Pertanika J. Trop. Agric. Sci. **33 (1)**: 39 - 44 (2010)
ISSN: 1511-3701

Physical Changes to Oil Palm Empty Fruit Bunches (EFB) and EFB Mat (Ecomat) during Their Decomposition in the Field

Christopher Teh Boon Sung[1*], Goh Kah Joo[2] and Khairun Nisa Kamarudin[1]
[1] Department of Land Management, Faculty of Agriculture,
Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
[2] Applied Agriculture Research, Locked Bag 212,
Sg. Buloh Post Office, Sg. Buloh, Selangor, Malaysia
[*]E-mail: cbsteh@yahoo.com

ABSTRACT

The main objectives of this study were to determine the physical changes in oil palm empty fruit bunches (EFB) and EFB mat (Ecomat), which were used as soil mulching materials, during their decomposition in the field, as well as to compare the soil water content under these mulches and with bare soil. A field experiment was conducted at an estate using ten-year-old oil palm trees. Experimental design was a Randomized Complete Block with two treatments (EFB and Ecomat) and three replications. EFB was applied at 1000 kg palm^{-1} as a single layer on the soil surface. Ecomat was applied as a single layer with an area of 4 m^2. Physical properties of EFB and Ecomat, measured every two month for six months, were bulk density, water content, water retention, and saturated hydraulic conductivity. Soil water content up to 750 mm depth was further measured on a daily basis. Results showed that EFB was better than Ecomat as a mulching material to conserve soil water. As compared to Ecomat, EFB had a lower bulk density (two times less dense), higher saturated hydraulic conductivity (about two times higher) and higher water content (between 20 to 57% more water). EFB was also found to hold its water more strongly than Ecomat. On average, the soil under EFB mulches had, nearly 27% more water than the soil under Ecomat mulches, and 38% more than bare soil. The soil under Ecomat mulches had only 8% more water than bare soil on average. Based on the model simulations, 5 layers of Ecomat would conserve as much soil water as 1 layer of EFB. Both mulching materials were estimated to fully decompose in the field in about 9 months.

Keywords: Empty fruit bunches, Ecomat, oil palm, soil conservation, water conservation, organic matter

INTRODUCTION

Malaysia and Indonesia are the two largest producers of palm oil in the world. In Malaysia, oil palm occupies over four million hectares, occupying about 12% of Malaysia's land area. One of the by-products of the palm oil milling process is the empty fruit bunches (EFB), and on average, every one tonne of fresh fruit bunches (FFB) produces about 220 kg of EFB as a by-product (Singh *et al*., 1999). Considering that Malaysia produces 2.8 to 3 million tonnes of EFB annually (Kamaruddin *et al*., 1997), determining ways to reuse the EFB waste is therefore vital. One of the most common methods practiced in oil palm estates is to use EFB as a mulching material to protect the soil surface and conserve soil water and nutrients.

Received: 11 May 2009
Accepted: 21 October 2009
[*]Corresponding Author

In terms of fertiliser use, one tonne of EFB is equivalent to 7 kg of urea, 2.8 kg of rock phosphate, 19.3 kg of muriate of potash, and 4.4 kg of kieserite (Singh *et al*., 1999). EFB is also a source of organic matter which increases soil aggregation, aggregate stability, and water infiltration, and hence, it reduces soil erosion.

Nevertheless, one well-known disadvantage of EFB is that it is rather bulky. One recent method used is to compress the EFB into a mat or carpet known as Ecomat. Being less bulky and easier to pack, transportation and handling of Ecomat is easier and cheaper than EFB. According to Yeo (2007), Ecomat is produced by shredding the EFB into its raw fibre and then combed out, after which EFB undergoes a high pressure hydraulic press to remove impurities such as water, sludge, and oil traces. EFB is then dried to about 15% gravimetric water content before it is trimmed to the required size and packed for shipping. In an unpublished study by the Beijing Forestry and Parks Department of International Cooperation conducted from 2002 to 2006, Ecomat was found to increase soil water content by 35.5% after two years, soil nitrogen by 3.5% and 6.7% in the summer and winter periods, respectively, as well as potassium content by between 20 to 128.6%.

