UNIVERSITI PUTRA MALAYSIA

EFFECT OF OIL PALM EMPTY FRUIT BUNCH (EFB) COMPOST MEDIA IN COMPARISON TO OTHER MEDIA ON GROWTH AND YIELD OF LETTUCE (LACTUCA SATIVA)

NOR AKRAM MOHAMED ALI

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(*Lactuca sativa*)

By

NOR AKRAM BIN MOHAMED ALI

A Project Report Submitted in Partial Fulfillment of the Requirement for the Degree of Bacelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences Universiti Putra Malaysia Bintulu Campus

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DEDICATION

My dedication is special to my mother Mariam Hj. Talipuddin and my father Hj. Mohamed Ali Hj. Harun and all my brothers Izhar, Nazrin, Khairuzan and my sisters Siti Nazirah, Siti Fakharati and Nor Sabila.

ABSTRACT

This study was undertaken to evaluate the effects of Empty Palm Oil Fruit Bunch (EFB) compost as a growing medium in comparison to other media with lettuce (*Lactuca sativa*) plant used as the model plant. The study was conducted at Universiti Putra Malaysia Bintulu Campus. The study was conducted on 28th November 2006 ended on 6th December 2006 whereby four media treatments each with 5 replications were evaluated during that duration. The media components used in this study, in addition to EFB compost, were top soil, sand, and decomposed chicken litter. These components were mixed in the required proportion to make the required media of the required treatment. Treatment 2 (EFB compost medium) had the highest of mean weight of lettuce growth, and significantly better than the other treatments. Details of these results are described in the main text.

ABSTRAK

Kajian adalah mengenai kesan-kesan daripada kompos Tandan Kosong Kelapa Sawit (EFB) yang digunakan sebagai media dan perbandingan dengan media yang lain terhadap pertumbuhan salad (*Lactuca sativa*) sebagai model tumbuhan. Kajian ini telah dijalankan di Universiti Putra Malaysia Kampus Bintulu. Kajian telah dijalankan pada 28 November 2006 dan berakhir pada 6 Disember 2006 dengan menggunakan empat rawatan dan lima replikasi yang dijalankan sepanjang tempoh tersebut. Di antara komponen media lain adalah seperti TS (Tanah permukaan), pasir, dan DCL (sisa tahi ayam yang telah dikompos). Kesemua komponen ini telah dicampurkan mengikut nisbah masing-masing mengikut rawatan yang diperlukan. Ukuran berat digunakan sebagai parameter utama untuk membandingkan di antara rawatan-rawatan. Rawatan 2 (media kompos EFB) mempunyai min berat yang paling tinggi bagi pertumbuhan salad, dan mempunyai perbezaan yang signifikan berbanding dengan rawatan-rawatan yang lain. Semua keputusan terperinci dinyatakan di dalam teks ini.

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APPROVAL SHEET

I certified that this research project report entitle "Effect Of Empty Palm Oil Fruit Bunch (EFB) Compost Media in Comparison to Other Media on Growth and Yield of Lettuce (*Lactuca sativa*)"has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

Mr. Michael Gregory T. Banta

Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Campus

Prof. Dato' Dr. Nik Mohamad bin Nik Abdul Majid

Dean
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Campus

Date: 14/8/07

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mt- metric tonne

CHAPTER I

INTRODUCTION

Background

The palm-oil industry in Malaysia is currently estimated at more than three million hectares of oil palm plantations (Lim, 2000). In total, about 90 million mt of renewable biomass (trunks, fronds, shells, palm pressed fiber and the empty fruit bunch) are produced each year. The empty fruit bunch residues, left after the fresh fruit bunches are pressed at oil palm mills and the oil extracted (Ma *et al.,* 1993; Kamarudin *et al.,* 1997) represent about 9% of this total biomass. It is estimated that the extraction of palm oil produces more than a million metric tonnes of empty fruit bunch (EFB) as waste material every year (Lim, 2000).

Empty fruit bunch has not been fully utilized economically and its disposal is always subjected to environmental concern. Although EFB can be used as energy source at the palm oil mills, it is still cost ineffective. Thus, the need to utilize EFB for development of useful products is necessary to address these concerns (Villalobos *et al.,* 1990).

In the past, the empty fruit bunch waste was either burnt off or left as mulching materials on the ground in the plantation, neither of which is environmentally and economically viable (Nik Ahmad *et al.,* 2002). The empty fruit bunches have traditionally been burnt in simple incinerators, as a means of disposal and the ash recycled onto the plantation as fertilizer. Burning process causes air pollution and now has been banned in some countries, for example Malaysia and Indonesia. Under this route of disposal no energy is recovered. Alternatively EFB can be composted and returned to the plantation, or returned directly as mulch (Kamarudin *et al.,* 1995).

The empty fruit bunch is now used mainly as mulch (Hamdan *et al.,* 1998). The beneficial effects of EFB mulching on oil palm growth and yield have been known since 1934 (Abdullah *et al.,* 1987). With the increasing cost of inorganic fertilizers, the utilization of oil palm empty fruit bunch as mulch and as a source of nutrients is an important alternative as a substitute for fertilizer when distributed and applied evenly (Gurmit *et al.,* 1999). The oil palm empty fruit bunch is capable of releasing nutrients slowly to the soil by the action of microorganisms and therefore effectively recycling the plant nutrients. In addition, soil structure is also greatly improved due to better aeration, increased water holding capacity and soil pH (Gurmit *et al.,* 1999).

The effects of EFB mulching with inorganic N and K fertilizer application to determine the optimum rates and frequency of EFB and inorganic fertilizer application for mature oil palm has not been properly investigated. In the absence of scientific data, oil palm estates have been applying large amounts of N and K fertilizers with the EFB because of the need to maintain high yields. The supplementation of inorganic N and K fertilizer is necessary due to the slow release of nutrients from the EFB. The yield increase was enhanced when mulching was supplemented with inorganic fertilizer (Lim and Zaharah, 2000).

More trials about the fertilizing effect of the new EFB compost would be necessary to find the optimum rotting time and compost application. The EFB compost produced is a source of nutrients and humus not only in oil palm plantation but also in other crop production such as for vegetable, fruits, nurseries, and other horticultural crops (Theo and Chia, 1993).

