WALAILAK JOURNAL
http://wjst.wu.ac.th Agricultural Technology and Biological Sciences

Effect of Palm Waste on Sloping Land to Fresh Fruit Bunch Production in Oil Palm Plantation

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Received: 27 September 2015, Revised: 8 March 2016, Accepted: 9 April 2016

Abstract

Palm waste is abundant and readily available. It is low cost and commonly used as a fertilizer on oil palm plantations. The effectiveness of oil palm waste on sloping lands in oil palm plantation was investigated. Data was collected from each block with sloping lands, including the type, dose, and timing of fertilizer, record of rainfall, and Fresh Fruit Bunch (FFB) production for each month. There was no significant difference on FFB production between the types of fertilizer: inorganic fertilizer, inorganic substitution with palm waste, and palm waste only. However, a significant difference on FFB production was found between types of sloping land. Optimum FFB production was 15.01 kg palm^{-1} month^{-1} for inorganic substitution with palm waste on undulating hilly (IH) areas. Fertilizing with only palm waste gave 15.93 kg palm^{-1} month^{-1} of FFB production on a flat gently sloping (FGS) area. It shows that palm waste has comparable potential with inorganic fertilizer, even when applied on sloping land.

Keywords: FFB production, sloping land, palm waste, inorganic subtitution, oil palm plantation

Introduction

Oil palm is a potential source of income in Indonesia. Oil palm plantation areas have expanded and grow rapidly every year. Riau Province has the biggest potential for oil palm waste, reaching 6 million ton in 2013, compared to other provinces in Indonesia. Beside CPO, the factory also produces oil palm wastes in the form of wastewater, fibre, shell, decanter solids (DS), emtpy fruit bunches (EFB), and boiler ash (BA) [1]. Riau province has different varieties of sloping land with unstable rainfall, making it interesting to take a look deeper and know its impact on FFB production. Sloping land is a considerable factor for oil palm productivity [2].

Oil palm waste is a recommended organic fertilizer [3]. The commonly used organic palm wastes as fertilizer in oil palm plantations are EFB, decanter solids, and boiler ash [4,5]. Every 1 ton of FFB may yield 23 % of EFB, 3,5 % of decanter solid, and 2.5 % of boiler ash [4,6]. Palm oil mill wastes (POMW) are well known to be rich in phosphorus, nitrogen, calcium, magnesium, sodium and potassium [7].

The yield response in a 10 year-period shows that EFB300 (300 kg palm^{-1} yr^{-1}) yielded higher FFB production than EFB150 and CHEM (inorganic fertilizer applications) [8]. EFB application can increase FFB as much as 7 - 75 % to many varieties of soil compared to inorganic fertilizers [9]. Application of EFB increases soil bacterial biodiversity, especially some beneficial generas involved in soil fertilizing [10]. Decanter solid has a lot of nutrients and boiler ash contains a high amount of potassium. When it is combined with inorganic fertilizer, it can repair the soil quality and increase FFB production up to 27 %

[11]. Boiler ash application has a positive impact on the physiochemical properties of soil, reduces inorganic fertilizer cost [12], minimalizes pollution [13], and increases FFB production [14,15].

In this study, we assessed FFB production by measuring the dose of inorganic fertilizer and palm waste applied on an oil palm plantation. We hypothesized that palm waste can affect FFB production. We also wanted to evaluate the impact of rainfall and slopes on FFB production. In this paper, we report the results obtained, including a recommended fertilizer dose to be applied for improving FFB production.

Materials and methods

PT. Sari Lembah Subur, an oil palm plantation, is located in Pelalawan district, Riau province, Indonesia. Geographically, it is located between $0^0$7'12" - $0^0$1'48" South and $102^0$7'12" - $102^0$15'0" East. Annual rainfall in 2013 was 2,200 mm with an average of 129 days of raining per year. The area of the whole plantation measured 15,000 ha. This study took 7,051 acres which was divided into 14 sections and 296 blocks. The industry has 2 processing factories for oil palm FFB; Factory 1 produces 60 tons of crude palm oil (CPO) per hour, whereas Factory 2 produces 30 tons of CPO per hour. The sloping land in this plantation varies. There are 3 groups of sloping land which are flat gently sloping (FGS), undulating hilly (IH), and mountainous (M) [16].