Although much has been researched, particularly on the effects of EFB on the properties of soil, little has been studied on the physical changes of EFB and Ecomat over prolonged periods. However, this particular study focused on the changes of both mulching materials, rather than on the changes of the soil properties due to these mulching materials. Therefore, the main objectives of this study were: 1) to determine the physical changes in EFB and Ecomat used as soil mulching materials during their decomposition in the field; and 2) to compare the soil water content under EFB and Ecomat mulches, as well as with bare soil. Understanding the temporal physical changes of both these mulching materials will enable a better understanding on how they affect soil properties, particularly the ones related to conserving soil water and reducing soil erosion.

MATERIALS AND METHODS

The field experiment was conducted in an oil palm estate located at Balau Estate (2.9325 °N and 101.8822 °E) in Semenyih, Selangor. The estate had ten-year-old palms (Elaeis guineensis), and the soil was of the Rengam series (Typic Paleudult). The oil palm trees were planted in 8-by-8 m spacing on a hill slope of 6°. The total area of the experiment was 2240 m^2. The experimental design was a Randomized Complete Block (RCB) with two treatments (EFB and Ecomat) and three replications. For each replication, EFB was applied as a single layer on the soil surface at a rate of 1000 kg $palm^{-1}$. The mean weight of EFB was 3.5 kg per bunch and the mean thickness was 130 mm. For the Ecomat treatment, it was applied as a single layer of four pieces of Ecomat carpet, arranged side-by-side and without gaps between the pieces. Each piece of Ecomat carpet had an area of 1 m^2 and average weight and thickness of 3.3 kg and 20 mm, respectively. The experiment was conducted for six months, starting from February to September 2008. The EFB and Ecomat samples were collected every two months. Two samples were collected randomly from every plot.

Four physical parameters of EFB and Ecomat were measured. They were bulk density (core ring method by Blake and Hartge, 1986), gravimetric water content (Gardner, 1973), water retention (ceramic plate method by Richards, 1947), and saturated hydraulic conductivity (method adapted from Klute and Dirksen, 1986). In addition, volumetric soil water content, up to 750 mm depth, was measured daily using a soil moisture probe AquaPro-Sensor (Aquatic Sensors, Nevada). The statistical analyses were done using SPSS version 14 (SPSS Inc., Chicago). Meanwhile, the mean separation tests were carried out according to Duncan's New Multiple Range Test.

In addition to the field measurements, a soil water model was also used to simulate the effects on EFB and Ecomat on soil water content. Simulations were for a three-month's dry period (i.e. no rainfall) using information collected about EFB, Ecomat and the soil properties. The soil water model was based on Hillel (1977), where the soil profile was divided into several layers, and the net water flux calculated for each soil layer was based on Darcy's law.

RESULTS AND DISCUSSION

The mean thickness of EFB and Ecomat, at the start of the experiment, was about 130 and 20 mm, respectively. As for the EFB, its thickness was reduced at the rate of 15.1 mm month^{-1}, and this was 1.7 mm month^{-1} for Ecomat, as shown in *Fig. 1*. Therefore, EFB and Ecomat would lose on average of 11% and 9% per month of their original thickness, respectively. Using the fitted linear regression curves (*Fig. 1*), it was estimated that both mulching materials would be fully decomposed (reduced to zero thickness) in about 9 months.

On average, Ecomat was two times more compact than EFB, as presented in *Fig. 2*. For example, at the application date (start of experiment), the bulk density of Ecomat was 0.24 Mg m^{-3} compared to only 0.11 Mg m^{-3} for the EFB. Hence, the bulk density for both the mulching materials was expected to increase with time because they would decompose into increasingly finer materials and, in turn, reduce the total pore size and increase compaction. Although the bulk density for both the mulching materials did generally increase with time, the ANOVA revealed that only the sole treatment factor had a significant effect on bulk density at 5% level of significance. The sole time factor and the interaction between the treatment and time factors were not significant at 5% level. Meanwhile, the non-significant effect of the time factor could be due to the high variability in the measurements of bulk density in this study.

