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Hot Water Treatment of Oil Palm Decanter Cake (OPDC) For Bio-organic Media of Oil Palm Seedlings

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Abstract
OPDC has high potential to be used as organic media for oil palm seedlings due to its substantial nutrient content. However, residual oil in OPDC could give negative effect to plant growth. This study was conducted to examine the potential of hot water-treated OPDC as bioorganic media and its effects on growth performance of oil palm seedlings. OPDC was treated with hot water to remove oil content and chemical analysis was determined on N, P, K, Ca and Mg. Then, treated OPDC was mixed with MPOB F1 fertilizer and soil at 25%, 50% and 75% to be used as bioorganic growing media. The results showed that after hot water treatment, residual oil was reduced from 15% to 10-11%. Once applied as planting media, highest growth performance and biomass accumulation was recorded by mixture of 25% treated OPDC with soil and MPOB F1 fertilizer. Plant height, stem girth, leaf number, leaf area, leaf dry weight, stem dry weight and root dry weight were improved by 28%, 15%, 10%, 60%, 72%, 45% and 18%, respectively as compared to control. In conclusion, appropriate amount of treated OPDC addition in growing media could improve the growth of oil palm seedling after oil content removal.

Keywords: Oil palm decanter cake, Oil content, Bioorganic media, Growth performance

Introduction

Oil palm industry is continuously expanding since it has been planted more than 100 years ago in Malaysia. Currently, Malaysia is the second largest country with oil palm cultivation after Indonesia. Oil palm plantation area in Malaysia has increased from 5.23 million hectares in 2013 to 5.81 million hectares in 2017 (MPOB, 2018). As the oil palm plantation industry has expanded, the waste productions from the palm oil mills has also increased. Approximately, there are about 416 palm oil mills operating in Malaysia. From the mill, the estimated waste generation from 1 ton of fresh fruit bunch (FFB) is in the range from 0.6 to 0.8 m^3 of palm oil mill effluent (POME), 22 to 23% of empty fruit bunch (EFB), 3.5% of oil palm decanter cake (OPDC) and 13.5% palm mesocarp fibre (PMF) (Ooi and Kumar 2008; Ng et al. 2011). In recent years, OPDC has been produced in higher amount due to more decanter machine installation in the mills to recover the remaining oil from the underflow of the sludge tank. Usually OPDC is dumped and left to degrade naturally in the dumping ponds. Despite high generation of OPDC, its utilization is still low and not yet commercialized. Several studies have been conducted to utilize OPDC as natural polymer composite (Adam et al. 2014), as solid fuel (Husin et al. 2012), cellulose and polyoses production (Razak et al. 2012), composting, and alternative energy and protein source for growing goats (Anwar, 2012). Up to date only a few studies have focused on the utilization of OPDC as bio-organic media. OPDC is known to be rich in N (2.42%), P_2O_5 (0.51%), K_2O (1.24%), CaO (1.68%) and MgO (0.54%) (Haron et al. 2008). Its application together with inorganic fertilizer had showed synergic effects and improved crops nutrient uptake by plants (Haron et al. 2008). Thus, OPDC has a potential as bio-organic media. Previous studied by (Embrandiri et al. 2013) utilized raw OPDC as fertilizer supplement at different rates. However, it gave negative effect to plant growth performance due to excess of nutrient present and high oil content in the raw OPDC used. Theoretically, the residual oil OPDC need to be removed before it can be used as fertilizer supplement and bioorganic media. This study was conducted to determine the physicochemical properties of raw and hot water treated OPDC and the effects of treated OPDC on the growth performances and biomass production of oil palm seedlings.

Materials and methods

Oil content removal

The raw OPDC was obtained from Sime Darby Kempas Oil Palm Mill, Melaka. The experiments for the oil content removal from OPDC and seedlings planting was performed in UiTM Jasin, Melaka. Raw OPDC was mixed thoroughly with hot water and soaked until the oil layer move upward. The oil layer and water were removed and the step was repeated 3 times. In order to determine the oil content loss, 10g treated OPDC was extracted by using 300ml hexane in soxhlet extractor for 8 hour. Then, the extracted oil was concentrated in vacuum rotary evaporator and dried in an oven. The oil content removal was then calculated.

$$Oil\ (\%\ dry\ basis) = \frac{Weight\ of\ extracted\ oil\ (g)}{Initial\ weight\ of\ dry\ sample\ (g)} \times 100\%$$

