Proceedings of 2010 International Conference on Agricultural and Animal Science (CAAS 2010)

Singapore, 26-28 February, 2010

Edited by
Senior Environmental Scientist, Saji Baby
Prof. Parvinder Singh Sandhu
IACSIT Editor, Yi Hang

CBEES www.cbees.org
IACSIT WWW.IACSIT.ORG
ACADEMIC World Academic Union

World Academic Union (World Academic Press)

Proceedings of 2010 International Conference on Agricultural and Animal Science (CAAS 2010)

Singapore, 26-28 February, 2010

Edited by

Senior Environmental Scientist, Saji Baby

Prof. Parvinder Singh Sandhu

IACSIT Editor, Yi Hang

World Academic Union (World Academic Press)

Proceedings of 2010 International Conference on Agricultural and Animal Science (CAAS 2010)

Singapore, 26-28 February, 2010

Editors: **Senior Environmental Scientist, Saji Baby**
Prof. Parvinder Singh Sandhu
IACSIT Editor, Yi Hang

Published by

World Academic Union (World Academic Press)
113 Mill Lane
Wavertree Technology Park
Liverpool L13 4AH, England, UK

ACADEMIC
World Academic Union

www.WorldAcademicPress.com
Sale: Please contact publishing@WAU.org.uk or PublisherMail@Gmail.com

ISBN13: 978-1-84626-022-3

ISBN 978-1-84626-022-3
Proceedings of 2010 International Conference on Agricultural and Animal Science (CAAS 2010)
Singapore, 26-28 February, 2010

Effects of Several Soil and Water Conservation Practices on Soil Physical and Chemical Properties in a Sloping Land Oil Palm Plantation

Abolfath Moradidalini [1], Christopher Teh Boon Sung [2 +], Ahmad Husni Mohd Hanif [2], Che Fauziah Ishak [2] and Goh Kah Joo [3]

[1] Department of Soil and Water Research, Agricultural and Natural Resources Research Center of Hormozgan, Bandar Abbas, Iran

[2] Dept. of Land Management, Faculty of Agriculture, Uni. Putra Malaysia, Selangor, Malaysia

[3] Applied Agriculture Research Sdn. Bhd., Sg. Buloh, Malaysia

Abstract. A field experiment was conducted at Balau Estate (2°55′57″ N and 101°52′56″E), with a slope of 6°, near Seminyeh , Selangor, Malaysia. Effects of three organic mulches, viz. stacked pruned palm fronds as a control, oil palm empty fruit bunches (EFB), Eco-mat, and silt pit on soil physical and chemical properties of a sloping land cultivated with 8-year-old oil palm trees were examined over time. Soil samples from three depths, 0-15, 15-30, and 30-45 cm, were collected every three months for one year and analyzed for pH, cation exchange capacity (CEC), total C, total N, C:N ratio, available P, exchangeable K, Ca and Mg, mean weight diameter (MWD) of soil aggregates, aggregate stability, and soil water content. Results showed that soil pH, total C, exchangeable K, Ca, Mg, available P, mean weight diameter (MWD) of soil aggregates and aggregate stability were significantly effected by the conservation practices. However, soil total N, C:N ratio and CEC were not affected. EFB generally increased soil pH, exchangeable- K and Mg and mean weight diameter (MWD) of soil aggregates significantly higher than the other practices. EFB affected soil aggregate stability up to 30 cm soil depth, and total C and average soil exchangeable Ca up to 15 cm depth. In most cases, effect of Eco-mat was not significantly different from silt pit and control. However, it was effective in increasing average mean weight diameter of soil aggregates, pH and exchangeable Ca at only the top soil but in the second order after EFB. Silt pit was effective in increasing available P significantly higher than EFB and Eco-mat at only 0-15 cm soil depth. Soil water content was also effected by the conservation practices. While EFB increased soil water content as much as 37.66%, the increasing rate for Eco-mat and silt pit were only 8.22 and 9.01%, respectively. In conclusion, EFB is an environmental friendly resource, and a good source of basic essential nutrients and organic matter, recommended to improve soil properties and water content in the sloping land oil palm plantations.

Keywords: empty fruit bunches, Eco-mat, silt pit, oil palm fronds, erosion, soil conservation

1. Introduction

Proper soil conservation practices are needed to maintain and improve soil fertility and oil palm productivity on steep lands. Organic mulches and silt pit are among the recommended conservation practices to reduce surface runoff and improve soil chemical and physical properties and water content which are important in maintaining soil fertility. Empty fruit bunches (EFB) of oil palm, Eco-mat and palm fronds are common organic mulches in Malaysia. EFB is the major waste of oil palm fresh fruit bunches after oil mill process, and Eco-mat is a carpet made from EFB so that its weight is lighter than EFB; therefore, its transportation and field application are easier. Silt pit is a trench, helping to trap running water and sediment on sloping lands which, in turn, conserves soil nutrients and water.

