Oil Palm Best Management Practices in Ghana

Mid Term Report

IPNI
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Acknowledgements

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Summary

The oil palm sector in Ghana is developing extensively, yet average yields at oil palm plantations and smallholder farms are very low. Lagging behind major producing countries in Southeast Asia and Latin America, oil palm plantations and smallholder farmers in Ghana have limited experiences and knowledge in intensifying yields through improved agronomic practices, including fertilizer management.

Availability of suitable land to cultivate oil palm is becoming increasingly scarce in Ghana and yield intensification on existing plantations and smallholder farms, through improved management practices, offer the best opportunities to increase production. By understanding and identifying the causes behind low productivity, management practices that are most effective at improving productivity can be evaluated and adapted accordingly.

The International Plant Nutrition Institute in partnership with Solidaridad West Africa and oil palm plantations established the Best Management Practice (BMP) project in 2012 with the overall goal to support plantations and smallholder farms to increase oil palm yields and profits by improving agronomic management. Between 2013 and 2015, the project has demonstrated substantial yield increases with introduction of BMPs and supported knowledge dissemination through training activities and development of BMP knowledge products.

The BMP Challenge

Overview of the oil palm sector in Ghana

i. The oil palm sector in Ghana is developing extensively, with current demand for palm oil and derived products much larger than the country can supply.
  - Present production is estimated at 244,000 t crude palm oil (CPO), with an annual shortfall of 35,000 t.
  - If current production is not increased, the supply gap in Ghana is expected to increase to 127,000 t by 2024.

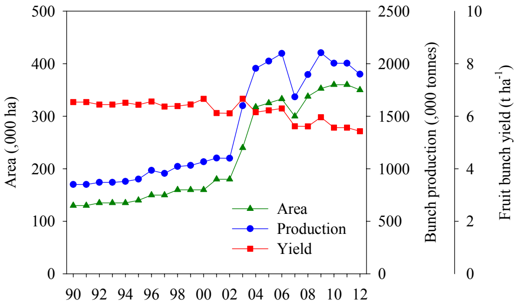

Figure 1. Total fruit bunch production in Ghana increased by 123%, from 850,000 tonnes in 1990 to 1,900,000 tonnes in 2012. The increase is largely due to the expansion in the area under production, particularly of small-scale oil palm farming. Over the same period, average bunch yields decreased from 6.5 t ha-1 in 1990 to 5.4 to ha-1 in 2012.

ii. The total area under oil palm cultivation in Ghana is estimated at 330,000 ha. This is about 1.5% of the total land area in Ghana.
  - Oil palm plantations occupy about 7% of the area under cultivation, and account for 20% of fruit bunch production.
  - The remaining 93% of the area under cultivation is occupied with independent smallholder farms, which produce 80% of the total output.
  - Smallholder farms represent the 'bulk' of the oil palm industry in Ghana.

iii. Fresh fruit bunch (FFB) yields in Ghana are very low.
  - In Ghana, the average FFB yield is only 5.4 t ha-1.
    a) Particularly smallholder farms have low yields, averaging 3 t FFB ha-1. This is about 30% of the yields obtained in oil palm plantations (10 t ha-1).
  - With potentially attainable yields of 25 t ha-1 in the most suitable growing areas in Ghana, current yield gaps are large.

- In contrast, FFB yields in the major producing countries in Southeast Asia and Latin America are 18.5–19.0 t ha-1 (Figure 2).

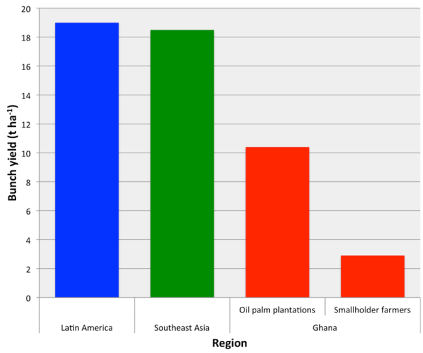

Figure 2. Bunch yields in Ghana compared with SE Asia and Latin America.

Why is fruit bunch production low in Ghana?

i. Smaller fruit bunch yields in Ghana are partly explained by a sub-optimal climate, low soil fertility, poor planting material, and poor (field) management.

ii. The most suitable climate and soils therefore restrict economic oil palm production to the rain forest and semi-deciduous forest zones in southern Ghana, also known as the 'oil-palm belt' (Figure 3).