Physicochemical analysis of OPDC

Wet raw and treated OPDC were weighed and dried in an oven at 104°C until constant weight obtained. Then, the samples were weighed again to calculate the moisture content. pH value was determined by using 1:10 (w/v) method, while total nutrients were determined by using dry ashing method (Pushparajah, 1977). Dried raw and treated OPDC were grounded separately and passed through 2mm sieve. 1g of each samples were put in porcelain crucible and placed in the muffle furnace at 300°C for 1 hour then gradually increased to 550°C for next 7 hours. After completed, few drops of deionized water and 2ml of concentrated HCl were added before put on hot plate. After ash was slightly dried, 10ml of prepared nitric acid (20% volume/volume) was added and placed in a water bath for 1 hour. Then, all the mixture was transferred to a 100ml volumetric flask and deionized water was added to volume. The solution was shaken and filtered with Whatman No.2 filter paper. The solution afterward was analysed by using ICP-OES for P, K, Ca and Mg. The sample was also analysed for N.

Bio-organic media preparation

The ratio of media was calculated based on the nutrient content needed by seedling for 8 months. Approximately, 25%, 50% and 75% of the treated OPDC was mixed with 75%, 50% and 25% MPOB F1 fertilizer, 2kg soil and cocopeat in polybag and left for 2 weeks before seedlings transplanting. Then, the polybags were arranged in triangular planting design in the open field. 3-months oil palm seedling was transplanted in all polybags randomly.

Growth performance and biomass

Plant height was measured by using measuring tape from base of stem above soil surface to the tip of highest leaf, stem girth was measured at height of 2cm above soil surface with vernier caliper, leaf number was collected by counting number of leaves (Putra et al. 2015) for 8 months. The biomass was determined by destructive growth analysis technique (Danso et al. 2013). The leaves, stem and root were separated at the end of the experiment and washed under running water to remove the soil and dirt. Then, leaves, stem and root were dried in an oven at 70°C until obtained constant weight. Sample were weighed using digital balance for dryweight determination. Leaf area was calculated using leaf area meter.

Statistical analysis

The statistical analysis was performed using Minitab software. All data obtained were subjected to one way ANOVA to detemine the significant difference of treatments where p value ≤ 0.05. Turkey was conducted for means comparison.

Results and discussion

Oil content removal

Figure 1 shows the oil content in OPDC after treatment with hot water. During the first stage of hot water treatment, the oil content in OPDC has reduced approximately 1%, followed by 2-3% at second stage and finally reduced approximately 4-5%. Altogether the oil content in OPDC has reduced from 15% to 10-11%. Eventhough the oil was not completely removed, this method could be practiced to make OPDC more useful as bio-organic media in large scale plantation because it is simple and cost effective.

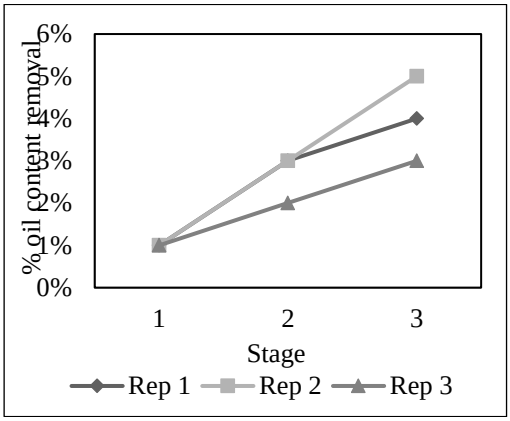

Figure 1: Percentage of oil content removal in different stages in three replicates (rep = replicate).

A study was conducted by Sahad et al. (2015) using n-hexane and d-limonene in sohxlet extraction to extract oil in OPDC. The oil was completely recovered. However, the method was expensive, time consuming, only small amount OPDC can be used at a time and not practical for large scale operation in plantation sector. In this study, the oil content in OPDC was partially removed before being used as bioorganic media for oil palm seedling in nursery stage. The amount of dried treated OPDC needed was about 80kg. In order to obtain 80kg of dried and treated OPDC, about 500 – 600kg raw OPDC was used.

