UNIVERSITI PUTRA MALAYSIA

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by :

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Page

Page

LIST OF PLATES

Abstract of the Thesis Presented to the Senate of Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Master of Agriculture Science.

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In palm oil milling process, a large quantity of stripped or empty fruit bunch (EFB) is produced and have been used for mulching. Research work was mainly on oil palm yield response to EFB application in field trials. Very little data and information were documented regarding EFB decomposition and nutrient release and effect on the soil characteristics. Thus, this study was conducted with the aim of determining the composition of EFBs from different palm of different ages and investigating EFB decomposition and nutrient release in the field over a 1 cycle EFB application period.

For the EFB composition study, ten EFBs from different ages were taken for analyses from the Dusun Durian estate in Banting, Selangor Darul Ehsan. The initial fresh fruit bunches (FFBs) were chosen from palms of eight, twelve and eighteen years old (10 EFBs from each age group). The fruitlets were removed, and the EFBs were analysed for the chemical composition. A batch of 10 FFBs were also taken from the mill (after processing) for comparison. The EFBs were analysed for organic and nutrient composition. A field experiment was then conducted in the Tanah Merah Estate, Negeri Sembilan for about 11 months to investigate the decomposition process of EFB and nutrient release in a one application cycle. The treatments involved in this study were (i) Chemical application (fertiliser) or the control, (ii) EFB application alone, (iii) EFB and chemical fertiliser application (EFB + fertiliser). The treatments were given just after planting. Effect of the EFB application on the soil characteristics was also studied. Six palms were randomly selected from each treatment plot . The EFB at a rate of 170 kg / palm, were placed in a circle, around the base of the young oil palm. Recording of EFB fresh weight and sampling of EFB tissue were done every 4 weeks for analyses of nutrient contents. Soil samples were taken collected every 1 - 2 months for analyses of mineral N and other soil characteristics.

Analysis of EFB samples for chemical composition showed no significant differences between the core and spikelet, and between the ages of the palms. Therefore, on the average, the EFBs had a chemical composition of C/N ratio

70.9 - 90.1, 25.0 - 29.9% lignin, 16.2 - 21.3% cellulose, 1.52 - 2.46% soluble polyphenols, 0.76 - 0.96% nitrogen, 0.13 - 0.19% phosphorus, 1.21 - 3.20% potassium, 0.36 - 0.60% calcium, and 0.22 -0.51% magnesium.

In the field trial for the decomposition of EFB, 50% dry matter weight (DMW) loss was recorded after 90 days in both the treatments (EFB alone or EFB + fertiliser). The C/N ratio of the EFBs decreased to 20 after 180 days in both the treatments. Lignin decomposition was found to be significantly accelerated by the addition of fertiliser to the EFBs, and this narrowed down the C to N ratio of the EFB.

During EFB decomposition, the concentrations of N, P,Ca and Mg in the EFB tissue increased with time. There were gradual releases of N, P, Ca and Mg from the EFB up to the 317th day (end of study). However, K concentration in EFB tissue decreased with time, and was released very rapidly to the soil. Fifty percent of the K in the EFB was released in 20 days, in both the treatments. By the 112th day, 90% of the EFB - K was released. Exchangeable K^+ in soil also increased in the top soil in the first 54 days coinciding with EFB - K release but it decreased at a later stage, indicating leaching of K from the topsoil. Decomposition of EFBs caused an increase in mineral N in soil. There was also occurrence of nitrification as indicated by high NO_3^- - N concentration throughout the period.

The study also shows that the first application cycle of EFB had already influenced some of the soil properties. After 317 days there was an increase in the cation exchange capacity (CEC) from 4.30 to 10.42 cmol (+)/kg for EFB applied alone and from 4.20 to 10.89 cmol(+)/kg for the treatment of EFB + fertiliser. Exchangeable Ca^{++} in the top soil increased from 0.55 to 0.64 cmol(+)/kg for EFB applied alone and from 0.53 to 0.88 cmol(+)/kg for treatment of EFB + fertiliser. Exchangeable Mg^{++} in the top soil increased from 0.13 to 1.70 cmol(+)/kg for EFB applied alone and 0.12 to 1.70 cmol(+)/kg for the treatment of EFB + fertiliser, respectively. Exchangeable K^{+} in the topsoil also increased from 0.08 to 1.05 cmol(+)/kg for EFB applied alone and 0.08 to 1.07 cmol (+)/kg for the treatment of EFB + fertiliser. Initially, there was a high increase in exchangeable K^{+} ,but towards the later stage it decreased tremendously, possibly due to uptake by plant and leaching loss of K^{+}. The pH of the soil had also increased by almost 1.0 unit . The bulk density of the soil had decreased after 317 days (end of study) from 2.66 for control to 2.39 for EFB applied alone and to 2.14 for the treatment of EFB + fertiliser.

