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Yield gap analysis and entry points for improving productivity on large oil palm plantations and smallholder farms in Ghana

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ABSTRACT

Oil palm production must increase in Ghana to meet the increasing demand for palm oil and avoid costly imports. Although maximum fruit bunch (FB) yields of > 20 t ha^{-1} yr^{-1} are achievable, average FB yields in Ghana are only 7 t ha^{-1} yr^{-1}. Despite the pressing need to increase palm oil production and improve yields, knowledge of the underlying causes of poor yields in Ghana is lacking. Closing yield gaps in existing plantings in smallholdings and plantations offers great opportunities to increase oil production without area expansion, thus sparing land for other uses. This study sought to understand the magnitude and underlying causes of yield gaps in plantation and smallholder oil palm production systems in Ghana based on a detailed characterization of management practices and yield measurements over a two-year period. Using a boundary line analysis, the water-limited yield (Yw) over a planting cycle was defined as about 21 t ha^{-1} yr^{-1} FB, with yield gaps of 15.4 t ha^{-1} yr^{-1} FB at smallholder farms and 9.8 t ha^{-1} yr^{-1} FB at plantations. Poor management practices, including incomplete crop recovery (i.e., harvesting all suitable crop) and inadequate agronomic management were the main factors contributing to these yield gaps. Productivity losses were further exacerbated by low oil extraction rates by small-scale processors of 12% as compared to 21% by the large-scale processors. The potential losses in annual crude palm oil (CPO) during the crop plateau yield phase therefore exceed 5 and 3 t ha^{-1} yr^{-1} for small-scale and large-scale production systems respectively. Investment to reduce yield gaps by appropriate agronomic and yield recovery practices across all production systems, while improving access of smallholder producers to more efficient oil palm processing facilities, can make a significant contribution to closing the supply gap for palm oil in Ghana. The impact of such investments on large-scale plantations could result in a doubling of CPO production. Smallholder farmers could benefit the most with a fourteen-fold increase in CPO production and economic gains of > 1 billion US$.

1. Introduction

The demand for palm oil in West Africa is outstripping supply, with an annual deficit estimated of > 1 million t crude palm oil (CPO) for the Economic Community of West African States (ECOWAS) in 2013 (FAO, 2017). Ghana had an annual CPO production shortfall of approximately 106,000 t in 2013. Part of the deficit was compensated by costly imports (165,000 t CPO, at a cost of US$140 million), whilst approximately 60,000 t CPO was exported (FAO, 2017). Oil palm production in Ghana must therefore increase to meet the high demand.

There are three main stakeholders in the Ghanaian oil palm industry: (i) large industrial plantations (≥ 1000 ha) with large-scale processing mills (processing capacity > 15 t hr^{-1} fruit bunches (FB)) (ii) smallholder farms of up to 100 ha and (iii) small-scale processors using semi-mechanized mills (processing capacities of < 1 t hr^{-1} FB) (Adjei-Nsiah et al., 2012a). In this paper, we define smallholder farmers as growers that cultivate oil palm on privately owned or rented land. They are not contractually bound to deliver their crop to a particular mill or association (MASDAR, 2011; RSPO, 2015).

Growth defining and limiting factors (e.g., radiation, planting material, climate and nutrient supply), as well as growth reducing factors (e.g., pests and diseases) and the quality of field management all

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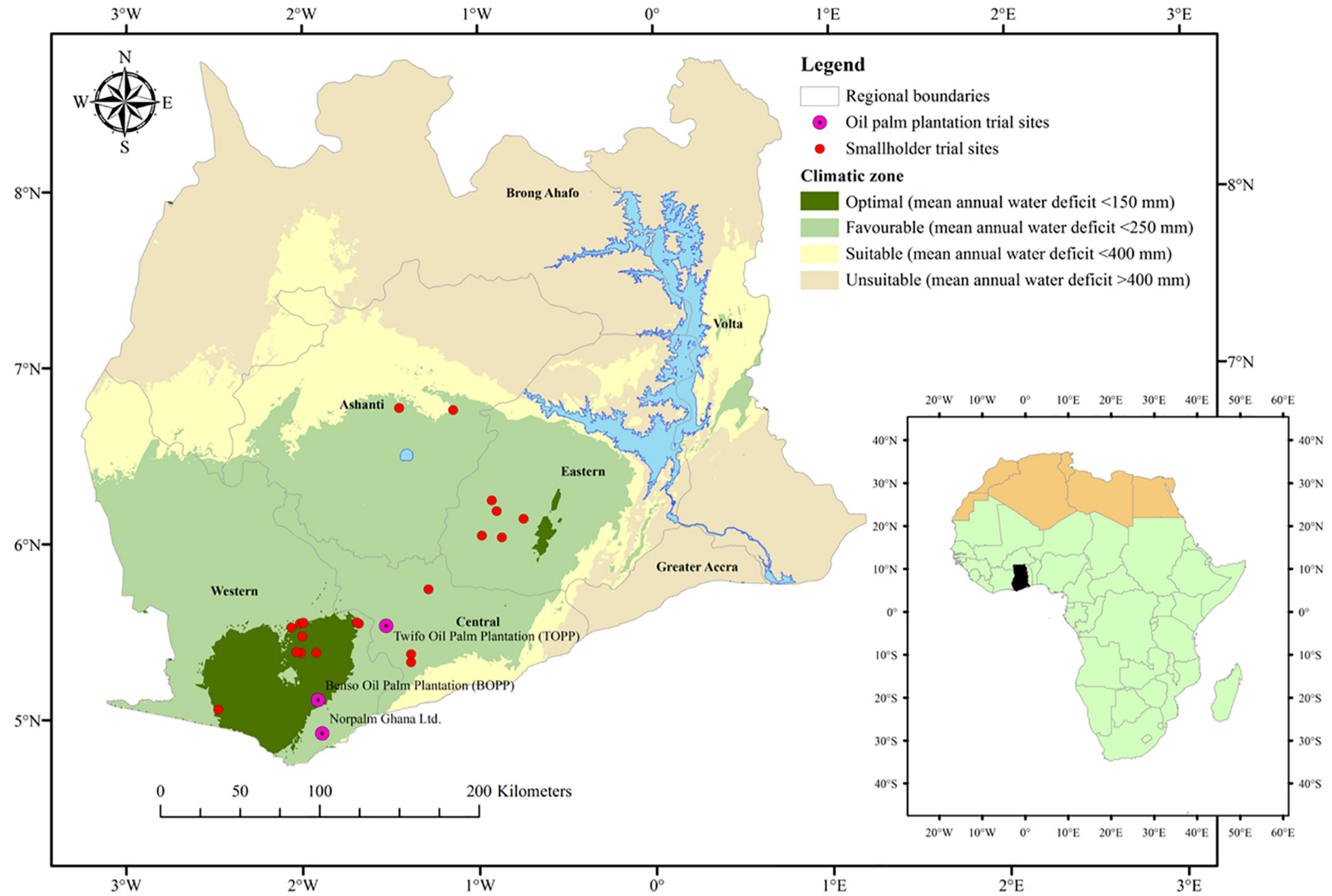