Physicochemical properties of OPDC

Table 1 shows the physicochemical properties of OPDC used in this study as compared with the other related studies. The pH value of the raw OPDC is higher compare to other studies. After treated with hot water, the pH value has reduced from 5.47 to 4.86. According to Singh and Agrawal (2010), reduction in pH value to become more acidic can be attributed to the acidic nature of OPDC and also to release of humic acid as a result of OPDC degradation due to hot water treatment. The result show that oil content is higher while moisture content and

nutrients contents of N, P, K and Mg are much lower than other studies which were 15%, 74.51%, 2.0%, 0.013%, 1.27% and 0.28% respectively. The Ca content is slightly higher than previous study by Yahya et al (2010) and Razak et al (2012) which is 1.18%. In this study, the OPDC sample was obtained from different oil palm mills with different way of handling the fresh fruit bunch (FFB) and processing. The FFB also came from different plantation sources resulting in different content of nutrients as well. The results also show that the nutrient content of OPDC has reduced after treated with hot water due to leaching process which are 2.2% N, 0.025% P, 0.20% K, 1.11% Ca and 0.10% Mg.

Growth performance and biomass

Figure 2, 3 and 4 show the growth performances, leaf area and total biomass of oil palm seedling for 8 months in nursery. Leaf area, leaf dryweight, stem dryweight and root dryweight were calculated at the end of experiment. The results show that the growth performances and biomass production of oil palm seedlings are significantly affected ($p \leq 0.05$) by the various ratios of treated OPDC. Maximum growth performances and biomass production are obtained for the experiment with the ratio of 25% treated OPDC where the plant height, leaves number, stem girth, leaf area, leaf dryweight, stem dryweight and root dryweight were 117.75cm, 22, 75.87mm, 11568cm², 108.31g, 150.93g and 82.63g respectively.

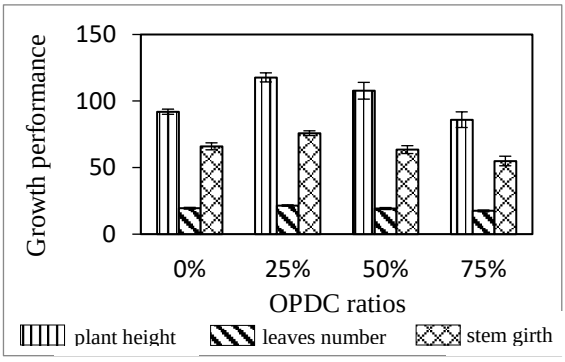

Figure 2: Growth performance of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

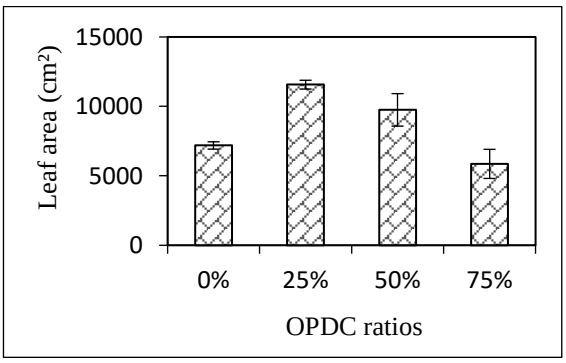

Figure 3: Total leaf area of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

From the above results it can been seen that the growth performances and biomass production had decreased as the ratios of the treated OPDC were increased. Plant height, leaves number, stem girth, leaf area, leaf dryweight, stem dryweight, and root dryweight had decreased from 107.75cm to 86.00cm, 19 to 17, 63.52mm to 54.97mm, 9752cm² to 5861cm², 84.06g to 49.06g, 132.1g to 68.91g, 62.33g to 30.8g of oil palm seedlings grown at 50% and 75% treated OPDC media. This could be due to the high nutrient content and toxicity effect of OPDC (Embrandiri et al, 2013). Similar result were observed by earlier studies using raw and decomposed OPDC on other types of crops.

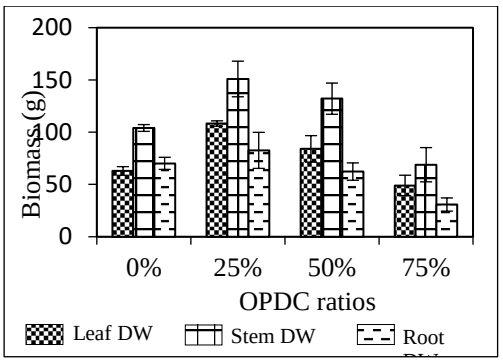

Figure 4: Biomass of oil palm seedlings. There is significant difference as p≤0.05. Values are mean of 4 replicates.