The benefit of utilizing oil palm empty fruit bunch for mulching is not fully realized by farmers who still regard the EFB as unwanted agro-waste and leftover. The main problem that can arise by letting this agro-waste to remain unattended for indefinite period of time is the storage space it requires as the production of EFB keeps increasing every year. Under such unattended condition the EFB mass will undergo slow natural decomposition, a situation which also attracts insects and indirectly make the EFB mounds as breeding grounds for some pests and infesting the oil palm crop in the plantation (Gurmit *et al.,* 1999). High transportation and distribution costs are also considered as problem factors for mulching activity (Schuchardt *et al.,* 2000).

Composting is a method of solid waste management whereby the organic component of the solid waste stream is biologically decomposed under controlled conditions to a state in which it is stable and can be handled, stored, and/or applied to the land without adversely affecting the environment (Fitzpatrick, 2001). Modern agriculture or agro-industries are producing high quantities of organic wastes that are typically rich in nutrients, which can be used in agriculture to conserve nutrients and to reduce waste discharge and the use of chemical fertilizers. Many community ordinances prevent the burning of leaves and refuse, and space for waste disposal is becoming scarce. Therefore, composting of waste is advocated, which produces both useful and an ecologically compatible product (Hansen and Mancl, 1988).

The agronomic utilization of organic compost not only represents a low-cost disposal method, but also a means to recycle nutrients for plant growth and to counteract the decreasing organic matter content of most modern agricultural soils. Composted manure can be an alternative source of fertilizer in organic farming where the use of manufactured chemicals is prohibited (Hodges, 1991).

Problem Statement

The amount of oil palm empty fruit bunch increases every year produced as wastes after the fresh fruit bunches are processed. The most common utilization of the EFB is for mulching purposes and as organic addition of inorganic fertilizer for the oil palms. The direct application of inorganic fertilizer onto the crop supplemented with the EFB mulch result in the slow release of nutrients into the soil.

The use of EFB as mulch can minimize the burning of large quantity of oil wastes and reduce the major problem of air pollution arising from such burning. However, the use of EFB as mulch in the oil palm plantation has not been cost effective logistically. With the prohibition to incinerate EFB in Malaysia, the EFB is simply returned back to the plantation and dumped to waste. Concerted effort is therefore needed to investigate the potential of the EFB waste for beneficial use such as for growing medium for crop plants, and other value-added products.

Objective

1. The main objective of this study was to evaluate the potential of empty fruit bunch of oil palm (EFB) waste as media for growing horticultural crops in which for this study lettuce (*Lactuca sativa*) was selected as the model vegetable crop. This selection was based on the short growing cycle of this vegetable crop which takes seven weeks, at the most, to complete the growing cycle. It is also a high value vegetable crop. The evaluation of the EFB compost media also included other common growing media for comparative evaluation of the results.

CHAPTER II

LITERATURE REVIEW

The Potential of Empty Fruit Bunch (EFB) as Compost

Oil palm empty fruit bunch (EFB) is a by-product left in huge quantities by the palm oil mills. It is commonly used as a raw material for producing compost and recycled back to the oil palm plantation and in some instances it is used as compost for some vegetables and fruit crops (Wan Rasidah *et al.,* 2000). The results from direct EFB application are generally better in terms of vegetative growth, palm nutrition and yield (Loong *et al.*, 1987).

The use of EFB as mulch helped the soil to preserve soil moisture, reducing the soil temperature and increasing nutrient uptake and crop productivity (Simpson and Gumbs, 1986). The application of EFB mulch is therefore recommended to alleviate the problem of water stress and to increase soil nutrient content in areas exposed to water deficit, at least during the first dry season after field transplanting, when the crops are more susceptible to water deficit (Chan *et al.,* 1980). The increased nutrient uptake with EFB could have been due to the more conducive environment resulting from the improved soil physical and chemical properties (Loong *et al.,* 1987) and the increased rooting activity could have been another factor.

The application of EFB as mulch also has been practiced in oil palm field nurseries (Gunn *et al.,* 1981) and has shown to be beneficial to the oil palm growth with higher yield in mature palms under different soils and rainfall regimes in Malaysia (Loong *et al.,* 1987).

Mulching with oil palm empty fruit bunch (EFB) supplemented with inorganic fertilizer is also widely practiced in oil palm plantations but with little evidence in support (Lim and Zaharah, 2000). Application of EFB at 37.5 t ha^{-1} yr^{-1} together with inorganic N and K fertilizers at the rate of 0.735 kg N and 1.75 kg K $palm^{-1}$ yr^{-1} improved the leaf N and K levels, bunch number, bunch weight and fresh fruit bunch yield (Lim and Zaharah, 2000). The frequency of fertilizer application did have some effect on the leaf nutrient levels and yield. Thus, EFB mulching supplemented with N and K fertilizers should always be advocated for improving oil palm nutrition and yield (Lim and Zaharah, 2000). The use of EFB also improved the nutrient content of the soil, increased the soil pH and cation exchange capacity, reduced erosion, decreased nitrogen losses, and controlled weed growth (Singh *et al.,* 1981; Loong *et al.,* 1987).

Nutrient Content of Empty Fruit Bunch of Oil Palm

According to Chan *et al.*, 1980, nutrient content of empty fruit bunch is estimated at 0.35 % Nitrogen, 0.03% Phosphorous, 2.29% Potassium, 0.18% Calcium, and 0.15 % Magnesium. Similar report on the nutrient content of EFB was also made by Hoong and Nadaraja (1988) as presented in Table 1.

Table 1: Nutrient content of Empty Fruit Bunch

Composition as a percentage of dry matter				
Nitrogen (N)	Phosphorous (P)	Potassium (K)	Magnesium (Mg)	Calcium (Ca)
0.44	0.144	2.24	0.36	0.36

Hoong and Nadaraja (1988)

According to Damanhuri (1998) the nutrient content of EFB was reported at 3.3% nitrogen, 0.05% phosphate, 0.2% potassium, 1.0% calcium and 0.2% magnesium. On a dry weight basis, the chemical composition of EFB as reported by Deraman (1993) were 6.3% ash, 8.9% oil, 42.8% carbon, 0.8% N, 0.22% P_20_5, 2.9% K_2O, 0.3% MgO and 0.25% CaO. Arokiasani (1989) had reported that Ca content in EFB increased in high K and this indicated a possible inverse relationship between soil Ca and K supplied through EFB application for crops.

