POCKET GUIDE
INDONESIAN OIL PALM SMALLHOLDERS

PUSAT PENELITIAN KELAPA SAWIT
Indonesian Oil Palm Research Institute
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EXTENSION

POCKET GUIDE BOOK
INDONESIAN OIL PALM SMALLHOLDERS

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University of Nebraska-Lincoln (UNL) and the Indonesian Oil Palm Research Institute (Pusat Penelitian Kelapa Sawit, PPKS) lead a major initiative focusing on sustainable intensification on existing oil palm fields managed by independent smallholders in Indonesia. The initiative also includes partners from the Indonesian Agency for Agricultural Research & Development (IAARD) that currently known as National Research and Innovation Agency (BRIN), local non-governmental organizations (NGO), and Wageningen University (WUR).

Results from the project are impressive and point to the tremendous potential for increased yields on existing oil palm areas. Smallholder farmers in pilot study sites are achieving less than half of the attainable yield that could be achieved with proper agronomic practices. This represents an opportunity for smallholder farmers and for Indonesia to produce more palm oil on existing plantation area and, more important, to increase their income. This pocket guide explains WHAT can farmers do NOW on their existing plantations to increase both yield and profit.

UNL and PPKS researchers are glad to provide, within this pocket guide, simple and concrete information about best management practices (BMPs) for smallholder oil palm plantations. The pocket guide includes recommendations for: better plant nutrition; improved weed and pest control; better pruning and frond arrangement; and improved harvest methods. The information is based on best available research and the expertise from PPKS and UNL researchers.

This pocket guide will help oil palm smallholders across the archipelago to adopt the proper BMPs for their fields and to increase their yield and bottom-line profit.

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Table of contents

CHAPTER 1. BEST MANAGEMENT PRACTICES (BMP) FOR YIELD INTENSIFICATION

1.1 Introduction

This section of the Pocket Guide describes the key best management practices (BMPs) for smallholders to increase and maintain high level of their fresh fruit bunches (FFB) yield in fields where oil palm is already in production. These BMPs have been developed & evaluated by researchers over decades of field experiments. Below is a photo of a well-managed oil palm field with good BMP implementation.

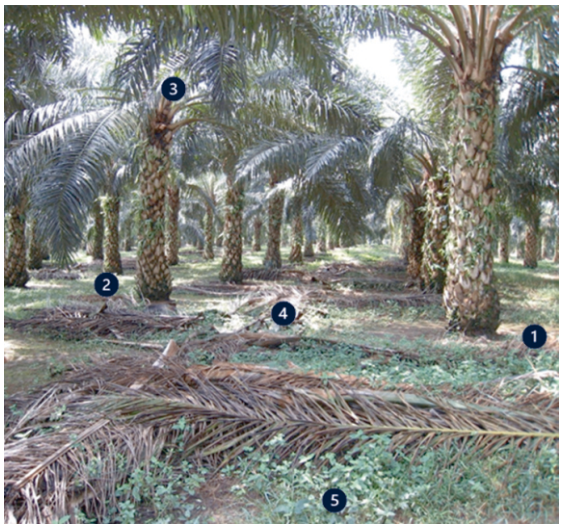


Photo 1.1 A field with best management practices (BMPs) including (1) clean circles, (2) clear paths, (3) well pruned palms, (4) pruned fronds stacked on 3 sides of the palms, and (5) adequate groundcover (Source: C. Donough).

1.2 Yield taking BMPs

Some BMPs are for 'Yield Taking' i.e., recovering the FFB already formed on the trees and ready for harvest. The impact of 'Yield Taking' BMPs can be almost immediate. These BMPs include:

1. Timely harvesting – high frequency harvest rotation to ensure high yield and low crop loss
2. Timely pruning – to avoid leaving too many fronds on the trees that will hinder harvesting
3. Maintaining clean palm circles – for easy collection of loose fruits
4. Maintaining good field accessibility – for easy movement & collection of harvested FFB.

1.3 Yield making BMPs

Other BMPs are for 'Yield Making' i.e., producing future FFB and sustaining high yield. The impact of 'Yield Making' BMPs need 2-3 years to be fully realized. These BMPs include:

1. Proper fertilizer management – so trees have enough nutrients for good growth and high yield

2. Proper pruning – to avoid removing too many fronds until too few are left to support yield
3. Proper spreading of pruned fronds – to protect the soil by keeping it moist & fertile
4. Proper management of weeds –
   a) Maintaining clean palm circles – where some fertilizers (urea, borate) may be applied
   b) Eradicating weeds outside the palm circles – to minimize competition with the palms, but
   c) Avoiding removal of all vegetation – to protect the soil outside of the palm circles
5. Proper management of pests and diseases – to minimize impacts on the health of the trees and loss of stand (decreased trees population).

1.4 Cost of BMP implementation

The cost of implementing BMPs depends on the existing condition of the field. The initial cost can be high if the field is in poor condition, and especially if the BMPs are implemented all at once.

Based on Global Yield Gap Atlas (GYGA) BMP field trials in Indonesia, the cost of BMP implementation is approx. IDR 5.5 million per ha. Breakdown of the BMP cost is given below:

- BMP harvesting (due to higher frequency and yield) — 35%
- BMP fertilizer application (material + application) — 55%
- BMP field upkeep (weeding, pruning, etc) — 10%

To lower the cost, BMPs can also be implemented in stages, but this means that the full impact will take longer to achieve. In such cases, it will be best to implement 'Yield Taking' BMPs first as their benefits come quickly.

Once BMPs are fully implemented, the cost to maintain most of them at a satisfactory standard will not be high, especially if a properly planned work routine is diligently followed. The main recurring costs that will remain higher (i.e., compared to the pre-BMP history of the field) are for:

- Fertilizer – to continuously give higher & balanced inputs to support higher yield with BMP, and
- Harvesting – to fully recover the higher yield with BMP.

CHAPTER 2.
BMP 1 - HARVESTING

"Objective of harvesting is to recover all available ripe bunches, and their loose fruits, from a field during the time it is visited for harvesting."

2.1 What is a ripe bunch?

A bunch is considered ripe when at least 1 fruit has detached from it i.e., there is at least 1 loose fruit fallen to the ground in the palm circle under the bunch. If a bunch is red but without any visible loose fruits, it is considered unripe, so should not be cut until the next round of harvesting.

Photo 2.1 Harvested bunches from a BMP field (Source: H. Sugianto).

2.2 What is the ideal frequency of harvesting?

More frequent harvesting i.e., shorter interval between successive harvesting occasions, will give higher FFB yield (Table 2.1).

Ideally, harvesting is done once every 10 days. The amount of FFB harvested each time may be less compared to harvesting once every 15 or 20 days, but in the longer term e.g., 1 month or 1 year, the total FFB yield obtained will be much higher.

2.3 Why is FFB yield higher with more frequent harvesting?

First, a ripe bunch, after it starts to shed loose fruits, can become rotten after 3 weeks. So, if harvest interval is 15-20 days, some bunches will become rotten before they can be harvested. The longer the interval, the more bunches will become rotten.

When the number of bunches is low e.g., during low crop season, the harvest interval can be up to 15 days because the potential loss of bunches is low. But the interval should not extend to 20 days or more.

Additionally, palm oil mills will impose penalties for over-ripe bunches, and old loose fruits, because oil in those bunches and fruits is of poorer quality.

Photo 2.2 Loose fruits left behind after harvesting (Source: C. Donough).

Second, when a bunch starts to shed loose fruits, the number of loose fruits increases quickly (Table 2.1). More loose fruits from longer harvest interval slows down harvesting work, and the risk of uncollected loose fruits becomes higher. All uncollected loose fruits are losses. And many of these uncollected loose fruits will later become volunteer oil palm seedlings that have to be eradicated – more effort (and cost) will be needed to do this.

Third, bunch weight also drops if the harvest interval is too long (Table 2.1) because number of loose fruits increase and they start to lose weight as they dry out after dropping off the bunch. So, even if all loose fruits are collected, there is still a loss of bunch weight.

Table 2.1 Harvest interval vs loose fruits & bunch weight.

Harvest Interval	7 days	10 days	15 days
Number of loose fruits per bunch	45	55	85
Number of loose fruits per ha	60,000	70,000	100,000
Average bunch weight (kg)	20	19	18.5

2.4 Suggested tools and equipment

1. Chisel (Photo 2.3A) – for trees with bunches just above head height ca. 3m (10 ft) above ground.
2. Sickle (Photo 2.3B) – for trees with bunches >3m above ground.
3. Spike (Photo 2.3C) or hook (Photo 2.3D) – for lifting or loading bunches.
4. Rake (Photo 2.3E) & basket (Photo 2.3F) – for collecting loose fruits.
5. Axe (Photo 2.3G) or machete (Photo 2.3H) – for trimming off the bunch stalk.
6. Wheelbarrow (Photo 2.3I) – for bringing harvested bunches and loose fruits to the collection point.

Photo 2.3 Harvesting tools and equipment.

2.5 Suggested work steps

Step 1 Check each tree in a field for the presence of ripe bunches.

Step 2 For ***short or young trees*** where harvesting is done using a chisel. Cut off the ripe bunch without removing the fronds below it. For ***tall or older trees*** where harvesting is done using a sickle. Cut off the ripe bunch and the fronds below it.

Step 3 Stack the cut fronds in the frond stacking area(s).

Step 4 Collect all loose fruits and put them near the cut bunch.

Step 5 Continue until all trees in the field are visited.

Step 6 Load all cut bunches and their loose fruits in a wheelbarrow and bring them out to the collection point in the field.

2.6 Extra steps - data recording

Step 7 At the collection point, count the total number of cut bunches and record the number and the harvesting date in your farm record book.

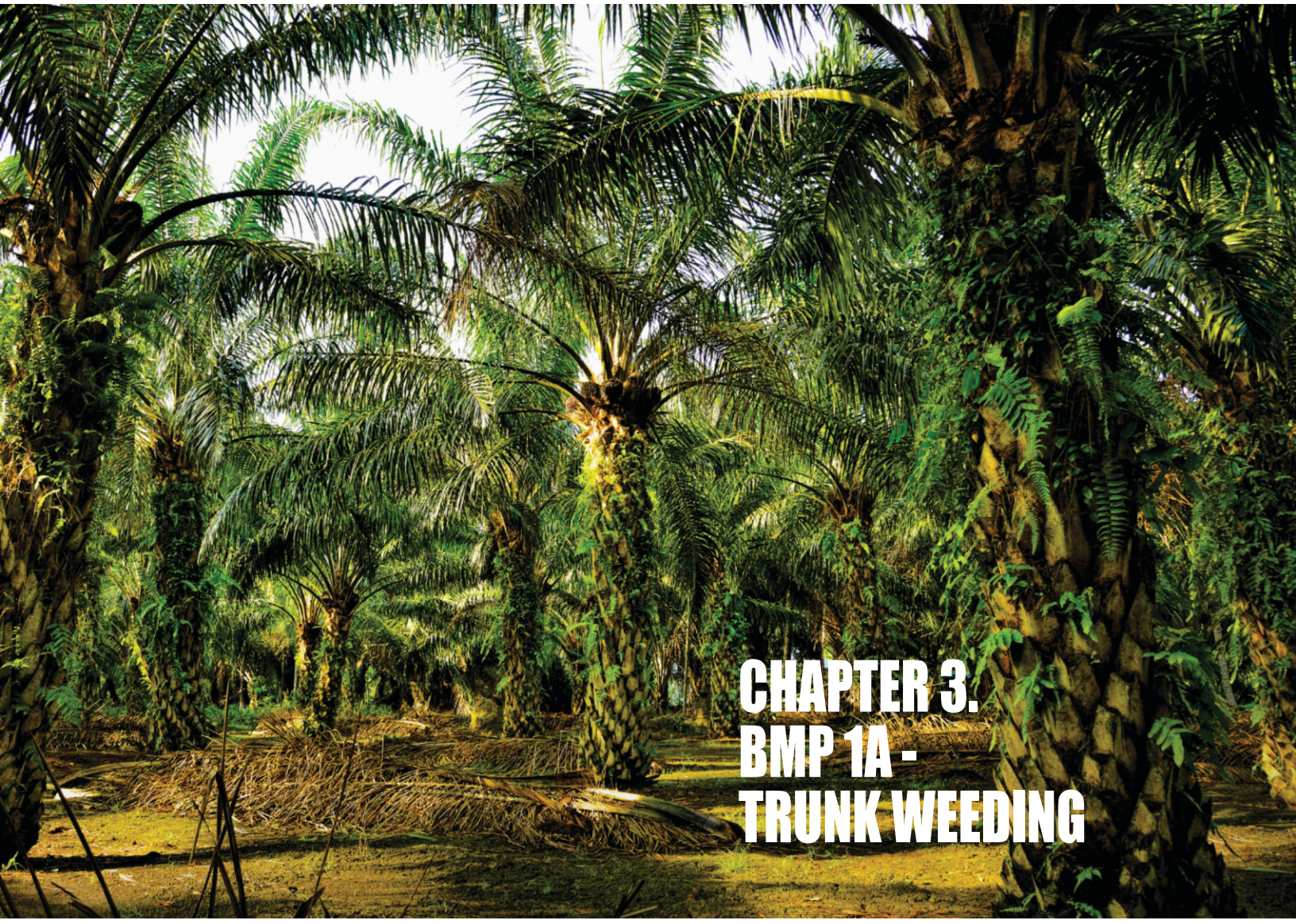
Step 8

a. If the bunches are collected by a collector, record the date of collection. If the collector weighed the bunches, record the total weight of bunches. Ideally, ask the collector to give you a note showing the total bunch weight and collection date.

b. If you deliver the bunches directly to the palm oil mill, keep the weighbridge ticket from the mill which shows the date and the weight of the bunches. Copy the weight into your farm record book later.

Value of data recording

These records of bunch numbers, total bunch weight, and dates of harvesting and collection, will be useful to monitor and show the productivity (and profitability) of your field / farm (see **Chapter 17 BMP #7 Record Keeping**).



CHAPTER 3. BMP 1A - TRUNK WEEDING

"Objective of trunk weeding is to remove certain plants that may grow in organic matter that was trapped in the pruned frond base on the palm tree trunk which may hinder harvesting if not eradicated."

Photo 3.1 Epiphytes on oil palm tree trunk (Source: I. Pradiko).

3.1 What kind of plants are not desirable on palm tree trunks?

1. Volunteer oil palm seedling – see Photo 3.1 (blue circle).
2. Fig (*Ficus* spp) plant – see Photo 3.2 a.
3. Ferns that can grow too big – bird's nest fern (see Photo 3.2 b) or stag horn fern (see Photo 3.2 c).

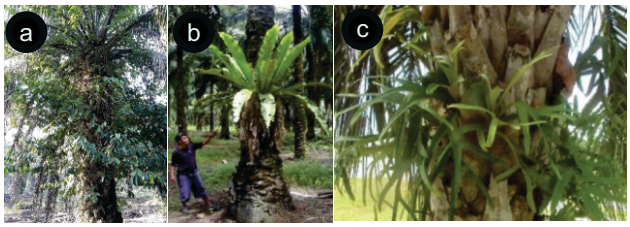


Photo 3.2 (a) Fig (*Ficus* spp),(b) Bird's nest fern, and (c) Stag horn fern (Source: (a) C. Donough; (b) Fayle, Turner & Foster (2013); (c) http://www.palmpedia.net/forum/threads/ferns-on-palm-trunks.1756/).

3.2 Small ferns are OK - if they do not obstruct harvesting

Small and soft ferns – for example, Davallia (see Photo 3.3 a), or Nephrolepis (see Photo 3.3 b) – can be left to grow. But if they become too thick and grow up to the level of the bunches until the harvester's view is block (see Photo 3.4 a), then they should be controlled.

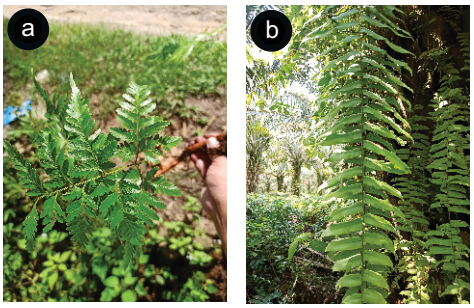


Photo 3.3 Small & soft ferns on palm tree trunk: (a) Davallia, (b) Nephrolepis (Source: I. Pradiko).

3.3 Plants on the tree trunk should not block harvesting

A clear area at the top of the trunk (at least 30 cm downwards from just below the lowest fronds – see Photo 3.4 b) should be kept free of plants – so that any ripe bunches can be seen by the harvester.

Photo 3.4 (a) Bunches blocked by epiphytes;
(b) Bunches visible above epiphytes (Source: C. Donough).

3.4 Do not leave long frond bases when fronds are cut

During pruning or when cutting fronds during harvesting, the fronds should be cut as close to the trunk as possible, so that less debris (including loose fruits) will be trapped in the remaining frond bases (see Photo 3.5). All the trapped debris will allow plants to grow.