As for the saturated hydraulic conductivity (K), the ANOVA revealed that the sole effects of time and treatment factors (but not the interaction between the two factors) on K were significant at 5% level. On average, K for the EFB and Ecomat was 3.8 and 2.0 mm s^{-1}, respectively (*Fig. 3*). This indicates that on average, the EFB would conduct water into the

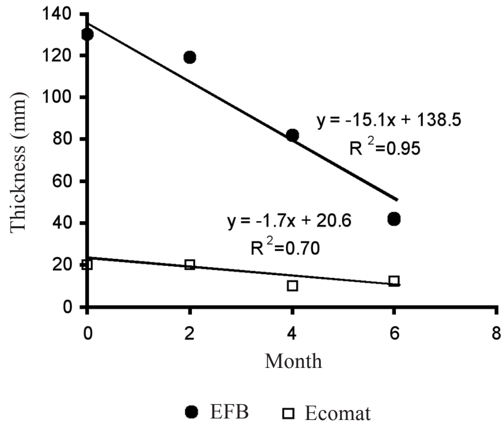

Fig. 1: Thickness of EFB and Ecomat

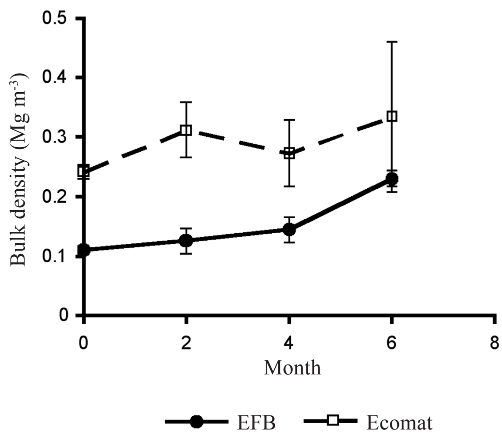

Fig. 2: Bulk density of EFB and Ecomat

soil nearly two times faster than Ecomat. For both the mulching materials, the reduction in their K over time was nearly two times. As for the EFB, its K was found to sharply decrease two months after the application (i.e. reduced from 5.0 mm s^{-1} in the second month to 2.5 mm s^{-1} in the fourth month), whereas for Ecomat, its K was shown to have reduced significantly immediately after the application (i.e. reduced from 3.5 mm s^{-1} at the start of the application to 1.8 mm s^{-1} two months later).

Similarly for the saturated hydraulic conductivity, the ANOVA revealed that the sole effects of time and treatment factors (but not the

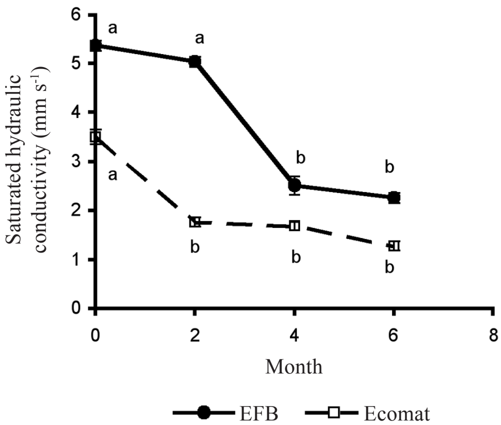

Fig. 3: Saturated hydraulic conductivity of EFB and Ecomat. For the same treatment, means with the same letter are not significantly different from each other at 5% level of significance

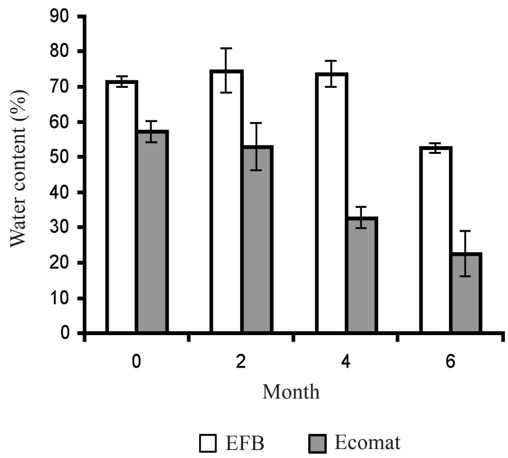

Fig. 4: Gravimetric water contents of EFB and Ecomat, at the time of sampling (mean separation test revealed that for the same month, the water content in EFB and Ecomat, were significantly different from each other at 5% level of significance)

interaction between them) on the water content of the mulching materials were significant at 5% level. On average, EFB was found to have 26.6 % more water than Ecomat at each sampling time (*Fig. 4*). At the start of the experiment, EFB had 20% more water than Ecomat, and this was increased to 57% at the sampling date on the sixth month. The mean separation test revealed that for the same month, the water content in the EFB and Ecomat was significantly different from each other at 5% level of significance.