Studied by Embrandiri et al (2013) and Singh and Agrawal (2009) reported that lady's finger maximum growth of shoot length and leaf number were obtained at 10% and 20% of raw OPDC and sewage sludge which were lower than this study. Studied by Radziah et al (1997) showed the highest growth of tomato and spinach by using 6% of decomposed OPDC. In this study, higher ratios of OPDC could be used compared to previous study which were between 25% to 75% treated OPDC after oil content removal. Oil content in media could cause stress to plant and created a situation of physiological drought where it interferes with water uptake and gaseous exchange (Omusun et al. 2008), blocks the xylem and phloem vessels and also slowing down root elongation (Bengough, 2003). Thus, removing oil content before used improved the efficiency of OPDC as bio-organic media. OPDC has high organic carbon which was 74.4 % (Embrandiri et al. 2016). Organic carbon encouraging microbes multiplication and enzymatic activities which leads to availability of nutrients in soil (Liu et al. 2016). Microbes decomposed the substrate and release the nutrients from it which will be absorbed by plants at suitable environmental condition. Thus, by reducing the oil content it has increased the rate of microbial activities that

was previously blocked by the oil layer and also improved the media condition, water and nutrient uptake, gaseous exchanged and translocation process. These conditions enhance the growth of oil palm seedlings and biomass production. Besides that, OPDC has high nutrient contents and application of treated OPDC with MPOB F1 fertilizer showed synergic effects and gives better growth performances of oil palm seedlings. The result obtained from this study is in agreement with previous study by Haron et al. (2008) where seedlings treated with OPDC and inorganic fertilizer have better growth due to increasing in nutrient content and improve the efficiency of nutrient uptake by crops. OPDC is an organic by-product and possess certain amounts of amino acid, crude protein and fibre which can be used as fertilizer (Ramli et al. 2012). The use of OPDC as growing media for 8 months allowed the decomposition process to be completed within that time and therefore, the nutrients become available for plant uptake and further increase growth performances. Media mixed with OPDC compost had 46.4% nitrogen, 17.9% phosphorus, 17.7% potassium and 23.1% calcium more than that media without OPDC (Yahya et al. 2010). Thus, treated OPDC gives positives effect in plant growth performances and biomass accumulation.

Table 1: Comparison of physicochemical OPDC

Parameters	This study	Yahya et al. 2010	Sahad et al. 2014	Razak et al. 2012	Haron et al. 2008	Paepatung et al. 2009	Kandiah and Batumalai. 2013	Embrandiri et al. 2016
pH	5.47 ± 0.04 / 4.86*		5.03 ± 0.04	4.08 ± 0.02	4.8	-	-	4.40 ± 0.01
Moisture (%)	74.51 / 84.32*	76.83	78.20 ± 1.27	76.46 ± 0.8	78	76.7	-	-
Oil content (%)	15 / 10-11	-	13.60 ± 3.33	-	-	-	12.25	-
Nitrogen (%)	2.0 / 2.2*	2.38	2.33 ± 0.06	2.8	2.42	2.21	-	6.52 ± 0.03
Phosphate (%)	0.013 / 0.025*	-	0.41 ± 0.01	0.2	0.51	-	-	-
Potassium (%)	1.27 / 0.20*	2.39	2.73 ± 0.06	1.4	1.24	-	-	0.07 ± 0.02
Calcium (%)	1.18 / 1.11*	1.02	2.10 ± 0.00	0.9	1.68	-	-	0.35 ± 0.02
Magnesium (%)	0.28 / 0.10*	0.8	0.62 ± 0.03	0.3	0.54	-	-	0.012 ± 0.03
Organic carbon	-	51.7	43.73 ± 0.09	55.17	-	43.6	-	74.4 ± 0.02
C/N ratio	-	21.72		19.7	-	-	-	11.4 ± 0.02

*treated OPDC

Conclusions

OPDC is one of the promising waste materials generated in the palm oil mills suitable for bio-organic media once the oil is partially removed. In this study, it shows that OPDC has high moisture and nutrient contents required by the plants. Through hot water treatment, the oil content of OPDC was able to be reduced from 15% to 10-11%. The ratio of treated OPDC bio-organic media can be mixed with normal media up to 25-50% in order to give higher growth performances and biomass production. In conclusion, appropriate amount of treated OPDC addition in growing media could improve the growth of oil palm seedling after OPDC oil content removal.

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