Photo 3.5 Leaf bases too long (not cut close enough to the trunk)
(Source: C. Donough).

3.5 How to do trunk weeding?

1. Manual removal – this is possible when the palm trees are still young and the plants on the trunk can still be reached when standing on the ground or using a short ladder; if the plants are out of reach, they can also be removed by hitting with a bamboo stick.
2. Pruning using a sickle – for taller trees, light ferns - for example, Davallia (Photo 3.3 a) can be pruned using a harvesting sickle.
3. Control with herbicide – Fig plants may be hard to remove manually, and if removal is incomplete it can regrow. So, a suitable herbicide can be used to ensure the plant is killed, which can then be removed.
   Triclopyr mixed with diesel can be used for this,

   - The rate of application depends on the product (there are different brands & concentrations) – consult the product supplier or an expert for advice.
   - The chemical mixture is applied by brushing on the stem(s) of the fig plant(s).

CHAPTER 4.
BMP 2 - PRUNING

Objective #1 of pruning is to maintain the number of green fronds in an optimum range.

Objective #2 of pruning is to minimize the obstruction to reach ripe bunch(es) that are available for harvesting, especially for tall trees. Under-pruning of the trees: –

a. Will make the harvesting more inefficient, i.e. work will be slower, if too many fronds have to be cut before reaching the ripe bunch(es), and
b. The harvester's sight of the available ripe bunch(es) may be blocked by the excessive number of fronds, and loose fruits from ripe bunches may be trapped by the fronds which can be missed during harvesting.

Objective #3 of pruning is to ensure that the fronds are cut as close as possible to the trunk (see Photo 4.1), so that loose fruits do not get trapped in between the pruned frond bases.

Photo 4.1 Fronds pruned close to the trunk (Source: https://www.vecteezy.com/photo/1355499-pruning-leaf-of-oil-palm).

4.1 Why is it important to have an optimum number of green fronds?

The green fronds capture 'energy' from sunlight. The energy is used to convert carbon dioxide (from air), water (from soil and rain), and nutrients (from soil and fertilizers) into materials (carbohydrates, proteins, etc) that the trees need to produce roots, trunk, fronds, male inflorescences, and female inflorescences that will develop into bunches.

- If the tree has too few green fronds, it will not grow at optimal rate and produce high yield.
- If the tree has too many fronds, it will make harvesting more difficult.
- And excessive lower fronds are shaded from direct sunlight so they will not contribute to productivity.

4.2 What is the optimum number of green fronds?

For young mature trees (≤8 years), it is best to maintain 48-56 green fronds per tree. A simple guide is to leave 3 fronds below the last bunch. If there are no suitable bunches to give guidance, then leave 6-7 fronds per spiral (a palm tree has 8 spirals).

For older trees (>8 years), the number of fronds that should be maintained is 32-48 (= 2 fronds below the last bunch), or 4-6 fronds per spiral.

Table 4.1 Pruning targets for oil palm (Source: UNL Technical flyer: Pruning and frond management).

Tree age	Target no. of fronds		
	Per Tree	Per Spiral@	Below bunch#
≤ 8 year	48-56	6-7	3
> 8 year	32-48	4-6	2

@ each tree has 8 spirals
# the last ripening bunch

4.3 What happens if the optimum number of green fronds is not achieved?

1. Over-pruning should be avoided (see Photo 4.2 c) – FFB yield can be reduced if the number of green fronds per tree falls below 32.

2. Under-pruning (see Photo 4.2 b) is also not good, especially for tall trees – FFB yield will be reduced because the excessive fronds can increase harvesting losses (see reasons below).

Photo 4.2 (a) Adequately pruned, (b) under-pruned, (c) over-pruned (Source: (a) & (b) C. Donough; (c) I. Pradiko).

4.4 When should pruning be done?

Pruning is normally done at the same time as harvesting because fronds are being removed to access the ripe bunches. This is called “progressive” (or “maintenance”) pruning. For older trees (>8 years), progressive pruning should normally be enough to maintain the optimum number of fronds per tree.

Pruning can also be done at a certain time interval, for example 6 monthly or annually. This type of “specific interval” (or “corrective”) pruning is more commonly done once a year, usually during the annual low yield period.

It may also be necessary to do an extra round of pruning when there is an extended low yield period, for example due to prolonged drought, causing a build-up of excessive number of fronds in many palms that have no bunches.

During or after a prolonged drought, the fronds may also 'fracture' and hang down to form a skirt around the tree trunk, making it almost impossible to see new bunches. In this case, the hanging fronds, including any dried fronds, should be pruned to avoid the trees from becoming unharvested.

4.5 Suggested tools and equipment

1. Harvesting chisel – for trees with bunches just above head height <3m (10ft) above ground
2. Harvesting sickle – for trees with bunches >3m above ground

4.6 Suggested work steps

Step 1 Check each tree in a field for the presence of excessive fronds.

Step 2 Cut off all dried / dead fronds.

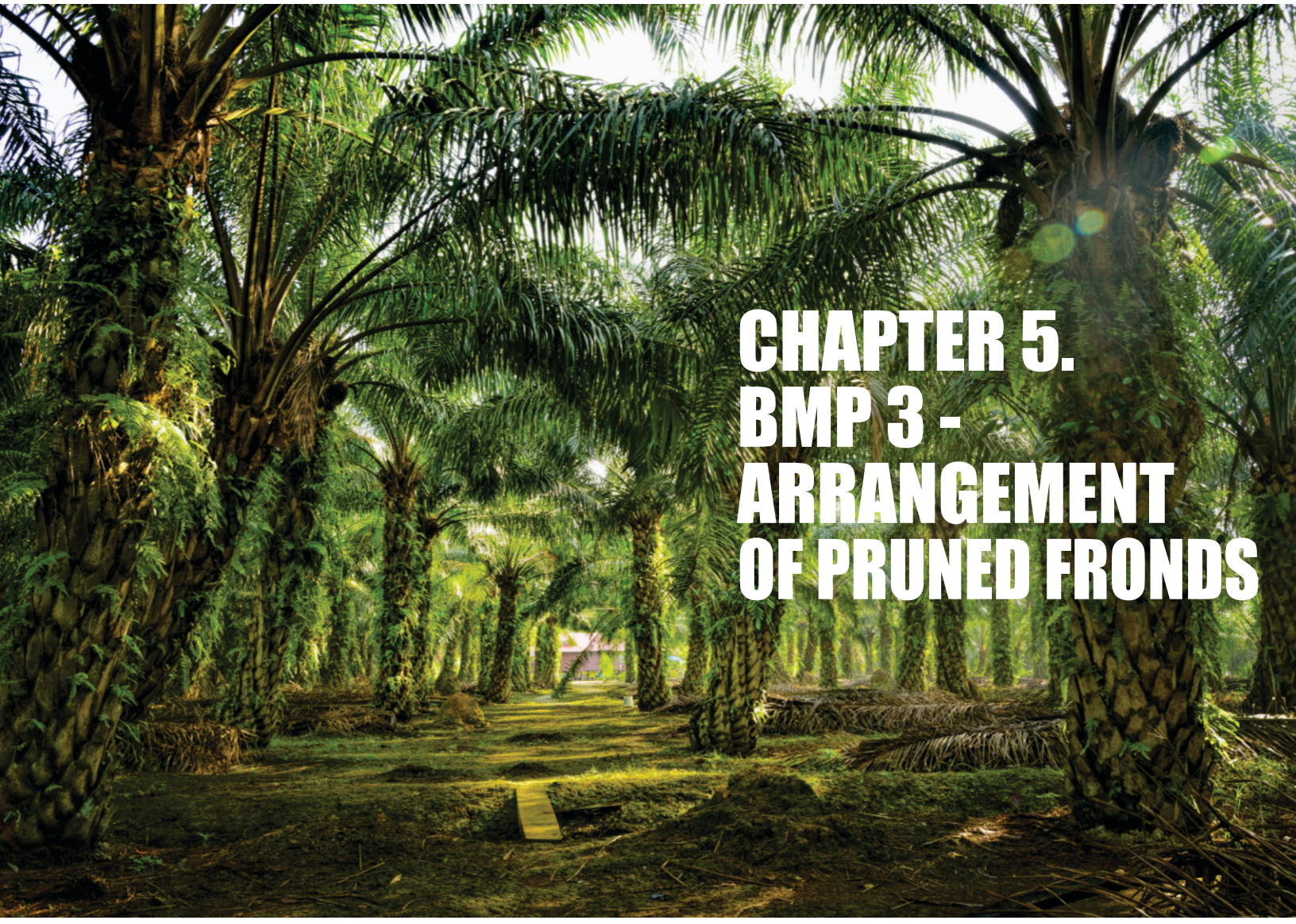
Step 3 Cut off all excess fronds (based on pruning targets – see Table 4.1 above for guidance).

Step 4 For trees with bunches ripe for harvesting, leave the target number of fronds below the lowest remaining unripe bunch (see Table 4.1). For young trees where harvesting is done using a chisel, ripe bunches can be cut without cutting off the supporting frond.

Step 5 Cut frond bases close to the trunk.

Step 6 Cut the thorny petioles from the leafy part of the pruned fronds, then stack them. For guidance on frond stacking / arrangement, see the next section **(BMP #3 Arrangement of pruned fronds).**

Step 7 Clear the palm circle of all other debris that may have fallen from the trunk or canopy during the pruning process.



CHAPTER 5. BMP 3 - ARRANGEMENT OF PRUNED FRONDS

Objective of fronds arrangement is to use the pruned fronds to cover as much ground surface as possible, leaving clear only the areas that are needed for movement and working i.e., the palm circles and the access paths. Therefore, the pruned fronds must be arranged in a way that can maximize benefits for the oil palm trees and conserve the soil which is like a 'nutrient bank' for the farm.

5.1 How should the pruned fronds be arranged?

1. The pruned fronds are arranged in a "U" or "C" shape (also called “open box”) i.e., covering the inter-row and around each palm tree, leaving clear only the harvesting path and the palm circle (see Photo 5.1). The width of the frond stacks can be adjusted according to the requirements for fieldwork, especially harvesting. The usual width of the harvesting path, as well as the palm circle radius, is 1.50m, but if the trees are tall, the width of the circle can be wider (up to 2.50m) so that harvesting is easier.

2. For the fronds that are placed between each palm, the petiole end of the fronds (i.e., the end with the thorns) should be placed towards the inter-row, and the leaflets end of the fronds is directed towards the harvesting path. This is for safety reasons – to minimize the risk of injury. Ideally, the thorny petiole is cut off and placed with the frond stacked in the inter-rows, while the leafy part of the frond is placed between the palms.

Photo 5.1 Recommended pattern of stacking pruned fronds (Source: Rhebergen, 2019).

5.2 What are the benefits of proper fronds arrangement?

There are several benefits from arranging the pruned fronds in letter "U" or "C" shape, compared to the common method of arranging fronds only in the inter-row area i.e., letter “I” shape:

1. Improve soil fertility - pruned fronds contain organic matter and nutrients. Spreading the fronds widely and more evenly will benefit a larger part of the soil in the farm. As the fronds decompose, nutrients in the fronds (which include nutrients from fertilizer previously applied) are returned to the soil.

2. Soil and water conservation - with the wider spreading of fronds, more soil surface is covered (see Photo 5.2) and protected from the impact of rainwater droplets.

Rainwater impact on the soil surface can cause erosion (and loss) of the topsoil – therefore covering more soil surface with pruned fronds will reduce topsoil loss.

More of the rainwater falling onto the fronds will enter the soil rather than flowing on the soil surface. This will keep the topsoil moist.

Photo 5.2 Pruned fronds stacked around each palm in "U" pattern to cover more soil surface (Source: H. Sugianto).

These first two "benefits" will also encourage the concentration of feeding roots of the oil palm trees in the soil under the frond stacks.

- In soil that is not covered with fronds (see Photo 5.3 a), the soil surface is damaged and the palm roots that become exposed are dry and dead.
- Whereas soil under the frond stack (see Photo 5.3 b) is moist and the palm roots (that have been purposely exposed for examination) are very fresh (alive).

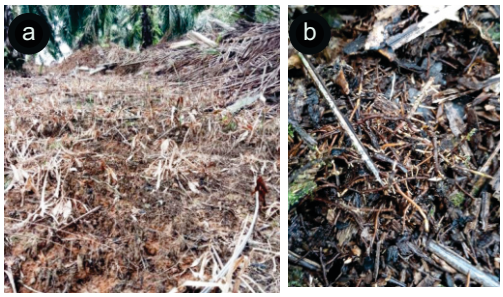


Photo 5.3 (a) Area without fronds – damaged soil surface, (b) area under frond stack – moist with fresh roots (Source: H. Sugianto).

The next two benefits are:

1. Improves the uptake of fertilizer when it is applied to the spread-out fronds. Further information on where to apply fertilizers is given in the next section **(BMP #4 Fertilizer Application).**
2. Helps to suppress the growth of weeds. This means savings in terms of weed control cost, and less competition with the oil palm trees for water and nutrients.

5.3 Suggested tools and equipment

Machete – for cutting the thorny petiole off from the leafy part of the frond.

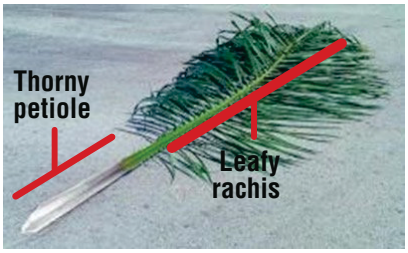
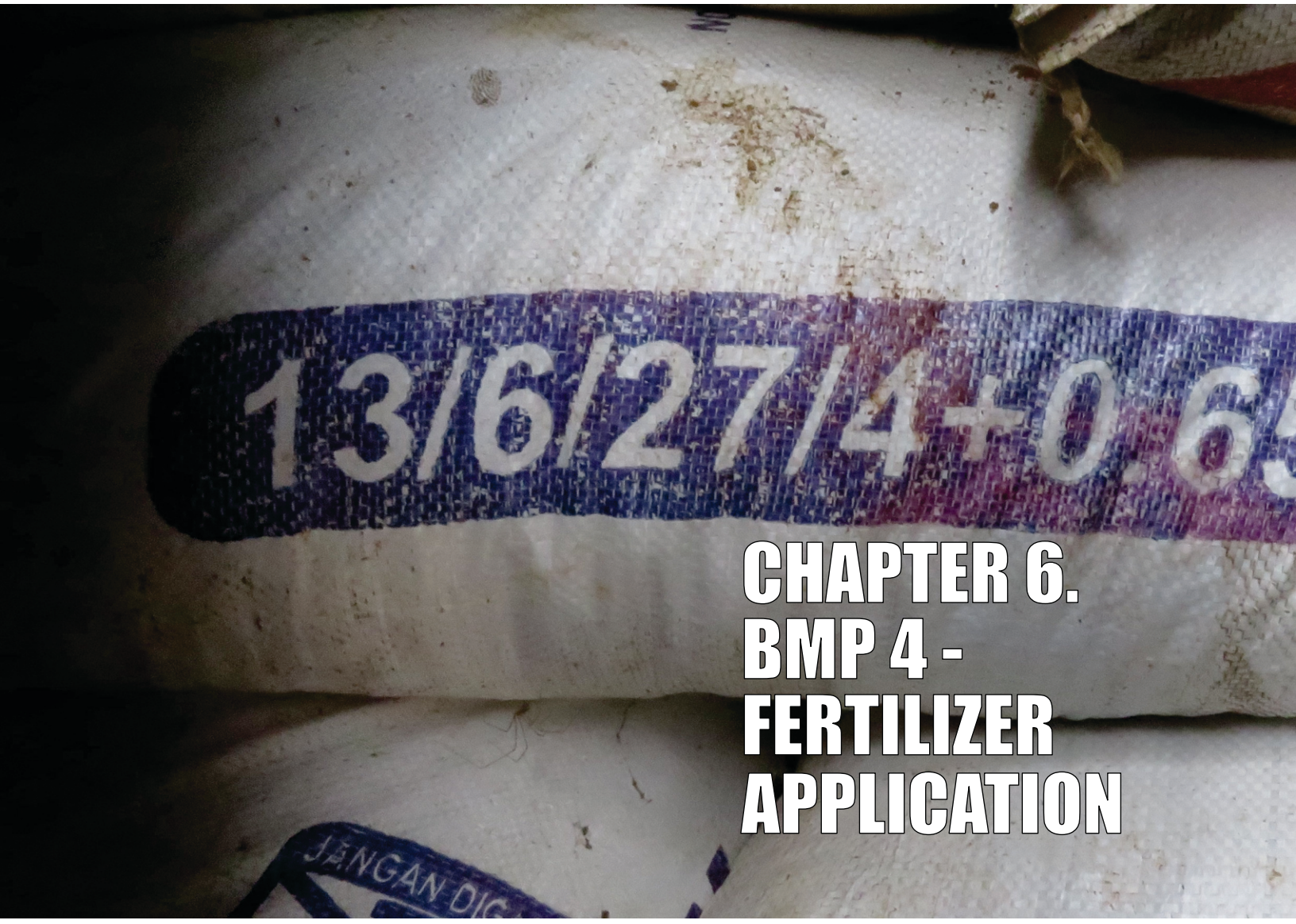


Photo 5.4 Oil palm frond sections (Source: Wahab *et al*, 2021).