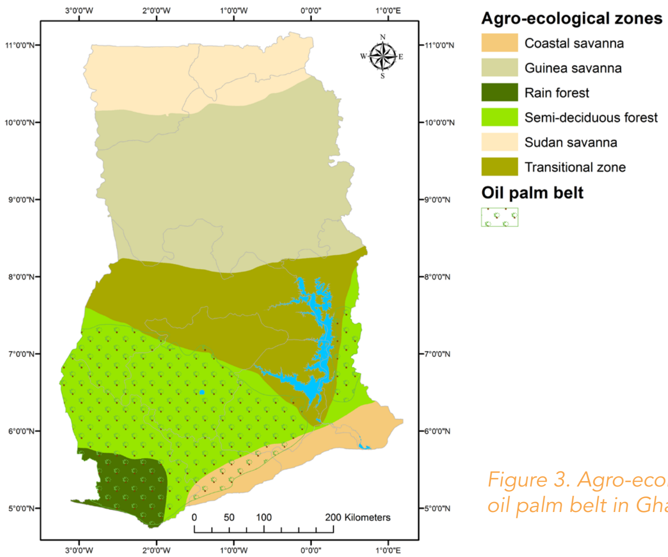

Figure 3. Agro-ecological zones and the oil palm belt in Ghana.

Suboptimal climate

Rainfall in the oil palm belt of Ghana is distributed bimodally (Figure 4):

- Long rains are from March–July and short rains September–November, separated by a short dry spell in August.
- December–February is the dry season with less than 50 mm rainfall in January and less than 100 mm in both December and February.
- The main period of water deficit occurs between November and March, typically coinciding with a period with high insolation. Water stress during this period is considered to be the main yield-determining factor in Ghana, with annual water deficits up to 600 mm $year^{-1}$.

Figure 4. Rainfall distribution and water deficits at two production sites in Ghana.

- Each 100 mm increase of water deficit reduces fruit bunch yields by 10–15% (Figure 5). The reduction can be as much as 40–50% if the palms experienced severe water stress in the year before as well.

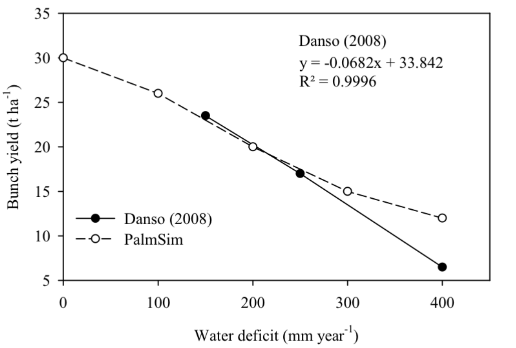

Figure 5. Relationship between water deficits and bunch yield at three trial sites (Danso et al., 2008), and bunch yield simulated by the PalmSim model (Hoffmann et al., 2014).

Poor soils

The soils in the oil palm belt of Ghana include Ferralsols and Acrisols. These soils generally have a good physical structure, but have a low inherent fertility (Table 1):

- Soil analysis for three oil palm plantations and twenty smallholder farms participating in the BMP project in Ghana indicate very low levels of soil organic matter and low N supply potential.
- The soil pH at oil palm plantations is very low.
- In smallholder farms, the amount of available P and soil exchangeable K is extremely deficient.
- These low soil chemical properties indicate that current fertilizer and crop residue management practices are suboptimal.

			pH						Exchangable Cations			
Sector	Zone	Depth	Water	KCl	C	N	C/N	(Bray 1)	K	Mg	CA	*n*
		cm	-	-	%	%	-	mg kg^{1}		cmol (+) kg^{1}		
Oil palm plantations	Circle	0-20 cm	4.4	3.8	1.3	0.12	11	83	0.44	0.44	1.6	21
		0-40 cm	4.5	3.9	1.1	0.10	11	40	0.33	0.44	1.6	21
	Interrow	0-20 cm	4.9	4.1	1.4	0.13	11	14	0.21	0.78	2.4	18
		20-40 cm	4.8	4.1	1.1	0.10	11	11	0.19	0.69	1.9	26
Average			4.7	4.0	1.2	0.11	11	37	0.29	0.59	1.9	86
Smallholder farms	Circle	0-20 cm	5.2	4.4	1.4	0.13	11	9	0.12	0.87	2.9	14
		20-40 cm	5.4	4.4	1.0	0.10	11	5	0.11	0.78	3.3	14
	Interrow	0-20 cm	5.2	4.4	1.6	0.15	11	5	0.15	1.01	3.1	14
		20-40 cm	5.1	4.4	1.2	0.11	11	4	0.12	0.81	3.0	14
Average		5.2	4.4	1.3	0.12	11	11	6	0.13	0.86	3.1	54

