PALM OIL MILL DECANTER CAKE AS SOIL CONDITIONER: A STUDY ON KAILAN (*Brassica oleracea var.* Alboglabra)

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by

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LIST OF ABBREVIATIONS AND ACRONYMS

AAS	Atomic absorption spectrophotometer
A-P	Available phosphorous
BA	Boiler ash
C:N	Carbon: Nitrogen ratio
Ca	Calcium
Cd	Cadmium
CPO	Crude Palm Oil
CPKO	Crude Palm Kernel Oil
Cr	Chromium
Cu	Copper
DAS	Day after sowing
DAT	Day after transplant
DC	Decanter cake
DW	Distilled water
EC	Electrical conductance
EFB	Empty fruit bunch
Fe	Iron
FFB	Fresh fruit bunch
HM	Heavy metal
K	Potassium
Mg	Magnesium
Mg/kg	Miligram/kilogram
Mn	Manganese
Mt	Million tonne

Na	Sodium
NPK	Nitrogen : Phosphorus : Potassium
OPA	Oil palm ash
Pb	Lead
PKO	Palm kernel oil
PKC	Palm kernel cake
PKS	Palm kernel shell
POME	Palm oil mill effluent
PPF	Palm press fibre
S	Soil
t	Tonne
WHO	World Health Organisation
Zn	Zinc

KEK PENYIRING DARI KILANG MINYAK KELAPA SAWIT SEBAGAI PERAPI TANAH: SATU KAJIAN KE ATAS KAILAN (*Brassica oleracea var*. Alboglabra)

ABSTRAK

Satu kajian telah dijalankan untuk menentukan kesesuaian kek penyiring dari minyak kelapa sawit sebagai perapi tanah. Ujikaji telah dijalankan dalam tiga fasa iaitu ujikaji percambahan biji benih, ujikaji proses penstabilan dan ujikaji pot. Ujikaji percambahan biji benih bertujuan untuk mengenal pasti nisbah campuran antara tanah dan kek penyiring yang bersesuaian serta untuk mengenal pasti jenis tumbuhan dedaun yang sesuai digunakan untuk ujikaji pot. Ujikaji ini dijalankan untuk 15 hari. Ujikaji proses penstabilan dilakukan selama 21 hari bagi menentukan tempoh masa yang diperlukan oleh campuran tanah dan kek penyiring untuk stabil. Ujikaji pot telah dijalankan sebagai ujian pertumbuhan tumbuhan dan telah diuji ke atas Kailan (*Brassica oleracea var*. Alboglabra) dan pemerhatian dibuat untuk tempoh 65 hari. Empat nisbah campuran kek penyiring dan tanah yang berbeza telah disediakan untuk ujikaji pot (0%, 5%, 10%, 20%) (berat/berat)(w/w). Satu pot tanah tanpa campuran telah disediakan dan dibajai dengan baja bukan organik sebagai pot perbandingan. Parameter yang diperhatikan dalam kajian ini ialah morfologi, pigmen fotosintetik, jisim, serta sifat-sifat fisikokimia. Analisa untuk kesemua parameter dijalankan dengan menggunakan benang dan jarum, meter pengukur luas permukaan daun, penimbang elektronik, spektrofotometer, dan spektrofotometri serapan atom (AAS). Secara morfologinya pot

perbandingan mencatatkan bacaan jumlah daun, luas permukaan daun, panjang akar dan batang serta biomass akar dan batang yang tertinggi diikuti dengan nisbah campuran 10%, 5%, 0% dan 20%. Untuk parameter fisikokimia, hasil kajian menunjukkan bahawa semakin tinggi nisbah kek penyiring, semakin tinggi kepekatan nutrient dan unsur surih. Nutrient dan unsur surih tersebut ialah nitrogen (N), kalium (K), kalsium (Ca), fosforus (P), magnesium (Mg), ferum (Fe), mangan (Mn), zink (Zn), kuprum (Cu), plumbum (Pb), cadmium (Cd), nikel (Ni) and kromium (Cr). Secara amnya 20% nisbah rawatan merekodkan unsur surih pada kepekatan yang lebih tinggi, dengan saiz fizikal yang lebih kecil. Keluasan daun, bilangan daun dan juga jisim tumbuhan untuk nisbah 20% direkodkan lebih rendah berbanding 5% dan 10% nisbah rawatan. Untuk pigmen fotosintesis, nisbah 5% dan 10% merekodkan bacaan yang lebih tinggi berbanding nisbah rawatan 0% dan 20%. Daripada kajian yang dijalankan ini, kek penyiring sesuai digunakan sebagai penghawa atau perapi tanah dengan kuantiti yang sedikit, iaitu kurang daripada 20% nisbah campuran. Penggunaan kek penyiring kurang daripada 20% menunjukkan kesan yang positif kepada tumbuhan. Seandainya digunakan pada kadar yang berlebihan (melebihi 20% nisbah campuran), ianya akan memberi kesan disebaliknya terhadap tumbuhan disebabkan oleh unsur surih yang berkumpul secara berlebihan