The oil palm plantation applies inorganic fertilizer (I), palm waste (PW), and also a combination between these two. Inorganic fertilizer is applied twice in a year, during semester I (February - June) and semester II (August - December). The fertilizers applied are NPK, Rock Phosphate (30 % P_2O_5), *Muriate of Potash* (60 % K_2O), *Kieserite* (27 % MgO), and Dolomite (60 % $CaCO_3$). One ton of EFB palm waste contains as the main nutrients: N (0.37 %), P (0.04 %), K (0.91 %), and Mg (0.08 %) [18]. Decanter solid (DS) is the last product of FFB processing in palm oil factories using a decanter system, containing N (0.472 %), P (0.046 %), K (0.304 %), and Mg (0.070 %) in every 1 ton [17]. Boiler ash (BA) is the last product of EFB burning in an oil palm factory incinerator. 1 ton of boiler ash contains N (0.14 %), P (2.78 %), K (21.1 %), and Mg (1.26 %) [11]. This research used secondary data from an oil palm plantation and literature study. From the plantation's monthly report, data about fertilizing, rainfall, rainy days, and FFB production were obtained. Data were collected in one year.

Some steps of statistical analysis were done in this research: comparison between samples of inorganic substitution with palm residue, statistical analysis by using parametric test (One way ANOVA) [18], and Scheffe Test. Determination of the correlation between rainfall and rainy days with FFB production was done using a multiple correlation test. Comparison between FFB production of different types of fertilizer and slopes, was done using a non-parametric test of Kruskal-Wallis, followed by a Mann-Whitney Test [19].

Results and discussion

By comparing the result of 3 fertilizer types, statistical analysis was done on fertilizer substitutes. ANOVA analysis was done, and the result is shown in **Table 1**.

Table 1 Comparison between several treatment groups of inorganic substitution with palm waste.

Treatment	I+EFB	I+EFB+DS	I+DS	I+EFB+BA	I+EFB+DS+BA	I+BA
I+BA	± 0.4899	± 0.6469	± 3.9544	± 1.0278	± 2.9444	0
I+EFB+DS+BA	± 3.4344	± 3.5913	± 1.0100	± 1.9167	0	
I+EFB+BA	± 1.5177	± 1.6746	± 2.9267	0		
I+DS	± 4.4444*	± 4.6013	0			
I+EFB+DS	± 0.1569	0				
I+EFB	0					

*Correlation is significant at $p = 0.05$

Note: I = inorganic, BA = boiler ash, EFB = empty fruit bunch, DS = decanter solid.

ANOVA result in **Table 1** followed by a Scheffe Test, describes that the use of EFB compared with the use of decanter solid as a substitute yields a significant difference in the FFB production. Inorganic substitution with EFB shows a better result.

Based on the sloping land types, different values of FFB production were achieved in every month. The Kruskal-Wallis Test gave a P-Value 0.000 < 0.05. Therefore, the Mann-Whitney Test was done with the results shown in **Table 2**.

Table 2 Comparison result between different types of fertilizer on different types of sloping land towards FFB production.