5.4 Suggested work steps

1. ***Step 1*** Cut each pruned frond to separate the thorny petioles (see Photo 5.4) from the rachis (the leafy part) of the pruned fronds.
2. ***Step 2*** Arrange the leafy rachis between the trees and in the inter-row area, spread out to cover as much soil surface as possible; leave clear only the palm circles and the harvesting paths.
3. ***Step 3*** Place the thorny petioles in the inter-row area, with the thorny edges facing down to minimize risk of injury to anyone working in the area.
4. ***Step 4*** If there is any leftover debris still in the palm circle after the fronds are cut & arranged, clear the debris from the circle and throw on top of the arranged fronds.



CHAPTER 6. BMP 4 - FERTILIZER APPLICATION

Objective #1 of fertilizer application is to ensure that the trees in a field are supplied with sufficient nutrients to support good healthy growth and sustain a high yield.

Objective #2 of fertilizer application is to maximize the benefits from each of the nutrients applied:

a. To ensure that the trees absorb a high proportion of the total amount of nutrient(s) applied, and
b. To ensure that the investment in fertilizer is cost-effective or profitable.

6.1 Why does oil palm need nutrients?

Oil palms need nutrients for healthy growth as well as high yield. This is because:

1. The trunk grows taller by about 50-60cm, and about 24 new fronds are produced, per year.
2. The fronds grow bigger each year until the tree is fully mature about 10 years after planting.
3. If the tree does not have enough nutrients for healthy growth, it cannot produce high yield.
4. The fruit bunches contain nutrients that are removed from the field when the bunches are harvested and sold, and these nutrients have to be replaced.

6.2 What are the nutrients that oil palms need?

Plants need 17 nutrient elements to live healthily and complete their life cycle; these are called essential plant nutrients. Out of the 17 elements, 14 are taken from the soil and they can be grouped into the following 2 classes based on the quantity needed:

1. Major nutrients: Nitrogen (N), Potassium (= Kalium, K), Phosphorus (P), Calcium (Ca), Magnesium (Mg), and Sulphur (S).
2. Micronutrients: Chlorine (Cl), Iron (= Ferrum, Fe), Boron (B), Manganese (Mn), Zinc (Zn), Copper (Cu), Molybdenum (Mo), and Nickel (Ni).

6.3 Can the soil provide enough nutrients for oil palms?

Oil palms need more N and K than P and Mg (see Figure 6.1). Most soils on which oil palm is cultivated in Indonesia do not have sufficient N, P, K and Mg to fully supply oil palm requirements.

Figure 6.1 Oil palm nutrient requirement (relative).

In some soils, other nutrients can also be insufficient:

- A common nutrient that is also lacking in many soils is the micronutrient B.
- In certain soils, such as very sandy soils, other micronutrients can also be lacking like Fe, Cu, and Mn.

If these soil nutrient deficiencies are left uncorrected, the consequences can be very severe:
a) the yield from the trees will be low, and
b) the soil in the farm may eventually be exhausted.

6.4 Fertilizers are used to supply nutrients that the soil is lacking

Applying fertilizer is a convenient way to add nutrients to the soil when the natural supply in the soil is not sufficient for the plant needs.

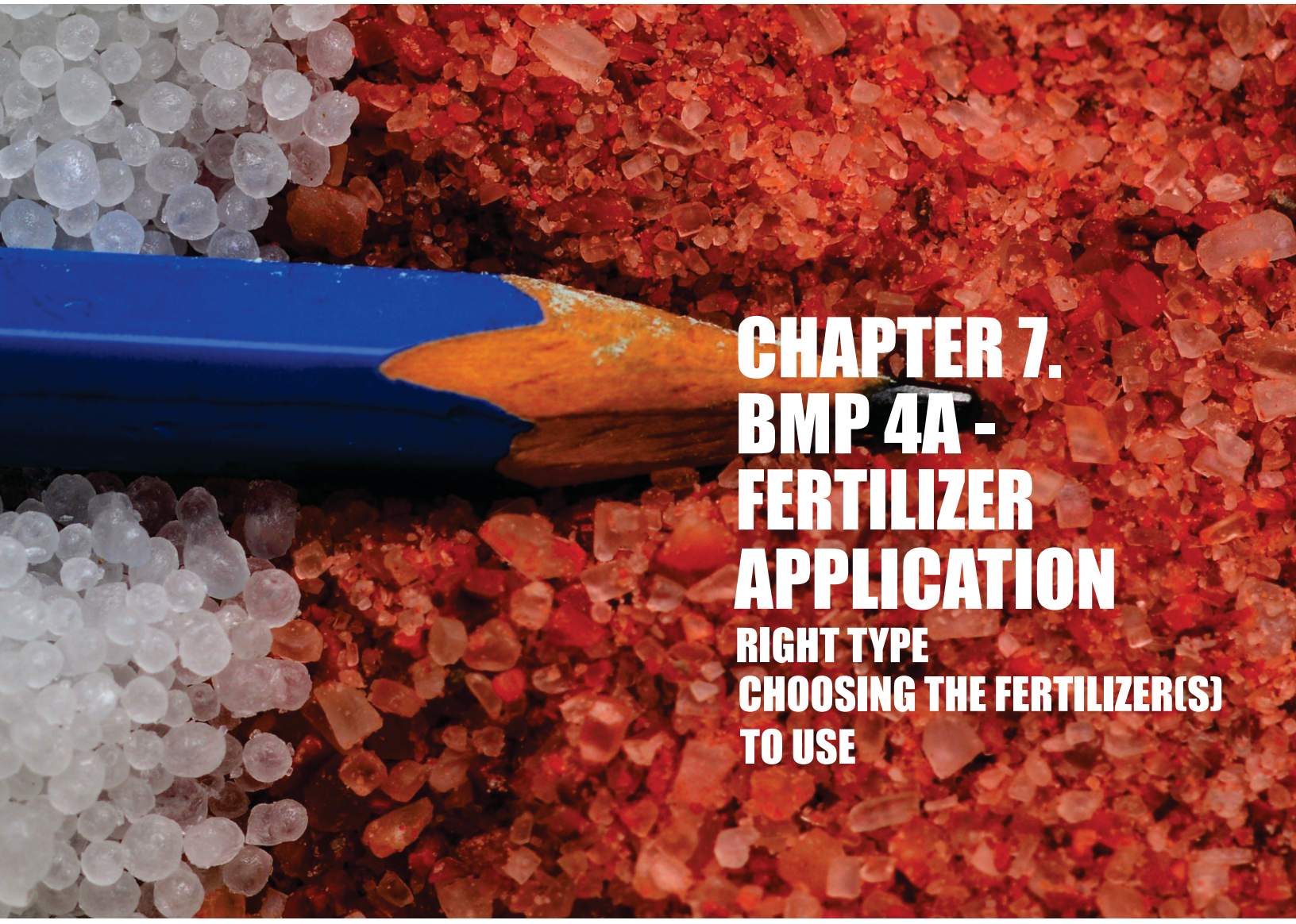
Fertilizers are expensive, so decisions on fertilizer use must be made carefully, and the fertilizers bought must be applied in a way that will allow the oil palm trees to absorb most of it. Therefore, the method and timing of fertilizer application is important.

Other plants (i.e., weeds) in the field can also compete with the oil palm trees and benefit from the applied fertilizers, so it is important to control these weeds to minimize their negative impact on oil palms.

With all these factors to consider, the best way to manage fertilizer use for optimum results is to make decisions following the principles of the four rights or 4R:

1) Right type – which fertilizer(s) should be used?
2) Right rate – what is the quantity to be applied?
3) Right time – when to apply it? And how often?
4) Right place – where and how to apply it?
These 4R considerations will be described in the next chapters.

There is also a chapter on the use of organic materials such as empty fruit bunches (EFB) and animal manures. These materials are useful to improve soil conditions that will help to improve the benefits from applied fertilizer nutrients.



CHAPTER 7. BMP 4A - FERTILIZER APPLICATION

RIGHT TYPE

CHOOSING THE FERTILIZER(S) TO USE

Choosing the RIGHT fertilizer(s) is related to ***Objective #1*** of fertilizer application:

- To ensure that the trees in a field are supplied with the nutrients needed to support good healthy growth and sustain a high yield.

7.1 What are the nutrients that must be applied?

The first consideration in choosing fertilizer(s) is knowing which nutrients are needed.
One thing is certain: Nutrients contained in the fresh fruit bunches (FFB) are being removed from the field. Those removed nutrients must be replaced or the soil in the field will slowly become depleted of those nutrients.
So, what are the main nutrients being removed in your FFB yield? The answer is in the Figure 7.1 – every 1 ton of FFB contains:

- Nitrogen (N) – 3kg
- Potassium (= kalium, K) – 4kg
- Phosphorus (P) – 0.4kg
- Magnesium (Mg) – 0.6kg

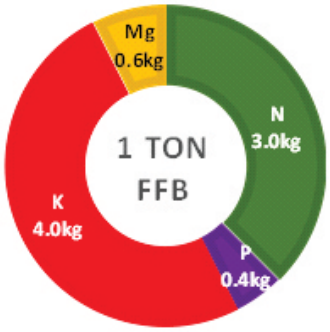


Figure 7.1 Nutrient contents in 1 ton of FFB.

Another way to know which nutrients may be lacking in the trees is to see if they show any nutrient deficiency symptoms. Certain nutrient deficiency symptoms are quite clearly visible in the oil palm leaves, but some may be less obvious. Please see ***Chapter 8 on "Nutrient deficiency symptoms"*** with photos, for guidance.

Once you know which nutrients are needed, you can then choose the fertilizers to supply those depleted nutrients.

7.2 Type of fertilizers

There are many types of fertilizers, considered from different aspects like:

1. How the fertilizer is produced (this can determine the fertilizer cost)
2. What nutrient(s) it contains (this determines if it meets the crop requirements)
3. How soluble is the fertilizer (this determines the availability of the nutrient(s) to plant(s)).

From the nutrient content aspect, fertilizers can be grouped into two types:

1. Straight fertilizers, and
2. Compound fertilizers.

Straight fertilizers are fertilizers that supply at least 1 plant nutrient (see Table 7.1). Common examples include:

- Urea to supply nitrogen (N)
- SP36 to supply phosphorus (P)
- MoP to supply potassium (= kalium, K)
- Kieserite to supply magnesium (Mg)

Table 7.1 Straight fertilizers commonly used in oil palm.

Nutrient supplied	Fertilizer name	Nutrient content*	
		On the bag	Actual
Nitrogen (N)	Urea		N 46%
	Ammonium Sulphate		N 21%
Phosphorus (P)	Superphospate (SP-36)	P_2O_5 36%	P 16%
	Triple Superphospate (TSP)	P_2O_5 46%	P 20%
	Rock Phosphate (RP)	P_2O_5 30%	P 13%
Potassium (K)	Muriate of Potash (MoP)	K_2O 60%	K 50%
Magnesium (Mg)	Kieserite	MgO 27%	Mg 16%
	Dolomite	MgO 18%	Mg 11%
Boron (B)	Borate	B_2O_3 46%	B 14%

**Normally written on product packaging in oxide as shown for P, K, and Mg. Actual content in element form is lower, after removing the oxygen.*

Compound fertilizers are fertilizers that supply more than 1 plant nutrient (see Table 7.2). Common examples include:

- Phonska contains N, P and K
- HiKay, Compound Blue and Compound Yellow, all contains N, P, K and Mg

Table 7.2 Compound fertilizers - some examples.

Fertilizer name	Nutrient content as shown on product bags*			
	Nitrogen (N)	Phosporus (P_2O_5)	Potassium (K_2O)	Magnesium (MgO)
HiKay	13%	8%	27%	4%
Phonska	15%	15%	15%	-
Compound Blue	12%	12%	17%	2%
Compound Yellow	15%	15%	6%	4%

**Normally written on product packaging in oxide as shown for P, K, and Mg. Actual content in element form is lower, after removing the oxygen.*

It is important to note the way the content of P, K and Mg (and also boron, B) are written on fertilizer bags. Usually, the content of these nutrients is given as the oxide form in combination with oxygen, so P = P_2O_5, K = K_2O, Mg = MgO, and B = B_2O_3 (see Photo 7.2, and also Tables 7.1 and 7.2).

The actual nutrient content in element form (P, K, Mg, and B) is lower (after 'removing' the oxygen by calculation). This is confusing but unfortunately it is the normal convention.

Photo 7.2 Examples of fertilizer bags showing nutrient contents in oxide form.

Organic materials also contain nutrients - examples are empty fruit bunches (EFB) and various animal manures.

However, their nutrient content tends to be very low (i.e., animal manures) or very variable (i.e., EFB); because these products are not produced & packed in a controlled way like inorganic fertilizers. This may caused the nutrients in organic materials to be washed out or diluted if kept for too long in poor storage conditions. Therefore, these organic materials are better to be considered as supplements to improve soil health than as nutrient sources like inorganic fertilizers.

More information on organic supplements is given in ***Chapter 9 "Organic materials".***

7.3 Which type of fertilizer is more appropriate?

Some factors that need to consider in choosing the type of fertilizer are:

1. ***Cost of the fertilizer*** – this is perhaps the most important factor for a farmer in choosing which type of fertilizer to use.

Some fertilizers are subsidized – for example, Urea and Phonska. There is nothing wrong in using these subsidized fertilizers. However, in the case of Phonska, extra MoP (to supply Potassium = kalium, K) and kieserite (to supply Magnesium Mg) should be added because these nutrients in the Phonska alone are insufficient for oil palm (see Figure 7.3).

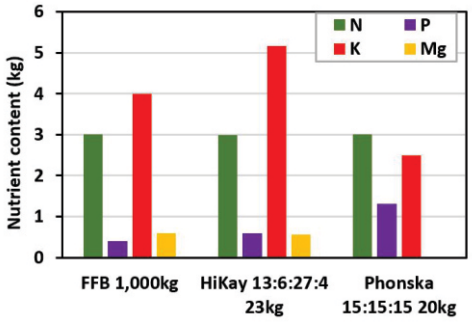


Figure 7.3 Nutrient content of two compound fertilizers vs 1 ton FFB.

2. Nutrient contents of the fertilizer compared to the nutrient requirements of oil palm – this is another important factor to consider when choosing the type of fertilizer.

- A compound fertilizer like HiKay (which is used in the GYGA BMP Field Trials) has a nutrient content ratio very similar to nutrient contents in FFB (see Photo 7.2).
- Therefore, HiKay is a good base fertilizer for oil palm, to replace nutrients removed in FFB. And if there are any nutrient(s) that are deficient (for example, based on visible symptoms in the leaves or based on laboratory analysis of leaf samples from the farm if such information is available), those deficiencies can be corrected individually using appropriate straight fertilizers.

3. Soil fertility of the farm or field – this is the last important factor to consider in choosing the type of fertilizer.

All plants obtain the nutrients that they need from the soil, but different soil types may differ in terms of their fertility (amount of available plant nutrients).

Unfortunately, without a laboratory analysis of soil samples, it is not possible to know the precise soil fertility, but if a balanced base fertilizer like HiKay is used, then the nutrient deficiency symptoms that are still visible can give some indication of what the soil is still lacking.

Smallholders need to adopt practices that suit their smaller scale of operation and make decisions based on their available farm or field information.

As stated above, and is practised in the GYGA BMP Field Trials, a suitable compound like Hikay is used as the base fertilizer to replace nutrients removed in FFB, and other nutrient imbalances or deficiencies are corrected using appropriate straight fertilizers.

If a smallholder is starting to implement BMP in a field that has been neglected or managed sub-optimally, it is better to use a compound like Hikay to quickly improve the nutritional status of the trees by providing a complete set of the most important nutrients in a balanced ratio suited for oil palm.

CHAPTER 8. NUTRIENT DEFICIENCY SYMPTOMS

If certain nutrients are deficient in an oil palm tree, symptoms of the deficiencies are usually visible from the leaves of the tree. By recognizing the symptoms, it will be possible to know which nutrients are lacking in the field. This knowledge will help guide what types of fertilizers are needed to supply those deficient nutrients.

In this section, the symptoms associated with the following important nutrients are shown and described:
1) Nitrogen (N)
2) Phosphorus (P)
3) Potassium (= Kalium, K), including N:K imbalance
4) Magnesium (Mg)
5) Boron (B)

Note that in the field, especially if past fertilizer applications have been inadequate or nil, the trees are likely to show multiple nutrient deficiencies, so only the most obvious symptoms may be visible.