The use of potassium with EFB improved water status of crops under conditions of water stress and the application of EFB mulch is recommended to alleviate the problem of water stress and to increase soil nutrient content in areas exposed to water deficit, at least during the first dry season after field transplanting, when the crops are more susceptible to water deficit (Villalobos *et al.*, 1990).

Ash and Fibre Content of Empty Fruit Bunch

The ash content of EFB which is rich in potassium was estimated at 30%, and is usually used as fertilizer (Lim, 2000) while Uribe and Bernal (1992) reported that the ash of EFB contains 30 to 35 % of K_2O and that high amount of Potassium could be available for oil palm uptake 120 days after the application of EFB.

In addition to ash component, EFB fiber is also composed of 45-50% cellulose and about equal amounts, at 25-35%, of hemicellulose and lignin (Damanhuri, 1998). The empty fruit bunches generated as a waste material by palm oil mills consist of fibres or bundles of fibres. The individual fibres are on average about 1 mm long, 25 µm wide and 3 µm thick and these fibres or bundles of fibres are physically stuck together to form vascular bundles (Deraman, 1993).

Current Utilization of EFB and other Organic Wastes on Crop

The empty fruit bunch (EFB) and palm oil mill effluent (POME) discarded by oil palm mills are useful organic wastes which could be used to sustain crop production (Aminuddin *et al.,* 1999). By embedding EFB in layers into planting holes, Aminuddin *et al.,* (1999) found the yield of papaya fruits increased significantly (Table 2).

Table 2: Yield of papaya on sand tailing with and without EFB compost

Treatments	Fruit Yield/Plot	
	Kg	No of Fruit
With 2 layers of EFB	87.3	196.8
Without EFB	29.9	63.8

Aminuddin (*et al.,* 1999)

In addition, studies on the yield response of cabbage to Palm Oil Mill Effluent (POME) showed the need for 60 t/ha POME. Yields obtained were 21 t/ha (Vimala *et al.,* 1998). With the application of 1.5 t/ha inorganic fertilizer, yields increased to 34 t/ha, indicating that organic fertilizer alone may not always be able to provide sufficient nutrients for high yields. Several organic fertilizers were evaluated on lettuce grown on peat soils and the results obtained showed that poultry manure (P.M) out yielded the other organic fertilizers (Table 3 and 4) (Vimala, *et al.*, 2000).

Table 3: Nutrient contents of various organic fertilizers for lettuce grown on peat

Organic source	Nutrient Content (%)					
	N	P	K	Ca	Mg	C/N Ratio
Chicken manure	2.6	2.9	3.4	7.9	1.1	8.3
Processed chicken manure	1.9	2.1	2.2	13.8	0.6	11.5
Worm compost	1.9	1.7	2.0	6.6	0.6	13.6
Kusocom	1.7	1.5	1.7	3.1	0.6	19.2

(Vimala *et al.*, 2000)

Table 4: Yield response of lettuce grown on peat to various organic fertilizers

Organic fertilizer	Yield of lettuce (t/ha)
Processed chicken manure	24.5a
Chicken manure	22.9a
Kusocom	21.2ab
Wormcompost	20.1ab
Inorganic fertilizer (600 kg/ha)	15.7b
Control	9.3c

(Vimala *et al.*, 2000)

Comparison of several organic nutrient sources on the yield of lettuce in Cameron Highlands showed that chicken manure as the sole source of nutrients gave yields equivalent to chicken manure + NPK. All the other organic sources gave lower yields compared to organic source + NPK (Vimala *et al.,* 2001). The nutrient contents of the organic sources and the yields obtained are presented in Tables 5 and 6 respectively.

Table 5: Nutrient content of some organic fertilizers for growing lettuce used in Cameron Highlands

	Percent					ppm					
Organic fertilizer	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn	B	C/N ratio
Chicken manure	2.59	2.93	3.39	7.97	1.07	475	2505	76	506	39	8.3
Processed poultry manure	1.93	2.09	2.21	13.8	0.9	467	7656	58	631	38	11.5
PM + sawdust compost	2.01	1.32	1.79	4.7	0.52	278	1088	76	328	71	14.9
Wormcompost	0.92	1.95	0.38	9.73	0.64	4.76	3007	69	459	49	21.6
PM + sawdust + rice husk compost	0.59	0.23	0.29	0.85	0.09	-	-	-	-	-	59

(Vimala, Salbiah *et al.*, 2001)

Table 6: Yield of lettuce in Cameron Highlands grown with and without NPK

Fertilizer	Yield (kg/plot)	Yield reduction with only organic fertilizer (%)
Poultry manure	12.96a	4.8
Poultry manure + NPK	13.61a	-
Worm compost	8.94b	28.4
Worm compost + NPK	12.48a	-
PM + sawdust compost	8.47b	32
PM + sawdust compost + NPK	12.45a	-
PM + sawdust + rice husk compost	5.28c	47.5
PM + sawdust + rice husk compost + NPK	10.05b	-

(Vimala, Salbiah *et al.*, 2001)

Effects of Some Composted Organic Waste on Crops

High-quality compost can provide soil nutrients for improved crop, garden, and/or turf productivity. Even compost relatively low in available nutrients can provide valuable organic matter to soil, thereby improving permeability and water-holding characteristics. Cured compost can be marketed as an amendment to improve soil productivity, as a component in potting soil, or as a mulch for landscaping and gardening. If high temperatures have been maintained in the composting process, the compost will be relatively free of weed seeds, insects, and pathogens compared to untreated organic wastes (Dana, 1996).

As a general principle, all material such as compost that has significant fertilizer value should be applied only up to the level of crop requirements. However, the way in which compost can be used is different when compared to mineral fertilizers. Different composts may vary in fertilizer value but a typical sample originating from organic waste compost is likely to have the following characteristics; pH of 5.7 – 8.7, moisture content of 25-30% and organic matter content of >25% (Changa *et al.,* 2003).

