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Sustainable Soil Management and Conservation

16-18 APRIL 2019

Equatorial Hotel, Melaka

EDITORS

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SOIL AND WATER CONSERVATION UNDER OIL PALM

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Soil conservation follows four broad strategies: 1) cover the soil to protect against rain splash impact, 2) increase water infiltration into the soil to reduce amount of runoff, 3) lower soil erodibility by increasing aggregate stability, and 4) increase surface roughness to reduce runoff velocity (Morgan, 2005). Application of organic matter such as through mulching is one very effective way to achieve all the aforementioned four strategies. Organic matter increases a myriad of soil chemical and physical properties that includes, among others, the soil's resistance against water erosion and soil infiltration (due to lowering of soil compaction). Mulching in particular additionally offers a soil cover to protect the soil against rain splash impact and being carried away by runoff water.

In Malaysia, four soil conservation practices are often recommended for oil palm (Elaeis guineensis Jacq.) plantations. These practices are oil palm empty fruit bunches (EFB), Ecomat (a compressed EFB mat; ECO), and pruned oil palm fronds (OPF). These three oil palm residues are used as organic mulching materials. The fourth method is silt pits (SIL) which are close-ended soil trenches to collect water and nutrients from runoff water and later redistribute them back into the soil.

Many studies (such as by Moradi et al., 2012) have shown the beneficial effects of EFB mulching. EFB was shown to be significantly better than the other three soil conservation practices in improving nearly all of the measured soil and plant parameters. Empty fruit bunches are most effective partly because of the combined effects of higher amounts of dry matter added and the higher nutrient concentrations in the EFB than in other mulching materials. Silt pitting was found not to be as effective as EFB because SIL could only trap and return nutrients back into the soil, whereas EFB could do both: trap nutrients and release additional nutrients into the soil as it decomposes.

Typically in the short term, larger improvements in soil chemical than soil physical properties can be observed due to these soil conservation methods. Moraidi et al. (2012) observed that the soil physical properties such as bulk density, total porosity, and water retention at saturation and permanent wilting point were not significantly affected by the conservation practices of EFB, ECO, SIL, and OPF. However, EFB significantly increased soil aggregate stability by 32%, soil aggregation by 5%, soil water content at field capacity by 13%, soil available water content by 31%, and relative proportion of soil mesopores by 14% compared with the OPF (control) treatment. The effects of ECO, SIL, and OPF on the evaluated soil properties were not significantly different from one other. However, their effects were significantly lower than EFB. Soil water content was significantly the highest, especially during the low rainfall periods, in EFB-treated soils compared with OPF and ECO. Average daily water content in the whole soil profile (0-0.75 m depth) was 20, 12, and 8% higher in EFB treatment compared with the OPF, ECO, and SIL, respectively. SIL was not as effective as EFB in increasing the soil water content in the top soil layer where oil palm feeding roots would be mostly located. Instead, SIL tended to increase the soil water content in the lower soil layers due to the depth of the silt pit floor. Overall, EFB was the best soil and water conservation practices on non-terraced oil palm plantations.

The huge beneficial effects of EFB is partly due to its higher amount of nutrients released than that released by other mulching materials. Decomposition studies showed that the pruned oil palm frond's leaflets had the highest initial concentration for most nutrients, and the frond's rachis and Eco-mat the lowest. The order of residue quality and rate of residue mass loss were: leaflets > fronds > EFB > Eco-mat > rachis. EFB however had a higher mass loss rate than the fronds. Residue mass loss and nutrient release rates were faster at the beginning than at the end of the decomposition period. Leaflets released the highest total amount of nutrients (except for K), and rachis the lowest. The fronds released either significantly higher (for N and Ca) or not significantly different (for P and Mg) total amount of nutrients than EFB. Converting EFB into Eco-mat had resulted in nutrient losses (e.g., N, K, and Mg) and a residue quality reduction in Eco-mat.

Silt pits can be effective to conserve soil water and nutrients. However, the dimensions of silt pits are important. It is commonly thought that the larger the silt pits, the more effective they are to conserve soil and water. However, studies have shown that making the silt pits too large would incur higher water loss by evaporation (through the pit opening) and percolation (through the pit floor). Moreover, it the pits are below the rooting zone, this would cause water to flow out of the pit and away from the root zone. Measurements and computer simulations have shown that the wall-to-floor (W:F) ratio of a pit is important. The larger the W:F ratio, the more effective the pit would conserve soil water and nutrients and enable them to return to the rooting zone.

The water conservation ability of silt pits is in ascending order with the total W:F ratio which defines that the silt pit with the smaller floor area and larger wall areas is able to serve increasingly more water (as well as keep the water for increasingly longer periods in the silt pits) into the top soil layers via lateral water flow through the silt pit walls.

Husam (2018) used a combination of HYDRUS 2D model and artificial neural network to determine the soil water flow patterns from various dimensions of silt pit in order to determine the optimum silt pit dimension given a soil texture, slope steepness, and rainfall intensity. Using data sets from 37 oil palm plantations in Peninsular Malaysia, Husam (2018) estimated that optimal width and depth of silt pit are between 1.0 to 1.6 m and 0.7 to 1.0 m, respectively. The length of the silt pits is fixed by Husam (2018) as 4 m. Given the rather narrow range for the optimal silt pit width and depth, we can take that the mean optimal silt pit size is 1.3 m wide and 0.85 m deep (length is 4 m) for Peninsular Malaysia.