Not only would EFB hold more water than Ecomat, the EFB was also found to hold or retain the water much stronger than Ecomat (*Fig. 5*). The mean negative slope of the water retention curve for EFB was 0.13 and this was 0.23 for Ecomat. A material with a smaller slope denotes water being held much stronger (therefore, harder to dry and more difficult to lose its water) than the material with a larger slope (which means it holds water less strongly). With the increase in time, the water retention slopes for both the mulching materials were generally increased. This meant that over time, both the mulching materials would hold their water increasingly less strongly due to the decomposition of the mulches.

However, the soil treated with EFB was found to have more water than the soil with Ecomat treatment (*Fig. 6*). On average, the total daily soil water content (up to 0.75 m depth), under EFB and Ecomat mulches, was 382 and 300 mm, respectively. In other words, the soil water content under EFB had, nearly 27% more water than the soil under Ecomat on average. The total soil water content for bare soil was the least as its surface was unprotected by any cover mulching material. On average, the soil with EFB mulches had 38% more water than the bare soil. Meanwhile, the soil with Ecomat mulches had only 8% more water than bare soil on average.

Therefore, the results gathered from the field experiment have indicated that a single layer of EFB is a better mulching material than a single layer of Ecomat in conserving more water in the soil. In order to determine the number of Ecomat layers which is required to equal the efficacy of a single layer of EFB to conserve soil water, this study has used a soil water model based on Hillel (1977), in which the soil profile was divided into seven layers (with

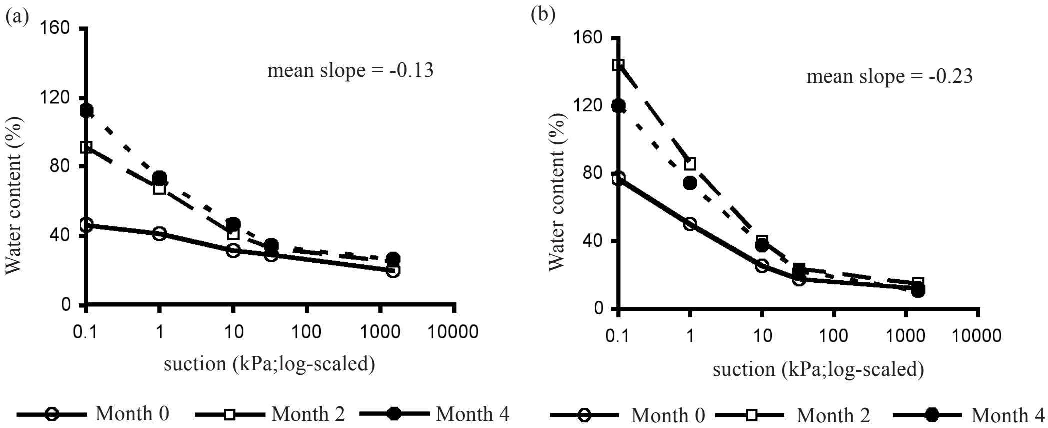

Fig. 5: Volumetric water retention curve of: a) EFB and b) Ecomat

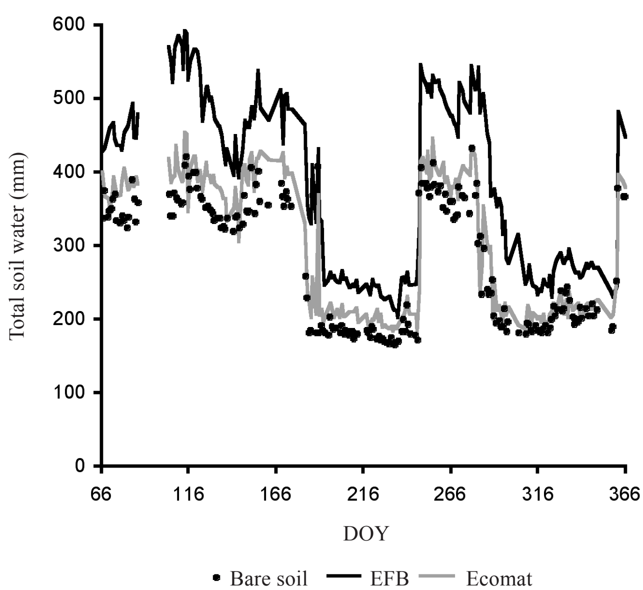

Fig. 6: Total daily soil water content (up to 750 mm depth) under EFB and Ecomat mulches and bare soil

