: The use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on productivity. This hypothesis was tested statistically using simple linear regression, where the amount of EFB compost use as *variable X* and productivity as *variable Y*.

The general equation between EFB compost use and productivity is as follows:

Y = 15.022–0.020 X

From the above equation it can be seen that the regression coefficient of using EFB compost as organic fertilizer is -0.020, which means that each ton of EFB compost use per hectare per semester will reduce productivity by 0.020 tonnes per hectare per semester. The t-value obtained is 0.531 and shows a probability value (P-value) with a significance level of 0.607> 0.05, which means that H0 is accepted and H1 is rejected. The hypothesis that states EFB compost use as organic fertilizer at PT Eastern Sumatra Indonesia has a

significant effect on productivity, must be rejected at the 95% confidence level. This insignificant effect may be due to an increase in the use of EFB compost.It will need much longer time to see an effect on the productivity of oil palm. In this case of the study, the data is taken as many as 6 years.

The third hypothesis proposed in this study is: The use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on GHG values. This hypothesis was tested statistically using simple linear regression, where the amount of use of EFB compost as *variable X* and GHG value as *variable Y*.

The general equation between the use of EFB compost and GHG values is as follows:

Y = 1050,293-4,022 X

From the above equation it can be seen that the regression coefficient of using EFB compost as organic fertilizer is 4.022, which means that each ton of EFB compost use per hectare per semester will reduce the GHG value by 4.022 kg CO2, eq / ton FFB. The t-value obtained is 2.791 and shows a probability value (P-Value) with a significance level of 0.019 <0.05, which means that H0 is rejected and H1 is accepted. The hypothesis which states that the use of EFB compost as organic fertilizerat PT. Eastern Sumatra Indonesia which has a significant effect on the GHG value is acceptable at a 95% confidence level. This significant effect is due to the use of compost to reduce the greenhouse effect of inorganic fertilizers. According to Wood and Cowie (2004), greenhouse gases, carbon dioxide, methane and nitrous oxide, are all either intentionalyor accidentally produced from the fertilizer industry. Methane and nitrous oxide are greenhouse gas compounds that are more dangerous than carbon dioxide, and their effects can be equivalent to carbon dioxide. It is estimated that for each kilogram of ammonium nitrate produced, then two kilograms of the greenhouse gas equivalent to carbon dioxide are released by the industry. Thus it needs to keep using EFB compost in oil palm plantations. The response curve for the amount of EFB compost effects on GHG values can be seen in Figure 8.

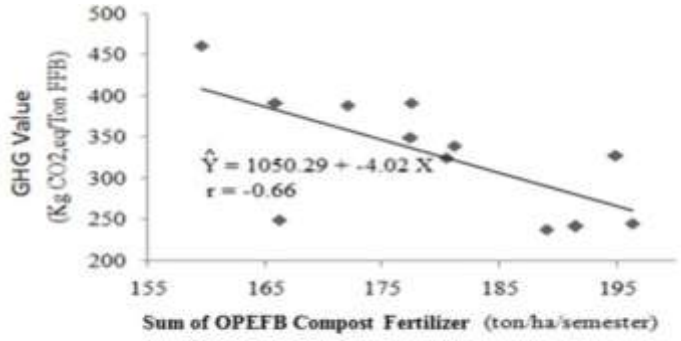

Figure 8. The Response Curve of The Effect of The Amount of EFB Compost on GHG Values.

V. CONCLUSIONS

Based on the results of the research and discussion, the following conclusions could be made:

The use of EFB compost is 9,096.67 tons per semester with an application area of 305.36 hectares, so that the application dose is 179.34 tons per hectare per semester. Meanwhile, the total cost of

1. fertilizer per semester is Rp. 3,236,888,566.56, consisting of Rp. 763,312,388.24 organic fertilizer costs and Rp. 2,473,576,178.32 inorganic fertilizer costs. On a per hectare basis, the average fertilizer cost is Rp. 13,875,206.94, consisting of Rp. 2,499,713.09 costs of organic fertilizer and Rp. 11,122,787.46 inorganic fertilizer costs.
2. The use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on the cost of fertilizer use, where each ton of EFB compost use per hectare will increase the cost of fertilizer by Rp. 395,766.9 per hectare per semester.
3. The use of EFB compost as organic fertilizer has no significant effect on productivity.
4. The use of EFB compost as organic fertilizer at PT Eastern Sumatra Indonesia has a significant effect on the GHG value, where each ton of EFB compost use per hectare will reduce the GHG value by 4.022 kg CO2, eq / ton FFB per semester.

VI. SUGGESTIONS

Based on the conclusions, the following suggestions could be made:

1. The company should use EFB compost as organic fertilizer continuously because it can reduce greenhouse gas emissions by reducing GHG values. It makes the company follow the ISCC certification scheme to get a premium value in the range of 20-30 USD / tons of CPO.
2. Further research is needed as an effort to increase nutrient content in EFB compost so that it can increase oil palm productivity.
3. It is necessary to do further research on the application schedule of EFB compost in oil palm plants in a period longer than 6 years or more to see the impact of applying EFB compost on oil palm productivity.

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