+ Corresponding author. Tel.: +603-89466976; fax: +603-89434419.
E-mail address: cbsteh@yahoo.com.

Both EFB and Eco-mat are rich in nutrients and organic carbon which can be released during decomposition process and improve soil physical and chemical properties. The positive effect of EFB on several soil properties have been documented [1, 2, 3, 4, 5, 6].

Information on the effects of Eco-mat and silt pit on soil properties is limited. However, a study by [7] showed that Eco-mat increased soil moisture and temperature, plant growth and N, P and K uptake by Acacia. [8] found that silt pit decreased surface runoff and soil loss on a sloping land. An experiment carried out in India [9] showed that silt pit was effective in conserving soil and N, P and K. [10] also reported a 23% reduction in soil loss due to the silt pit in an oil palm plantation on sloping lands.

From literature review, it can be inferred that most of the research were focused on the effects of EFB, Eco-mat, palm fronds and silt pit on soil properties separately. Furthermore, effects of silt pit and Eco-mat on soil properties and water conservation were not documented well. Therefore the objective of this experiment was to compare the effects of these conservation practices on several soil chemical and physical properties and water content.

2. Materials and Methods

A field experiment was conducted at Balau Estate (2°55′57″ N and 101°52′56″ E) near Seminyeh, Selangor in Malaysia. The field site had a slope of 6°. Effects of four conservation practices, EFB, Eco-mat, oil palm fronds and silt pit on several soil chemical and physical properties of a sloping land cultivated with 8-year-old oil palm trees were examined.

The experimental layout was split split block, arranged in a completely randomized block design with three replications. The conservation practices (CP) including EFB, Eco-mat, silt pit and oil palm fronds (as control) were allocated to the whole plots, soil sampling times (T) and soil depths (D) were considered as sub- and sub-sub plot, respectively. 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. EFB applied as 1000 kg per plot according to the rate proposed by [11], and four pieces of 1×2 m Eco-mat having 2 cm thickness were placed on the soil surface between the trees.

Soil samples from three depths, 0-15, 15-30 and 30-45cm, were taken in the middle of each EFB and Eco-mat treatment plots and 0.5 m away from the silt pit and palm fronds plots every three months for one year from Dec. 2007 until Dec. 2008. The samples then were analyzed for soil aggregate size distribution, aggregate stability, pH, CEC, total C and N, available P, exchangeable K, Ca, and Mg. Soil C:N ratio was also calculated.

In order to measure soil water content, an access tube was installed in the centre of the EFB and Eco-mat treatment plots, and 50 cm away from the silt pit and control (oil palm fronds) plots. Soil water content up to 75 cm profile depth and at 15 cm increments was measured using an Aqua Pro Sensor (Aquatic Sensors, Nevada) at daily intervals for a ten-month period form Mar. until Dec. 2008. Due to a fault in soil moisture probe, soil water content for a 20-day period (day 86-105 of the year) was not recorded. The data were analyzed by SAS version 9.2 (SAS Institute Inc, Cary, NC, USA) and means separation test was done by LSD.

3. Results and Discussion

Analysis of variance revealed that the three-way interaction effect of CP (conservation practice) × T (time) × D (soil depth) on soil aggregate stability, total C, available P and exchangeable Ca, and the CP×T effect on soil CEC, exchangeable K, Mg and C:N ratio were significant at 5% level of significance. Furthermore, both CP×T and CP×D and the main effects of the conservation practices were significant for pH and exchangeable K and Mg. For soil aggregate size distribution, represented as the index mean weight diameter (MWD), only the main effects of conservation practices was significant.

There was no significant effect due to the conservation practices on soil total N. This may be contributed to the high mobility of N in soil, which can accelerate the leaching of N from the soil profile and low N-release pattern of the mulching materials. A study by [3], for example, did not detect any EFB-N release during the 10 months of EFB decomposition.

Changes in soil pH due to different conservation practices are shown in Fig. 1. The highest soil pH was due to EFB followed by Eco-mat. Soil pH for silt pit was not significantly different from control. Average soil pH in EFB was 5.72 which was significantly higher than Eco-mat (4.70), silt pit (4.43) and control (4.42). In comparison to control, EFB increased soil pH by an average of 28.9%, as compared to 5.85% due to Eco-mat. Silt pit did not increase soil pH significantly.