8.1 Nitrogen (N)

8.1.1 What does a N-deficient tree look like?

An oil palm tree that is deficient in nitrogen (N) will usually look smaller and generally unhealthy, with pale green or yellowish fronds (Photo 8.1a).

- Fronds look sparse and letting through a lot of light.

- The tree may appear shorter and thinner.
- The frond rachis and leaflet midribs are yellowish (Photo 8.1b).
- The leaflets may become narrow and rolled inwards.

Photo 8.1 Symptoms of N deficiency: (a) smaller size tree with pale green fronds, (b) leaflets with yellow midribs (Source: (a) C. Donough, (b) H. Sugianto).

8.1.2 What conditions can cause it?

Conditions that are conducive for N-deficiency include:

- Sandy soils and soils with low organic matter
- Shallow soils and soils with hardpan
- Severe weeds infestation
- Poor drainage and waterlogging

8.2 Phosporus (P)

8.2.1 What does a P-deficient tree look like?

Phosphorus (P) deficiency is difficult to recognize in oil palm trees. One possible sign is a tapering trunk (Photo 8.2), but many palms look similar due to the normally bulgy trunk base, so it is hard to be sure.

Photo 8.2 Palm with trunk tapering to the top – possible P deficiency (Source: C. Donough).

An indirect way to know if the soil is P-deficient is to look at grasses that may be growing in the field. P-deficient grasses will have purplish leaves (Photo 8.3).

Another sign of low soil-P is the presence of *Dicranopteris* ferns (Photo 8.4a) and *Melastoma* shrubs (Photo 8.4b).

Photo 8.3 P-deficient grass with purplish leaves (Source: C. Donough).

Photo 8.4 P-deficient areas have more of these plants: (a) *Dicranopteris* ferns, (b) *Melastoma* shrubs (Source: (a) https://www.nparks.gov.sg/florafaunaweb/flora/1/5/1547, (b) C. Donough).

8.2.2 What conditions can cause it?

Some conditions that are conducive for P-deficiency include:

1. Areas with eroded topsoil
2. Various soil properties including:
   - High acidity
   - High content of iron (= ferrum, Fe) and aluminium (Al),

- Low organic matter,
- High clay content, and
- Soils derived from volcanic ash

3. Excessive application of lime (or dolomite), i.e., high calcium (Ca) content materials

8.3 Potassium (K)

8.3.1 What does a K-deficient tree look like?

Potassium (K) deficiency is probably the most common deficiency symptom in smallholder farms, and often very severe, due to low (or even nil) K fertilizer input.

The most common symptom of K-deficiency is orange spotting on the leaflets of the older (lower) fronds. The spots transmit light when held up against the sun (Photo 8.5a).

As the deficiency becomes worse, brown spots develop inside the orange spots, and the leaflets start to turn brown from the tips, eventually becoming brittle and shattered (Photo 8.5b). In severe cases, even the upper fronds become orange as the lower fronds turn dry and die (Photo 8.5c).

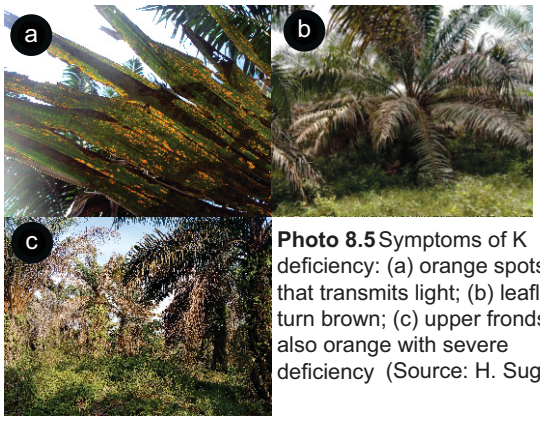


Photo 8.5 Symptoms of K deficiency: (a) orange spots that transmits light; (b) leaflets turn brown; (c) upper fronds also orange with severe deficiency (Source: H. Sugianto).

Another symptom of low K in oil palm is called “white stripe”, with 2 pale green or whitish lines running along the whole length of the leaflets on either side of the midrib (Photo 8.6). This is a sign that the level of K in the leaf is too low compared to N (nitrogen), or N:K imbalance.

Photo 8.6 White stripe-symptom of N:K imbalance i.e., K too low compared to N (Source: C. Donough).

This can happen if N fertilizer (such as Urea) is applied but little or no K fertilizer applied. It may also happen if Phonska is applied because it has a higher content of N compared to K. Since the N and K content in Phonska have the same value, while oil palm require higher K, therefore, the nutrient imbalance occurs.

If the planting material used is of uncertified origin, there may be some palms with “genetic orange spotting”, where most fronds of the tree are full of orange spots, but the fronds remain intact and alive (Photo 8.7). The orange spots of such palms will not disappear even if K fertilizer is applied.

Photo 8.7
Palm tree with genetic orange spotting
(Source: C. Donough).

A 'symptom' that can be mistaken for K-deficiency is ''red algal leaf spot''. When humidity is high, in certain places, red algae will colonize oil palm fronds.

Unlike the translucent orange spots of K-deficiency, the reddish algal spots do not transmit light when the affected leaflets are held up against the sun (Photo 8.8).

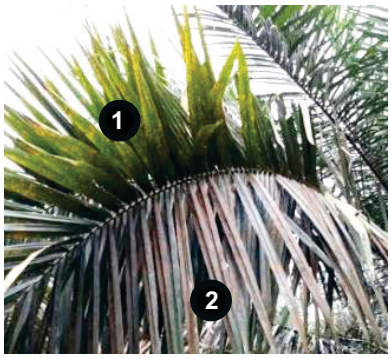


Photo 8.8
(1) K deficiency (translucent orange spots) in leaflets pointed up, and (2) red algae on surface of leaflets pointed down
(Source: C. Donough).

8.3.2 What conditions can cause it?

1. Most soils do not contain enough K for oil palm requirements. The worst cases include:
   - Sandy soils with low pH (acidic)
   - Shallow or compacted soils or soils with a hardpan
   - Degraded soils after intensive cropping

2. Incorrect use of fertilizers resulting in K imbalance, for examples:

- Excessive use of urea or
- Phonska without additional K fertilizer, or
- Excessive use of dolomite (due to its high Ca content)

8.4 Magnesium (Mg)

8.4.1 What does a Mg-deficient tree look like?

Oil palms deficient in magnesium (Mg) are quite easily recognized due to the unique way of yellowing of the older (lower) fronds (Photo 8.9a). Only the leaflets that are exposed to sunlight will turn yellow,

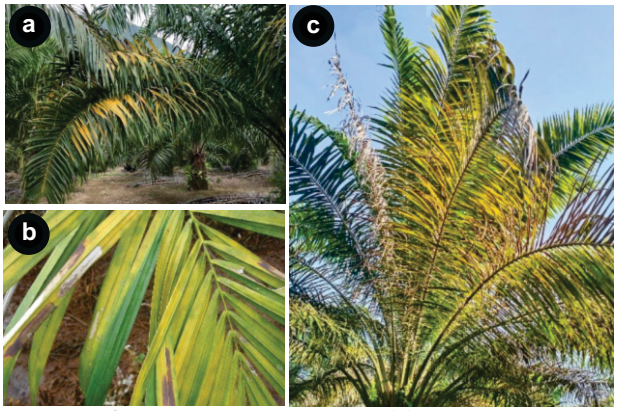


Photo 8.9 Symptoms of Mg deficiency: (a) yellowing exposed leaflets or lower fronds, (b) shaded leaflets remain green, (c) severe deficiency with drying of leaflets (Source: C. Donough).

while the leaflets (or parts of leaflets) that are shaded remain green (Photo 8.9b). In severe cases, the affected fronds turn very yellow and can become dry (Photo 8.9c).

8.4.2 What conditions can cause it?

1. Mg-deficiency occurs commonly in:
   - Sandy or light-textured soil
   - Areas where topsoil is eroded, such as on slopes or tops of ridges in hilly terrain
   - Areas with very high rainfall
2. Incorrect use of fertilizers resulting in Mg imbalance, for example the excessive use of urea.

8.5 Boron (B)

8.5.1 What does a B-deficient tree look like?

Among the micronutrients, Boron (B) deficiency is probably the most common. The symptoms of B-deficiency appear first on the new (upper) fronds of the oil palm tree. The symptoms are structural, affecting the shape of the leaflets or the fronds.

Therefore, once a frond has B-deficiency symptoms it will remain that way. So, a palm that suffered B-deficiency in the past will still show those symptoms in its lower (older) fronds, but the new fronds will be normal.

Hence, to know if there is a current deficiency of B, one must look at the new fronds, not the old.

There are many types of B-deficiency symptoms. Perhaps the most common are the following:

- Crinkly leaflets (Photo 8.10a)
- Hooked leaflets (Photo 8.10b)

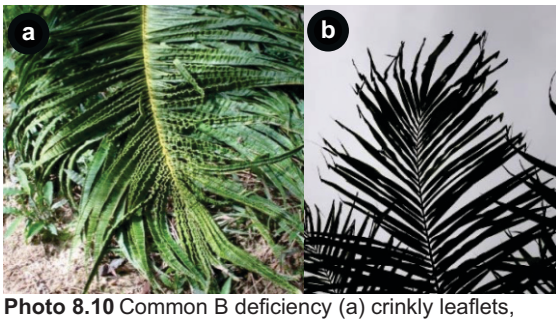


Photo 8.10 Common B deficiency (a) crinkly leaflets, (b) hooked leaflets (Source: H. Sugianto, C. Donough).

Other B-deficiency symptoms include:

- Blind end frond or younger fronds are shortened and looks like not having the midrib tip (Photo 8.11a).
- Fishbone younger frond (Photo 8.11b & 8.11c).

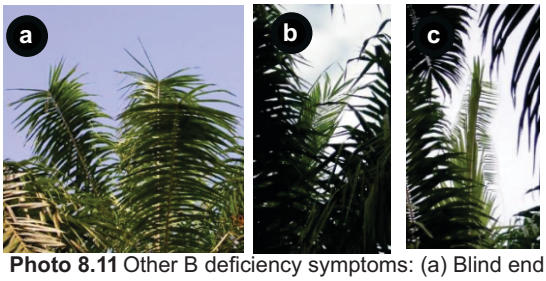


Photo 8.11 Other B deficiency symptoms: (a) Blind end frond, (b) & (c) Fishbone frond (Source: H. Sugianto, C. Donough).

And when the B-deficiency is severe:

- Little leaf or frond (Photo 8.12a), and
- Twisted fronds (Photo 8.12b)

Photo 8.12 Severe B deficiency symptoms: (a) Little leaf, (b) twisted new fronds (Source: C. Donough).

Severe symptoms are similar to symptoms of frond damage caused by rhinoceros beetles. If the cause is pest damage, there will be other symptoms (for example, entry holes in the frond petioles, or characteristic V-shaped cut-outs in new fronds – see **Chapter 15 Common Pests**).

B-deficiency may also have an impact on fruit set of FFB, because in palms with low B status, pollination may become poorer.

8.5.2 What conditions can cause it?

B-deficiency can occur because:

1. Soils are very acidic (low pH below 4.5) or alkaline (pH higher than 7.5)
2. In sandy areas after a very heavy rainy season (Boron is leached from the soil)
3. After large applications of N or K fertilizers, or fertilizers containing high Calcium (Ca)

CHAPTER 9. ORGANIC MATTER FOR FIELD APPLICATION

Organic materials also contain nutrients. Some examples of organic materials that relatively easy to find in oil palm plantation are empty fruit bunches (EFB) and various animal manures. These materials have additional benefits than just their nutrients because they can help to improve soil conditions, especially in certain situations like sandy or acidic soils.

However, their nutrient content tends to be very low (i.e., animal manures) or very variable (i.e., EFB) because (i) these products are not produced and packed in a controlled way like inorganic fertilizers, and (ii) their nutrients might be washed out or diluted if they are not properly stored.

There are also commercially produced organic fertilizers, usually based on animal manure, often with added inorganic nutrients. These types of fertilizers also tend to have very low concentration of nutrients like nitrogen (N), phosphorus (P), and potassium (=kalium, K), though may claim to have other contents such as humic acids. In general, these products do not contain sufficient nutrients to satisfy the needs of oil palms unless applied in large quantities.

Therefore, such organic materials or products are better to be considered as soil amendments rather than as replacement for inorganic fertilizers.

9.1 Improving soil quality and fertility using organic materials

If the soil in your field is very sandy with little or no organic matter, application of organic materials will be helpful to improve the soil. The organic materials can be spread out in areas where you will apply fertilizers (in weeded circle, interrow, or frond stack). This application will help to improve soil moisture and nutrient retention, and reduce soil erosion (the function is just like spreading pruned fronds – see **Chapter 5 Frond Arrangement**).

Below are some guidelines on how EFB can be applied in oil palm fields. For use of other organic materials (e.g., animal manure, organic fertilizer products), you should seek advice from a qualified and/or experienced oil palm agronomist.

9.2 Empty fruit bunches (EFB)

9.2.1 How is the nutrient content in EFB?

1. EFB contains nitrogen (N), phosphorus (P), and especially potassium (= kalium, K).
2. However, the nutrient contents of EFB are not consistent (unlike inorganic fertilizers) and depend on the freshness of the EFB and its moisture content. So at the time of application in a field, the actual nutrient content is uncertain.

9.2.2 How much to apply?

1. In large plantations, the normal application rate for mature trees is 35-40 tons per ha.
2. In sandy areas, large plantations apply up to 70-80 tons per ha to improve the soil until the trees achieve normal growth and productivity, then continue at the normal rate.
3. However, for small farmers, the rates stated above may be too high, especially if the EFB has to be purchased and transported to the fields. Therefore, application rates as low as 10 tons per ha can still be useful to improve poor soil conditions.

9.2.3 How to apply?

1. EFB can be spread out in the same areas as pruned fronds i.e., in the 'C' or 'U' shape around each palm tree or alternated (i.e., one round applied between trees within the row, next round in the inter-row).
   - The EFB can be placed on top of the pruned fronds, and
   - As they decompose, they can be covered with newly pruned fronds but not too thick.
   - In places where growth is poor due to poor soil (e.g., sandy area) and there are insufficient pruned fronds to cover the 'C' or 'U' area completely, the EFB can provide extra coverage.

Photo 9.1 Empty fruit bunches (EFB) properly applied in thin layer between trees (Source: Rhebergen, 2019).

2. Be sure to spread out the EFB in a thin layer (i.e., not more than 1 EFB thickness)
   - This will maximize the soil area that can be improved, and
   - In areas with rhinoceros beetles (see **Chapter 15 Common Pests**), it will minimize the breeding of this pest in the EFB heaps.

3. Wheelbarrows can be used to transport EFB into the field from the side of the field where it is dumped. Loading spikes can be used to load, unload and arrange the EFBs.