Compost applied as a soil amendment can improve the soil organic content, the water and nutrient retention in soils susceptible to leaching, and stabilize soil pH. Compost can be a source of both macro- and micro-nutrients. However, these benefits can be reduced in hot humid climates, in which the decomposition of organic matter is faster than in temperate climates (Dick and McCoy 1993). Stoffella and Graetz (1996) reported that total tomato yields, and also early marketable yields, were higher and mean fruit size (g/fruit) was larger, in plots amended with sugarcane filtercake compost (224 mt/ha) as compared to control plots without compost.

Fonteno *et al.,* (1996) reported that aeration and water-holding capacity are the media physical properties of primary interest to growers because they directly affect plant growth and cultural practices like irrigation. Particle size is another physical property of interest to container plant growers. The size distribution of the particles and pores affects the air and water holding capacities of the media. Many types of composts, especially those high in fiber or with larger particles, can be used as mulches, although research results on this application are limited.

The agronomic utilization of manure compost not only represents a low-cost disposal method, but also a means to recycle nutrients for plant growth and to counteract the decreasing organic matter content of most modern agricultural soils. Composted manure can be an alternative source of fertilizer in organic farming where the use of manufactured chemicals is prohibited (Hodges, 1991). The main problems that can arise from excessive manure applications are plant toxicity due to high salt content (Meek, 1994) and accumulation in plants of trace metals which may pose a health risk when humans or livestock consume the plant (Donahue, 1997).

The use of organic materials as mulches also can slow the evaporation of water from the soil surface, moderate soil temperatures, serve as a source of slow release nutrients, reduce the germination of weed seeds and subsequent weed growth, and protect soil from erosion and structural breakdown by sun, wind, and rainfall (Palada *et al.,* 1992). Organic mulches also improve the soil, by reducing erosion by heavy rain, minimizing compaction, increasing the water-holding capacity of the soil, slowing the release of nutrients, increasing microbial activity in the soil, and controlling soil temperature (Anonymous, 1987). Organic mulches can be as effective as conventional herbicides in controlling weeds (Aparbal *et al.,* 1985).

A few recent studies do seem to support the claim that compost can increase crop yields. An Ohio State University study (Subler *et al.,* 1998) found that raspberries treated with hog manure vermicompost had slightly greater growth than raspberries grown with commercial fertilizer. Unfortunately, other compost types, including yard waste, leaf litter, bark, and chicken did not do as well and even suppressed growth. It is believed that this anomaly maybe due to the compost being immature and thus, containing phytotoxins (compounds poisonous to plants). In this same study (Subler *et al.,* 1998), Marigolds and tomatoes grown in a potting mix amended with compost had significantly higher chlorophyll levels and greater growth than those grown in the potting mix alone did. This increase was noted for all compost types in the study except leaf compost. They also noted that the best results occurred when only small amounts of compost were added (as little as 5%).

Effects of Mature and Immature Compost on Crops

In addition to nutrient content and availability, particularly for nitrogen, other important characteristics of composts used as potting media include stability and maturity. Compost maturity refers to suitability is the resistance of the material to further microbial decomposition and is free of phytotoxic substances (Sullivan and Miller, 2001).

Sullivan and Miller (2001) had reported about the effectiveness of a bioassay at predicting Ivy leaf Morning glory injury was tested. Ivy leaf Morning glory seeds were sown in pots filled with sand at 1.0 cm depth with immature (3-day-old) compost, mature compost or commercial artificial media, applied as a 7.5 cm deep mulch layer on the sand. A randomized complete block design with six replications per treatment was used. Plant emergence and seedling growth (shoot and root dry weight) were recorded. Immature compost (3-day-old) delayed emergence by four days and decreased percent emergence by 50% as compared to the control. Shoot and root dry weights per pot were lower in immature compost than mature compost, artificial media and the control (Sullivan and Miller, 2001).

Similar results were reported by Chanyasak *et al.,* (1983) with immature compost that inhibited the growth of Komatsuna (*Brassica rap v. Pervidis*). This inhibitory effect on growth, especially in the early stages of composting, may be associated with the presence of low molecular weight fatty acids, especially propionic acids and n-butyric acid. Higher shoot dry weight occurred when mature compost was applied, and may have resulted from the higher nutrient content and absence of phytotoxins in the compost. In general, compost applications reduced the dry weight of roots, as compared to the control (no mulch). Salt content, heavy metals, and C/N ratio may be responsible for a decrease in the percent germination, percent emergence, and shoot and root dry weight. However, a chemical analysis of the composts indicated that only small chemical changes occurred in compost after it was three days old until it reached maturity (Gray and Biddlestone, 2000).

CHAPTER III

MATERIAL AND METHOD

Growing Media

This study was to evaluate the effect of EFB compost media on the growth of lettuce (*Lactuca sativa*). This was compared to three other common growing media. There were four media components used in this study as indicated below:

a) Top soil (TS)

b) Empty Oil Palm Fruit Bunch compost (Shredded EFB + POME)

c) Chicken litter (CL)

d) Sand

Shredded EFB compost was supplied by Golden Hope Plantation Sdn. Bhd., Bintulu, in the form of a mixture of palm oil mill effluence mixed with shredded EFB undergoing microbial decomposition (Pers. Comm with En. Junaidi, Golden Hope Plantation, 2006). The top soils, sand and chicken litter were supplied by the Farm of University Putra Malaysia Kampus Bintulu.

Treatments Media

Four different media were evaluated as treatments in this study as indicated below:

a) Treatment 1 (T1): Top soil only (TS) (control)

b) Treatment 2 (T2): EFB compost only

c) Treatment 3 (T3): Mixture of top soil and chicken litter (TS+CL) in 3:1 ratio by volume.

d) Treatment 4 (T4): Mixture of top soil, sand and chicken litter (TS+S+CL) in 3:2:1 ratio by volume.

The media for each treatment were filled into black polybags of size 14” wide by 17” high and filled up to 12 inches depth and labeled accordingly (Figure 1).

