Improving sustainability and circularity of palm oil production upstream and downstream

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Introduction

Colombia is the largest palm oil producer outside of Asia. To expand the sales market, it is important to improve the sustainability and circularity of palm oil production. The aim of this project is to increase the efficiency of land, biomass, and nutrient in both the upstream and downstream production of palm oil. The upstream research investigates the options on closing the yield gap of fresh fruit bunch (FFB) between current and potential production. The downstream research investigates the options of a more sustainable and circular use of palm oil mill residues.

Upstream improvements: Increasing production through closing yield gaps

The oil palm simulation model PALMSIM was calibrated using soil and yield data of different palm oil companies, radiation data of NASAPOWER, and temperature and precipitation data of local weather stations. It was subsequently used to assess water limited and exploitable yield of the current oil palm variety (*Elaeis guineensis*) in different areas of Colombia (Figure 1). Data from similar age plantations showed a large variety in actual yields. A benchmark of exploitable yield was defined at 80% of the water limited yield. Averaged for the entire palm life cycle, actual yields were circa 10 t/ha·y below the exploitable yield and circa 25 t/ha·y below at the plateau phase. The yield gap suggests that plantations could increase their yield through better and more equally distributed management practices.

Water limited yield

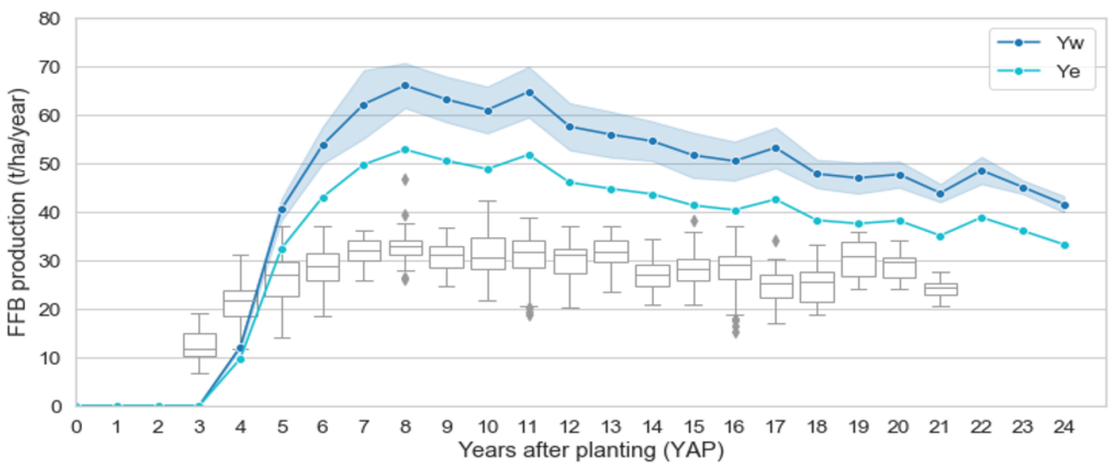

Figure 1. Simulated water limited yield (Yw), exploitable yield (Ye), and actual yield (bxpl) for a plantation in Central Colombia.

Discussion and conclusions upstream improvements

- A hybrid palm will replace *E. guineensis* because it is more resistant against bud rot.
- A literature study was combined with data from Cenipalma to parametrize the PALMSIM model for this hybrid.
- A sensitivity analysis has been performed to identify which of the missing parameter values need still be collected by Cenipalma to allow modulization of water limited yield for the hybrid variety.
- By comparison with the current variety, the potential yield gain can be assessed when the hybrid will be massively introduced.

Downstream improvements: Anaerobic digestion of EFB, MF, and POME

A palm oil mill processes FFB into crude palm oil (CPO) and palm kernel oil. Per tonne of CPO an equal amount (in dry weight) of residue is generated, including empty fruit bunch (EFB), mesocarp fiber (MF), palm kernel shell, and palm oil mill effluent (POME). The sustainability and circularity of the production of palm oil can be improved by anaerobic digestion of POME, EFB, and MF. Anaerobic digestion experiments with untreated and steam treated EFB and MF were performed. Current and alternative conceptual palm oil mill set-ups were analyzed on techno-economic, environmental, and circularity aspects (Figure 2).

Circularity performance

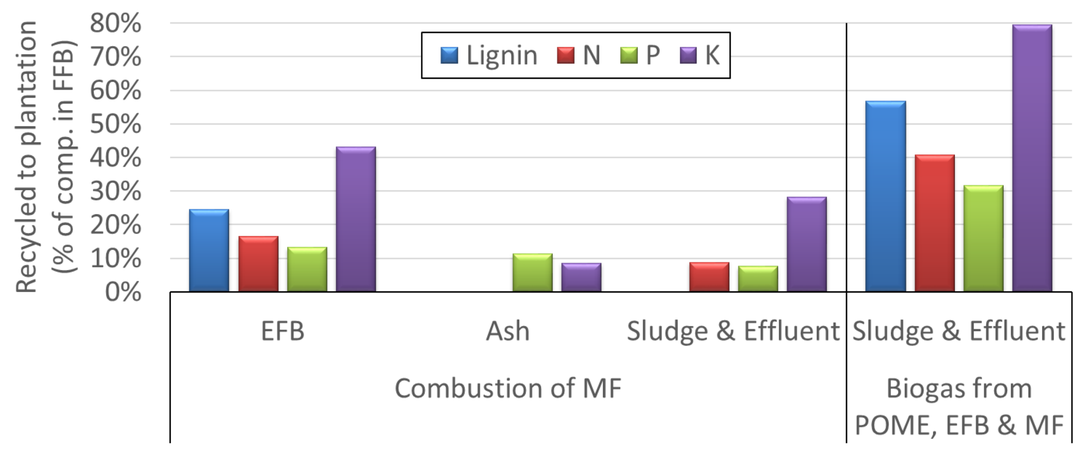

Figure 2. Circularity performance of a mill burning MF to generate steam (left) compared to a mill generating steam from biogas from POME, EFB, and MF (right). By burning the MF, the lignin (recalcitrant organic matter) and N can not be recovered. By anaerobic digestion of POME, EFB and MF, the lignin and N are preserved in the sludge and effluent.

Discussion and conclusions downstream improvements

- Preventing methane emission from open POME ponds drastically decreases GHG emission.
- It was experimentally proven that steam treatment of EFB and MF improves the anaerobic digestibility of these residues.
- The biogas from the EFB, MF, and POME can provide enough energy to be self-sufficient in steam and electricity.
- If the steam boiler runs on biogas instead of biomass, no cyclone and electrostatic filter are required for emission control, which equalizes the fixed capital costs related to a biogas system.
- The nutrients and recalcitrant organic matter are preserved in the sludge and effluent, which can be returned to the soil of the plantation.
- Valorizing the fiber and cellulose of the MF in material applications can increase the total added value of palm oil mill products and potentially results in land sparing as it replaces biobased fiber and cellulose sources.

Acknowledgements

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