UNIVERSITI PUTRA MALAYSIA

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By

ABOLFATH MORADI

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2012

DEDICATION

Dedicated to allah

my parents

wife

and

my lovely son "Kooshan"

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirements of the degree for the degree of Doctor of Philosophy

EFFECTS OF DIFFERENT SOIL AND WATER CONSERVATION PRACTICES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES IN A NON-TERRACED OIL PALM PLANTATION

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April 2012

Chairman: Christopher Teh Boon Sung, PhD

Faculty: Agriculture

Malaysia is the one of the two largest palm oil producers in the world and hence produces a huge amount of oil palm residues every year. Utilization of these residues as mulch and silt pitting are common practices used to conserve soil nutrients and water on non-terraced sloping lands and to improve soil physical and chemical properties linked to soil fertility. Therefore, a 3-year field experiment was set up to compare the effects of soil mulching with three different oil palm residues i.e. pruned oil palm fronds were considered as control, oil palm empty fruit bunches (EFB) and Eco-mat (ECO) which is a carpet like material made from EFB; and silt pitting on the soil physical and chemical properties and water conservation on a non-terraced oil palm plantation. EFB (37.5 t ha^{-1} y^{-1}) and ECO sheets were applied annually on the soil surface as a single layer and pruned oil palm fronds (24 fronds per palm per year) were continually loaded in frond heaps. The silt pits were constructed by digging a trench along the hill contour, so that each one had a dimension of 4.0, 1.0, and 0.5 m in length, width, and depth, respectively. Soil samples from 0-0.15, 0.15-0.30 and 0.30-0.45 m depths were collected every three months for the first two years

from each treatment plot and analyzed for organic C, total N, available P, exchangeable- K, Ca and Mg, pH, CEC, aggregate size distribution and aggregate stability. Soil bulk density, total porosity, water retention at different soil suctions, available water content and pore size distribution were also determined for 0-0.15 and 0.15-0.30 m soil depths. Soil water content up to 0.75 m depth was also measured daily. Frond No. 17 of the palms contributed to each plot was sampled every six months and analyzed for N, P, K, Ca and Mg. In the third year, decomposition and nutrient release patterns of the EFB, Eco-mat, pruned oil palm fronds and its components (leaflets and rachis) were also evaluated. Results showed that various oil palm residues had almost different patterns of decomposition and nutrient releases. EFB increased soil organic C, aggregate stability, mean weight diameter of soil aggregate, soil available water content, relative proportion of soil mesopores, pH, N, exchangeable K, Ca and Mg and improved oil palm leaf N, P, K, and Mg levels significantly. However, soil bulk density, total porosity, water retention at saturation and permanent wilting point, soil CEC and leaf Ca concentration were not affected by the soil conservation practices significantly. The effects of ECO and silt pitting on soil properties and oil palm nutrition were statistically the same and not different from control. Soil water content was also increased as a result of EFB mulching and silt pitting practices. However, silt pitting was not as effective as EFB in increasing water content in the topsoil. Therefore, utilization of the EFB as mulch is recommended for the purpose of increasing soil physical and chemical properties and water conservation in non-terraced oil palm plantations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN BEBERAPA AMALAN PEMULIHARAAN TANAH DAN AIR KEATAS SIFAT-SIFAT FIZIK DAN KIMIA TANAH DI LADANG KELAPA SAWIT YANG TIDAK DITERES