Average soil exchangeable K and Mg in the EFB treatment were 1.15 and 0.23 cmol/kg, respectively, which were significantly higher than those for other conservation practices. In comparison to control, EFB increased soil exchangeable K and Mg by an average of 310.71 and 283.33%, respectively. Eco-mat increased soil exchangeable K and Mg significantly higher than silt pit.

Most of changes in soil total C, available P and exchangeable Ca due to the conservation practices occurred in the 0-15 cm depth. Generally, there were no significant differences among the conservation practices at 15-30 and 30-45 cm soil depth for the mentioned nutrients. Fig. 2 shows changes in soil total C, at 0-15 cm depth over the time. Soil total C was significantly higher in EFB than other conservation practices for almost all periods.

Average total C in this soil depth for EFB, Eco-mat and silt pit were 2.20, 1.72 and 1.72%, respectively. In comparison to control (1.68), EFB increased soil total C by 30.40% which is significantly higher than percentage increase for both Eco-mat and silt pit (1.90%). In general, there was no significant difference in soil C content between Eco-mat, silt pit and control for all the soil depths.

Soil available P was significantly higher in silt pit than the other conservation practices at only three months after field application of the treatments (March), after which, it became not significantly different from Eco-mat, control and EFB (Fig. 3). Furthermore, the soil available P averaged across all times showed that at all of the soil depths, the highest P was due to the silt pit. Soil P in Eco-mat and EFB were not generally different from each other and control. Therefore, these practices were not as effective as silt pit in increasing soil P. The higher P in silt pit may be contributed to the low mobility of phosphorous in soil and therefore, more movement through surface water rather than deep percolation.

Changes in soil exchangeable Ca at 0-15 cm depth, due to different conservation practices are shown in Fig. 4. Although, mean comparison by LSD showed there was no significant different among EFB, Eco-mat and silt pit, they generally, increased soil exchangeable Ca significantly higher than control.

While the effects of EFB, Eco-mat and silt pit on exchangeable Ca were nearly the same, the average soil exchangeable Ca for EFB across all times was higher than those for others. In comparison to control, EFB, Eco-mat and silt pit increased soil exchangeable Ca in the 0-15 cm soil depth by an average of 260.47, 144.19 and 120.93%, respectively.

The soil CEC and C:N ratio averaged across all soil depths and times generally showed no significant differences between the different conservation practices.

The highest mean weight diameter (MWD) was obtained in the EFB treatment (Fig. 5). However, there was no significant difference between EFB and Eco-mat. The lowest MWD was due to the silt pit which was not significantly different from control.

Soil aggregate stability at 0-15 and 15-30 cm depths were significantly higher in EFB than the other conservation practices (Fig. 6). There was no significant difference between Eco-mat and silt pit. At 30-45 cm soil depth, the differences among the conservation practices were not significant. However, silt pit treatment resulted in higher aggregate stability than control. Furthermore, except for silt pit, soil aggregate stability due to the EFB, Eco-mat and control decreased with increasing soil depth which may be contributed to decreasing in soil organic matter with soil depth. The increasing trend of aggregate size distribution and aggregate stability in the EFB treatment may be contributed to higher soil carbon content and exchangeable cations in this treatment.

Fig. 7 shows changes in daily total soil water content for different conservation practices over the time from 7 Mar. 2008 until 31 Dec. 2008. Soil water content in the EFB treatment was higher than the other conservation practices. The highest mean daily amount of soil water content was obtained in EFB (381.65 mm) and the lowest was in the control treatment (277.22 mm). Eco-mat and silt pit had nearly the same amount of soil water content. In comparison to control, EFB increased soil water by an average of 37.66% as compared to 8.22 and 9.01% for Eco-mat and silt pit, respectively.

4. Conclusion

Soil pH, total C, exchangeable K, Ca, Mg, available P, soil aggregate size distribution and aggregate stability were significantly effected by the conservation practices. However, soil total N, C:N ratio and CEC were not affected. EFB generally increased soil pH, exchangeable K and Mg and mean weight diameter (MWD) of soil aggregates significantly higher than the other conservation practices. Soil aggregate stability up to 30 cm soil depth and total C up to 15 cm depth was affected significantly by the EFB. Eco-mat was effective in increasing the average mean weight diameter of soil aggregates, soil pH and exchangeable Ca at only the top soil but in the second order after EFB. Silt pit was effective in increasing soil available P significantly higher than EFB and Eco-mat at only 0-15 cm soil depth. EFB increased soil water content by as much as 37.66%, higher than the percentage increase for Eco-mat (8.22%) and silt pit (9.01%). In conclusion, the use of EFB is environmental friendly resource and a good source of basic essential nutrients and organic matter. EFB is recommended to improve most of the soil chemical and physical properties as well as soil water content which are for maintaining soil fertility in the sloping land oil palm plantations.