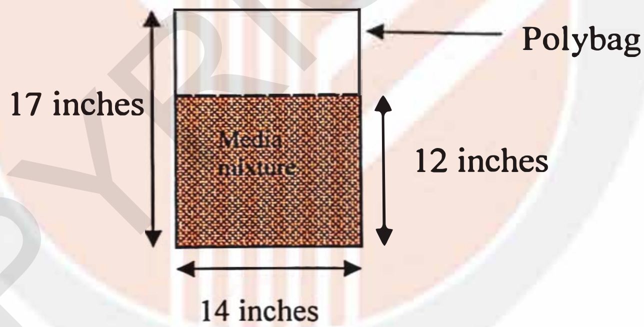


Figure 1: The size of polybags filled with media mixture

Experimental Design

Each of the four treatments was replicated five (5) times to give a total of 20 experimental units. The entire experiment was conducted under rain shelter in completely randomized design (CRD). All experimental units were laid at random. The experimental model was a fixed model as shown below:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Where, Y_{ij} = yield

μ = overall mean

T_i = treatment effect

E_{ij} = experimental error

Arrangement of Treatments

There were 20 polybags representing the 20 experimental units. The polybags filled with the treatment media were placed at random in four (4) rows at five (5) polybags per row at 1 foot spacing between polybags kept under rain shelter structure (Figure 2). The spacing of 1 foot between polybags was to facilitate movement and work activities. This spacing was also considered appropriate in providing sufficient space to accommodate full expansion of the broad growing leaves of the lettuce plants. Figure 2 shows the arrangement of the polybags containing the various treatments set under the rain shelter structure.

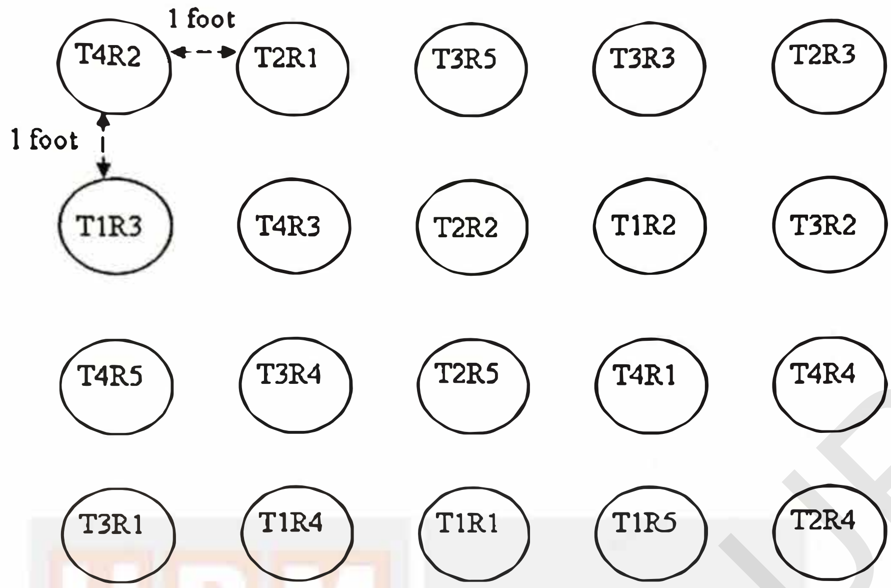


Figure 2: Arrangement of polybags containing the treatments

Treatment Preparation

The top soil used for the treatments was sieved to separate unwanted debris such as stones, plant roots, and others. The EFB compost supplied by Golden Hope Plantation was rather moist and lumpy and needed to be dried and pounded to break the lumpy condition so that it could be used for the study. About 120 kg of EFB was obtained for this purpose. As for the chicken litter and sand, both of which were supplied by the University Farm, these were ready for immediate use.

Determination of Nutrient, pH, Ash and Fibre Content of Treatment Media

Samples of each treatment media of 1 g each were taken and prepared for determination of pH and nutrient content using the AAS machine. In addition to pH and nutrient content, additional samples were also taken from EFB to determine its ash and fiber content using the AOAC (1992) procedure. These samples were sieved and ground finely for analysis. The pH of each treatment was determined by the potentiometric method using pH-KCl (1:2.5) and pH-H_2O (1:5) procedures. The N content was determined by the Kjeldahl method. The determination of cations, K, Ca, Mg, Fe, Na, Mn, and Zn was made by single dry ashing method and determined by AAS machine.

Site Preparation

The rain shelter structure was equipped with transparent plastic roofing, sprinkler watering system with gravel-covered floor. The four sides of the structure were partially covered, at half-way down from the roof, with black plastic netting. The choice of using the rain shelter structure was to facilitate management and prevent direct impact of rain and other extreme environmental condition. Before setting the experiment, the site was cleared of all vegetation and other undesirable debris.

Germination of Lettuce Seeds

Lettuce seeds (Green Star K-8) was supplied by the University Farm, UPM Bintulu Campus. The seeds were pre-germinated on 28th October 2006 using wet paper towels placed in a tray under normal condition. After 48 hours the pre-germinated seeds were sown into Jiffy pellets. Before sowing the seeds, all Jiffy pellets were soaked in water in a pail for several minutes to attain full expansion. Jiffy pellets containing the pre-germinated seeds were placed in a plastic germination tray. The tray holding the Jiffy cubes with the seeds was then placed under shade for two days after which it was then exposed to sunlight every morning from 8.00 am to 12.00 noon for another one week. Watering was given twice daily, morning around 8.00 am and evening around 5.00 pm.

The germinating seedlings were thinned out by hand leaving 5-6 seedlings per Jiffy cube to continue growth until transplanting.

Transplanting of Lettuce Seedlings

The lettuce seedlings were transplanted into Jiffy pellets growing medium after attaining 14 days of growth (Figure 3). Transplanting was done with the aid of a hand trowel by planting the entire Jiffy pellets ball into the black plastic polybags containing the treatment media (Figure 4). Each Jiffy pellet ball contained 5 – 6 lettuce seedlings. The polybags containing the transplanted lettuce seedlings were labeled to indicate the various treatments and treatment replications. Adequate watering was given immediately after the transplanting process. After one week of transplanting, thinning was done leaving only one healthy and vigorously growing young lettuce plant per polybag to continue growth for the study.

Figure 3: Lettuce seedlings in Jiffy pellets placed in a germination tray

Figure 4: Transplanting lettuce seedlings into the treatment media

Crop Management and Maintenance

Watering

Lettuce requires about an inch of water. To meet this requirement watering was given regularly using the over head sprinkler watering system. During the drier period watering was given twice daily at 3 – 4 minutes each time. Manual watering was also conducted whenever necessary.