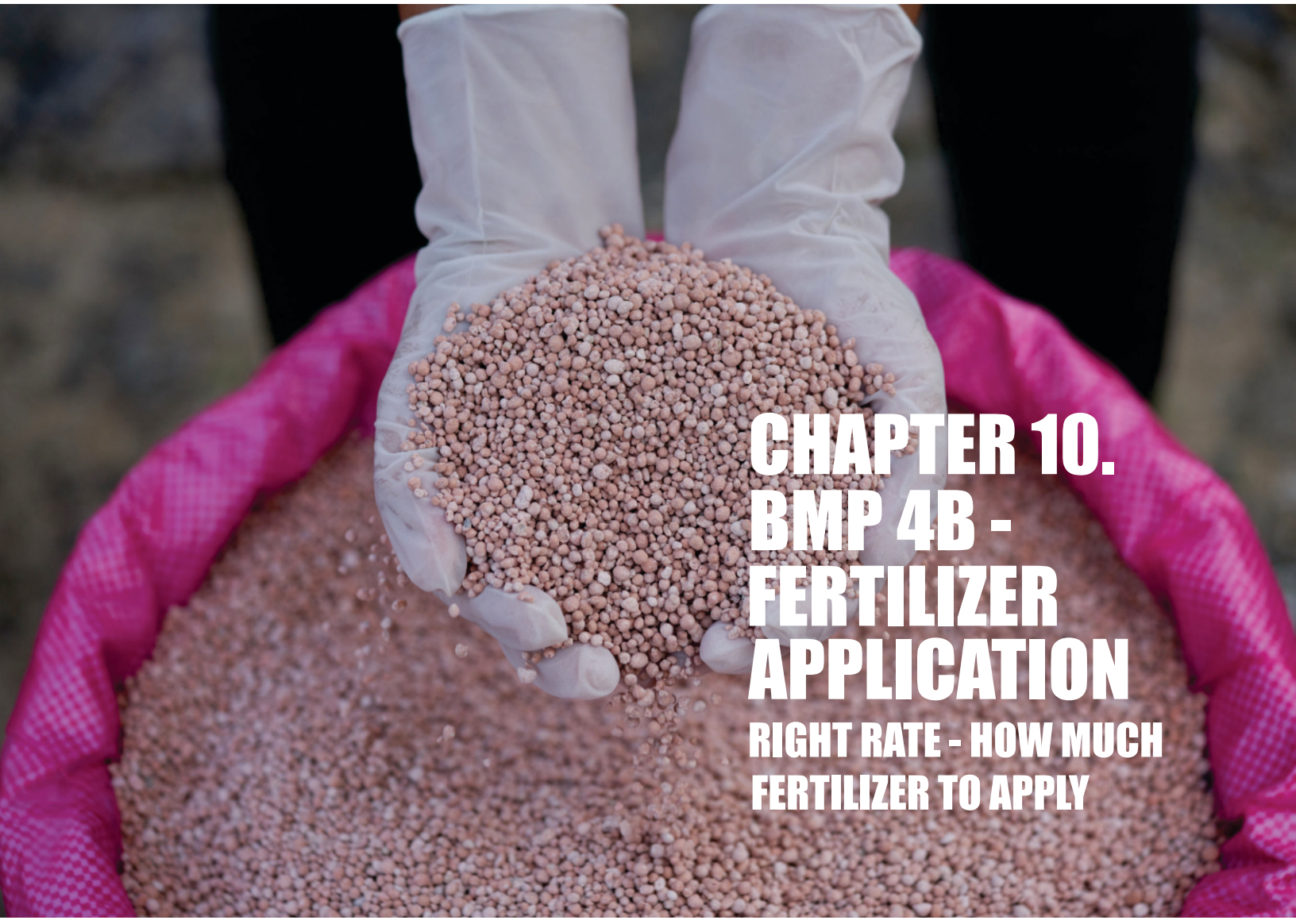
9.2.4 Quantity guidelines

1. EFB weight varies (likely ranges from 3-5kg) but, on average, may be ca. 4kg per EFB
2. The application rate is 10 tons (=10,000kg) per ha:

    - If applied in the inter-row only, ca. 270kg (i.e., 65-70 EFBs) is arranged between every 4 palms, or
    - If applied in between palms within rows, ca. 135kg (i.e., 30-35 EFBs) is arranged between every 2 palms.

9.2.5 Application frequency

After application, the EFB should be fully decomposed in less than 1 year, so if you have access to a steady supply, applications can be repeated annually.



CHAPTER 10. BMP 4B - FERTILIZER APPLICATION

RIGHT RATE - HOW MUCH FERTILIZER TO APPLY

After having selected the RIGHT type of fertilizer(s) to use (see **Chapter 7 BMP 4a Right Type**), the next consideration is to decide how much to apply.

Deciding the RIGHT rate is related to ***Objective #1*** of fertilizer application:

- To ensure that the trees in a field are supplied with sufficient quantity of nutrients needed to support a good healthy growth and sustain a high yield.

It is also related to ***Objective #2*** of fertilizer application:

- To maximize benefits from the applied fertilizers by
  a) Ensuring that trees can absorb the maximum amount of nutrient(s) from the fertilizers applied, and
  b) Ensuring that the rate applied is cost-effective or profitable.

10.1 Soil is like *a 'bank account'* of nutrients – keep the bank balance positive!

When considering how much fertilizer to apply, first we must understand that the soil in your field is like a 'bank account' of nutrients for your oil palm trees.

1. The trees 'withdraw' from the bank account the nutrients they need to grow and produce fruits.
2. In Chapter 7 BMP 4a Right Type, we stated that nutrients contained in fresh fruit bunches (FFB) are removed from the field; this is like a 'withdrawal' from the ***bank account***.

3. If 'withdrawal' continues for too long without any 'deposits', the bank 'balance' will become smaller until it is exhausted; how long this takes depends on the fertility of the soil.
4. To have an idea of the fertility of your farm soil, soil samples should be taken for nutrient analysis in a laboratory – if this is not done, then the safest thing to do is to replace at least the nutrients that are removed with the FFB.
5. Nutrients removed in FFB should be replaced regularly to maintain the fertility of the soil; in other words, you must make regular 'deposits' to keep the bank 'balance' positive; fertilizer applications are the 'deposits'.

10.2 Minimum amount of fertilizer to apply

The minimum quantity of fertilizer to apply must be sufficient to at least replace the nutrients removed in the FFB from your field, so that the fertility of the soil is maintained. This quantity is specific for a field based on its actual FFB produced, unlike general recommendations (i.e., 'standard' rates or ranges).

Why apply only the 'minimum'?

1. Because in smallholder fields, the additional requirements for growth and nutrient deficiencies are difficult to accurately estimate:
   - Tree growth in smallholder fields is usually very highly variable for various reasons, and
   - Usually, plant analysis data is not available to show if any nutrients are deficient.
2. While this minimum amount will not be enough to support optimal tree growth, it will at least ensure that soil fertility is maintained. To determine this minimum amount, the data needed are:
   - The fresh fruit bunch (FFB) amount removed from the field; and
   - The total number of trees in the field.
   - All smallholders should have these data.

10.3 Calculate how much FFB was removed from the field

Step 1 – decide the length of period of FFB removal to use for calculation

- If you have been applying fertilizer regularly in your field, and the records of fertilizer application (more details in Section BMP7 Record Keeping) are accurate, up-to-date and properly maintained, then a period of 1-year of FFB production can be used for calculation.
- If you have not applied fertilizer regularly or did not keep proper records of past fertilizer application(s),

then it is better to use a shorter period of FFB production for calculation. For example, start with 3 months of FFB production. Then after 1 year:

- 4 times of 3-monthly calculations to 1 year interval calculation.
- 2 times of 3-monthly calculation to 6 months interval calculation.

Step 2 – determine how much FFB was produced and removed from the field during the period decided in Step 1 above.

- Every farmer should have a record of the FFB weight that is removed and sold after each round of harvesting. This record may come from:
  (a) A fruit collector who collects or buys the FFB directly from the field,
  (b) A fruit collection centre where the FFB is delivered and sold to, or
  (c) A palm oil mill if the FFB is sold there.
- The records from b) and c) above will likely be in the form of a printed ticket from a weighbridge, but for a) it may be a handwritten note. Whatever form it is, this information must be properly maintained for reference, accurate and up to-date (more details are given in **Chapter 17 BMP7 Record Keeping**).
- The FFB weight records above will allow you to calculate the total FFB weight removed from your field for any period – e.g., 1 month, 3 months, 6 months, or 12 months (i.e., 1 year).

Reminder:

- This calculation must be revised with new data at the end of each period decided in Step 1.
- Therefore, the application will not be fixed but will change with the change in the FFB production over time.

10.4 How much fertilizer(s) to apply?

Step 3 – determine the quantity of fertilizers to apply to replace nutrients removed with the FFB weight determined in Step 2 above. The quantities for various types of suitable fertilizers needed to replace the nutrients removed at various levels of FFB production are shown in Tables 10.1 and 10.2 below.

- If you prefer to use only straight fertilizers, refer to Table 10.1
- If you prefer to use a compound fertilizer suitable for oil palm, refer to Table 10.2

Note that the numbers given in Tables 10.1 and 10.2 for fertilizer quantity may be used on 'per field' basis or 'per ha' basis. The numbers are all given in multiples of 50kg i.e., the typical weight of 1 bag of fertilizer.

Table 10.1 Quantity of straight fertilizers to replace nutrients removed at various levels of FFB yield.

FFB Yield (tons)	Fertilizer (kg)			
	Urea	SP36	MoP	Kieserite
5-10	50	50	100	50
10-15	100	50	100	50
15-20	100	50	100	50
20-25	100	50	150	50
25-30	150	50	150	100
30-35	150	50	200	100

Urea = 46% N, Sp36 = 36% P_2O_5, MoP = 60% K_2O, Kieserite = 27% MgO

Table 10.2 Quantity of NPK compound + straight fertilizers to replace nutrients removed at various levels of FFB yield.

FFB Yield (tons)	Fertilizer (kg)		
	NPK 13-6-27-4	Urea	Kieserite
5-10	150	50	50
10-15	250	50	50
15-20	350	50	50
20-25	400	50	50
25-30	500	50	50
30-35	600	50	50

NPK = 13% N, 6% P_2O_5, 27% K_2O, 4% MgO; Urea = 46% N, Kieserite = 27% MgO

Example 1

- Your field produced 21 tons of FFB in 2021
- And you prefer to use only straight fertilizers
- Therefore, refer to Table 10.1 and find which row in the column "FFB yield range" that includes 21 tons – i.e., row "20-25"
- Which shows the quantities of straight fertilizers you need to apply in 2022:
  - Urea – 100kg
  - SP36 – 50kg
  - MoP – 150kg
  - Kieserite – 50kg

Example 2

- If you prefer to use a compound fertilizer suitable for oil palm like NPK 13-6-27-4 (which is used in the GYGA BMP Field Trials), then refer to Table 10.2
- Which shows that for FFB yield in the range of 20-25 tons in 2021, the quantities of fertilizers you need to apply in 2022 are:
  - NPK – 400kg
  - Urea – 50kg
  - Kieserite – 50kg
- Urea and kieserite are also needed because the N and Mg supplied in the 400kg of NPK are slightly insufficient compared to the requirements to replace these nutrients in 21 tons of FFB.

10.5 How many kg to apply per tree?

Step 4 – determine the rate of application per tree

For this, you must know the actual total number of trees in your field that are alive and capable of producing FFB. Just like the FFB data, this data must also be kept accurate and up to-date.

For example:

- There are 206 living and productive trees in a field, and
- The quantity of fertilizers to be applied is as given in Example 1 in Step 3 above
- Therefore, the rate of application for each fertilizer in 'kg per tree' will be:
  - o Urea = 100kg ÷ 206 tree = 0.49 kg/tree
  - o SP36 = 50kg ÷ 206 tree = 0.24 kg/tree
  - o MoP = 150kg ÷ 206 tree = 0.73 kg/tree
  - o Kieserite = 50kg ÷ 206 tree = 0.24 kg/tree
- If the quantity of fertilizers to be applied is as given in Example 2 in Step 3 above, then
- The rate of application for each fertilizer in 'kg per tree' will be:
  - o NPK 13-6-27-4 = 400kg ÷ 206 tree = 1.94 kg/tree
  - o Urea = 50kg ÷ 206 tree = 0.24 kg/tree
  - o Kieserite = 50kg ÷ 206 tree = 0.24 kg/tree

10.6 Ensure that the right rate is applied per tree

After the application rate is calculated in Step 4 above, it is important to make sure that each tree in the field receives the correct dose. The following steps can help to ensure this is achieved:

1) According to the number of trees that can be applied with 1 bag of fertilizer

- For example, if the rate per tree is 1.5 kg and 1 fertilizer bag is 50 kg, then
- 1 fertilizer bag is enough to apply (50÷1.5) = 33.3 tree
- Therefore, place 1 unopened fertilizer bag at every 33rd tree
- This should ensure that all parts of the field, and all trees, will receive fertilizer

2) Use an appropriate application tool

- For rates of application of 500 g per tree or higher, a cup or bowl of appropriate size can be used. Appropriate size means the required dosage per tree can be achieved with 1-2 scoops of cup or bowl.
- However, for borate fertilizer, the application rate is much lower, so a spoon can be used.
- Often, farmers use scoops made from used herbicide or pesticide containers. This practice may not be allowed in some certification schemes by Roundtable on Sustainable Palm Oil (RSPO) that require the proper treatment or disposal of such containers.

3) Whatever type of tool is used, it must be calibrated each time before it is used.

- Each fertilizer has a different density so even if the same tool is used for 2 different fertilizers, the weight per scoop for each fertilizer will be different.

- If your fertilizer program includes 3 different fertilizers, you may need to have 3 different tools i.e., one for each type of fertilizer.

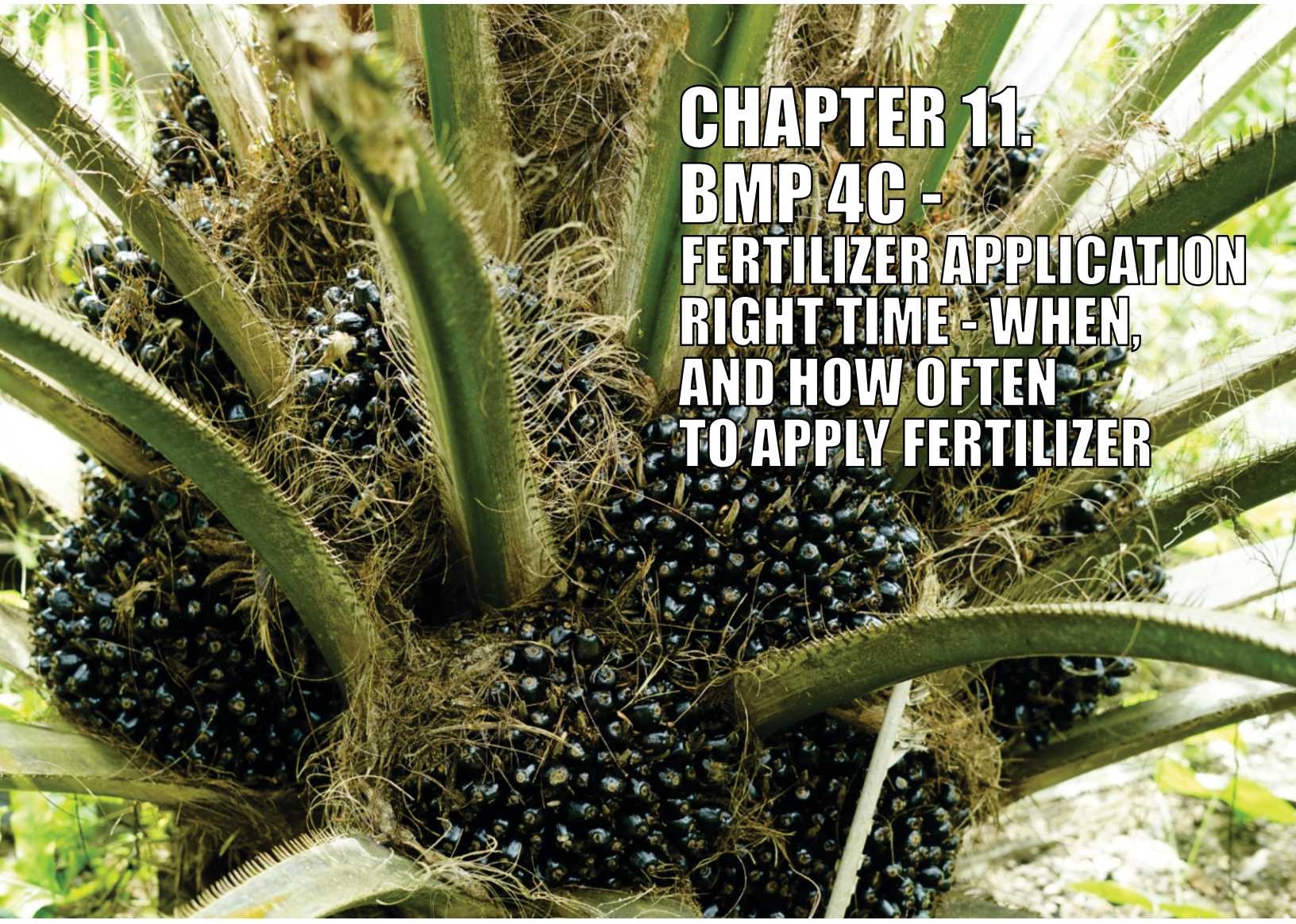
4) Calibrating the application tool

- Using a kitchen or shop scale (see Photo 10.1a), weigh out 250 g (or other known amount) of the fertilizer.
- Then find a container (or cut to correct size a cleaned used herbicide or pesticide container) that will hold the known weight of fertilizer (see Photo 10.1b).

Photo 10.1 (a) Scale for calibration of fertilizer scoop bowl; (b) weighing a filled scoop of fertilizer (Source: C. Donough).

- Adjustable scoops are also available today (see Photo 10.2) from Agricultural store, that can be adjusted to fit variable amounts of any fertilizer.

Photo 10.2
Adjustable scoop suitable for use with different types of fertilizer (Source: C. Donough).



CHAPTER 11. BMP 4C - FERTILIZER APPLICATION RIGHT TIME - WHEN, AND HOW OFTEN TO APPLY FERTILIZER

Planning the right time, and frequency (i.e., how many times a year), to apply fertilizer is related to ***Objective #2*** of fertilizer application:

- To maximize benefits from the applied fertilizer by
  a) Ensuring that trees can absorb the maximum amount of nutrient(s) from the fertilizer applied, and
  b) Minimizing the risk of fertilizer losses after application.