PALM OIL MILL DECANTER CAKE AS SOIL CONDITIONER: A STUDY ON KAILAN (*Brassica oleracea var*. Alboglabra)

ABSTRACT

Study has been performed to determine the applicability of decanter cake (DC) from palm oil mill as soil conditioner. Study conducted in three phase started with germination test, stabilisation test and pots experiment. Germination test aim to find out suitable percentage of soil and DC mixture and suitable leafy vegetable to be used in the pots experiment. The duration of the germination test is 15 days. Stabilisation process was done for 21 days to figure out the time needed for the mixture to stabilise. Pots experiment was done as plant growth study and tested on Kailan (*Brassica oleracea var.* Alboglabra) and monitored for 65 days. Four different mixture ratios of DC and soil were prepared for pots experiment (0%, 5%, 10%, 20%) (weight/weight)(w/w). One pot filled with unamended soil fertilised with inorganic fertiliser as comparison pot. Parameters observed in this study are morphology, photosynthetic pigments, biomass, and physicochemical characteristics. Analyses were done for all the parameters using thread and ruler, leaf area meter, spectrophotometer, analytical balance and atomic absorption spectrophotometer (AAS). Morphologically, comparison pot recorded the highest reading for leaf number, leaf area, shoot and root length and root and shoot biomass followed by 10%, 5%, 0% and 20% treatment ratios. For physicochemical properties, the outcome shows that the higher the ratio of DC, the higher the concentrations of nutrients and trace elements accumulated. The nutrients and trace elements are nitrogen (N), potassium (K), calcium (Ca), phosphorous (P), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr). Overall, 20% treatment ratio recorded a higher trace elements concentration, with smaller physical appearance. The leaf area, number of leaf as well as the biomass for 20% treatment ratio recorded lower compared to 5% and 10 % treatments ratio. For photosynthetic pigments test 5% and 10% treatments ratio recorded to be higher than treatments 0% and 20%. Based on the study performed, shows that decanter cake is suitable to be applied as soil conditioner in small amount, below 20% treatment ratio. Application of DC below 20% shows positive results in plant. Excess application of DC (exceed 20% treatment ratio) potentially cause adverse effect to the plant growth due to the excess accumulation heavy metals.

CHAPTER 1

INTRODUCTIONS

1.1 The Oil Palm

The oil palm trees (*Elaeis guineensis*) said to be origin from Africa continent. It is a tropical plant that grows best in a tropical climate with an abundant rainfall. It was first introduced to Malaysia as an ornamental plant in the Botanical Garden Singapore in 1874 by the British (MPOC, 2013; O'Holohan, 1997). Later, the usage of this plant discovered and the commercial planting begun in 1911 at Deli district Sumatra, Indonesia and in 1917 at Tennamaran Estate, Selangor (Abdullah and Sulaiman, 2013; MPOC, 2013; O'Holohan, 1997). Leading by Indonesia 30.0 million tonne, Malaysia comes second with 20.0 million tonne of palm oil production. Other part of the world contributes only 13% to 16% of world production. They are Africa and America. Malaysia use to be the world major producer of palm oil. In 2004 Malaysia palm oil production was the highest. Until 2005 – 2006, Indonesia manages to take over Malaysia to lead the way. To date Indonesia and Malaysia remain as the world major producer of this vegetable oil which accounts about 87% of world supply (Basiron, 2015; Abdullah and Sulaiman, 2013; Rifin, 2010).

1.2 Palm Oil Extraction Process and Biomass

Oil palm fresh fruit bunch (FFB) harvested when it is mature and fully ripe. The fruit need to be press and squeeze to extract its oil from the fibrous flesh of the fruit. The main products of the palm oil industry are crude palm oil (CPO) and crude palm kernel oil (CPKO). The extractions processes are as follows.

1.2.1 Sterilisation Process

The extraction process begin by sterilising the fresh fruit bunch (FFB) inside a huge steriliser with a very high pressure (3×10^5 Pa) set up between 120°C to 140°C for about 90 minutes. This helps to loosen the fruitlets from its bunch and the mesocarp become soft and easy to be press and extract for oil (Lam and Lee, 2011; Siew, 2011). At this stage, the main biomass or by-product is the sterilisation condensate which becomes palm oil mill effluent (POME).