Fertilizing

All treatments were given the usual 12:12:17:2 (N:P:K:Ca) fertilizer formulation in equal amount at the rate of 60 g per polybag which is based on the rate and type of fertilizer used by standard practice for lettuce vegetable cultivation (Jackson, 1996). The application of fertilizer was made every two weeks.

Weeding

Weeding is important as the roots of the lettuce plants are very close to the media surface. In order to avoid damaging the roots, weeding was done manually by light shallow cultivation at the surface of the media just deep enough to cut the weeds off below the surface. No chemical weedicide was applied. All treatments were checked once in 2 days from the first week until the fifth week.

Pest and disease management

Lettuce crop is prone to leaf diseases. During the crop growing period in this study, diseases prevention was practiced by regular spraying of fungicide, Maneb, at standard rate at two weekly intervals for all treatments. In addition, Thiram was also used to prevent mould growth at the rate of 10 g per liter of water sprayed onto the leaves using a sprayer bottle.

Harvesting

The lettuce plants were harvested after 45 days (about six weeks) of growth after transplanting. Harvesting was done in the morning at 8.00 am until 11.30 am by picking the whole plant including roots with a hand trowel by digging the entire plant out at about 4 inches deep from the growing media. The base of the lettuce head was then sliced with knife to separate the root part out. Each lettuce head, without the roots, was weighed using standard weighing device (with 2 kg scales) and the total weight of yield of each treatment was determined and recorded.

Data Collection and Analysis

Yield data for all treatments was determined on the basis of the weight of lettuce heads produced and the mean weight of five (5) reps for each treatment was computed. All data were analyzed using the Statistical Analysis System (SAS) software version 9.1 and all statistical comparisons of data were made in according to the Duncan's New Multiple Range Test (DNMRT) procedure.

CHAPTER IV

RESULTS

The main parameter used in this study was the yield of lettuce produced on the basis of weight of the lettuce heads harvested after 45 days of growth, from 28th October 2006 (seed germination) until 6 th December 2006 (harvest) for all treatments (Appendix B).

Weight of Lettuce Heads

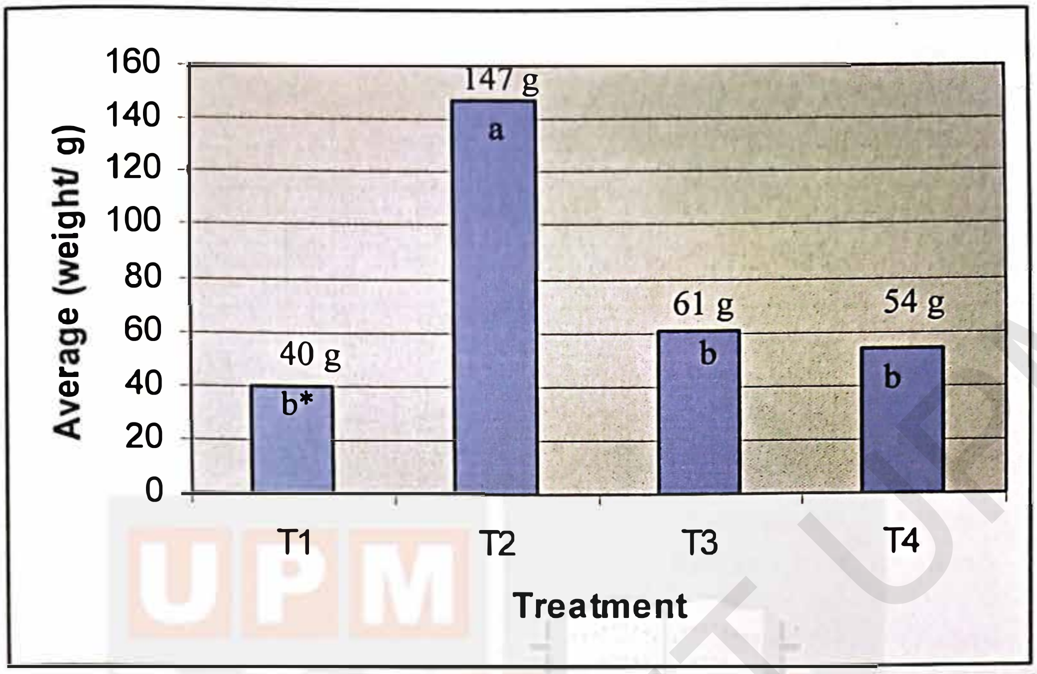
Table 7 shows the results of the comparison of mean weight of lettuce heads from the different treatments. The mean weight of lettuce head grown on T1 (top soil) was 40g, T2 (EFB) 147g, T3 (TS+CL) 61g, and for T4 (TS+S+CL) 54 g.

Table 7: Mean weights of lettuce heads for the four treatments

Treatment Media	Lettuce Head Mean weight (g)
T1 (TS)*	40
T2 (EFB)	147
T3 (TS:CL)**	61
T4 (TS:S:CL)#	54

* TS – Top Soil; EFB – Empty Fruit Bunch; CL – Chicken Litter; S – Sand
** TS:CL – 3 Top Soil:1 Chicken Litter by volume
\# TS:S:CL – 3 Top Soil: 2 Sand: 1 Chicken Litter by volume

The statistical comparison of the various treatment means using the DNMRT procedure is given in the graphs shown in Figure 5.



* Means with the same letter are not significantly different at $P \leq 0.05$

Figure 5: DNMRT comparisons of lettuce mean weight of the various treatments

Ash and Fibre Content of Empty Fruit Bunch

Table 8: Ash and fibre content of EFB

EFB media	Ash	Fibre
Average*	31.24%	31.21%

* Average of six samples at 1 g per sample

Nutrient Content of Treatments

Table 9: Analysis of nutrient content of the various media treatments

Treatment	Nutrient Content							
	(%) [a]	(ppm) [b]						
	N	K	Ca	Mg	Fe	Na	Mn	Zn
T1 (TS)*	0.84	6.51	43	305	3740	400.4	30.20	17.40
T2 (EFB)*	1.68	13.23	934	1758	4110	1100	266	76.8
T3 (TS:CL)**	0.56	9.38	5892	494	3152	10.98	171.8	196.7
T4 (TS:S:CL)#	0.56	7.69	5512	430	2586	10.21	155.6	144.2

* TS – Top Soil; EFB – Empty Fruit Bunch; CL – Chicken Litter; S – Sand
** TS:CL – 3 Top Soil:1 Chicken Litter by volume
# TS:S:CL – 3 Top Soil: 2 Sand: 1 Chicken Litter by volume
a By Kjehdhal method
b By AAS method

Results of pH Determination

The pH readings are presented in Table 10 for pH-KCl and pH-H_20 method.

