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Biogeosciences Discussions

Interactive comment on "Herbicide weed control increases nutrient leaching as compared to mechanical weeding in a large-scale oil palm plantation" *by* Greta Formaglio et al.

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RC> Line 23-28 Could you consider the specific data (e.g., low solute concentrations, small drainage: : :) should be added, and thus increasing the persuasiveness for the readers? (Maybe it is important in the Abstract).

AR> We agree that is important to insert some specific data but we want to avoid getting a long abstract. We think that the difference in leaching losses between conventional and reduced management are the most important numbers to be shown so we will include them in the abstract by revising l 27-31 as follows: "Mechanical weeding reduced leaching losses of all nutrients compared to the conventional herbicide

weeding, because herbicide decreased ground vegetation, and thereby reduced the efficiency of soil nutrient retention. The leaching of total N was the highest with conventional management (73.6 kg N ha-1 yr-1) and the lowest in mechanical weeding with reduced fertilization (32.0 kg N ha-1 yr-1) whereas its yield remained comparable among all treatments".

RC> 1. Line 41 The term "e.g" should be "e.g.".

AR> We will correct the punctuation in the revised manuscript.

RC> Line 52-54 Could you provide some references? Thank you.

AR> Since we don't have strong evidence to justify this sentence, we will restructure it in the following way: "The decline in soil fertility reinforces the dependency on fertilizer inputs and threatens the long-term productivity of the area (Syers 1997), possibly exacerbating land-use change". [Phil. Trans. R. Soc. Lond. B. 352 (1356) :1011-1021]

RC> Line 57-63 Indeed, high precipitation rate is a critical driver for surface runoff and associated nutrient losses. Particularly for considerable plantations. However, the leaching losses may be offset by a high nutrient cycling due to the rapid uptake of plants.

AR> Thank you for this observation; this was expanded in the manuscript in the second paragraph.

RC> Line 92 How far the radius of the palm circle?

AR> We will include it in the revised manuscript.

RC> Line 98-99 Could you describe more details about the root distribution of oil palm? I am not sure the roots of palm only grow around the trunk. I think the root biomass between inter-row area may be high in somewhere.

AR> The root density is higher in the palm circle because it's closer to the palm stem and because of the repetitive fertilization in this area, whereas the inter-row has the

lower root density. We will include a sentence at l 97 in the revised manuscript: “Root uptake is related to root density, which is high inside the palm circle and lower in the inter-row (Jourdan and Rey, 1997; Lamade et al. 1996)”. [Jourdan, C. and Rey, H.: Plant and Soil, 190, 235–246, 1997].

RC> Line 159 Replace the “x” between “the 50 x 50 m” with “_”.

AR> We prefer to not modify this because the symbol “_” may cause confusion to the reader since we want to indicate a mathematical product, normally identified by the symbol “x”.

RC> Line 160 Where is the plant materials from the mechanical weeding? Are they transported far away from the plots?

AR> The plant material is left inside the plot. We will add this detail to the text.

RC> Line 232 Is the runoff set to 0? Do you mean “no overland runoff”?

AR> Yes, we meant this, we will specify no overland runoff in brackets in the revised manuscript.

RC> Line 243 Soil physical-chemical characteristics.

AR> We will modify this in the revised manuscript.

RC> Line 247 See comment 1.

AR> Please see the answer to comment 1.

RC> Line 265 Please simplify the statistical analyses section.

AR> Although we understand that the statistical analyses section may seem too long, we cannot simplify it without removing essential information. We think that is in line with good scientific practices to report all the statistical analyses used, for reproducibility.

RC> The results section is well-organized manner. However, some statements are so long that they (e.g., the section “3.2 Differences in leaching losses: : :”) should be

simplified to delete some non-key contents.