Comparison		N	Mean Rank		Mann-Whitney Test	Asymp. Sig. (2.Tailed)
I	J		I	J		
I+FGS	I+IH	296	35.54	28.67	388.000	0.157
	I+M	296	47.51	26.53	307.000	0.000*
	I&PR+FGS	296	87.47	70.26	1.702.500	0.030*
	I&PR+IH	296	40.32	35.21	602.000	0.312
	I&PR+M	296	52.8	35.02	541.000	0.001*
	PR+FGS	296	22.93	2375	79.000	0.905
	PR+IH	296	23.54	8.33	19.000	0.048**
	PR+M	296	23.22	12.67	32.000	0.169
I+IH	I+M	296	37.98	23.51	204.500	0.001*
	I&PR+FGS	296	70.06	65.71	1.210.500	0.614
	I&PR+IH	296	28.04	30.54	373.000	0.58
	I&PR+M	296	42.96	30.76	349.000	0.016*
	PR+FGS	296	13.71	19.25	29.000	0.212
	PR+IH	296	15.17	4.67	8.000	0.031**
	PR+M	296	14.67	8.67	20.000	0.217
I+M	I&PR+FGS	296	50.75	78.03	1.130.000	0.001*
	I&PR+IH	296	26.01	42.99	289.000	0.000*
	I&PR+M	296	40.5	39.62	748.000	0,866
	PR+FGS	296	17.82	33.75	11.000	0.007**
	PR+IH	296	20.03	7.33	16.000	0.051
	PR+M	296	19.56	12.67	32.000	0.29
I&PR+FGS	I&PR+IH	296	69.62	77.47	1.633.000	0.332
	I&PR+M	296	83.34	61.78	1.745.000	0.006*
	PR+FGS	296	55.81	75.13	141.500	0.243
	PR+IH	296	57.07	17.33	46.000	0.035**
	PR+M	296	56.64	32.83	92.500	0.206
I&PR+IH	I&PR+M	296	47.99	33.97	493.500	0.007*
	PR+FGS	296	19.16	22.38	56.500	0.584
	PR+IH	296	20.21	5.33	10.000	0.022**
	PR+M	296	19.9	8.83	20.500	0.09
I&PR+M	PR+FGS	296	23.78	38.75	35.000	0.045**
	PR+IH	296	25.28	12.83	32.500	0.136
	PR+M	296	25	17	45.000	0.338
PR+FGS	PR+IH	296	5.5	2	6.000	0.032**
	PR+M	296	5.25	2.33	1.000	0.074
PR+IH	PR+M	296	3.33	3.67	4.000	0.827

*significantly different at p = 0.05 level of probability by Mann-Whitney

Note: fertilizer code; I = inorganic, PR = palm residue/waste, and sloping land code; FGS = flat gently sloping, IH = undulating hilly, M = mountainous

The Kruskal-Wallis Test continued by the Mann-Whitney Test shows that sloping lands affect FFB production. Commonly, application of inorganic fertilizer on FGS area yields a significantly different value of FFB production, compared to the application of palm waste only and substitution of inorganic fertilizer with palm waste on a M area.

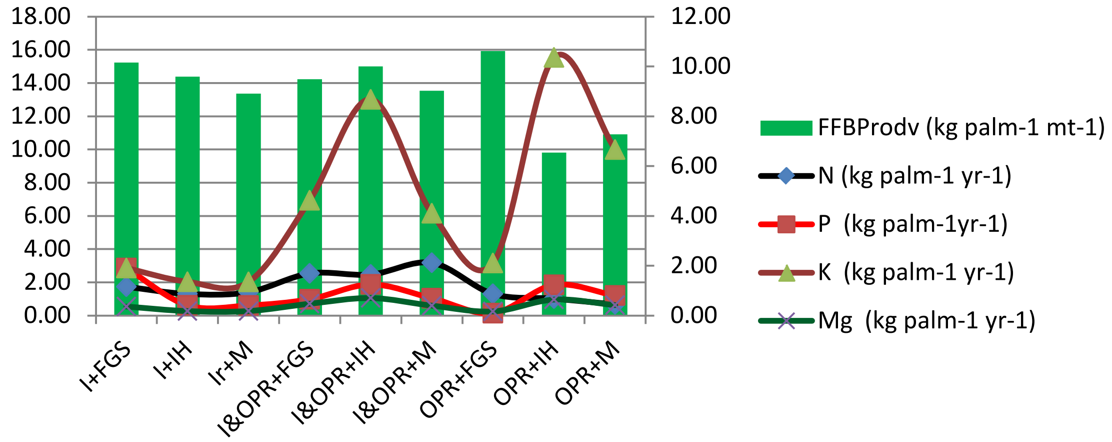

Figure 1 Nutritional comparison between different sloping land types and its effect on FFB production.

Different sloping land yields different levels of FFB production. The FGS area has the highest level of FFB production, regardless of the fertilizer type. On the FGS area, the application of palm waste only yields higher FFB production compared to that of inorganic fertilizer and inorganic substitution with palm as shown in **Figure 1**. It can be seen in **Figure 1**, that better FFB production can be achieved by optimum fertilizer substitution on the IH area, as much as 15.01 kg palm^{-1} month^{-1}, and by palm waste only on FGS area, as much as 15.93 kg palm^{-1} month^{-1}.