Oleh

ABOLFATH MORADI

April 2012

Pengerusi: Christopher Teh Boon Sung, PhD

Fakulti: Pertanian

Malaysia adalah satu daripada dua pengeluar terbesar minyak kelapa sawit di dunia. Maka, Malaysia menghasilkan sejumlah besar sisa-sisa kelapa sawit setiap tahun. Penggunaan sisa-sisa ini sebagai sungkupan dan perangkap kelodak adalah amalan yang biasa digunakan untuk memulihara nutrien tanah dan air pada tanah bercerun yang tidak diteres dan untuk memperbaiki sifat-sifat fizik dan kimia tanah yang berkaitan dengan kesuburan tanah. Oleh itu, satu kajian ladang selama tiga tahun telah dijalankan untuk membandingkan kesan empat amalan pemuliharaan tanah dan air ke atas sifat-sifat fizikal dan kimia tanah dan pemuliharaan air ke atas ladang kelapa sawit yang tidak diteres. Tiga daripada amalan pemuliharaan tersebut adalah daripada sisa kelapa sawit: cantasan pelepah kelapa sawit (diambil sebagai kawalan), tandan kelapa sawit kosong (EFB) dan Ecomat (ECO) (sejenis karpet yang diperbuat daripada EFB). Amalan pemuliharan tanah dan air keempat adalah perangkap kelodak. Aplikasi EFB (37.5 tan hektar^{-1} tahun^{-1}) dan kepingan-kepingan ECO dibuat setiap tahun ke atas permukaan tanah dengan satu lapisan dan cantasan pelepah kelapa sawit (24 pelepah per pokok per tahun) ditimbunkan setiap bulan. Perangkap

kelodak dibina dengan menggali lubang di sepanjang kontur bukit, dimana setiap satu mempunyai ukuran 4.0, 1.0 dan 0.5 m untuk panjang, lebar dan kedalaman masing-masing. Sampel tanah dari kedalaman 0-0.15, 0.15-0.30 dan 0.30-0.45 m diambil setiap tiga bulan untuk dua tahun yang pertama daripada setiap plot rawatan dan dianalisis untuk organik C, jumlah N, P tersedia, kation pertukaran K, Ca dan Mg, serta pH, CEC, taburan saiz agregat dan kestabilan agregat. Ketumpatan pukal tanah, jumlah keliangan, sifat pegangan air tanah, kandungan air tersedia dan taburan liang saiz juga ditentukan untuk kedalaman tanah 0-0.15 dan 0.15-0.30 m. Kandungan air tanah hingga kedalaman tanah 0.75 m juga diukur setiap hari. Pelepah sawit no. 17 pada setiap plot disampel setiap enam bulan dan dianalisis untuk N, P, K, Ca dan Mg. Dalam tahun ketiga, corak kadar pereputan dan pembebasan nutrien oleh EFB, ECO, cantasan pelepah kelapa sawit dan komponennya (bahagian daun dan tulang belakang yang menyokong struktur daun) juga dinilai. Keputusan menunjukkan setiap jenis sisa kelapa sawit mempunyai pola pereputan dan pembebasan nutrien yang agak berbeza. EFB meningkatkan organik C tanah, kestabilan agregat, pengagregatan, kandungan tanah air tersedia, relatif nisbah liang meso tanah, pH, N, kation pertukaran K, Ca dan Mg, serta memperbaiki tahap N, P, K dan Mg daun kelapa sawit dengan nyata. Walau bagaimanapun, ketumpatan pukal tanah, jumlah keliangan, takat air tanah tepu dan takat layu tetap, CEC tanah dan kepekatan Ca daun tidak dipengaruhi oleh amalan pemuliharan tanah dengan nyata. Kesan ECO dan perangkap kelodak ke atas sifat-sifat tanah dan nutrien kelapa sawit secara statistiknya adalah sama dan tidak berbeza daripada kawalan. Kandungan air tanah juga meningkat akibat daripada EFB dan perangkap kelodak. Walau bagaimanapun, perangkap kelodak tidak berkesan seperti EFB dalam meningkatkan kandungan air dalam tanah lapisan atas. Oleh itu, penggunaan EFB sebagai

sungkupan adalah dicadangkan untuk tujuan meningkatkan sifat-sifat fizikal dan kimia tanah dan pemuliharaan air dalam ladang kelapa sawit yang tidak diteres.

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APROVAL

I certify that a Thesis Examination Committee has met on 17 April 2012 to conduct the final examination of Abolfath Moradi on his thesis entitled "Effects of different soil and water conservation practices on soil physical and chemical properties in a non-terraced oil palm plantation" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at University Putra Malaysia or at any other institution.

ABOLFATH MORADI

Date: 9/5/2012

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