Table 1. Soil chemical properties at oil palm plantations and smallholder farms participating in the BMP project in Ghana.

Poor management practices

The most common deficiencies in management causing low yields in Ghana include:

- Insufficient in-field access (lack of weeded circles, paths and over/under pruning), and poor crop recovery (Figure 6A).
- Poor canopy maintenance (insufficient frond removal at harvest, insufficient pruning) (Figure 6B).
- Poor supply planting, or infilling during the immature stage (Figure 6C).
- Lack of, or insufficient drainage in inland valley swamps (Figure 6D).
- Presence of dense woody undergrowth that competes with palms for nutrients and water (Figure 6E).
- Poor nutrient management, including the failure to diagnose correctly the nutrient requirements of oil palm, as well as the failure to implement fertilizer and crop residues adequately (Figure 6F).

Figure 6. Common management deficiencies in oil palm farming.

The BMP Solution

The need to improve oil palm production in Ghana

1. The oil palm sector in Ghana is developing extensively, partly due to a growing interest of investors to expand and develop the area planted to oil palm. However, land that is suitable for oil palm production, i.e., land that meets the ecological requirements for oil palm, is limited and fragmented.

2. The need to find alternative ways to increase oil palm production in Ghana therefore becomes a necessity.

   Yield intensification on land already planted to oil palm may therefore be an important aspect in developing policy on sustainable oil palm development in Ghana:

   - 'Yield Gap Analysis (YGA)' offers scope to identify entry points in improving yields (Figure 7).
   - YGA provides a systematic process to assess opportunities in increasing yields.
   - Adapting 'Best Management Practices (BMPs)' to local conditions provides a basis for identifying and correcting management practices that underlie yield gaps.

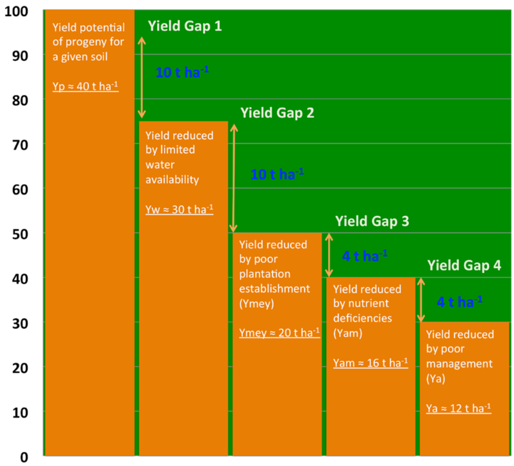

Figure 7. Yield Gap Analysis (YGA) partitions yield gaps between different causes, such as environment or management. When analyzing yield gaps in Ghana, water-limited yield is the most relevant benchmark because of the sub-optimal climate.

Improving oil palm yields in Ghana with Best Management Practices (BMPs)

Increasing plantation and smallholder yields with 'Best Management Practices (BMP)' is put forth as a strategy to systematically close yield gaps in Ghana.

In oil palm, BMPs are defined as the most cost-effective and practical agronomic methods to improve fruit bunch production. BMP operations are split in two components:

- Yield taking focuses on achieving full crop recovery by improving access for harvesting and appropriate scheduling of harvest intervals.
- Yield making refers to all operations that contribute to building large and sustainable yields, such as soil-, water-, canopy- and nutrient management.

By identifying which yield gaps contribute most to yield losses at a particular site, BMPs can be adapted and applied accordingly.

Effective use of BMPs not only benefits palm growth and productivity, but also soil-, water-, and nutrient conservation.