5. Acknowledgements

This research is funded by the Ministry of Science, Technology and Innovation, Malaysia (Project No. 05-01-04-SF0632). We are grateful to Mr. Subra and his field workers at Balau Estate and the laboratory staff at the Dept. of Land Management, UPM for their help in this research.

6. References

[1] L.V. Kheong. *Effects of Empty Fruit Bunches Application on Oil Palm Root Distribution, Proliferation and Nutrient Uptake.* PhD Thesis, Universiti Putra Malaysia, 2008.

[2] K.C. Lim, and A. R. Zaharah. The effects of oil palm empty fruit bunches on oil palm nutrition and yield, and soil chemical properties. *Journal of Oil Palm Research.* 2002, **14**: 1-9.

[3] A.R. Zaharah, and K.C. Lim. Oil palm empty fruit bunch as a source of nutrients and soil ameliorant in oil palm plantations. *Malaysian Journal of Soil Science.* 2000, **4**: 51-66.

[4] A.B. Rosenani, and R. Wingkis. Empty fruit bunch application on newly transplanted oil palm: its decomposition and nutrient release. In: S. Zauyah et al (eds.). *Proc. Soil Science Conference of Malaysia*, 1999, pp. 112-129.

[5] R. Wingkis. *Chemical Composition of Oil Palm Empty Fruit Bunch and Its Decomposition in the Field.* Master of Science Thesis, Universiti Putra Malaysia. 1998.

[6] R. A. Ortiz, E. Villalobos, and O. Fernández. *Mulch and Fertilizer Effects on Soil Nutrient Content, Water Conservation and Oil Palm Growth.* ADS Oil Palm Papers No. 6, 1992.

[7] W. A. Ibrahim. *Optimization of Mulch Mat Production from Oil Palm Empty Fruit Bunches and Its Effects on Growth Performance of Acacia Hybrid Seedlings on Sandy Tailings.* PhD Thesis, Universiti Putra Malaysia. 2006.

[8] B.B.F. Soon, and H.W. Hoong. Agronomic practices to alleviate soil and surface runoff and soil losses in an oil palm estate. *Malaysian Journal of Soil Science.* 2002, **6**: 53-64.

[9] S. George, J. John, A. Philip, M.D. Jessy, and K.I. Punnoose. Influence of silt pits on conservation of soil, nutrients and moisture in a mature rubber plantation. *Indian Journal of Natural Rubber Research.* 2003, **15**: 14-18.

[10] K.H. Lim, J.H. Chuah, and C.Y. Ho. Sustainable soil and water management practices under oil palms on slopes. In: *Proc. Int. Conf. Soil Resources and Sustainable Agriculture, Kuala Lumpur, Malaysia*, 1995, pp.71-80.

[11] K.W. Chan, I. Watson, and K.C. Lim. Use of oil palm waste material for increased production. In: E. Pushparajah et al (eds.). *Proc. Conference Soil Science & Agricultural Development in Malaysia.* 1980, pp. 213-242.

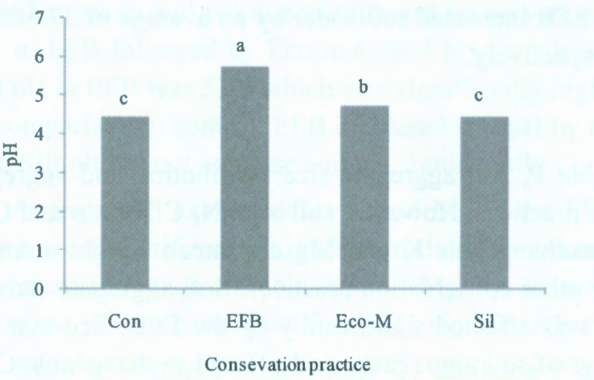

Fig. 1. Soil pH for different conservation practices (means with the same letter are not significantly different according to LSD at p<0.05)