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KOMPOSISI KIMIA TANDAN KOSONG KELAPA SAWIT (EFB) DAN PEREPUTANNYA DI LADANG

Oleh

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Semasa pemprosesan kelapa sawit dikilang, tandan kelapa sawit kosong (empty fruit bunch - EFB) dikeluarkan dalam kuantiti yang banyak. Walaupun EFB telah digunakan sebagai sungkupan, sehingga kini, kajian penyelidikan ladang yang utama adalah keatas kesan penggunaan EFB terhadap hasil kelapa sawit. Maklumat dan data berkenaan penguraian EFB dan pelepasan nutrien dan kesannya terhadap ciri - ciri tanah adalah kurang. Keadaan ini berlaku kerana kurangnya penyelidikan asas tentang penguraian EFB. Oleh yang demikian, kajian ini telah dijalankan dengan tujuan untuk melihat komposisi kimia EFB pada umur pokok yang berlainan umur dan penguraian EFB serta pelepasan nutrien di ladang untuk satu kitaran penambahan EFB.

Pada peringkat permulaan ia itu kajian komposisi EFB, 10 tandan buah segae (FFB) yang berbeza umur telah diambil untuk dianalisis dari estet Dusun Durian, Banting, Selangor Darul Ehsan. Tandan kelapa sawit ini dipilih dari pokok berusia lapan, dua belas dan lapan belas tahun (10 FFB bagi setiap kumpulan umur). Buahnya diasingkan dari tandan dan EFB diambil untuk dianalisis. Sepuluh tandan EFB juga diambil dari kilang (selepas pemprosesan) untuk tujuan perbandingan. Dalam kajian ini EFB tersebut telah dijalankan dianalisis komposisi organik dan nutriennya. Kemudian satu lagi kajian telah dijalankan di estet Tanah Merah, Negeri Sembilan selama 11 bulan untuk mengkaji proses penguraian EFB dalam satu kitaran penambahan dan pelepasan nutriennya. Rawatan yang digunakan dalam kajian ini, adalah (i) Baja kimia (control), (ii) EFB, (iii) EFB + baja. Rawatan ini dimulakan sebaik sahaja selepas penanaman. Kawasan yang dipilih merupakan kawasan yang baru ditanam semula. Enam pokok kelapa sawit telah dipilih secara rawak dan EFB ditambah pada kadar 170 kg / pokok yang diletakkan disekeliling pokok kelapa sawit yang muda itu. Proses merekod berat basah EFB dan pengambilan sampel tisu EFB dilakukan setiap 4 minggu untuk analisis kandungan nutrien. Sampel tanah diambil setiap 1 - 2 bulan untuk analisis kandungan N mineral dan ciri - ciri lain tanah.

Keputusan statistik menunjukan tidak terdapat perbezaan nyata dalam komposisi diantara tangkai buah dan teras buah dan diantara umur pokok. Oleh itu secara amnya, komposisi kimia EFB ialah nisbah C/N 70.9 - 90.1, lignin 25.0

29.2% , selulosa 16.2 - 21.3% , polifenol larut 1.52 - 2.46% , nitrogen 0.76 - 0.96% , kalium 1.21 - 3.20% , kalsium 0.36 - 0.60% dan magnesium 0.22 - 0.51%.

Kajian ladang menunjukan penguraian EFB berlaku dan kehilangan 50% berat kering (BK) selepas hari ke 90 pada dua rawatan. Nisbah C/N bagi rawatan EFB menurun sehingga 20 selepas 180 hari penguraian EFB berlaku pada kedua - dua rawatan. Penguraian lignin didapati meningkat dengan penambahan baja kepada EFB. Ini telah merendahkan nisbah C/N untuk EFB.