Fig. 1. Map showing location of oil palm plantation and smallholder trial sites and suitability zones for oil palm cultivation in the southern regions of Ghana.

determine the yields that can be achieved at a particular site (van Ittersum et al., 2013). Despite maximum observed FB yields in individual fields of 20 t ha^{-1} yr^{-1} or more, average FB yields on large plantations are estimated to be 10–13 t ha^{-1} yr^{-1}, while smallholder farmers achieve very low average FB yields of about 3 t ha^{-1} yr^{-1} (Ofosu-Budu and Sarpong, 2013). Oil extraction rates (OER) are lower at small-scale processors that provide services to most smallholder producers; 10–14% as opposed to 19–22% achieved at large-scale mills (Adjei-Nsiah et al., 2012a). The yield of crude palm oil (CPO) may therefore be an order of magnitude greater in estates compared with smallholders given the combination of larger fruit bunch yields and higher oil extraction rates.

In response to the increasing demand for palm oil, programmes supported by the Government of Ghana during the period 2002–2013 led to rapid expansion in the area planted with superior *tenera* (i.e., *dura* x *pisifera* (DxP)) oil palm seedlings by smallholder farmers. The area planted increased by 20,000 ha between 2004 and 2010, (MASDAR, 2011) and total FB production increased by > 110%, from 1,100,000 t in 2002 to 2,326,920 t in 2013. Over the same period, however, average FB yields stagnated between 5.6 and 7.3 t ha^{-1} yr^{-1} (FAO, 2017). In 2014, average FB yields in Ghana (7.0 t ha^{-1} yr^{-1}) were slightly less than the average FB yield for West Africa (8.2 t ha^{-1} yr^{-1}), and small compared with FB yields achieved in Southeast Asia (15.9 t ha^{-1} yr^{-1}) and Latin America (12.9 t ha^{-1} yr^{-1}) (FAO, 2017). Whilst several authors have attempted to quantify and explain yield gaps in oil palm (e.g., Corley and Tinker, 2016; Euler et al., 2016; Hoffmann et al., 2017; Woittiez et al., 2017), most have focused on production systems in Southeast Asia. Despite the pressing need to increase palm oil production, knowledge of the underlying causes of poor yields in Ghana is lacking. By closing yield gaps in existing plantings in smallholdings and plantations, palm oil production could be increased without area expansion thus sparing land for other uses.

We analysed yield gaps in oil palm production systems in Ghana due to genetic, environmental (climate and soil), and agronomic management factors. Such analysis helps to identify opportunities and entry points for yield intensification. Recently, Euler et al. (2016) and Hoffmann et al. (2014, 2017) applied the crop simulation model PALMSIM to determine oil palm yield gaps in Southeast Asian production systems. However, without further development, the PALMSIM model is not applicable to regions such as Ghana where rainfall deficit regularly limits crop growth and yield. The size of yield gaps can be estimated by measuring the time-lagged effect of implementing best management practices (BMPs) that effectively eliminate constraints due to poor agronomic management (Fairhurst and Griffiths, 2014). In this context, we define BMPs as agronomic methods and techniques found to be the most cost-effective and practical means to reduce the gap between actual and maximum economic yield and minimize the impact of the production system on the environment by using external inputs and production resources efficiently (Donough et al., 2009).

The BMP approach also provides the means to estimate maximum economic yield (Ymey) in a particular field and to quantify yield gaps caused by crop losses (Yield Gap 4) and agronomic management (Yield Gap 3) (Fig. 2; Fairhurst and Griffiths, 2014). Yield gap analysis can therefore be used to indicate the aspects of plantation management with the greatest potential for yield improvement. The specific objectives of this study were to: (i) describe the various oil palm production systems in Ghana and their current levels of productivity, (ii) estimate yield gaps on oil palm plantations and smallholder farms, and (iii) assess the underlying causes of yield gaps and identify remedial measures.

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