Other conservation methods are currently being investigated such as the use of oil palm trunk as a mulching material. In 2011, Malaysia produced 81.5 million tonnes of dry biomass, 13 million tonnes (16% of the total) of which came from the biomass of oil palm trunk. The average economic lifespan of oil palm trees is 25 to 30 years, after which the trees are cut down for replanting. The trunks are discarded either by burning or leaving them to decay in the field. Nonetheless, freshly felled trunks contain high moisture content so the trunks do not burn easily, and leaving the trunks in the field becomes a physical hindrance to replanting and other field operations. Moreover, these trunks can take up to five years to completely decompose in the open field.

One recent solution is to shred the trunks and leave the shredded materials in the field as a soil mulch. Shredding the trunk means the trunk become much less of a physical hindrance and eliminates the air-polluting problem of burning.

But compared to EFB and OPF, much less is studied about shredded oil palm trunk (OPT): its decomposition rate in the field, its nutrient release rate into the soil, and ultimately, its effects on soil properties and oil palm growth and yield. Nurul Hidayah (2014) determined that the decomposition of OPT was slow, similar to that of oil palm frond rachis, that within 12 months, about 30% of the original OPT biomass remained on the soil surface. Without shredding the trunk, the decomposition rate of the trunk increases. Merely chopping the trunk, for instance, the decomposition rate is 0.07 (Kee, 2004). The rate of decomposition of decreased in the following order: leaflets > EFB > ECO > fronds (rachis and leaflets) > rachis > OPT (Nurul Hidayah, 2014; Moraidi et al., 2014).

Increases in soil organic matter is typically rapid within the first few months of mulching, but this upward trend will gradually slow down and then stop at some threshold level. Moreover, studies have shown buildup of soil organic matter only occurs if mulching is done regularly, failing which the organic matter levels in the soil can gradually decline over time. Moraidi et al. (2012, 2014) measured that over 50 months of EFB application, soil C had increased by nearly two times, compared with 1.2 times increase in the ECO soil plots. EFB had a larger effect on increasing soil C than ECO and OPF because of EFB's higher loading rate and faster decomposition rate. The amount of C added by EFB was between three to four times higher than that added by OPF and ECO. Moraidi et al. (2013) further estimated that 9 and 3% of the C in EFB were used to increase soil C in the 0-0.15 and 0.15-0.30 m soil depths, respectively. For ECO, about 4% of its C was used to increase soil C in the 0-0.15 as well as the 0.15-0.30 m soil depths. For OPF, the fractions were 5 and 2% in the respective aforementioned soil depths. Even after 50 months, only a small portion of the oil palm biomass C was sequestrated in the soil, the much larger portion of C presumably lost as CO2 emission, erosion runoff, leaching, and soil biota use. On the other hand, application of shredded OPT as soil mulch also increased soil C in the 0-100 mm soil depth at a rate of 0.157 g C kg-1 soil per month for nearly a year (Hidayah, 2015). After 10 months, shredded OPT increased soil C by 1.3 times, from which about 3% of the C in the shredded OPT had been sequestrated in this soil depth.

There is an increasing demand and interest today in Malaysia for oil palm biomass for fuel and bio-based chemicals. But removal of biomass from the oil palm plantations means losses in nutrients and lesser protection for the soil against erosion and leaching. This means more fertilizers would have to applied to replace these nutrient losses. Teh (2015) estimated that for a mature oil palm plantation producing 30 t ha-1 yr-1 FFB, no more than 3 to 5 t ha-1 yr-1 of additional biomass can be removed from the field. This amount is in addition to the FFB removed at harvest at the rate of 30 t ha-1 yr-1 . Approximately, for every 1 t ha-1 yr-1 of biomass removed, about 11 kg ha-1 yr-1 of additional fertilizers are required to replace the lost nutrients. How much biomass can be removed from the field is most limited to N and K nutrient losses.

REFERENCES

Husam, H. A. Al-S. (2018). Optimal size of silt pits for different soils, slope steepness, and rainfall intensities. Ph.D. dissertation. Serdang, Malaysia: Uni. Putra Malaysia.

Kee K.K. (2004) Nutrient reserves and recycling from oil palm (Elaeis guineensis Jacq.) trunks at replanting. In Proceedings for the 4th International Crop Science Congress, 26 September – 1 October 2004. Eds T. Fischer, N. Turner, J. Angus, L. McIntyre, M. Robertson, A. Borrell and D. Lloyd. Brisbane, Australia: The Regional Institute Ltd.

Moraidi A., Teh C.B.S., Goh K.J., Husni M.H.A., Fauziah C.I. (2013) Soil organic C sequestration due to different oil palm residue mulch. In Advances in Tropical Soil Science, Vol. 2, pp. 169-186. Eds J. Hamdan and J. Shamshudin. Serdang, Malaysia: Universiti Putra Malaysia Press.

Moraidi A., Teh C.B.S., Goh K.J., Husni M.H.A., Fauziah C.I. (2014) Decomposition and nutrient release temporal pattern of oil palm residues. Annals of Applied Biology, 164, 208-219.

Moraidi A., Teh C.B.S., Goh K.J., Husni M.H.A., Fauziah C.I. (2012) Evaluation of four soil conservation practices in a nonterraced oil palm plantation. Agronomy Journal, 104, 1727-1740.

Morgan R.P.C. (2005) Soil Erosion and Conservation. 3rd edn. UK: Blackwell Publishing

Nurul Hidayah I. (2014) Decomposition Rate of Pulverized Oil Palm Trunk Mulch within Thirteen Months. B. Agric. Sc. Final Year Project Report. Serdang, Malaysia: Uni. Putra Malaysia.

Teh. C.B.S. (2016) Availability, use, and removal of oil palm biomass in Indonesia. Report prepared for the International Council on Clean Transportation. Washington, D.C.: ICCT.