The BMP Framework

Introducing BMPs in Ghana

In 2012, IPNI Sub-Saharan Africa and Solidaridad's Sustainable West Africa Palm oil Programme (SWAPP) initiated a BMP project to improve oil palm yields in Ghana. The project was initiated in collaboration with three plantations located in Western- and Central Region, and twenty smallholder farms across the oil palm belt (Figure 8).

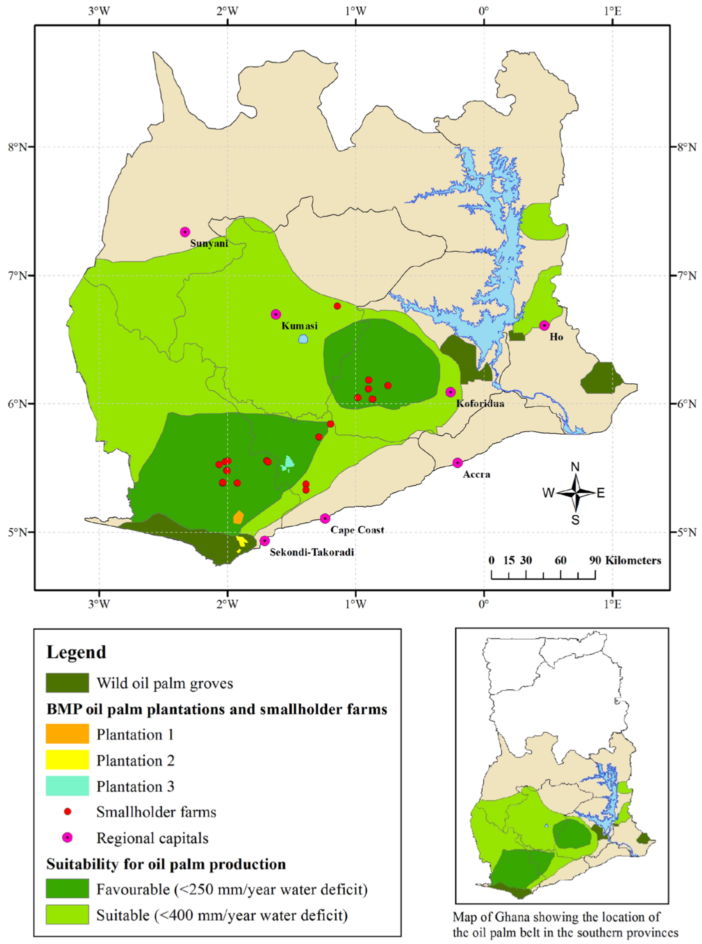

Figure 8. Location of oil palm plantations and smallholder farms.

The goal of the BMP project is to improve yields by identifying and then correct management practices that account for the yield gaps, by applying the concept of YGA.
Because of the time lag between the implementation of BMPs and their effect on yield, all BMP plots are expected to reach their maximum yield potential by 2016. Fruit bunch yields will be monitored from 2012 to 2016 to obtain accurate data on the maximum achievable yield at all sites.

The experimental design

At each participating plantation and smallholder farm, pairs of experimental plots are selected:

- Each paired plot is similar in terms of planting material, soil type and palm age.
- In one plot, in-field BMPs are tested, while the other plot serves as a control/ reference (REF) treatment maintaining current management practices.
- In plantations, each plot is a commercial plantation block (>20 ha) whilst in smallholder farms, BMP and REF plots are approximately 1 ha (Figure 9).
- All plots are mature oil palm stands, expect at plantations, which also include immature experimental plots.