11.1 When should fertilizer be applied?

Unlike for short term annual crops, there is no specific time or season for fertilizer application in oil palm fields. The oil palm trees are continuously growing, and producing inflorescences (female and male), so they will continuously need nutrients. Therefore, fertilizer application for oil palm can be done throughout the year.

11.2 When should fertilizer NOT be applied?

1. Fertilizer applications should NOT be done during rainy days.
   - o If the rainfall is too high, the rainwater can wash off the applied fertilizer.
   - o There are weather forecast apps for smartphones that will give a prediction (with a % likelihood or chance) of rain for any given day, even for several days ahead – such information can be useful for deciding if fertilizer application should be carried out.

2. After rain, if the field is still waterlogged, fertilizer application should be postponed until the water level has gone down.
   - o The oil palm roots system must not be completely underwater to function effectively.
     - If the soil drainage is good, the soil surface should be dry (i.e., no more water stagnant on the surface) after 2 days with no rain.
     - If after 2 days with no rain, there is still stagnant water on the soil surface, then some field drains may be necessary to construct to draw away the stagnant water.

3. Fertilizer application should also NOT be done when the weather is too dry and hot.
   - o Especially for urea fertilizer, application during hot weather should not be carried out to avoid excessive loss of nitrogen through volatilization.
   - o A sign that the weather is too hot and dry is when the palm trees (in general) have unopened spears (specifically, more than 2) because moisture is insufficient for the new fronds to expand. This should not be confused with trees having unopened spears due to Ganoderma infection (see **Chapter 16 Common Diseases**).

11.3 How often should fertilizer be applied?

The frequency of fertilizer application depends on several factors:

1) The fertilizer rate

- If the rate is high, then it should be split into several smaller doses and applied separately; otherwise, a larger portion of the applied fertilizer may become unavailable or lost.
- So if the rate is higher than 2 kg per tree, it should be split into 2 (or more) applications.
- Especially for urea fertilizer, if the rate is higher than 1 kg per tree, the loss of nitrogen through volatilization becomes higher even if the weather is not dry and hot.

2) The soil texture

- If the soil is very sandy and lacking in organic matter to help hold the applied nutrients, the fertilizer should be applied in small doses more frequently.

3) The fertilizer type

- Compound fertilizers which contain several nutrients like nitrogen (N), phosphorus (P), potassium (= kalium, K), or magnesium (Mg) (see **Chapter 7 BMP 4a Right type**) should be applied several times a year, for example 3-6 times.
- Straight fertilizers which supply one main nutrient (see **Chapter 7 BMP 4a Right type**) are usually applied 1-3 times per year as follows:

- N-fertilizers (e.g., Urea, Ammonium Sulphate) – 2-3 times a year
- K-fertilizer (e.g., MoP) – 1-2 times a year
- P-fertilizers (e.g., SP36, TSP, RP), Mg-fertilizers (e.g., Kieserite, Dolomite), and Boron (B) fertilizer (e.g., borate) – all once a year

11.4 Avoiding negative fertilizer interactions

Certain straight fertilizers should not be applied together, or too close in timing to each other, especially if the application rate is high.

- Particularly dolomite which can interfere with the availability or absorption of Potassium (= kalium, K) due to its high content of Calcium (Ca), so it will be best to apply dolomite at least 1 month before or after application of fertilizers that contain K (e.g., MoP).

11.5 Apply fertilizers after weeding

1. If your field is too dense with weeds, weeding should ideally be done before applying fertilizer(s), so that there will be less competition for the oil palm trees.

2. If weeding is done using herbicides, be sure NOT to spray out all weeds leaving bare soil conditions; it is sufficient to suppress the growth of the weeds, not to eradicate them, especially the soft weeds that have a short life as they can help to 'hold' the fertilizer nutrients and then release them when they die or are sprayed again.

3. If there are woody weeds which have a long lifespan or can potentially grow into trees, these must be eradicated; otherwise, they will absorb and lock up fertilizer nutrients for a long time.

11.6 Planning an annual fertilizer application program

1. If you have already decided on the type(s) of fertilizer(s) to use (i.e., from Chapter 7 BMP 4a Right type) and how much to apply for a period of 12 months (i.e., from Chapter 10 BMP 4b Right rate), you can then make a fertilizer application plan for a year.
2. To do this, knowledge of the rainfall pattern for your location will be helpful, so that you know which time of the year, or months, to be avoided due to too high rainfall or being too dry.
3. You may be able to obtain rainfall information from your local weather station – this will normally be:
   - Total monthly rainfall (in mm), and
   - Number of rainy days per month.
4. Alternatively, a rain gauge can be installed in your village to collect daily rainfall data for your specific site (as is being done for the GYGA BMP field trials) that your community can share.
   o The important information to record are:
   - the quantity of rainfall (in mm per day), and
   - the date the rain was recorded.
5. Ideally, several years (e.g., 3 years) of rainfall data should be used to estimate the average rainfall for each month in a year (i.e., January to December). With the data, the months to be avoided can be decided:

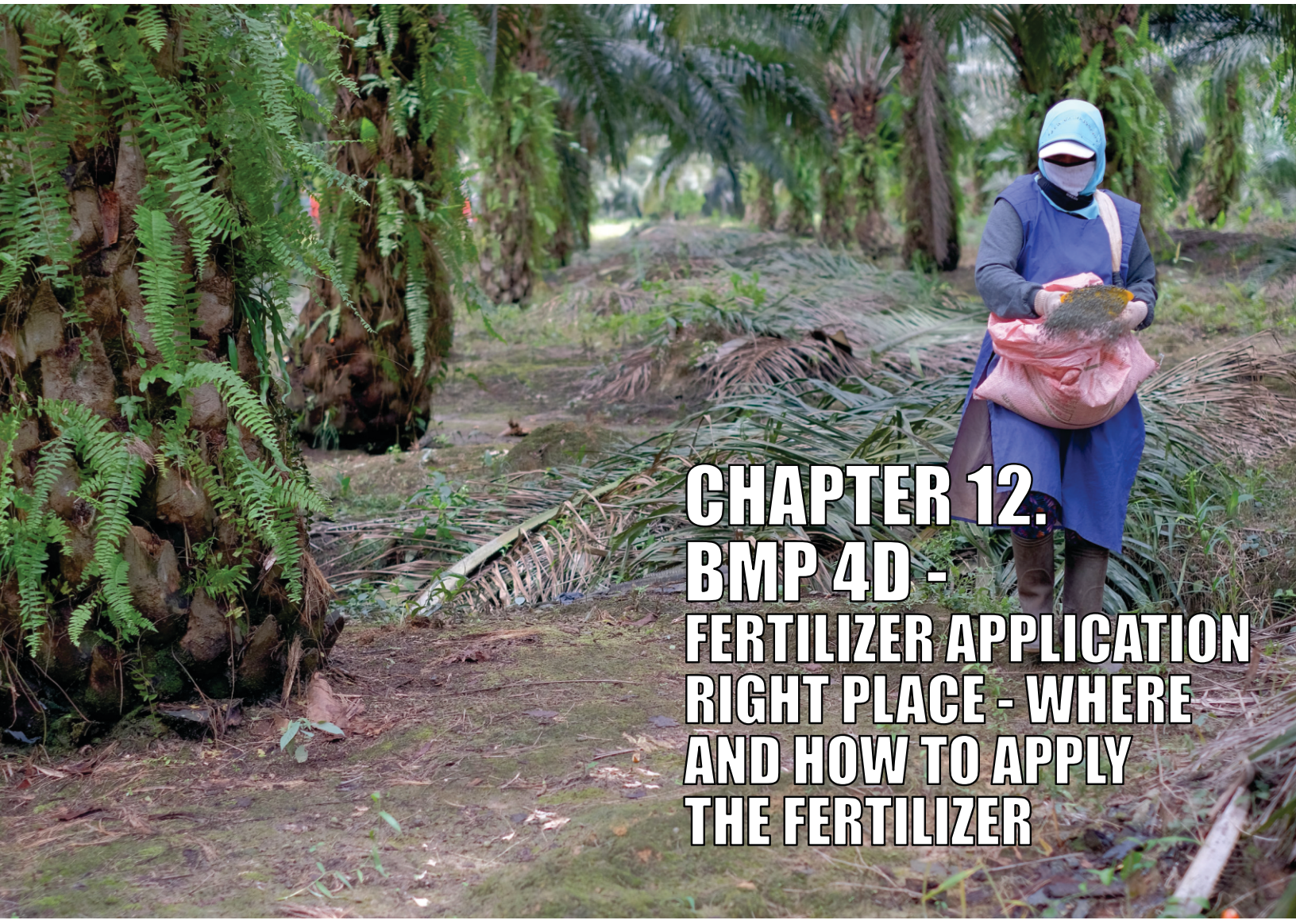
   - Months with rainfall quantity >250mm (too wet) or <25mm (too dry),
   - Months with high rainfall intensity (i.e., >25mm per day), and
   - Months with too frequent rainfall (i.e., >20 rainy days per month).
6. Note that this same rainfall pattern data can also be used to plan the timing of weeding using herbicides.

11.7 Proper storage of fertilizers while waiting for field application

Purchased fertilizers may need to be stored until field application is possible. To ensure that the quality of the fertilizer remains good, the fertilizer bags must be properly stored. The most important consideration to ensure the fertilizer quality is protection from moisture. This is because:

- If moisture gets into the fertilizer bags, the fertilizer can become lumpy and will be difficult to apply evenly in the field later.
- Also, if the nutrients in the fertilizer are easily soluble, some of it can be washed out, for example if the fertilizer bags are left exposed to rain or become soaked if the storage area is waterlogged.

Therefore, for storing fertilizer bags, it is best to raise them from the ground, and to ensure that the storage area is protected from rainfall. Moreover, the storage place should be secured from possible theft.



CHAPTER 12. BMP 4D - FERTILIZER APPLICATION RIGHT PLACE - WHERE AND HOW TO APPLY THE FERTILIZER

Proper placement of fertilizers is related to ***Objective #2*** of fertilizer application:

1. To maximize benefits from the applied fertilizers by
- Ensuring that trees can absorb the maximum amount of nutrient(s) from the fertilizer applied,
- Minimizing the risk of fertilizer losses after application, and
- Ensuring that all trees in the field receive fertilizer.

Photo 12.1 below shows the places recommended for the application of various types of fertilizers in fields where the trees are fully mature, and fronds of adjacent trees are touching or overlapping.

Photo 12.1 Right placement of fertilizer in mature oil palm field with overlapped tree canopies. (1) Compound (NPK, NPKMg) and P, K, or Mg straight fertilizers applied onto spread fronds; (2) Urea and borate applied inside the weeded circle (Source: H. Sugianto).

2. Compound fertilizers (NPK, NPKMg) and P, K or Mg straight fertilizers should be applied on the spread fronds (which have been arranged like a 'U' shape around the trees – see Photo 12.1 above) after any woody weeds have been eradicated.
- The frond heaps will protect the fertilizer from being washed away after application, and
- There is a high density of oil palm feeding roots under the frond heaps (see Photo 12.2) so absorption of the nutrients will be more efficient.
- If woody weeds are still present in the area where fronds are spread, all fertilizers should be applied inside the palm tree circles.

Photo 12.2 Feeding roots of oil palm under frond heap (Source: C. Donough).

3. Urea should be applied inside the palm circle (see Photo 12.1)
- The circles should be clean so that the applied urea fertilizer comes directly in contact with the soil – this will help to minimize losses through volatilization.

4. Borate should also be applied inside the palm circle (see Photo 12.1) close to the base of the tree trunk.

If the trees are already in production but are still young and the fronds of adjacent trees are not yet touching, then ALL fertilizers should be applied inside the clean-weeded palm circles.

- The growth of the oil palm tree roots system follows the growth of the tree canopy (see Photo 12.3 below), so if the fronds of the trees are not yet touching, most of their roots will still be within the palm circles.

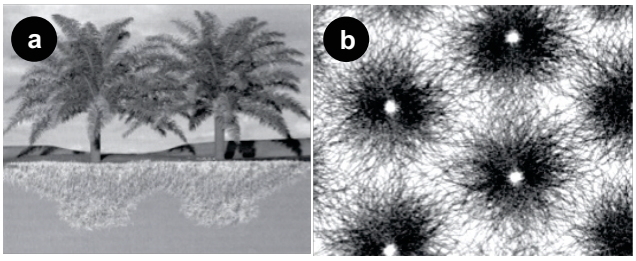


Photo 12.3 Growth of oil palm roots follow growth of the tree canopy: (a) Roots overlapped as canopy overlapped in mature trees; (b) roots mostly in circles in young trees (Source: Corley & Tinker, 2016).

Some fields may be subjected to flooding to the extent that the oil palm trees are either planted on raised platforms or bunds, or soil is heaped up to make platforms for work to be done around the palm trees.

In such cases, the fertilizers should be applied on the raised platforms.

- This may be done by spreading the fertilizer on the soil surface, or
- It can be done by 'pocketing' i.e., burying the fertilizer in holes in the ground (3 holes per tree).

CHAPTER 13. BMP 5 - GROUNDCOVER MANAGEMENT

Objectives of groundcover management are:

(a) To ensure good accessibility in the field at all times for harvesting and other field operations,

(b) To keep palm circles weed-free so that loose fruit collection is easy,

(c) To minimize competition (for nutrients, water) with the oil palm trees,

(d) To conserve the soil and moisture in the farm (reduce erosion, add organic matter) by avoiding blanket spraying or large areas of exposed soil, and

(e) To maintain plants that support beneficial fauna that are important for natural pest control.

13.1 Groundcover conditions

These pocket guide provides basic guidelines on ideal conditions for groundcover in a well-maintained field of mature oil palms, and some practical actions that can be taken to manage certain conditions.

13.2 What are undesirable conditions?

Photo 13.1 (a)-(c) below show groundcover vegetation that is too thick, dense or tall.

Photo 13.1
Undesirable groundcover conditions: (a) clear path but other parts too thick;
(b) so dense the path is almost hidden; (c) tall and climbing up the oil palm trees
(Source: Rhebergen, 2019).

13.3 What is the target condition?

Photo 13.2 (a)-(c) below show the target conditions that should be achieved.

- Clean palm circles – for easy harvesting & collection of loose fruits
- Clear paths – easy movement in the field, all parts of the field must be accessible
- Inter-row & between palms covered with light vegetation, pruned fronds (& empty fruit bunches, EFB) – conserve moisture & soil, minimal competition to palms

Photo 13.2 Target groundcover conditions: (a) & (c) clean circles and light groundcover in other parts; (b) clear path with proper frond stacking and empty fruit bunches (EFB) spread thinly between the oil palm trees (Source: Rhebergen, 2019).

13.4 Some common plants in oil palm fields

1. Woody weeds and shrubs

Melastoma malabrathicum

Local name: Senduduk / Senggani

Source: https://butterflycircle.blogspot.com/2009/11/when-melastoma-blooms.html?m=0

Clidemia hirta

Local name: Senduduk batu / Kutu babi

Source: I. Pradiko

Mimosa pudica

Local name: Putri malu

Source: Sheldon Navie https://keyserver.lucidcentral.org/weeds/data/media/Html/mimosa_pudica.htm

Lantana camara

Local name: Tahi ayam

Source: https://www.flickr.com/photos/macleaygrassman/48735662157

Chromolaena odorata

Local name: Putihan

Source: https://apps.lucidcentral.org/pppw_v10/text/web_full/entities/siam_weed_485.htm

2. Ferns

Dicranopteris linearis

Local name: Paku resam

Source: https://commons.wikimedia.org/wiki/File:Resam_(Dicranopteris_linearis)_2.jpg#filelinks

Stenochlaena palustris

Local name: Paku udang

Source: https://en.wikipedia.org/wiki/Stenochlaena_palustris

Nephrolepis biserrata

Local name: Paku pedang

Source: I. Pradiko

3. Soft/ herbaceous/ creeping plants

Asystasia gangetica

Local name: Ganda rusa

Source: https://www.acacia-ae.com/product/asystasia-gangetica/

Mikania micrantha

Local name: Sembung rambat

Source: http://camping-malaysia.blogspot.com/2011/02/selaput-tunggul-mikania-micrantha.html

4. Grasses

Imperata cylindrica

Local name: Alang-alang

Sources: https://www.flickr.com/photos/36517976@N06/3693698823

Ischemum muticum

Local name: Suket resap

Sources: https://www.biolib.cz/en/image/id242791/

Paspalum conjugatum

Local name: Papaitan

Source: https://portal.wiktrop.org/files-api/api/get/raw/img//Paspalum%20conjugatum/pasco_20060908_161317.jpg

5. Beneficial plants

- Certain flowering plants produce nectar as a food source supporting insects that prey on larvae of oil palm pests. Examples of such beneficial plants are Turnera and Antigonon.
- Such plants need light, so they tend to be found at the edges of fields exposed to sunlight.