Table 10: pH Readings of the Various Treatment Media

Treatment	pH	
	KCl	H_2O
T1- TS*	4.7	5.73
T2- EFB	6.73	7.5
T3- TS+CL**	6.53	7.25
T4- TS+S+CL#	3.83	4.82

* TS – Top Soil; EFB – Empty Fruit Bunch; CL – Chicken Litter; S – Sand
** TS:CL – 3 Top Soil:1 Chicken Litter by volume
# TS:S:CL – 3 Top Soil: 2 Sand: 1 Chicken Litter by volume

CHAPTER V

DISCUSSION

Comparison of Lettuce Heads Yield among Treatments

The results in Table 7 shows the mean weights for the four treatments with T2 at 147g has the highest yield than T3, T4 and T1 at 61g, 54g, and 40g respectively. The results of the statistical analysis as shown in Figure 5 showed the yield of lettuce heads grown on T2 (EFB media) was significantly different higher to the other treatments at $P<0.05$, whereas no significant different was shown between T1, T3, and T4 which were Top Soil, Top Soil + Chicken Litter mixture, and Top Soil + Sand + Chicken Litter mixture at $P<0.05$, respectively. These results meant that the EFB compost media have shown to be the better media for growing lettuce in comparison to the other media used in this study. The use of EFB as media for growing lettuce has not been reported so far. However, the beneficial effect of EFB had been demonstrated for papaya in which EFB placed in layers in planting holes gave significant increase of yield (Aminuddin *et al.*, 1999)

The addition of chicken litter in T3 and T4 did not produce any significant yield difference of lettuce to that of the top soil media in T1. Based on the previous study, (Table 3), Vimala, *et al.*, (2000) reported that the application of chicken manure as fertilizer have produced higher yield of lettuce grown on peat soil compared to organic control. The most likely cause of the lower yield of lettuce heads from T3 and T4, although both media were added with chicken litter, in this study could be attributed to the immaturity of the chicken litter used in these treatments. The sand component, which contains very low nutrients, used in the media mixture could be another contributing factor for the lower lettuce yield in T3 and T4. Similarly, the low lettuce yield from Tl could be due to the poor top soil quality. This is clearly indicated by the result of the analysis which showed that this soil has very low nutrient content indicating that the top soil did not exhibit the true top soil quality which should have good fertility with reasonably high nutrient content.

Throughout this study period, factors such as the application of fertilizer, weeding, irrigation, temperature, moisture and others were assumed as uniform for all treatments. However, there is also the possibility that these assumptions may be violated at times which could contribute to the variability in lettuce yields obtained from this study. Pictures in Figure 6 are showing some examples of growth comparison among lettuce plants grown on the different media treatments. From these pictures, T2R1 Fig. 6(b) has larger leaf compared to T3R5 Fig. 6(c), T4R4 (Fig. 6(d)) and T1R2 (Fig. 6(a). All pictures also shown from the four media treatments and replications presented in Appendix A1 and Appendix A2.

Figure 6: Picture shows the different weights and leaf sizes of lettuce grown on the various treatment media used in this study

Effect of nutrient content of treatment on Lettuce Yield/Weight

Nutrient content for all sample of treatment was obtained by AAS Machine and is presented in Table 9. The nutrient reading shows that T2 (EFB) media has the highest N level at 1.68% compared to 0.84% for T1, and 0.56% for each of T3 and T4.

Media added with chicken manure usually contained higher level of N compared to media without chicken manure. (Table 5) According to Vimala, Salbiah *et al.,* 2001, chicken manure has higher N content at 2.59% than PM + sawdust at 2.01% (Table 5). However, the media containing the chicken litter used in this study, T3 and T4, have lower N compared to the EFB media (T2). Nitrogen is important for promoting rapid growth through formation of chlorophyll, synthesis of amino acids and protein. It thus appears that the low N in these treatment media might have some influence for the lower yield of lettuce grown on them compared to lettuce grown on EFB media. The lowest yield of lettuce was obtained from plants grown on T1 where the mean weight of lettuce head was at 40g. This yield was obviously a reflection of the overall nutrient content of this treatment media (T1) of having the least amount of nutrient content among all the treatment media in this study and contributed to the stunted growth of lettuce grown on it.

Even though the N content of T1 was higher than T3 and T4, the influence of other nutrient such as K on growth and yield of lettuce should also be taken into consideration. This is shown in T2 having 13.23 ppm of K which is higher than K in other treatments. Levels of K concentration are shown for T1 at 6.51 ppm, T3 at 9.38 ppm, and T4 at 7.69 ppm all of which were rather low and can be the influencing factor causing the stunted lettuce growth grown on these media treatments. The low Ca in EFB with increase K also indicated a possible inverse relationship between soil Ca and K supplied through EFB application for crops (Arokiasani, 1989). Magnesium was found highest in treatment 2 at 1758 ppm compared to other treatments. Magnesium is important in promoting lettuce growth because it aids nutrient uptake from the medium.

Effects of Ash and Fibre Content in EFB Compost on Lettuce Growth

Table 8 shows that from 1g of EFB sample, 31.24% of ash was obtained (Table 8). This result is similar to the report by Lim (2000) of 30% ash with potassium obtained from Palm Oil Empty fruit bunch. In addition, Uribe and Bernal (1992) also reported that EFB ash contained 30 to 35 per cent of K_2O. Fibre consists of cellulose, hemicellulose and lignin and these substances, when decomposed, produce the nutrients for plants growth. According to Damanhuri (1993), EFB is composed of 45-50% cellulose and about equal amounts (25-35%) of hemicellulose and lignin. However, this result depends on production of stringy strands of different lengths, sizes, and mechanical cutting of EFB. As reported by Fonteno *et al.,* (1996), the size and distribution of these particles and pores can affect air and water holding capacities of the media. This physical characteristic could have caused the mean weight and yield of lettuce in T2 (EFB media) to be highest compared to other treatments.