1.2.2 Stripping

The sterilised bunches then moves to the next stage which is called stripping. Here the fruits are separated from its bunch inside a rotary drum stripper. The individual fruitlets then channel to digester by a conveyor bucket (Lam and Lee, 2011). Empty fruit bunch (EFB) is the main biomass generated from this stage.

1.2.3 Digestion and Pressing

The next stage is digestion. The fruitlets reheat at the temperature around 80°C to 90°C. The steam heat purpose is to further soften the mesocarp flesh and also to loosen the nut from the flesh. The fruits are then passing to the following stage which is the screw press. The steam cooked fruit then pressed and squeezed for the oil (Siew, 2011; Wu et al., 2010; Igwe and Onyegbado, 2007; Lam and Lee, 2011). No biomass generated from this stage since the homogenous oil channel to next stage.

1.2.4 Crude Palm Oil Extraction

The homogenous oil then channelled to clarification tank to purify the oil from all the excess water and impurities. The mixed oil passes through a vibrating screen, a hydrocyclone and decanters to remove fine solids and water. Centrifugal and vacuum driers are used to further purify the oil for the crude palm oil (CPO) before sending it to a storage tank. The temperature of oil (60°C) in the storage is maintained with steam coil heating before the CPO is cold. This is the end of oil extraction process. At this stage, decanter cake produced as the by-product.

1.2.5 Nut / Fibre Separation and Cracker

Whilst, the press cake from the screw press stage further treat in nut or fibre separator or depericarper, in order to separate between the nuts and fibre. The nuts then need to undergo several stages for extraction of the palm kernel oil (PKO). Upon pressing the kernel for oil extraction, the nuts will be fed into nuts cracker to separate the kernel and the shell (Siew, 2011). Palm kernel shell (PKS) and palm oil mill effluent (POME) are the biomass generated at this stage.

The extraction of PKO is either done at the same mill or need to be transfer to other mill if the first mill did not provide the facilities for PKO extraction. The flow diagram of the extraction process is as shown in Figure 1.1. According to Sulaiman et al. (2011), approximately 4 kg of by-product produced in every kg of CPO production. Table 1.1 shows amount of biomass generated in percentage.