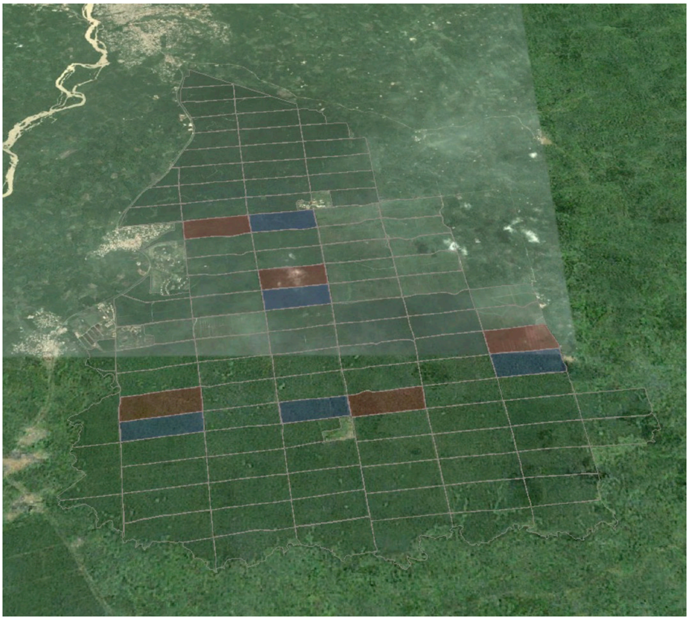

Figure 9. BMP (blue) and REF (red) blocks at an oil palm plantation.

Applying BMPs in experimental plots

Yield gap analysis and yield intensification is a ***data-driven process***. A large amount of data for each site and plot is therefore collected, before drawing up any BMP recommendations.

Data collected include:

- Yield and harvesting data to assess harvest intervals, crop recovery, harvester productivity, and yield performance,
- Soil- and leaf nutrient data, to analyze nutritional deficiencies and soil fertility constraints, and to develop corrective site-specific fertilizer programs,
- Amount of applied fertilizers and crop residues,
- Vegetative growth measurements, including palm height and petiole cross section (PCS), amongst others,
- Palm census data to assess initial and current palm density, and potential yield loss due to incomplete palm stands,
- Climate data, including rainfall and rain days.

Furthermore, field audits (Figure 10) are regularly performed to identify all agronomic constraints that explain yield gaps. Examples include:

- Poor pruning; over-, or under pruning,
- Poor in-field access due to the lack of harvesting paths, and/or, excessive woody growth,
- Insufficient drainage outlets and field drains in enclosed low-lying areas,
- Incomplete crop recovery and loose fruit collection.

Based upon the data and field audit results, a portfolio of BMPs are then developed for each individual plot (referred to as site-specific BMPs, or SS-BMPs).

One of the key aspects of yield intensification is improving palm nutrition, through the application of fertilizers and crop residues:

- Plantations typically apply moderate amounts of mineral fertilizer (typically 5–8 kg palm-1 NPK compound fertilizer such as 10-10-30) and recycle crop residues.
- Most smallholder farmers apply little if any mineral fertilizer and do not recycle crop residues.

Based upon the leaf nutrient analysis results, fertilizer programs are developed:

- Fertilizer doses are based on the leaf nutrient levels and compared to standard leaf critical levels derived from fertilizer trials to determine the application rates.
    - o If the leaf nutrient levels fall below the leaf critical levels, then a maximum fertilizer dose is applied.
    - o If the leaf nutrient levels are higher or equal to the leaf critical levels, then a maintenance fertilizer dose is applied.

- For oil palm plantations, a combination of different fertilizer sources is recommended, including Urea, Triple Superphosphate (TSP), Potassium Chloride (KCL), Kieserite, and Borate. Total applications range from 8.0 to 10.0 kg palm-1, depending on the nutritional status of the block.
- For smallholder farms, a baseline application of NPK 10–10–30 is recommended. Additional straight applications of Urea, TSP, KCL and Borate are applied to correct extreme deficiencies. Depending on the farmer's resources, total applications range from 6.0 to 9.0 kg palm-1.
- Where applicable, crop residues are applied to each BMP plot. This includes pruned fronds, which are aligned in a 'box' pattern around the palm, and the application of empty fruit bunches (EFB) at 40 t ha-1.
    - o Smallholder farmers generally do not have access to the crop residues derived from fruit bunches sold to plantation mills because empty bunches are usually recycled by plantation-owned mills to their own plantings.

Figure 10. Field audit in progress.

BMP implementation is largely a trial-and-evaluation process in which a set of agronomic practices is identified and assessed, until the most desirable combination of BMPs for a particular site is developed. This is done in collaboration and full participation of the farmers, and plantation managers and field staff to facilitate knowledge transfer.

The effectiveness of BMPs is expressed as the yield increase compared to the REF plot. However, sustainable improvement of the production system, such as increasing soil fertility and crop nutrition is equally important.