Semasa penguraian EFB kepekatan N, P, Ca dan Mg dalam tisu EFB meningkat berkadar terus dengan masa. Pembebasan N, P, Ca, Mg adalah perlahan. Walau bagaimanapun kepekatan K berkadar songsang dengan masa dan K dibebaskan dengan cepat. Sepanjang tempoh kajian, didapati kepekatan NO_3^- - N adalah tinggi , ini menunjukan berlakunya proses nitrifikasi. Lima puluh peratus K dalam EFB dibebaskan selepas 20 hari penguraian berlaku. Pada hari ke 112, lebih daripada 90% EFB - K telah dibebaskan. Selain dari pembebasan K dari EFB, K^+ tukarganti dalam tanah lapisan atas juga meningkat dalam 54 hari yang pertama, tetapi kemudiannya menurun kerana proses larutlesap.

Kajian ini juga menunjukkan bahawa penguraian EFB telahpun mempengaruhi kepada sifat kimia kandungan tanah. Selepas 317 hari terdapat peningkatan kepunyaan penukaran kation (KPK) dari 4.30 kepada 10.42

cmol(+)/kg untuk penggunaan EFB sahaja dan daripada 4.20 kepada 10.89 cmol(+)/kg untuk rawatan EFB + baja. Tukarganti Ca^{++} pada lapisan tanah atas bertambahan daripada 0.55 hingga 0.69 cmol(+)/kg untuk pengunaan EFB sahaja dan daripada 0.53 hingga 0.88 cmol(+)/kg untuk rawatan EFB + baja. Tukarganti Mg^{++} pada lapisan tanah atas bertambah daripada 0.13 hingga 1.70 cmol(+) / kg untuk penggunaan EFB sahaja dan 0.12 hingga 1.70 cmol(+) / kg untuk rawatan EFB+ baja. Tukarganti K^{+} pada lapisan tanah atas daripada 0.08 hingga 1.05 cmol(+)/kg untuk penggunaan EFB sahaja dan dari pada 0.08 kepada 1.07 cmol(+)/kg untuk rawatan EFB + baja. Pada peringkat permulaan, kepekatan K^{+} dalam tanah meningkat dengan cepat, tetapi semakin mengurang dengan peningkatan masa. Ini menunjukkan K^{+} telah diambil oleh tanaman dan mungkin hilang akibat larutlesap. Didapati juga pH tanah meningkat sehingga 1.0 unit berdasarkan pelepasan bes tukarganti daripada EFB. Sifat fizik tanah turut berubah, ketumpatan pukal tanah menurun selepas 317 hari daripada 2.66 kepada 2.39 untuk penggunaan EFB sahaja dan 2.14 untuk rawatan EFB + baja.

CHAPTER I

GENERAL INTRODUCTION

Malaysia is today the world' s largest producer and exporter of palm oil, accounting for some 60% of world production. However, it is facing serious competition in the international edible oil market, not only from other major palm oil producing countries such as Indonesia, but also from producers of other oils and fats (Tiong , 1992). In 1991, palm oil accounted for 5.3% of the country's total export, making it the largest contributor among agricultural commodities and second only to petroleum among all the commodities exported (Ramly , 1993). Export of palm oil from Malaysia in 1991 was valued at RM 5.03 billion, an increase of about 14% from the previous year (Anon, 1991). Malaysian crude palm oil (CPO) production in 1996 was estimated to 7.7 - 7.8 billion tonnes (Chow and Jamaludin, 1995). The palm trunks and fronds, empty fruit bunches (EFB), pressed fruit fibres (mesocarp fibres), shells and palm oil mill effluent (POME), which are produced at the palm oil mill, have economic values. In the past, these products of oil palm were not effectively utilised and in many instances had caused severe pollution problems (Ahmad, 1994).