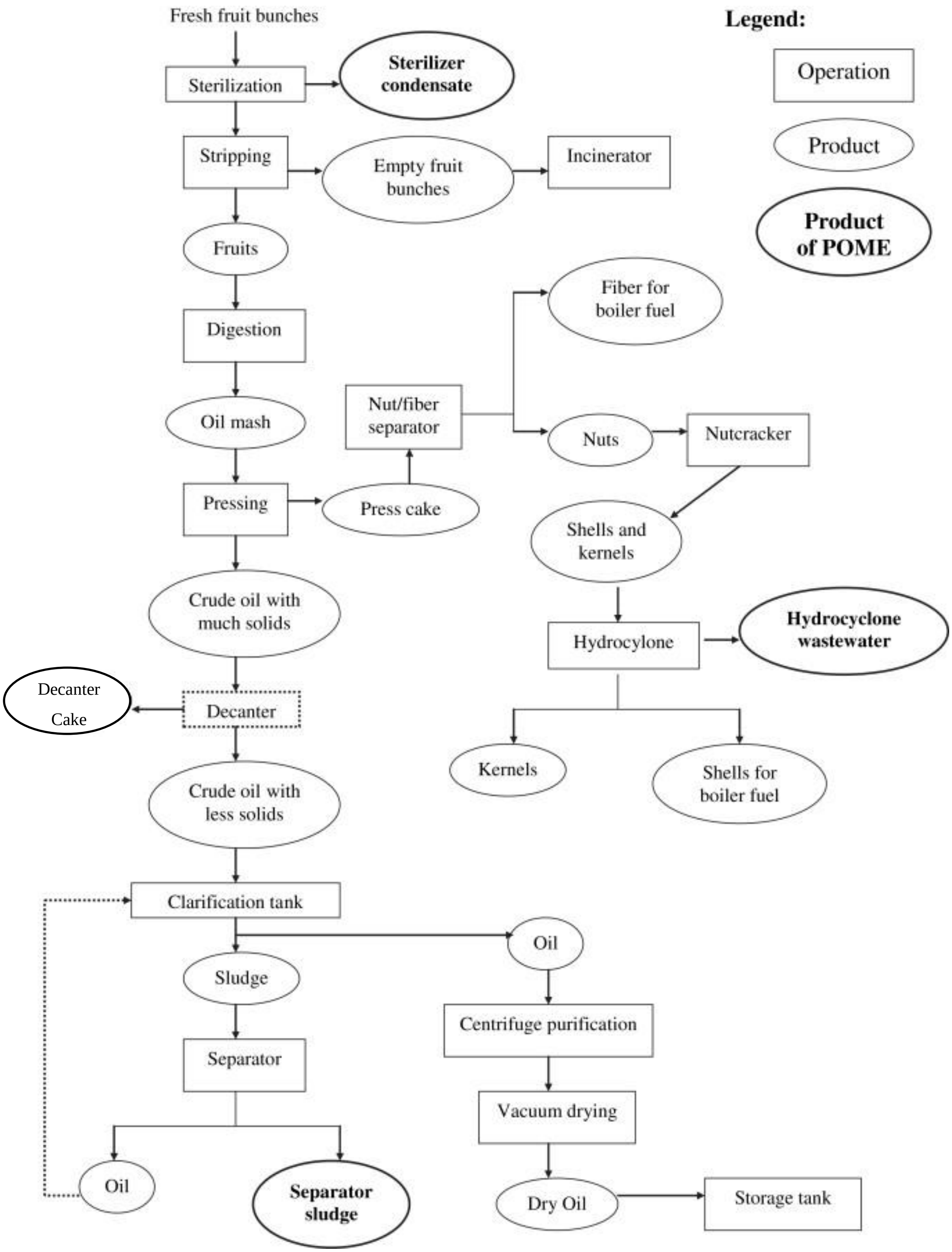

Figure 1.1: The flow diagram of extraction process. Decanter cake produced from the decanter centrifuge after pressing (Wu et al., 2010)

Table 1.1: Percentage of palm oil mill by-products on wet basis

Type of By-products	% of Fresh Fruit Bunch (FFB)	References
Palm Oil Mill Effluent (POME)	60	Abdullah and Sulaiman, 2013
Empty Fruit Bunch (EFB)	20	Ng et al., 2011; Abdullah and Sulaiman, 2013
Mesocarp Fibre	13	Nutongkaew et al., 2014
Palm Kernel Shell (PKS)	5	Ng et al., 2011; Abdullah and Sulaiman, 2013
Decanter Cake (DC)	4	Nutongkaew et al., 2014

1.3 Decanter Cake

Decanter cake (DC) is a solid waste from palm oil mill. Fresh DC possess certain amount of moisture and have a paste like texture. It got its name from the equipment that it is originated from which is a decanter centrifuge. Decanter centrifuge installed at the clarification process as separator to remove fine solids from the CPO. Crude oil mixture after pressing will be fed into decanter centrifuge. The benefit of decanter centrifuge usage is that it can reduce the amount of POME generated (Siew, 2011; Lim et al., 2009; Mohd Husin et al., 2009). Decanter cake consider as a minor biomass generated from the extraction process. Thus, it is usually dumped beside the mill. The caution rise when the amount of dumped DC accumulates through times. To date, sporadic researches have been done regarding the utilisation of DC. Decanter cake has been utilised as animal feed or ruminant feed by shaped it into pellet form (Chavalparit et. al., 2006). According to Abubakr et al. (2014) DC can be an alternative as a cheap animal feed in order to overcome the problem of the scarcity of its sources. Earlier, the same group of researcher suggested that only small amount of DC needed in goats diet since high dietary level might affect the goats or small ruminant growth negatively (Abubakr et al., 2013). Study perform by Gafar et al. (2013), decanter cake can be an additional ingredients of kacang goats up to 30%. This believes to aids the animal feed crisis. While Afdal et al. (2012) find out the fresh decanter cake is more suitable as an alternative feed especially for ruminant. Since it contains quite a high amount of moisture, some DC will be dried before being utilised as fuel or animal feed (Sridhar and AdeOluwa, 2009; Chavalparit et al., 2006).

Recent studies also show the capability of DC to be utilised as fuel or renewable energy source. According to Mohd Husin et al. (2009), decanter cake have a great potential as solid fuel due to high heat transferred value compared to wood charcoal. Other uses of decanter cake are as natural polymer composite (Adam et al., 2014) and utilisation for cellulase and polyoses production (Abdul Razak et al., 2012).

In agricultural field, besides as animal feed decanter cake also utilised as fertiliser, soil conditioner or soil amendment. Decanter cake used as added ingredients in fertiliser making process. According to Seng and Subramaniam (2008), co-composting of palm oil mill by-products such as EFB, POME, DC and boiler ash (BA) is the best solution for sustainable and zero waste crude palm oil production. In some researched done, decanter cake were mixed with other palm oil mill waste such as boiler ash (BA), empty fruit bunch, palm press fibre and inorganic fertiliser to produce palm-based bio-fertiliser and palm bio-organic (Haron and Mohammed, 2008). However, palm-based bio-fertiliser was tested only on oil palm seedling. There are other studies utilising decanter cake as compost component with several different other compost mixture and different kind of treatments. Baja Bio 5 by Sime Darby Plantations made up from dried decanter cake mixed with inorganic fertiliser to enhance its nutrient content. While United Plantation Bhd., took 6 weeks of composting period of decanter cake and inorganic fertiliser mixture followed by palletisation in making of their own fertiliser named Supergo (Lim et al., 2009). Study by Nutongkaew et al. (2014), compost made of decanter cake, palm empty fruit bunch and palm oil mill biogas sludge incubate for 60 days with the added of biogas effluent. While compost study by Yahya et al. (2010) mixture of empty fruit bunch, palm oil mill effluent and decanter cake slurry undergo three month of composting period with turning. The outcome of this study shows that decanter cake slurry helps in enhance the composting process as well as enriched the compost nutrients content.