Based on statistical analysis, there is no correlation between rainfall and rainy days on FFB production, shown by the value of R 0.531, R square 0.282, and Sig. F change 0.225 > 0.05. This result indicates that rainfall and rainy days does not affect FFB production. There is no correlation between rainfall and FFB production. This result differs with the statement that low rainfall may cause depression on plants 2 months later, and high rainfall will increase productivity 2 months later [20].

The main finding of this study is that the application of palm waste can fulfill the nutritional need of oil palm, even on different slope conditions. The most important things in sustainable oil palm development are adequate nutrition, balanced proportion, optimized growth and FFB production [15]. Integration between inorganic fertilizer and palm waste can repair growth and give better yields. Palm wastes such as EFB mulching, decanter solid, boiler ash and compost have quite high content of organic matter, and thus have a beneficial impact on the soil [21].

Application of EFB mulch has a significant effect on some soil chemical properties, such as soil pH, exchangeable Mg, and total N. EFB mulch is financially beneficial; it can replace inorganic fertilizer leading to reduced costs in oil palm plantations [12]. Decanter cakes are the major wastes in the crude palm oil industry which are currently disposed in the landfill or reused as other applications. Decanter cakes contains a noticeable amount of nutrients, while boiler ash contains a high percentage of potassium [11]. Decanter solid application as fertilizer has the potential to replace inorganic fertilizer [5,22]. Decanter solids are characterised by several key properties, such as high moisture content, high biodegradability, and nutrient-rich content [23]. Boiler ash is recycled as a fertilizer and factory floor cleaning agent [14]. In the bid to achieve a zero discharge of the palm oil mill, boiler fly ash has been used to reduce the biochemical oxygen demand (BOD), total suspended solid (TSS), colour and other contaminants from POME before discharge [24].

Applying palm waste to young oil palm trees can effectively improve growth and yield [3]. Macronutrients are needed in huge amounts so that additional nutrition through fertilizing is necessary [25]. Organic fertilizer is commonly applied in oil palm plantations, especially the ones composed of oil palm waste, since it is cheap, easily obtained, environmental friendly. [26], and containing nutrients needed by the plants [27].

Overall, FFB production shows a better result on the FGS area since organic matter accumulation is often favoured at the bottom of hills. There are 2 reasons for this accumulation: conditions are wetter than at mid- or upper-slope positions, and organic matter is transported to the lowest point in the landscape through runoff and erosion [28]. Flat land conditions on top of the slopes, slight tilting on sideslopes, and mountain peaks in Indonesia can affect FFB production [29]. Topography conditions on the oil palm plantation can also affect FFB production.

On high sloping lands, EFB application is very suitable for fertilizing [30]. On various land topography, fertilizing recommendations have to be exact and precise. The organic fertilizers should be applied regularly to loamy-sand uplands (Hillyslope) to sustain soil fertility [10]. Sloping land on a flat ground, which is gently sloping, has a high yield potential. High yield potential is present on undulating and hilly lands, while mountainous land has a low yield potential [16,31].

Conclusions

FFB production was measured to assess the effectiveness of fertilizing on various sloping lands. This study suggests that inorganic substitution with palm waste yields comparable FFB production. Although the result doesn't differ significantly with only palm waste application, it can give optimum FFB production as much as 15.93 kg palm^{-1} month^{-1} on FGS areas. Palm waste has high potential to replace inorganic fertilizer, as long as it is adjusted by considering the nutritional needs and sloping lands. A complete information and comparison approach between several oil palm plantations in Indonesia are convincing enough to validate response on various sloping lands. We recommend palm wastes (EFB, decanter solid and Boiler ash) to replace inorganic fertilizers on FGS, IH, and M sloping area. However, nutritional needs are still important to be taken as consideration in deciding the right dose for applying palm waste as a fertilizer.

Acknowledgements

We would like to express our gratitude to PT. Sari Lembah Subur (PT. SLS) Kerumutan-Riau for facilitating this study, and also the Amanah Pelalawan Foundation as our funder in this study.

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