BMP Results

Key results

- After the first 12 months of BMP implementation, yields in BMP blocks at oil palm plantations increased from 7.2 t ha^{-1} (REF) to 8.4 t ha^{-1} (+ 1.2 t ha^{-1}, +17%).
    - o In the second year yields increased further, from 11.6 t ha^{-1} (REF) to 14.1 t ha^{-1} (+2.5 t ha^{-1}, +22%).
- At smallholder farms, yields increased from 5.1 t ha-^{1} (REF) to 6.9 t ha^{-1} (+ 1.7 t ha^{-1}, +35%).

o In the second year, yields increased from 8.3 t ha-1 (REF) to 12.6 t ha-1 (+4.4 t ha^{-1}, +52%).

- Yield gaps (Yw-Ya) are larger in smallholder farms, compared to oil palm plantations (Figure 11).

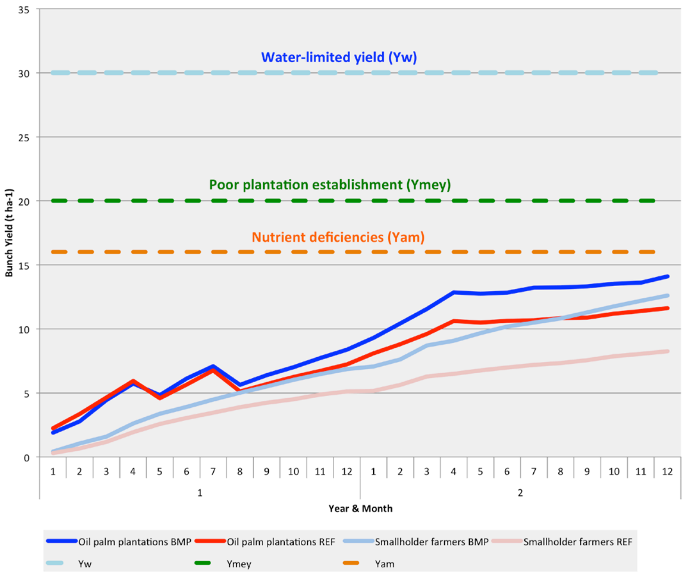

Figure 11. The yield for BMP plots on plantation and smallholder farms compared with the reference plots

- Smallholder farms had a larger increase in yield with BMP than oil palm plantations. This is because of the very poor state and the initial lower productivity of smallholder farms in Ghana, compared to oil palm plantations (Figure 12).

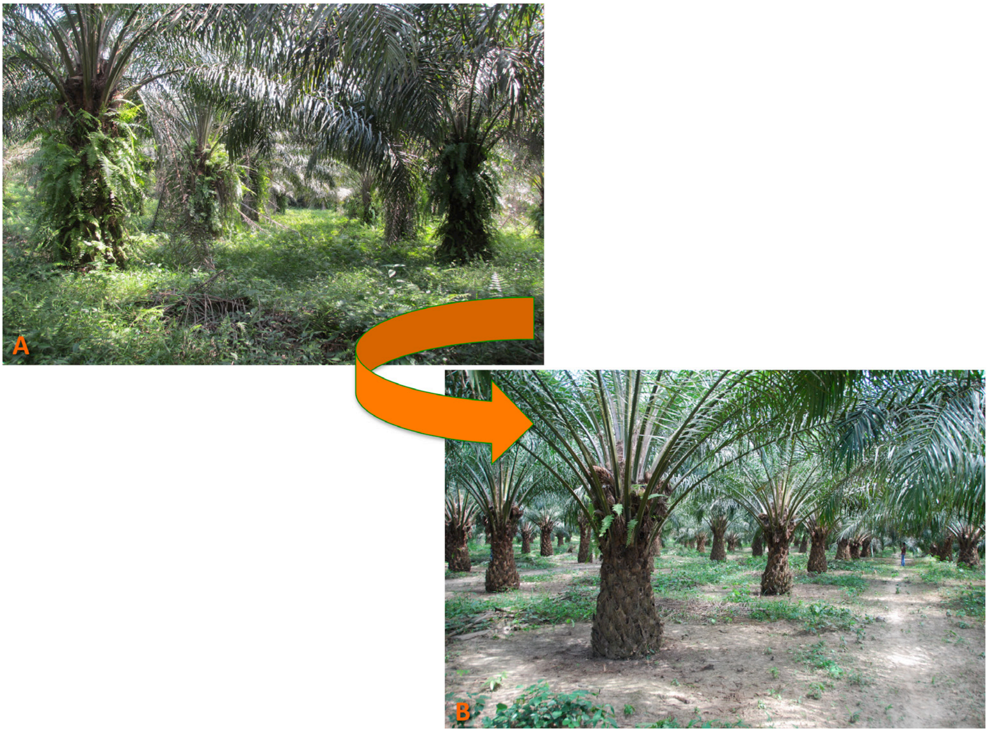

Figure 12. Before (A) and After (B) rehabilitating a smallholder farm.