Since decanter cake is of organic origin, it possesses several useful nutrients content. Decanter cake says to be rich in nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). It is also possess several micro nutrients or minerals such as copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn). Table 1.2 below shows characteristics per kilogram of DC from several previous studies.

Table 1.2: Decanter cake characteristics

Parameters	Percentage (%) / milligram/kilogram (mg/kg)	References
pH	4 - 5	Abdul Razak et al., 2012; Haron and Mohammed, 2008; Sahad et al., 2014
Nitrogen (N) (%)	2 - 2.8	Haron and Mohammed, 2008; Lim et al., 2009; Abdul Razak et al., 2012; Sahad et al., 2014
Phosphorus (P) (%)	0.2 - 0.5	Lim et al., 2009
Potassium (K) (%)	1.24 - 2.73	Lim et al., 2009; Abdul Razak et al., 2012
Magnesium (Mg) (%)	0.54 - 0.8	Lim et al., 2009; Abdul Razak et al., 2012
Calcium (Ca) (%)	0.8 - 1.6	Lim et al., 2009; Abdul Razak et al., 2012
Iron (Fe) (mg/kg)	4438 - 4800	Lim et al., 2009; Abdul Razak et al., 2012
Copper (Cu) (mg/kg)	45 - 59	Lim et al., 2009; Abdul Razak et al., 2012
Manganese (Mn) (mg/kg)	36 - 60	Lim et al., 2009; Abdul Razak et al., 2012
Zinc (Zn) (mg/kg)	30 - 60	Lim et al., 2009; Abdul Razak et al., 2012

1.4 Problem Statements

As the palm oil industry has established a long time, the situation which once not considered as a problem now becoming a threat to the nature and surrounding due to the accumulation of these by-products. These valuable by-products by hook or by crook need to be utilised in order to restraint its negative impacts to the environment and climate change (Sahad et al., 2014).

In every steps of crude palm oil (CPO) production, significant amount of by-product produced. Following the concept of demand and supply, where the supplies will directly proportional to demand. The demand of palm oil increased tremendously. Thus, land use for oil palm plantation and number of palm oil mill increased significantly. This increment of supplies does contribute to the increment of by-product in every steps of oil palm production. Started from the oil palm plantation itself, until the final product production that is the CPO.

For every tonne of CPO produced, about 5.8 tonne of fresh fruit bunch (FFB) needed (Pleanjai et al., 2007). According to Sulaiman et al. (2011) and Ng et al. (2012), approximately 4 kg of by-product produced in every kg of CPO production. One third derived from the fresh fruit bunch and the other two third derived from the oil palm plantation itself. From the amount of by-products generated, it is estimated that amount of decanter cake generated from the CPO extraction process is around 3.5 to 4.2% from fresh fruit bunch (Sahad et al., 2014; Nutongkaew et al., 2014; Adam et al., 2014). And in the near future, this amount is believed to increase due to the increase in number of decanter centrifuge installed in the palm oil mill (Adam et al, 2014).

According to Zanirun et al. (2014), the biomass or by-product management in Malaysia still not operates effectively. This includes the disposal and the utilisation of waste. Cost of operation might be one of the causes of the inefficiency. Moreover, despite of various kind of research attempted not all turnouts to have a positive result. For example research done by Zanirun et al. (2014) the finding shows DC is not so suitable to be use as substrate for cellulase production. Even though DC is well known utilised as fertiliser, the most effective method with the shortest duration time of utilising it still can be explore. So that it can be directly applicable to public.

Even though decanter cake produced in a very small amount compared to the other waste, the accumulation of this waste started ever since the industry begin in 1917 till now (Sulaiman and Abdullah, 2013; O;Holohan, 1997). Since decanter cake is of organic origin, it possesses certain amount of beneficial nutrient for plant growth. All these minerals that helps the decanter cake binds together like a paste, holding moisture when wet. Moreover, physically, the texture of the decanter cake is powdery form when dry, it is expected that it could mix thoroughly and homogenously with soil as soil conditioner. These criteria possess by decanter cake that increase its ability to enhance the physical properties or structure of sandy soil sample used in this study. Leafy vegetable plant chose as experiment plant due to its short shelf life. The harvesting period last for several months to less than one year (Suzanne et al. 2012). This ensures that the applicability of decanter cake as soil conditioner monitored in short period of time. Apart from that, a leafy vegetable has a hairy roots type that suitable to be planted in sandy soil.