the first layer the given mulching material), and the net water flux calculated for each soil layer was based on Darcy's law. Simulations were for a three-month dry period of no rain and the model parameters were based on those properties collected from EFB, Ecomat and soil in the experimental site. The simulations revealed that between 4 to 6 layers of Ecomat were required to give comparable soil water content as the soil under 1 layer of EFB (Table 1). Thus, based on the findings of the present study, it is concluded that 5 layers of Ecomat is equivalent to 1 layer of EFB so as to conserve the same amount of soil water.

TABLE 1
Simulated total soil water content under EFB (1 layer) and under different numbers of Ecomat layers for a three-month's dry period

Days	EFB (1 layer)	Ecomat (1 layer)	Ecomat (2 layers)	Ecomat (4 layers)	Ecomat (6 layers)
30	253.2	239.0	242.7	248.6	253.8
60	215.8	207.8	208.8	212.1	215.9
90	210.2	202.3	203.3	206.6	210.1

CONCLUSIONS

This study has showed that EFB is better than Ecomat as a mulching material to conserve water in soil. As compared to Ecomat, EFB has a lower bulk density (two times less dense), higher saturated hydraulic conductivity (about two times higher) and higher water content (between 20 to 57% more water). In addition, EFB can also hold its water much stronger than Ecomat. All these properties have helped the soil treated with EFB to have more water than the soil treated with Ecomat. The soil under EFB mulches had, on average, nearly 27% more water than the soil under Ecomat mulches, and 38% more than the bare soil. Meanwhile, the soil under Ecomat mulches had an average of only 8% more water than the bare soil. Based on model simulations, this study determined that 5 layers of Ecomat were required to conserve as much soil water as that equivalent to 1 layer of EFB. Finally, both the mulching materials were estimated to fully decompose in the field at nearly the same time, i.e. about 9 months.

REFERENCES

Blake, G.R. and Hartge, K.H. (1986). Bulk density. In A. Klute (Ed.), *Methods of soil analysis. Part 1. Physical and mineralogical methods* (2nd edn.) (pp. 363-375). Wisconsin: ASA-SSSA.

Gardner, W.R. (1973). *Soil Physics*. New York: John Wiley & Sons, Inc.

Hillel, D. (1977). *Computer Simulation of Soil-water Dynamics: A Compendium of Recent Work.* Ottawa: International Development Research Centre.

Kamaruddin, H., Mohamad, H., Ariffin, D. and Jalani, S. (1997). An estimated availability of oil palm biomass in Malaysia. Occasional Paper No. 37. PORIM: Bangi.

Klute, A. and Dirksen, C. (1986). Hydraulic conductivity and diffusivity: Laboratory methods. In A. Klute (Ed.), *Methods of soil analysis. Part 1. Physical and mineralogical methods* (2nd edn.) (pp. 687-734). Wisconsin: ASA-SSSA.

Richards, L.A. (1947). Pressure-membrane apparatus - construction and use. *Agricultural Engineering*, *28*, 451-454.

Singh, G., Kow, D.L., Lim, K.C. and Loong, S.G. (1999). Empty fruit bunches as mulch. In G. Singh, K.H. Teo and L.K. David (Eds.), *Oil palm and the environment: A Malaysian perspective* (pp. 171-183). Kuala Lumpur: Malaysia Oil Palm Growers' Council.

Yeo, K.L. (2007). Processing empty fruit bunch (EFB) to fibre. In *Proceedings of the Seminar on Ecomat Research and Promotion: Towards Enrichment of the Environment 2006* (pp. 38-39). Bangi: Malaysian Palm Oil Board.