Influence of Treatment pH

The results of pH determinations are shown in the Tables 10. By using pH-KCl method, T4 shows pH of 3.83 which is more acidic than T1 at pH 4.7, T2 at 6.73 and T3 at 6.53. The pH-H_2O method also show pH for T4 at 4.82 as being more acidic compared to T1 with pH 5.73, T2 with 7.25 and T3 with 7.5. Changa *et al.*, (2003) recommended that the best pH value for organic compost should be in the range of 5.7-8.7. Only T2 and T3 had pH values within this range.

Lettuce commonly grows well at pH range of 5.5-6.5. For T2 (EFB media), the presence of K and Ca could have contributed to the higher pH value at 6.73 in pH-KCl and 7.5 in pH-H_2O which are near the standard pH range for lettuce which explained the high yield of lettuce plants grown on T2 media. Although the pH of T3 was also within the pH range for lettuce, other factors could have contributed to the lower yield obtained from plants grown on this media.

Other Factors Affecting Lettuce Yields

Water Absorption

Lettuce has shallow root system which needs constant supply of moisture during the growing period. Variation in soil moisture, especially during the late stage of development (from hearting to harvest) is an influencing factor that can result in reduction of crop yield. A variable supply of moisture from irrigation activity will result in uneven growth rates and variable uptake of nutrient can lead to increased incidence of disorders such as tip-burn. Sandy soil that was used in T4 requires more frequent irrigations because sandy soil has very low water retention and high evaporation rate under the heat of sunlight. Texture like loam soil in T1 may result the water being blocked on surface area during irrigation process and this can cause water unable to move to all parts of the medium in the polybag. Villalobos *et al.*, (1990) showed that the use of K from EFB improved water status of crops under conditions of water stress and this may also be the reason for T2 to have the highest yield.

The high content of fibrous material in EFB media also provides more pores in the media which increased aeration and the rooting ability of lettuce in the medium. This factor also minimizes compaction in the medium during water entry. These conducive environment also result in better lettuce growth and yield in T2 media.

Weed

The use of EFB media for T2 was considered as a good way for controlling weed growth in the medium. Weed growth was more serious in the other treatments which may be due to the immature compost used and the unfavorable physical structures of the media.

Influence of Compost Maturity on Lettuce Growth

Compost maturity refers to its suitability and the resistance of the material to further microbial decomposition (Sullivan and Miller, 2001). Treatment 3 and T4 media were both containing chicken litter, a component that was not fully decomposed. Incomplete decomposition of this material leads to high moisture in both treatments and tends to encourage the survival of weed seeds in growing media. This anomaly was reported by Subler *et al.*, (1998), and in addition immature compost also contains phytotoxins or compounds poisonous to plants. However, T3 and T4 gave better growth of lettuce compare to T1 which may be due to the daily watering that leached out the poisonous compounds from the media. Irrigation leaches out salt accumulation in well-drained soils and prevents plant damage from the effect of high salt concentration (Liu, 2000). On the basis of visual observation, the compost media for T2 appeared to be relatively more matured than the chicken litter used in T3 and T4. The T2 media was therefore the best media treatment with very little weed problems.

Pest and Disease

There were some pests and disease feeding on the lettuce plants which affected the growth performance of lettuce. Cutworm was mostly found feeding on young lettuce and causing leaf-cuts. The leaves of lettuce were attacked by cutworm on some of the leaves even with application of pesticides. The population of cutworms was higher on weedy and wet media as in T3 and T4. Cutworms attack on T2 plants was lower. Infection of Aster yellow and Downy Mildew diseases were also noted which produced yellowish area on the upper surface of the leaves.

CHAPTER 6

CONCLUSION

The use of Palm Oil Empty Fruit Bunch (EFB) compost as growing media have produced the highest yield of lettuce in term of weight of lettuce heads. Based on this finding, the potential of EFB compost for use as growing media for vegetable crop production is good, particularly for the organic farming production system. However, EFB would need to be properly processed and packages and available for large scale application. The fact that EFB is an agro-waste by-product of the oil palm industry available in large scale makes it an ideal cheap source of growing media that would encourage wider interest in its use especially among the lower income groups. In addition, it will also help to address the environmental concern associated with the mounting amount of this form of agro-waste.

Recommendation

It was noted that the top soil quality supplied for this study project was questionable as indicated by the poor nutrient content in the analysis and the poor soil structure observed that clearly lacked organic matter content. The quality of chicken litter supplied for this study was also organically immature in appearance. The use of matured organic compost should be considered as an important factor for any media mixture. The use of cheap agro-waste as in the case of the empty fruit bunch compost can be cost-effective for vegetables and fruits production.

Other analyses such as moisture content, C/N ratio, particle size, water holding capacity of the EFB media have not been undertaken in this study. Other parameters that have not been evaluated are crop parameters such as leaf width and length. In addition to EFB, the abundance of other organic waste such as sawdust and green waste or botanical waste should also be evaluated for crop production purpose.

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APPENDIXES

Appendix A1

Figure 7: Treatment 1

Figure 8: Treatment 2

Appendix A2

Figure 9: Treatment 3

Figure 10: Treatment 4

Appendix B

Table 12: Weight for lettuces

Treatment	Weight (g)
1. T1R1	25
2. T1R2	65
3. T1R3	20
4. T1R4	40
5. T1R5	50
Average	**40**
6. T2R1	230
7. T2R2	120
8. T2R3	200
9. T2R4	90
10. T2R5	95
Average	**147**
11. T3R1	50
12. T3R2	70
13. T3R3	40
14. T3R4	45
15. T3R5	100
Average	**61**
16. T4R1	45
17. T4R2	65
18. T4R3	50
19. T4R4	70
20. T4R5	40
Average	**54**

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Effect of Empty Palm Oil Fruit Bunch (EFB) Compost Media in Comparison to other Media on Growth and Yield of Lettuce (*Lactuca sativa*)" by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

Nor Akram bin Mohamed Ali

Date: 4 MAY 2007