1.5 Objectives

This research conducted with several objectives as a guidance or aim of the successfulness of this research. There are;

i. To study the physicochemical characteristics of decanter cake and soil sample.

ii. To evaluate the effect of the decanter cake application as soil conditioner on seed germination and growth, plant morphological, biomass, photosynthetic pigments, and nutritional quality at different amendments rates

iii. To evaluate the physicochemical properties of plant growth in decanter cake and inorganic fertiliser

1.6 Scope of Research

In order to achieve the listed objectives, this research study carried out with these limitations. The raw material analyse is palm oil mill by-product, specifically the decanter cake collected from MALPOM Industries Sdn. Bhd. located at Nibong Tebal, Pulau Pinang. Only single type of soil used which obtained from Kampung Sungai Kechil, Nibong Tebal, Pulau Pinang. The experimental plant used is a leafy vegetable type of plant since it is a short term crop and the vegetable chosen is Kailan (*Brassica oleracea var.* Alboglabra*)* which is one of the commonly consume vegetable by local people.

The analyses for this study was done in two parts, the plant part and the soil part with the interested parameters in plant part are morphological characteristic, biomass, photosynthetic pigments and physicochemical analyses. While the parameters of interest in soil part consist of physicochemical analyses. The elements of physicochemical analyses are pH, electrical conductance (EC), C:N ratio, potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), lead (Pb), nickel

(Ni), cadmium (Cd), and chromium (Cr). Only fresh soil sample were tested for soil physical characteristics.

CHAPTER 2

LITERATURE REVIEWS

2.1 Utilisation of Oil Palm Biomass

In accordance with the economic theory, increment in supply will be proportional with the increment of demand. Thus, with the tremendous increment in demand for palm oil worldwide, Malaysia as one of the biggest palm oil producer has worked so hard to achieve or meet this demand. Various efforts have been focused on this matter. Started from increasing the size of oil palm plantation, increasing in number of processing mills to the upgrading the processing technology. In the ecstasy to multiple the profits, quite a number of cases or issues regarding the degrading impact of or to the environment. The issues of deforestation for oil palm plantation that related to the threat of the flora and fauna and the issues of the by-products or biomass residue generated both from the plantation and processing mill.

Palm oil industry besides being a profitable industry, it also generates a significant amount of biomass or by-product. And the conditions worsen over the year with the rapid expand of the industry when the amounts of the by-product accumulate and not being treated properly. Oil palm industry by-product divides into two. By-product generated at the plantation and at the mill.

To date Indonesia and Malaysia remain as the world major producer of this vegetable oil which accounts about 87% of world supply (Basiron, 2015; Abdullah and

Sulaiman, 2013; Rifin, 2010). According to Shuit et al. (2009), around 50 to 70 tonnes of by-product produces from a hectare of oil palm plantation. While a report by Agensi Inovasi Malaysia stated that almost 80 million dry tonnes of palm oil industry produced per acre in 2010 and around 60 million tonnes of the liquid biomass, palm oil mill effluent (POME) produce in the same year. From this amount, approximately 75% of the dry biomass produced from the plantation while the remaining 25% dry biomass produced from the palm oil mill. This percentage represent two thirds plantation originated by-products and a third palm oil mill generated by-products (Sulaiman et al., 2010; Abdullah and Sulaiman, 2013).

Approximately 4 kg of by-product produced for every one kilogram of crude palm oil (CPO) production (Ng et al., 2012; Abdullah and Sulaiman, 2013). There are various types of biomass derived from palm oil industry. The by-products generated at the plantation are mainly solid include oil palm frond (OPF) and oil palm trunk (OPT). The OPT will only give quite a significant numbers of biomass every 25 to 30 years for a particular plantation. It is only during replanting of oil palm taken place. While OPF generated throughout the year resulted from the pruning activity of the oil palm tree especially during harvesting period. Oil palm fronds often recycle within the plantation as nutrient supply, mulch and soil conditioner (Abdullah and Sulaiman, 2013; Abas et al., 2011). It can also be utilise as alternative source of animal feed.

