Identification and elimination of yield gaps in oil palm plantations in Indonesia

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Introduction

Worldwide demand for vegetable oil is expected to increase from the present 120 M t to 240 M t by 2050, driven by per capita income increases coupled with population growth, particularly in the rapidly growing economies of India and China (Corley, 2009). Palm oil now accounts for about 30% of global vegetable oil production and almost 60% of global vegetable oil exports (Carter et al., 2007). An additional 12 M ha of oil palms will be required to meet future demand given current trends (Corley, 2009).

Over the past thirty years, crude palm oil production in Indonesia has increased from 0.7 M t in 1980 to almost 17 M t in 2008 and now contributes more than 40% of world production (FAO, 2010). Increased production is explained almost entirely by area expansion (11.7% increase per year) because, during this period, oil yields have stagnated or even decreased in Indonesia despite genetic improvements in planting material (Corley and Tinker, 2003). There is much concern over environmental impacts where area expansion of oil palm has contributed to forest destruction and loss of biodiversity (Fitzherbert *et al.*, 2008). Oil palm is an efficient crop in terms of input utilization (de Vries *et al.*, 2010) mainly because it produces about eight times more oil per hectare than other vegetable oil crops (Basiron, 2007). Yield intensification and area expansion on so-called degraded land can reduce pressure on Indonesia's remaining forest reserves (Fairhurst and McLaughlin, 2009; Tisdell and Nantha, 2008). Here we describe techniques to quantify and eliminate yield gaps for yield intensification in mature oil palm plantations in Indonesia.

Evans and Fischer (1999) define yield potential (YP) as the yield of a cultivar grown in environments to which it is adapted without agronomic constraints. The YP for commercial oil palm over a production cycle of 25 years (including an immature period of two years) is at least 26 t ha^{-1} fruit bunches (or 6.5 t ha^{-1} vegetable oil) per year. Such yields have been obtained in areas of Indonesia and Malaysia with good management where soil and climate conditions are favourable. Unlike annual crops, yield responses to improved management in oil palm take a long time because the interval between the initiation of a flower and the production of a ripe bunch is about 40 months.

Methods

Our approach to eliminating yield gaps involves a three-step process. First, the economic opportunity for production improvement in a particular plantation is assessed using best *estimates* of YP based on yields obtained in optimal nutrient treatments in well-managed fertilizer trials on corresponding soil types under similar climatic conditions. Yield gaps for each field of ±30 ha are calculated by comparing actual yields with YP based on yield profiles estimated for each soil type. Yield gaps are then aggregated to estimate the economic opportunity for production improvement for all fields in the plantation. Size of yield and production gaps are calculated for each soil type and palm age group to provide spatial information on the opportunity for yield improvement. Second, a pilot phase is set up where paired blocks similar in present yield, soil type, planting material, agronomic conditions are selected in five management units each of 1,000-1,500 ha at each plantation site. In the higher yielding of the two blocks management and agronomic practices are continued according to standard estate practices. Best management practices (BMP) are introduced in the lower yielding block of each pair. An inventory of limiting factors is prepared for both fields, including less than optimal management and soil properties. Corrective action is taken only in the BMP block where management ensures complete crop recovery by careful and rigorous supervision and a short interval of seven days between harvests. Once complete crop recovery is achieved, management focuses on timely and accurate fertilizer application, implementing correct standards for leaf canopy (pruning, frond retention) and ground cover (weed and woody plant growth control), and soil conservation measures are installed as required. In the second year, fertilizer application rates may be adjusted in the BMP block if deficiencies are detected by leaf analysis and visual inspection. Monthly yield component data as well as labour and input use data are collected and stored for each pair of fields. Third, the cost-benefit ratio of implementing best management practices is determined. If yield improvement provides a

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satisfactory economic return, the improved practices are scaled up and implemented in the respective plantation management unit of 1,000-1,500 ha. This approach was implemented in six plantation sites across Sumatra and Kalimantan starting in 2006 and is ongoing.

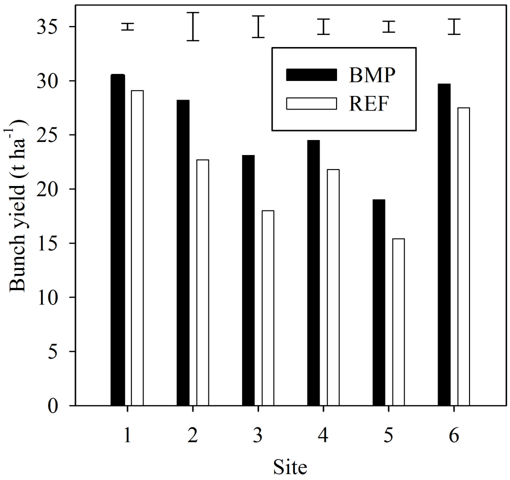

Figure 1 Fruit bunch yields in BMP and reference (REF) treatments at six sites in Sumatra and Kalimantan, Indonesia. Bars represent standard error of means for each site, *n*=5).

Results and discussion

Fruit bunch yields were greater in BMP compared with REF blocks at all six sites (P<0.05). At Site 1 the yield increase was small because yields are already close to YP for the respective age of planting. In the five other sites, yields were increased in BMP blocks by 2.2 to 5.5 t ha^{-1} fruit bunches (8-28%) and the average increase over all sites was 3.4 t ha^{-1} (15%). Yield increases were mainly due to increased bunch number because of improved crop recovery, increased female-male sex ratio and reduced flower and bunch abortion as a result of improved agronomic practices.

Conclusions

The pilot phase showed that yields had already reached YP in Site 1 but there was much scope for economic yield improvement in the other five sites. Average yields across all sites were increased to almost 26 t ha^{-1} - 50% greater than the present average yield in Indonesia of 17 t ha^{-1}. Such an improvement over Indonesia's 5 M ha of oil palm would be equivalent to the production from 2.6 M ha at current yield levels. In addition to reducing requirements for area expansion, yield intensification increases economic returns (Donough et al., 2010). Efforts to improve the yield of oil palm by breeding need to be matched with improved standards of agronomic management to exploit the full potential of new planting materials in Indonesia's rapidly expanding oil palm industry.

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