- The short-term yield response with BMP is explained by yield taking operations including:
    - o Shorter harvest intervals, and,
    - o Complete crop recovery after the installation of proper access (weeded circles an paths, pruning) in BMP fields.
- Improved crop recovery resulted in a greater number of bunches and larger average bunch weight, mainly due to complete collection of loose fruit.

BMP Conclusions

The success of BMP

Best Management Practices were successfully adapted in oil palm plantations and smallholder farmers in Ghana:

- The results show a large potential to increase yields, particularly in smallholder fields, simply by improving crop recovery.
- The basic requirements to achieve full crop recovery are:
  - The installation of proper access:
    - Clean, and accessible weeded circles and harvest paths,
    - Pruning; removal of surplus (i.e. old, dead, damaged, or diseased) fronds.
  - Tight control of harvesting intervals, particularly during the peak crop months.
- Soil and leaf analysis data showed that there are significant nutritional constraints, particularly in smallholder farms, that must be addressed to close the yield gap caused by poor nutrient management:
  - For each plot, yield-making activities, such as site-specific fertilizer programs and crop residue application, have been implemented to improve soil fertility and leaf nutrient status.
  - Because of the time-lagged yield response in oil palm, the impact of yield making is too early to assess.
- Further improvements expected to increase yields in BMP plots include:
  - Replacement of woody growth in palm inter rows,
  - Drainage in low-lying areas using excavators equipped with 'V' buckets (Figure 13),
  - Removal of unproductive palms,
  - Supply planting/infilling in plots with a lot of vacant areas.
- It is expected that the combined effect of yield taking and yield making (nutrient management) will increase BMP yields even more by the end of 2015.

Figure 13. 'V' Shaped drain at BOPP.

BMP impact

BMP plots established at plantations and smallholder farms not only prove the success of yield intensification, but also serve as learning centers for plantation staff and smallholder farmers (Figure 13). The main objectives of these 'learning centers' are to:

- Enable the transfer of successful methods and techniques to improve yields, and,
- Generate knowledge by training plantation staff and smallholder farmers to strengthen their capacity in identifying production constraints and implementing BMP practices.

Figure 14. Training smallholder farmers.

Closing yield gaps in Ghana's plantations and smallholders could lead to greatly increased profitability for investors and farmers alike and make a significant contribution to closing the gap between the supply and demand for palm oil in Ghana.

Table 2 shows the potential benefits of BMPs at macro-level, assuming moderate impact and equal costs to standard estate/smallholder practices.

Table 2. Potential Economic benefits of adapting BMP practices.

Sector	Current area ha	Current production t ha^{-1}	Economic value* US$ yr-1	Potential yield increase with BMP %	Economic value with BMP US$ yr-1
Oil palm plantations	29,700	10.4	68 M	35	92 M
Smallholder farms	300,300	2.9	192 M	52	291 M

**Assuming an Oil Extraction Rate (OER) of 22% and a Crude Palm Oil (CPO) price of US$1000 t CPO-1*

Further research

Two of the main causes for low yields in oil palm in Ghana include poor water availability, and low fertilizer use, causing yield gaps of an estimated 10 t ha-1 and 4 t ha-1 (Figure 7). The need for further research into these yield-limiting factors is therefore essential for yield improvement in Ghana.

In mid-2014 and early 2015, several experiments including a fertilizer-, irrigation-, and soil moisture trial were established (Figure 15).

The goal of these experiments is to generate new agronomic knowledge on the interaction of water and nutrients on bunch production in a West African context.

Results of the trials will greatly benefit oil palm plantations and smallholder farmers by identifying and then correcting management practices that account for yield gaps caused by nutrient- and water constraints.

Figure 15. Investigating the role nutrients and water on bunch production in Ghana.

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