At the palm oil processing mill, several types of by-product produced either in liquid form or solid. The characteristics and the name of the by-products depend on from which palm oil processing stage that it generated from. Liquid by-product is in the form of palm oil mill effluent (POME). The liquid by-product originated from several points of palm oil processing stages. It is a mixture of the sterilisation condensate then mix with the waste water from the separator sludge a phase after clarification taken place. For a mill with palm kernel oil (PKO) extraction phase, hydro cyclone waste water included in the mixture of POME (Wu et al., 2010).

Whilst solid biomass consist of empty fruit bunch (EFB), palm press fibre (PPF), decanter cake (DC), palm kernel cake (PKC), and palm kernel shell (PKS). The EFB is the very first solid phase by-product generated at the mill. It is a by-product after the stripping of the fresh fruit bunch (FFB). After all the loosen fruitlets being stripe out from the bunch, the EFB produce as the residue. Most of this biomass being utilised back inside the mill as a fuel for its incinerator (Abas et al., 2011; Abdullah and Sulaiman, 2013). This will resulted for another residue which called oil palm ash (OPA) or boiler ash (BA). Apart from that, EFB also used as mulch and soil conditioner at the plantation in order to reduce the uptake of the inorganic fertiliser (Ng et al., 2012; Shuit et al., 2009).

The PPF is a by-product after the separation between fibre and nuts. It is also served as boiler fuel to generate steam at the mill (Abas et al., 2011). For mill with decanter centrifuge installed as the separator between the CPO and suspended solid, DC will be the result as the by-product fruit bunch (Sahad et al., 2014). And palm kernel shell that generated after the nut cracking is usually utilised as the fuel while the PKC has the potential for feed and organic fertiliser (Abubakr et al., 2013; Alimon and Wan Zahari, 2012). According to Ng et al. (2011), most of the oil palm biomass or by-product are utilised back in compost mixture, as a mulch, plywood and so forth. Table 2.1 below is a list of the various usages of the various types of oil palm biomass.

Table 2.1: Types of biomass, quantity and its potential usage in million tonne (mt) and tonne (t)

Biomass	Quantity (dry weight)	% from Fresh Fruit Bunch	Quantity utilised	% utilised	Uses/Potential	References
Oil Palm Trunk (OPT) (at replanting)	1.38 million tonne		1.1 million tonne	80	Mulch, plywood	Abdullah and Sulaiman, 2013; Ng et al., 2011; Dam and Elbersen, 2004
Oil Palm Frond (OPF) (annually)	27.20 million tonne		25.83 million tonne	95	Mulch, animal feed	Dam and Elbersen, 2004; Abdullah and Sulaiman, 2013
Empty Fruit Bunch (EFB)	21.27 million tonne	23	13.83 million tonne	65	Mulch, fuel, pulp, paper, medium density fibre-board	Abdullah and Sulaiman, 2013; Ng et al., 2012; Abas et al., 2011; Ng et al., 2011; Sulaiman et al., 2011; Shuit et al., 2009; Yusoff, 2006; Dam and Elbersen, 2004
Palm Press Fiber (PPF)	10.9 million tonne	13	9.81 million tonne	90	Fuel, medium density fibre-board, brick manufacturing, paper production, compost, fertilizer, animal feed	Abdullah and Sulaiman, 2013; Ng et al., 2011; Sulaiman et al., 2011; Shuit et al., 2009; Yusoff, 2006; Dam and Elbersen, 2004
PalmOil Mill Effluent (POME)	50.3 million tonne	60	17.61 million tonne	35	Organic fertiliser	Abdullah and Sulaiman, 2013; Ng et al., 2012;

(wet weight)						Sulaiman et al., 2011; Chavalparit et al., 2006; Dam and Elbersen, 2004
Palm Kernel Shell (PKS)	5.92 million tonne	5.5	5.33 million tonne	90	Fuel, road cover	Abdullah and Sulaiman, 2013; Abas et al., 2011; Shuit et al., 2009; Yusoff, 2006; Dam and Elbersen, 2004
Oil Palm Ash (OPA)	48 tonne	0.48	0.05 tonne	< 10	Absorbent, compost material, fertiliser	Abdullah and Sulaiman, 2013; Sulaiman et al., 2011; Shuit et al., 2009; Haron and Mohammed, 2008
Decanter Cake (DC)	42 tonne	0.042	0.005 tonne	< 10	Animal feed, fertiliser, compost material	Haron and Mohammed, 2008; Chavalparit et al., 2006

2.2 Land Application and Soil Conditioner

Land application can be define as applying or mixing compostable substance into or onto the soil surface in order to enhance its properties (Perez, 2010). Soil need to be in a good condition for plant growth, in terms of its physical and physicochemical characteristics (Tullock, 2014). Condition of a soil can be enhanced by using soil additives or soil amendments. Soil amendment can be classified base on how the amendment affects the soil. Amendment that provide nutrients often refer as fertiliser.