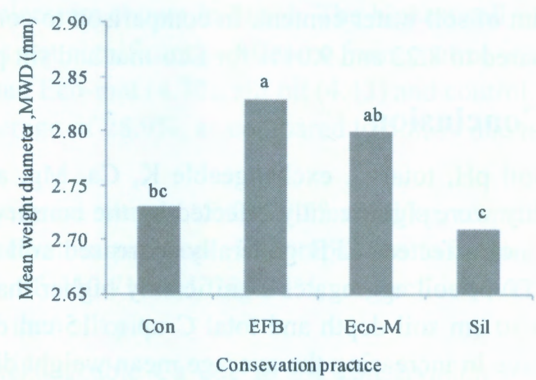

Fig. 5. Mean weight diameter (MWD) for different conservation practices (means with the same letter are not significantly different according to LSD at p<0.05)

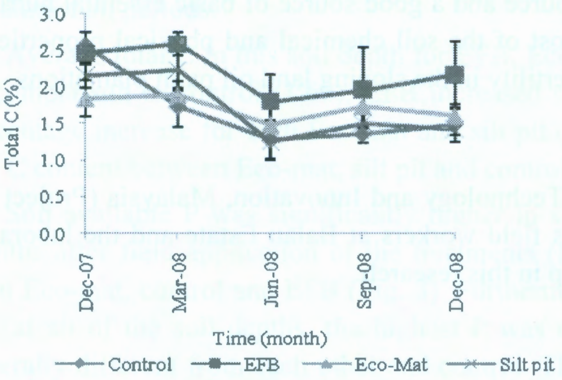

Fig. 2. Changes in soil total C due to different conservation practices for 0-15 cm soil depth

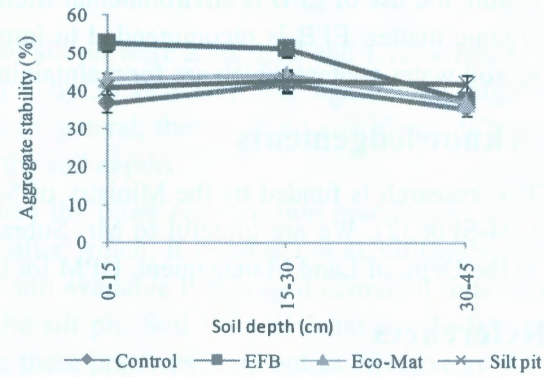

Fig. 6. Changes in soil aggregate stability due to different conservation practices over the soil depth

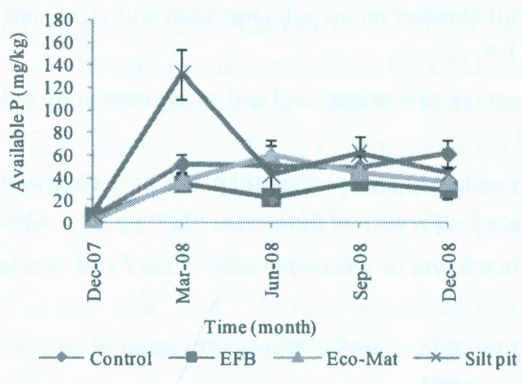

Fig. 3. Changes in soil available P due to different conservation practices for 0-15 cm soil depth

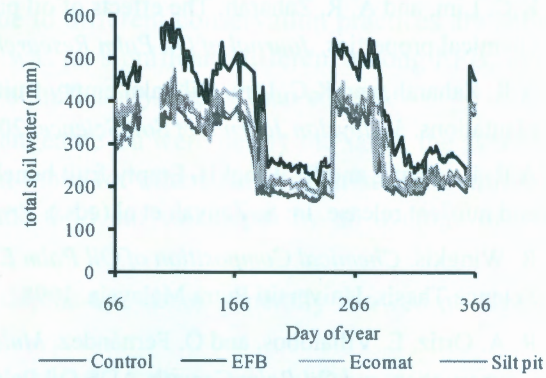

Fig. 7. Changes in soil total water content for different conservation practices over the time

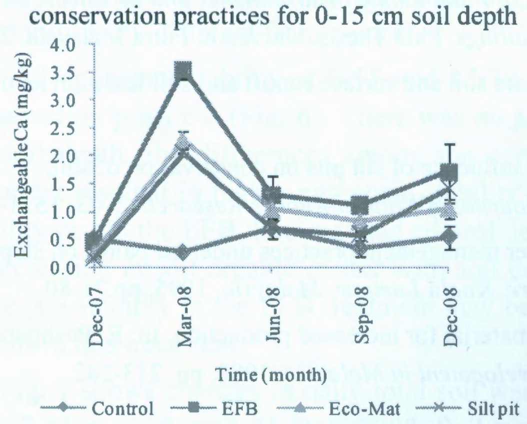

Fig. 4. Changes in soil exchangeable Ca due to different conservation practices for 0-15 cm soil depth