The EFBs are part of the oil palm waste which were thrown away from the oil palm mills (Singh et al., 1989). In the palm oil milling process, one tonne of fresh fruit bunches (FFB) produce about 0.22 tonne of EFB. With the present stringent Department of Environment (DOE) regulation on air pollution, much of the EFB produced by palm oil mills are used for mulching the oil palm plant. The nutrient contents of EFB is quite variable. It contains on the average of 0.65 - 0.94%N, 0.18 - 0.27% P_2O_5, 2.0 - 3.9% K_2O, 0.15 -0.48% CaO and 0.25 - 0.40% MgO on dry weight basis (Singh et al.,1985). It has been shown to be valuable for nutrient recycling back to the oil palm crop (Loong et al.,1987). Khoo et al., (1982) noted that one tonne of EFB applied as mulch is equivalent to 7 kg of Urea, 2.8 kg of Christmas Island Phosphate Rock (CIPR), 19.3 kg of Muriate of Potash (MOP) , 4.4 kg of Keiserite. The EFB as an organic manure and mulch has since became popular until now.

Due to the high nutrient content in EFB, it is now utilised as a mulch and as a nutrient source in the field. Another advantage of using EFB as mulch is its non - polluting nature. Application of EFB in the oil palm fields is done in various methods. They are placed in a circle around the base of the young palm. For matured palms, EFBs are placed in a heap on the ground in between 2 palms. It is also placed in the palm row or in the middle of 4 palms in alternate interrows of palms. Although, EFBs have been used for mulch, research work was mainly concerned with oil palm yield response to EFB application in the field trials. Very little data and information are documented regarding EFB decomposition and nutrient release, and its effects on the soil characteristics. For more efficient utilisation of EFBs, it is crucial to study the decomposition rate of EFBs in the field and the release patterns of nutrients. Therefore, the objectives of the present study were to investigate:

a) The inorganic and organic composition of EFBs from different ages of oil palms.

b) The decomposition of EFB in the field, its nutrient release, and its contribution to soil organic matter and soil chemical characteristics.

CHAPTER. II

REVIEW OF LITERATURE

Oil Palm Industry in Malaysia

The oil palm in Malaysia was first introduced in the year 1917. Planting of the oil palm crops at the commercial scale started in the year 1961, when Malaysia was conducting large-scale program of cultivating various commodity crops. The purpose of this effort was to reduce the country's dependency on traditional based rubber and iron-ore industries (Zakaria, 1991).

Malaysia, now has about 2.3 million hectares of land under oil palm plantation, mostly in Peninsular Malaysia. However, future expansion should occur more in the East Malaysian states of Sabah and Sarawak, where land suitable for oil palm plantation is still abundant. The planted area is expected to exceed 2.8 million hectares by the year 2000, by which time the oil production should already exceed 8 million tonnes (Ahmad, 1994).

Current Trend in Utilisation of EFB

Production of EFB

The EFB is one of the major products from the processing of palm oil at the mills. For every 100 tonnes of fresh fruit bunches (FFBs) processed, 20 - 25 tonnes of EFB is produced. It was estimated that by the year 2000, the EFB production will increase up to 9.5 million tonnes (Singh et al., 1989)

Utilisation of EFB

a) EFB as fuel

EFB from oil palm were initially utilised as fuel. It has a moisture content of 60 - 65%. Before it can be used as a fuel for the boilers, the moisture has to be reduced to 40% or less. This is achieved through the use of a special screw press, which presses out the moisture from the EFB. According to Lim and Ratnalingam (1980), EFB can produce total energy as much as 2568 calorie/kg (screw pressed EFB), if used a fuel. Since the discovery of high contents of nutrients, EFB is now, no longer used as fuel.

b) EFB as bunch ash

Initially EFBs were used as bunch ash due to its high potassium content of about 25% - 33% and a high pH of 5.2 However, the bulk of nutrient content like nitrogen and organic matter are lost during this ashing process. Therefore, the utilisation of EFB as bunch ash is no longer implemented.

c) EFB as industry material

Empty fruit bunches are also used as industry materials for the production of pulp and paper, compact fuel and chemical materials such as, ethanol and fulfural (Abdul, 1987).

d) EFB as mulch

Agronomic benefits of EFB as mulch

Although the agronomy and economic benefits of EFB mulching in the oil palm plantations are well known, information on the processes of nutrient release is still lacking. As the demand for EFB mulch in oil palm plantations has increased, it is necessary to apply EFBs more efficiently. The utilisation of fresh EFBs as mulch has increased extensively, especially in oil palm, rubber and cocoa estates. The practice of placing EFBs on the soil surface has brought economic benefits as it enhance vegetative growth and increased production (Yeow et al., 1985).