Amendment that supply biology such as bacteria for the improvement of the soil food web known as soil inoculants. While amendment that improve the soil properties called soil conditioner (Usry, 2014). However certain materials possess both criteria and properties to be used both as fertiliser and soil conditioner. A poor soil condition such as extremely sandy soil can be amended by conditioning the soil with a suitable soil conditioner.

Soil conditioner is a material that contains a limited amount of nutrients but still affects the properties of the soil biologically, physically and chemically. This makes it suitable to be used as planting medium. It can be either organic origin or inorganic origin. As organic material release its nutrients content slowly, thus organic origin soil conditioner, might potentially act as fertiliser later than just a soil conditioner (Geltink, 2010). Soil conditioner is a substance or mixture of substances aiming to enrich or correct the soil properties for plant growth and productivity. Soil conditioner aiming to repair soil physical structure thus enhanced soil quality by improving soil structure and aeration, soil pH, increased the water holding capacity, soil compaction and improve absorption of water by plant. There are several types of soil conditioner available, organic soil conditioner, mineral soil conditioner and synthetic soil conditioner (Wang et al., 2012; Hickman and Whitney, 1988).

2.3 Leafy Vegetable: Kailan

Vegetables are plants that are suitable and safe to be consumed. Not all plant can be consumed as some of the plants are of poisonous type. There are various varieties of vegetables. There are vegetables in fruits group, root crops, legumes and leaves, stems or flower group (Tullock, 2014). Leafy vegetable such as spinach and cabbage are vegetables in leaves, stems or flower group. Leafy vegetables are a short-term crop plant, a plant that ready to harvest less than one year. It is also known as annual plant (Suzanne et al., 2012). It's harvesting period range between three weeks to 75 days depending on the vegetable (Ganesan, 2013). Besides, leafy vegetable is perishable in nature, thus it has a short life span. If it is not preserve after harvested, it will start to wither, deteriorate and decay (Kakade and Neeha, 2014). Leafy vegetable is a very powerful food. It possesses nutritional ingredients like vitamins and minerals that beneficial towards our health (Karuna and Kamaeswararao, 2014). Leafy vegetables are rich with calcium, iron, potassium, and magnesium as well as rich in vitamin K and vitamin C (Madhvi et al., 2014). Dark green vegetables are high in carotenoid and ascorbic acid minerals that both are good for health (Kakade and Neeha, 2014).

Kailan is one of the annual plants from leafy vegetable group. It is a vegetable that is widely consume by public especially in this country Malaysia. Kailan (*Brassica oleracea var.* Alboglabra) also known as Chinese Kale or Chinese broccoli (Sendi et al., 2013). Kailan has a dark green leaves and rich with vitamin A, B, and C. It is also loaded with calcium and iron that good for teeth and bone as well as blood. Kailan is a low calorie food and rich with fibre and mineral and act as a good antioxidant. Thus, consuming kailan can really benefit one health. In temperate area with enough sunlight, kailan can grow mature rapidly, healthy and bloom (Ab Rashid, 2013; Wyk, 2005).

2.4 Plant Nutrients

Plant needs balance nutrients to produce excellently. There are more than 60 elements discovered in the plant tissue. To date, researcher found out that at least 16 nutrients or elements needed by plant for optimal growth. These elements readily exist in the earth in minerals form (Raven et al., 1976). These nutrients categorise in two categories, macronutrient and micronutrient. Macronutrients required by plant in large quantity (more than 0.5% of the plant dry weight) while micronutrients needed in small or trace amount (only a few parts per million (ppm)) (Moore et al., 1998).

Among the macronutrients are carbon (C), hydrogen (H) and oxygen (O), nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca) and sulphur (S) (Moore et al., 1998; Fisher et al., 2012). Carbon, oxygen and hydrogen are major components of plant's organic compound as they are an essential component in all protein, carbohydrate and nucleic acid molecules (Rost et al., 2006; Moore et al., 1998). Nitrogen is taken up by plants in the form of nitrate (Tullock, 2014). It enhance plant growth via efficient photosynthetic process. Scarcity of nitrogen will eventually affect number of leaf of a plant (Adediran et al., 2015). Phosphorus helps cell division in plant that contributes the development of the plants part (Adediran et al., 2015). Potassium plays an important role in flower and fruit production (Tullock, 2014). Deficiency of potassium may cause weak stems and roots (Moore et al., 1998). Moreover, potassium is an important element for human body that helps in controlling heart rate and maintaining appropriate blood pressure (Hossain et al., 2014). While magnesium, as part of chlorophyll structure, is also an important plant nutrient for human as it requires for energy metabolism and several other process (Raven et al., 1976; Moore et. al., 1998;