Turnera subulata

Local name: Bunga pukul delapan

Source: I. Pradiko

Antigonon leptosus

Local name: Bunga air mata pengantin

Source: https://id.wikipedia.org/wiki/Air_mata_pengantin#/media/Berkas:Antigonon_leptopus_0.jpg

13.5 Recommended actions for groundcover management

The recommended actions include manual weeding (physical control) and use of herbicides (chemical control).

- Manual/physical methods should be preferred for personal safety, as well as safety to your environment and others, but may need considerable effort and energy to carry out.
- Using herbicides/chemical methods may be easier and quicker, but there are risks associated with their use.
- If herbicides are used, avoid blanket spraying that can lead to large areas of exposed soil.
- If your field is neglected and weeds have grown too thick, large or tall, spraying is too risky, so it will be better to slash down the weeds first.

13.6 Important notes on use of herbicides

When using herbicides (or any other agrochemicals), care must always be taken to ensure that –

- Personal safety (your own or your workers') is assured by following the recommended measures usually provided with the chemical product, and other guidelines for compliance with national (e.g., ISPO) or other certification (e.g., RSPO) standards

- Application tools are properly used – follow recommendations from the manufacturer
- Chemicals (including empty containers and any leftover product) are properly handled and managed to minimize danger to your environment and to others.

In general, herbicide use should be based also on 4R principles (similar to fertilizer application):

- Right herbicide
  - o The product must be suited to the weeds targeted; check to see what kinds of weeds are present in your field. For example, is it all grasses? Or broadleaf herbaceous plants? Or woodies? Or a mixture?
  - o Herbicides contact that kill on contact give quicker results, but the control may not last.
  - o Herbicides systemic that are absorbed by the plants kill more slowly but control may last longer.
- Right application rate
  - o To ensure a good kill of the targeted weeds.
- Right application time
  - o Herbicide spraying will likely be more effective during dry weather.
    - > So plan to spray during times of the year when the weather is normally drier, while at other times machine weeding can be done.

- Spray at the right growth stage of the weeds, e.g., before they start to flower.

- Right application method (& equipment)
  - Knapsack sprayer for spraying paths and circles
  - Wiping for large woody plants or trees
  - All equipment should be properly calibrated

Ideally, if you are going to undertake herbicide spraying / application by yourself, you should seek training by approaching your local farmers' organization who may be able to direct you to a training provider. If you hire a contractor to do it, ensure he/she is also properly trained to do the work.

Usage of herbicides (and other agrochemicals) must be properly recorded – see **Chapter 17 Records Keeping.** These records are useful for monitoring the cost and resource inputs needed for good field maintenance; they are also mandatory for all certification standards including ISPO.

For the rest of this section, when use of herbicides is suggested, it is implicit that you must:

(i) be self-aware of the risks,

(ii) seek prior advice on proper usage of the suggested products and methods of application, and

(iii) ensure compliance with any statutory or certification limitations.

13.7 Maintain clear paths & palm circles

- Any old tree stumps in the paths or logs lying across the paths should be removed. Ideally, these should have been removed during field preparation for planting.
- Vegetation in the paths and circles should be cut low using an appropriate tool (e.g., grass knife or motorized cutter) or uprooted (using a hoe).
  - This can be done as often as needed – based on your own assessment (or feedback from your workers) of ease of movement in the field. It is recommended that the weeded circle should be clean manually with rotation once in 1-1.5 month.
  - Chemical control is recommended started on TBM 3 (immature 3) with once in 2 months period. Meanwhile, ground cover plant control in harvesting path should be done 3 times alternately with chemical control (if needed) and 1 time with manual control.
  - Ground cover plant control can be carried out manually by clearing as high as 30 cm from the ground and rotation every 3 months.

    If spraying using herbicide is done:
    > Do not spray paths more than 1 m wide.
    > Do not spray circles wider than 2 m radius around the base of the palm tree trunk.

13.8 Some recommendations for action

1. Woody-stemmed weeds

- These weeds must be eradicated – they absorb and fix-up nutrients for as long as they are alive, making those nutrients unavailable for your oil palm trees.
  - Ideally, uproot these woody weeds and remove them from the field to avoid regrowth.
  - Such weeds can also be selectively sprayed out using suitable herbicides (e.g., triclopyr or methsulfuron-methyl).

2. Rubber sapplings

- If your field was converted from rubber, and the stumps were not uprooted or properly killed, rubber saplings may re-grow from the stumps.
  - They compete with the oil palm trees and may be a source of *Ganoderma* fungus that can infect your oil palm trees – so they must be eradicated.
  - Ideally, uproot the stumps and remove them from the field.
  - Poisoning can also be done to kill the living stumps and any regenerated saplings.
    - Triclopyr mixed with diesel can be used for this.
    - The rates depend on the product (there are different brands and concentrations), so be sure to consult the product supplier or an expert for advice on correct and safe usage.

    - Use a brush to apply the chemical mixture on the base of the tree stump or sapling.

3. Soft herbaceous plants and creepers

- Such plants should be controlled from becoming too dense.
  - *Asystasia* can grow under the shade of mature palm trees. It flowers freely and will spread rapidly through seed, therefore, timing of control is important – it should be cut back or sprayed before flowering starts.
  - *Mikania* needs sunlight, so it tends to be found in vacant areas and is more of a problem in younger mature palms when the tree canopy is not yet fully closed. It is a rapid growing creeper which can cover the fronds of palm trees when they are still small or short. It also flowers and spreads by seed. If manual control is attempted, pulling & slashing back the creepers must be done regularly before flowering starts.
    - 2,4-D Amine or fluroxypyr are examples of chemicals for effective control of *Asystasia and Mikania.*

4. Grasses

- Grasses are relatively easy to control and manage by regular cutting either manually or using grass cutter machines.
  - An effective herbicide for grasses is glyphosate.

5. Volunteer oil palm seedlings (VOPS)

- These germinated from uncollected loose fruits (Photo 13.3 a) or harvested bunches left to rot in the field (Photo 13.3 b).

Photo 13.3 Volunteer oil palm seedlings: (a) From uncollected loose fruits; (b) From harvested bunch left to rot in the field (Source: C. Donough).

- They should be uprooted and removed or sprayed out.
  - o Herbicides that are effective for eradicating VOPS are glyphosate monoammonium*; both chemicals are quick acting (90-100% kill within 2 weeks after spraying) and give relatively long-lasting control (up to 8 weeks after spraying).
- ***There are several types of glyphosate – perhaps most commonly used as a grass killer is glyphosate isopropylamine. Glyphosate monoammonium is less common.***

CHAPTER 14. BMP 6 - PESTS & DISEASES MANAGEMENT

Objectives of pests & diseases management are:

1) To avoid an outbreak of pest and/or disease, and
2) If there is an outbreak, to quickly bring it under control.

14.1 Normal, healthy, and balanced field

In your field, besides the oil palm trees, there are many other plants and living organisms including animals and insects. In normal conditions, all the living organisms should be inter-dependent on each other in a stable way.

- There may be pests present, but their impact on the palm trees will be minimal because their number will be low as they are being 'controlled' by other insects.
- Healthy oil palm trees are usually not easily susceptible to be infected by diseases.

14.2 What is a pest or disease outbreak?

An outbreak is a situation where the numbers of a pest, or cases of a disease, in a field becomes uncontrolled and increases quickly which will be very detrimental economically.

14.3 What is the impact of an outbreak on your oil palms and your field?

Fresh fruit bunch (FFB) yield is directly reduced, because:

- Bunches are damaged – for example by rats, *Tirathaba* (insect), and *Marasmius* (fungus)
- Bunches that are poorly pollinated (and likely will be rejected by palm oil mills) may increase – due to reduced population of pollinator insects and/or insufficient pollen when male flowers are damaged by rats
- Bunches are lost (i.e., cannot be harvested) when a diseased tree falls over or it's trunk breaks – for example due to internal stem rot caused by *Ganoderma* (fungus)

Future (i.e., potential) FFB yield is reduced, because:

- Fronds are severely damaged and cannot function optimally – for example due to leaf-eaters, most commonly nettle caterpillars (example – Setora) and/or bagworms (example – Metisa)
- Growth is stunted and new fronds are damaged and/or reduced in size – for example due to damage by rhinoceros beetles
- Unhealthy palms dying slowly from internal stem rot caused by *Ganoderma.*

14.4 What situations or practices can cause an outbreak in a field?

Below are some examples of situations and practices that can cause an outbreak in your field:

- Improper use or over-spraying of herbicides – resulting in large (or whole) areas of bare soil conditions in the field.
  - o Until there are no more (or not enough) plants to support beneficial insects that help to control leaf-eating pests such as nettle caterpillars and bagworms.
- Poor nutrient status (i.e., health) of the oil palm trees – for example due to insufficient or imbalanced use of fertilizers
  - o Unhealthy trees are more susceptible to diseases like *Ganoderma* stem rot.
- Under-pruning, and/or too long harvest interval, will create conditions conducive for disease like *Marasmius* bunch rot and pests like *Tirathaba* bunch moth to spread.
- Presence of breeding/nesting/resting sites for pests and/or disease-causing organisms – for example:
  - o Pruned fronds stacked too high – become breeding sites for rats,
  - o Dead/rotting trees not quickly destroyed – become breeding sites for rhinoceros beetles

and likely source of *Ganoderma* fungus,

- o Too many rotten bunches and/or fruits – become sources for *Marasmius* fungus.

14.5 Maintain good field conditions & palm health to manage pests & diseases

From the above, you can see that maintaining good field conditions as well as good palm health are very important basic steps in managing pests and diseases, by:

- Maintaining a healthy and balanced environment in the field,
- Encouraging and maintaining the presence and population of beneficial insects, and
- Ensuring the oil palm trees are in a healthy state to resist disease infection.

14.6 Additional steps to manage pests & diseases

Besides proper maintenance of field conditions and palm tree health, the following steps are also important:

- Regularly look out for the presence of pests and/or diseases so that quick remedial action(s) can be taken if needed – for example walk through your whole field once a month; and
- If there is a sign of pest(s) or disease(s), take quick action to eliminate them or minimize their spread or escalation in population.

14.7 Importance of community cooperation for effective control of pests & diseases

- Pests or diseases do not recognize field or farm boundaries, so can spread from farm-to-farm / field-to-field. Especially as farmers' fields tend to be small and many are adjoining or close to each other, what happens in one field will have an impact on the neighbouring field(s).
- An individual farmer's action can cause an outbreak not only in his/her own field but can easily spread to neighbouring fields. Likewise, any one farmer's action(s) to control a pest or disease outbreak in his/her own field will not be effective if the outbreak is already occurring in more than 1 farm or field, or if the outbreak or infestation is occurring at the boundary between farms or fields.
- Therefore, communication among farmers – especially those with neighbouring farms / fields – is critical, either voluntarily or through farmers' organizations, or coordinated by an extension agency.
- In an outbreak situation, ALL affected farms / fields, as well as farms / fields surrounding them (even if not affected), must be managed in a coordinated way to (1) limit the spread of the outbreak, and (2) effectively bring the outbreak under control.

14.8 Important considerations when implementing control measures, especially using pesticides

If actions are taken to control pests or diseases, ensure that:

- Actions are properly targeted – especially when using pesticides (i.e., insecticides, fungicides) – to minimize harm to non-target organisms, especially beneficial insects;
- All pesticides are properly handled (including storage and disposal) – for your personal safety, for safety of other natural life, and to avoid contamination of the environment in the field;
- Application tools are properly used – follow recommendations from the equipment manufacturer; and
- Chemicals (including empty containers and any leftover product) are properly handled and managed to minimize danger to your environment and to others.

In general, pesticide use should be based also on 4R principles (similar to fertilizer application):

- **Right pesticide**
  - The product must be suited to the pest or disease targeted – therefore, correct identification of the pest or disease is important. If in doubt, consult an expert or extension agent.

- Especially insecticides, some are broad spectrum and will kill indiscriminately, so they must be used with extreme care; some are selective (i.e., will kill only certain types of insects), so they are safer for non-target organisms.
- Some insecticides act after they are eaten by the pest, so crop damage may continue until the pest outbreak is under control.
- Another type acts by repelling the pests (usually by a strong smell), so can be dangerous to the person applying it, therefore application must follow strict safety guidelines.

- **Right application rate**
  - To ensure a good kill of the targeted pest or disease-causing organism.
- **Right application time**
  - For insect pests, certain stages in the insect life cycle are more susceptible to insecticides – so applications should be timed to match the correct life cycle stage (usually the young stages or the adult stage).
  - For diseases especially those caused by fungi, treatment should ideally be done before there are fruit bodies that release spores that spread the disease.
- **Right application method (& equipment)**
  - Safety to the person applying the chemical,

as well as safety for non-target organisms and the environment, must be considered.

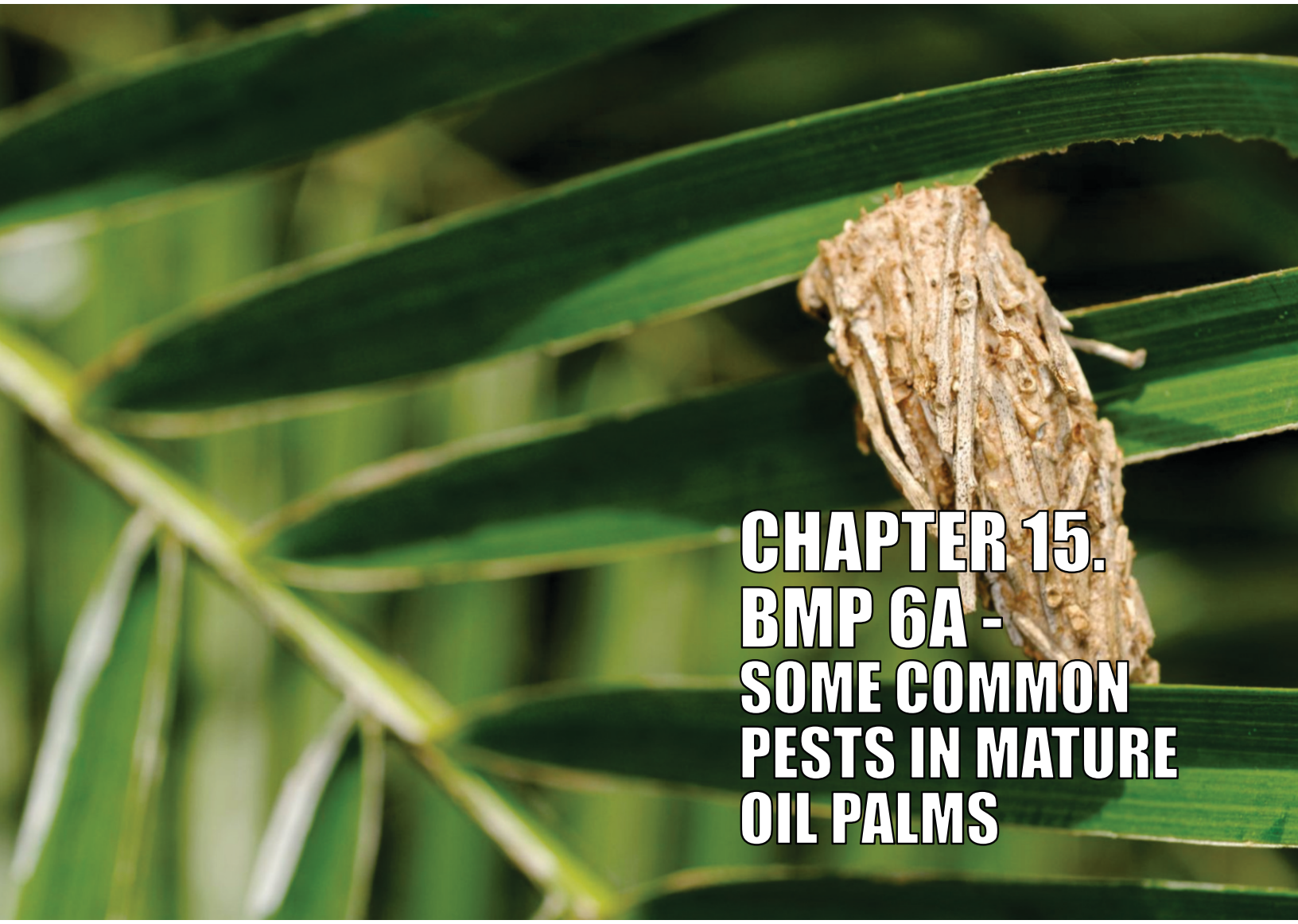
- Insecticides for leaf-eating pests can be applied in several ways:
  - Spraying – if the fronds to be treated are within reach from the ground,
  - Fogging – if the fronds cannot be reached by sprayers; for fogging, use a selective insecticide to minimize harm to non-target organisms,
  - Trunk injection – with systemic insecticide that can move from the trunk up to the fronds.
- For treatment of bunches:
  - Fungicides for Marasmius bunch rot, or insecticides for Tirathaba, can be applied using sprayers – if bunches that need treatment can still be reached from the ground.
  - For bunches that are out of reach, fogging can be used to apply a selective insecticide for Tirathaba; but for bunch rot, it may be safer to just ensure timely harvesting, proper pruning and removal of affected bunches than applying fungicide.
- All equipment used should be properly calibrated.