AR> We decided to include some explanation sentences in the results to guide the reader since we presented a lot of results. Following this comment, we carefully re-examined the manuscript and decided to modify the l 343 as follows: “On the other hand, base cation leaching fluxes had opposite patterns as their concentrations as Ca, K, and Mg leaching were higher in the frond-stacked area than the palm circle and inter-row (all $P < 0.01$; Fig. 4). Leaching of Na was higher in both the frond-stacked area and inter-row than the palm circle ($P < 0.01$; Fig. 4)”.

RC> Line 310-311 The drainage flux is low. Do you investigate the stem flow (may be influenced by “funnel effect” of canopy of oil palm?)? Some studies demonstrated that the infiltration was enhanced around the tree trunk.

AR> The model used did not allow to parametrize the stem flow and the funnel effect. Nevertheless, the values from the water model were calibrated with field measurements of soil matric potential, reflecting the actual field conditions.

RC> Line 346 Why is different between the various elements leaching?

AR> The differences in nutrient leaching fluxes between management zones depend on 1) differences in water drainage fluxes (the same of every element) and 2) differences in element concentrations in deep soil-water (which varies for each element). For example, much higher Al concentrations in the inter-row compared to the frond-stacked area resulted in higher Al leaching even if the frond-stacked area have higher water drainage. On the other hand, Mg concentrations were comparable among inter-row and frond-stacked area, but due to the large drainage of the latter Mg leaching was higher in the frond-stacked area.

RC> Line 391 I recommend the ratios of runoff/interception/evaporation/transpiration to precipitation was supplemented in the Table 2 for better understanding.

AR> We would prefer to not include that in Table 2 to have a simpler table and because

the ratios can easily be extrapolated. However, we will include the ratio if requested by the editor.

RC> Line 434-438 How to understand the use of organic amendments and slow-release fertilizers? E.g., mulching application? Under the high temperature and precipitation in some tropical areas, the plant materials decompose quickly, and the litterfall may have very short residence time on the ground. Could you provide any information on the standing plant litter in your treatments? Thank you!

AR> In the studied plantation, there were two peaks of leaching due to the overlapping of high drainage fluxes and fertilizer application. Since it is complicated to predict the periods with high drainage, it may be useful to use organic or slow-release fertilizers. These can distribute the nutrient input to the soil over a longer period of time, thus reducing the overlapping of high nutrient input and high drainage, and also avoiding peaks of high nutrient inputs. Indeed, the decomposition in the tropics happens fast but it would still provide nutrients slower than mineral fertilization. The organic amendments more used in oil palm plantations are the waste from the palm oil processing, namely the empty fruit bunches (EFB) or the palm oil mill effluent (but this is normally applyied just close to the mill). In a study on decomposition rates and nutrient release by EFB in oil palm plantation, 75% of the EFB was decomposed in 8 months, with a deposition constant k= 0.2 month-1 (Moradi et al. 2014, Ann Appl Biol 164: 208–219). Another organic amendment in the oil palm plantation is the litterfall, which is represented by the frond stack. This can provide plenty of nutrients to the plantation as it can be seen from the high nutrient contents in the frond-stacked area in our manuscript (Table 1). Also, the addition of cut fronds is regular, at a rate of 16 fronds palm-1 yr-1 in the studied plantation. However, this positive effect on soil fertility is restricted to the frond-stacked area and it is unsure if the palm can benefit from these nutrients. Recent literature (Rüegg et al., 2019) found higher root density under the frond-stacked area compared to the inter-row, indicating that the palm may indeed take up the nutrients from the decomposition of the frond stack.

RC> Line 552-553 Although the mechanical weeding is sustainable way in ecological view, the farmers were reluctant to adopt due to its money-consuming and labor-consuming. Undoubtedly, mechanical weeding is a promising measure to reduce nutrient leaching.

AR> Indeed we would expect the farmers to be reluctant to adopt this weeding method because it requires more labor. However, the economic analysis done in Darras et al. (2019) showed that the costs to implement mechanical weeding would be comparable to the ones for herbicide application. In fact, the prolonged use of glyphosate as standard weeding practice has favored woody and resistant understory vegetation that have to be cut periodically with mechanical weeding.

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