Ideally, if you are going to undertake pesticide application by yourself, you should seek training by approaching your local farmers' organization who may be able to direct you to a training provider. If you hire a contractor to do it, ensure he/she is also properly trained to do the work.

Usage of pesticides must be properly recorded – see **Chapter 17 Records Keeping.** These records are useful for monitoring the cost and resource inputs needed for good field maintenance; they are also mandatory for all certification standards including ISPO.

In the following chapters, whenever use of pesticide is suggested, it is implicit that you must (i) be self-aware of the risks and (ii) seek prior expert advice on proper usage of the suggested products and method(s) of application.

In the next 2 chapters, we describe some common pests & diseases in fields of mature oil palm trees and suggest some action(s) if there is an outbreak.



CHAPTER 15. BMP 6A - SOME COMMON PESTS IN MATURE OIL PALMS

There are numerous pests of mature oil palm trees, including insects and animals (e.g., rats). Here we describe what are likely the most common pests that you may encounter, and what you can do to manage them in order to achieve the objectives of pests & diseases management, which are to avoid outbreaks, and to bring any outbreak under control quickly.

In this section, we describe the following important pests:

1) Leaf eaters – Nettle caterpillars & Bagworms,
2) Rhinoceros beetle,
3) Bunch moth, and
4) Rats

Note that in the field:

- several pests may be present at the same time,
- some pests may not be seen (because they are active only at night), so their presence is known from the symptoms of damage that they cause to the oil palm fronds or bunches.

15.1 Leaf eaters - Nettle caterpillars & Bagworms

15.1.1 Common types

Many forms or species of nettle caterpillars and bagworms can attack oil palm:

- Common nettle caterpillars include *Setora* (Photo 15.1a), *Sethosea* (Photo15.1b), and *Darna* (Photo 15.1c)
- Common bagworms include *Pteroma* (Photo 15.1d) and *Mahasena* (Photo 15.1e).

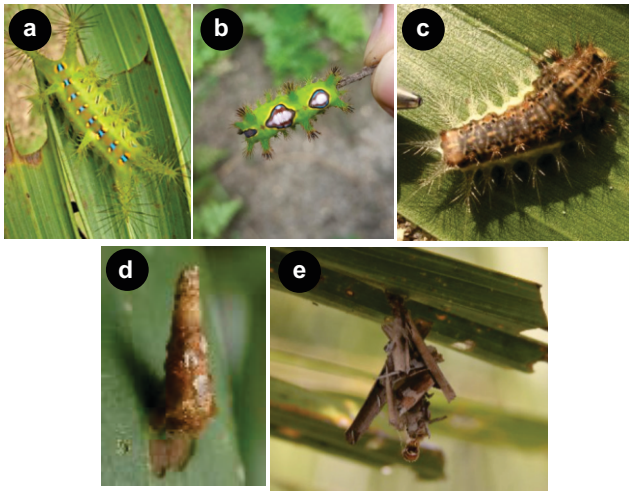


Photo 15.1 Common leaf eating pests of oil palm - nettle caterpillars (a) *Setora*, (b) *Sethosea*, (c) *Darna*, (d) *Pteroma*, (e) *Mahasena* (Source: (a) Indonesian Oil Palm Research Institute, (b & c) I. Pradiko, (d) C. Donough, (e) H. Sugianto).

15.1.2 Damage symptoms

Nettle caterpillars and bagworms feed on the leaflets of oil palm fronds (Photo 15.2a: damage by nettle caterpillars; Photo 15.2b: damage by bagworms).

If the pest population is very high (e.g., in an outbreak), the damage can be so severe that only the midribs of the leaflets remain (Photo 15.2c).

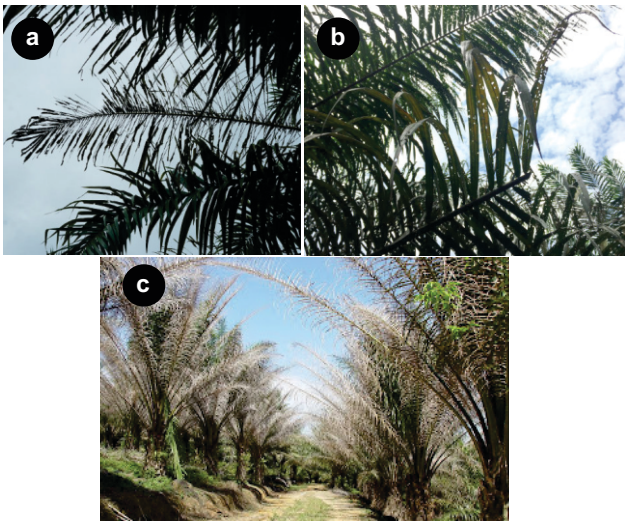


Photo 15.2 Symptoms of damage by leaf eating pests on oil palms - (a) damage by nettle caterpillars, (b) damage by bagworms, (c) severely damage fronds (Source: (a) & (b) I. Pradiko; (c) C. Donough).

15.1.3 Natural enemies

- Some insects – e.g., sucking bugs (Photo 15.3a & 15.3b) or parasitic wasps (Photo 15.3c) – are natural enemies of nettle caterpillars.
- Beneficial insects are present if there are other flowering plants that help support them (see **Chapter 13 Groundcover management).**

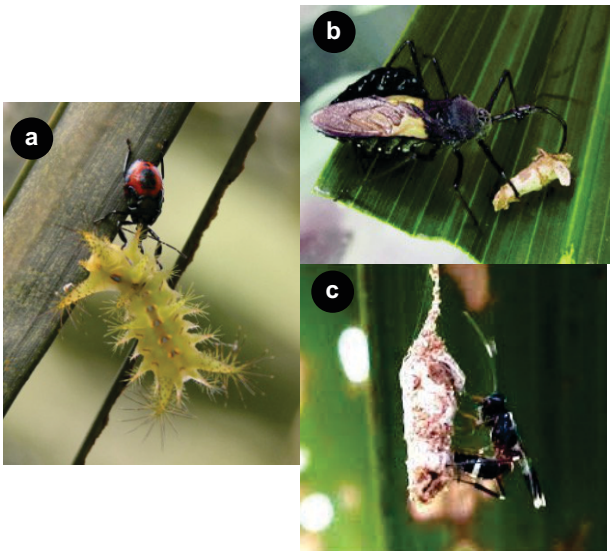


Photo 15.3 Some natural enemies of leaf eating pests of oil palms – (a) Sucking bugs attacking nettle caterpillar, (b) sucking bug attacking bagworm, (c) parasitic wasp on bagworm (Source: (a) H. Sugianto, (b) Ahmad et al., 2020, (c) Amit, 2019).

- Some nettle caterpillars may be naturally infected and killed by a virus
- If virus is present, you will see some dead or infected caterpillars which are usually reddish or brown, and immobile (see Photo 15.4).

Photo 15.4 Healthy nettle caterpillar (right) and infected nettle caterpillar (left) (Source: Priwiratama et al., 2018).

15.1.4 Other host plants

- Nettle caterpillars and bagworms may also live on volunteer oil palm seedlings if they are present in the field and left to grow large without eradication.
- This is another reason to eradicate volunteer oil palm seedlings (see **Chapter 13 Groundcover management**).
- Nettle caterpillars and bagworms may also live on other types of palm trees; and bagworms may also live on other plants including banana, cocoa, or citrus.
  - If such plants are in the field or nearby, they should also be observed for the presence of pests.

15.1.5 Avoidance and control

- Ensure that your field is **NOT** over-weeded (e.g., by blanket spraying), and establish or maintain (if they are already present) flowering plants that support beneficial insects.
- If symptoms of damage are seen on the fronds during pruning or harvesting, check the pruned fronds (immediately, or later) to see if there are live pests – if any are found, destroy them.
- If the damage is only on the lower fronds, those fronds can be pruned and live pests can be picked off and destroyed; this may be an alternative action if suitable pesticide(s) are unavailable, and if the pest population is still low.
- Light traps (deployed at night) can be used to trap adult stages (moths) of these pests – destroying the trapped moths will help to break the life cycle of the pests.
- If the pest population is too high for above methods to be effective, application of insecticide will become necessary:
  - A fogger can be used with a selective insecticide (examples – BT-Plus, BT-Max, Dipel, Thurex) quickly to all affected trees, or
  - Trunk injection can be used with a systemic insecticide (examples – Azodrin, Methamidophos).

When using insecticides, always be mindful of avoiding or minimizing harm to non-target organisms (i.e., the beneficial insects such as predators and pollinators).

15.2 Rhinoceros beetles

Rhinoceros beetles – also called *Oryctes (*Photo 15.5) – can be a serious pest in mature oil palm trees, especially in areas where there is oil palm replanting nearby (where they can breed in the old rotting palm tree trunks), or where there are coconuts (which is their preferred host plant).

Photo 15.5 Rhinoceros beetle = *Oryctes rhinoceros* L. (Source: Indonesian Oil Palm Research Institute).

15.2.1 Breeding sites

- The beetles lay their eggs in rotting woody material (Photo 15.6), or other decomposing organic material (e.g., piled up empty fruit bunches). Their larvae (called grubs) then feed on the decomposing organic matter.
- In oil palm replants field where the old trunks are poisoned and left standing, or if trunks of trees killed by *Ganoderma*, upper stem rot remain standing, the rotting tops of these standing trunks are the common breeding sites – so it's best to push over dead trees or trunks and chop them up to hasten decomposition.

Photo 15.6 Larvae of rhinoceros beetle in rotting palm trunk (Source: https://apps.lucidcentral.org/ppp/text/web_full/entities/coconut_rhinoceros_beetle_oryctes_108.htm).

- If such fallen trunks are left intact, it's better if a quick growing cover (e.g., *Mucuna bracteata*) can be grown to cover them up to block adult beetles from nesting in them.
- EFB should not be heaped high to avoid beetles from breeding in the heaps.

15.2.2 Damage caused to oil palm trees, and symptoms of damage

- This pest likes to eat the soft tissues inside the palm shoot – so they burrow into the shoot from the fronds, creating characteristic entry holes in the frond petioles (Photo 15.7a), and creating characteristic V-shaped cut-outs in the leaflets of emerging fronds (Photo 15.7b).

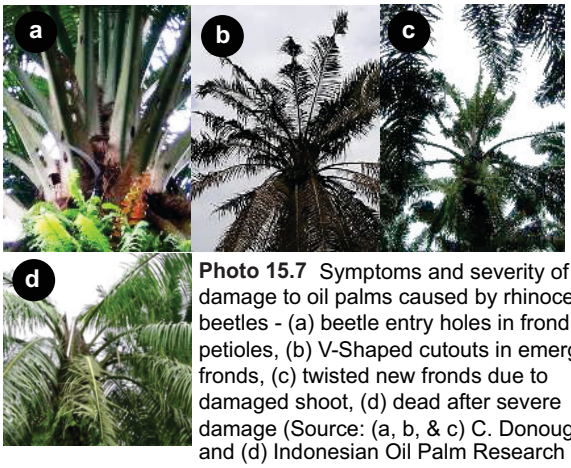


Photo 15.7 Symptoms and severity of damage to oil palms caused by rhinoceros beetles - (a) beetle entry holes in frond petioles, (b) V-Shaped cutouts in emerging fronds, (c) twisted new fronds due to damaged shoot, (d) dead after severe damage (Source: (a, b, & c) C. Donough and (d) Indonesian Oil Palm Research Institute).

- If trees are repeatedly attacked, the damage can become severe even in fully mature trees, resulting in stunted and abnormal growth of the damaged shoot (Photo 15.7c), or death (Photo 15.7d).
- The numerous entry holes and damage to the shoot area of a severely attacked tree can also become entry points for other pathogenic organisms that can kill the tree – e.g., causing spear rot.

15.2.3 Control measures

- Avoid having breeding sites for the pest; destroy any that may be present.
- Use light traps or pheromone-baited traps to capture the beetles and destroy them.
- Insecticides must be applied to the shoot area where new fronds are emerging to be effective and to minimize harm to non-target organisms; or can be applied into beetle entry holes located near the frond base. Therefore, it is only possible to treat mature trees while they are still young (e.g., less than 6 years old) and the shoot area or damaged frond bases can still be reached from the ground:
  - Effective insecticides include Marshal (active ingredient = carbosulfan) and Furadan (active ingredient = carbofuran); these insecticides are granular and can be applied by hand, but they are very toxic and care must be taken during application,

including wearing of masks (and goggles) because these insecticides produce gas (which also acts to repel the pest).

- Control can also be carried out using *Metarhizium sp.* fungus for *O. rhinoceros* larvae.

15.3 Bunch moth

The moth called *Tirathaba* can infest oil palm bunches, especially in young mature trees in the early years of harvesting.

Infestation can occur on both male & female inflorescences. The young larvae tend to be more on male inflorescences; the older larvae (Photo15.8a) move to developing bunches where they bore into the palm fruits (Photo 15.8b).

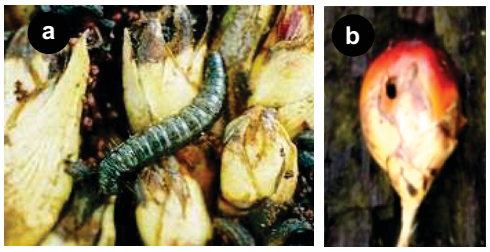


Photo 15.8 (a) Larva of *Tirathaba* bunch moth, and (b) fruit with entry hole made by*Tirathaba larva* (Source: (a) Lim, 2016, (b) Yaakop & Manaf, 2015).

15.3.1 Symptoms of infestation and damage caused

Infested bunches tend to be covered in frass (i.e., droppings of the larvae, see Photo 15.9a).

The frass is reddish when fresh and turns dark colored later. The surface of the fruit around the stigma tends to be damaged (see Photo 15.9b). Affected bunches tend to be poorly pollinated and can become rotten. Affected male inflorescences can develop to anthesis and produce pollen if the infestation is not severe but will fail if severe.

Photo 15.9 Symptoms of *Tirathaba* – (a) bunch covered with frass (i.e., droppings) of *Tirathaba* larvae, (b) fruit surface around stigmas damaged (Source: (a) Lim, 2016, (b) http://soenarko.blogspot.com/2014/02/hama-penyakit-utama-tanaman-kelapa.html).

15.3.2 Natural enemies

- Earwigs (Photo 15.10a)
- Red ants (Photo15.10b)
- Parasitic flies

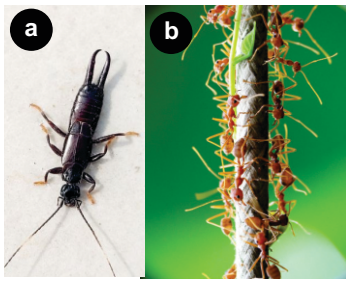


Photo 15.10 Natural enemies of bunch moth - (a) Earwig, and (b) Red ants (Source: (a)nz/taxa/713351-Chelisochinae, (b) https://en.wikipedia.org/wiki/Oecophylla_smaragdina).

15.3.3 Avoidance and control measures

- Avoid having over-ripe and rotten bunches by ensuring timely harvesting.
- Ablation (i.e., removing and destroying developing male & female inflorescences that are infested).
- Use light traps to capture adult moths and destroy them.
- Spray infested bunches with a selective insecticide (examples – BT-Plus, BT-Max, Dipel, Thurex); repeating as necessary until the infestation is over.

15.4 Rats

Several species of rats (Photo 15.11) may be found in oil palm fields. They most commonly nest under frond heaps but may also nest in the tree canopy. They can multiply very quickly so an infestation may escalate very fast if left unchecked.

Figure 15.11 Rats - a common mammalian pest of oil palm (Source:https://www.cabidigitallibrary.org/doi/abs/10.1079/cabicompendium.46832).

15.4.1 Damage caused

- Rats cause damage to oil palm bunches, both unripe and ripe (Photo15.12a). Damaged bunches are usually unacceptable for sale.
- Rats carry off and consume loose fruits (Photo 15.12b).
- Rats damage male inflorescences that have finished shedding pollen (Photo 15.12c) when consuming the larvae of the pollinating weevil that live inside the inflorescence.

This can cause a drop in the pollinator population and subsequently poor pollination of bunches.

Photo 15.12 Damage to oil palm caused by rats - (a) outer fruits of ripe and unripe bunches eaten down to the seed nuts, (b) rat eating a loose fruit, (c) damaged male inflorescence (Source: (a) Indonesian Oil Palm Research Institute, (b) & (c) SOPPOA, 2016).

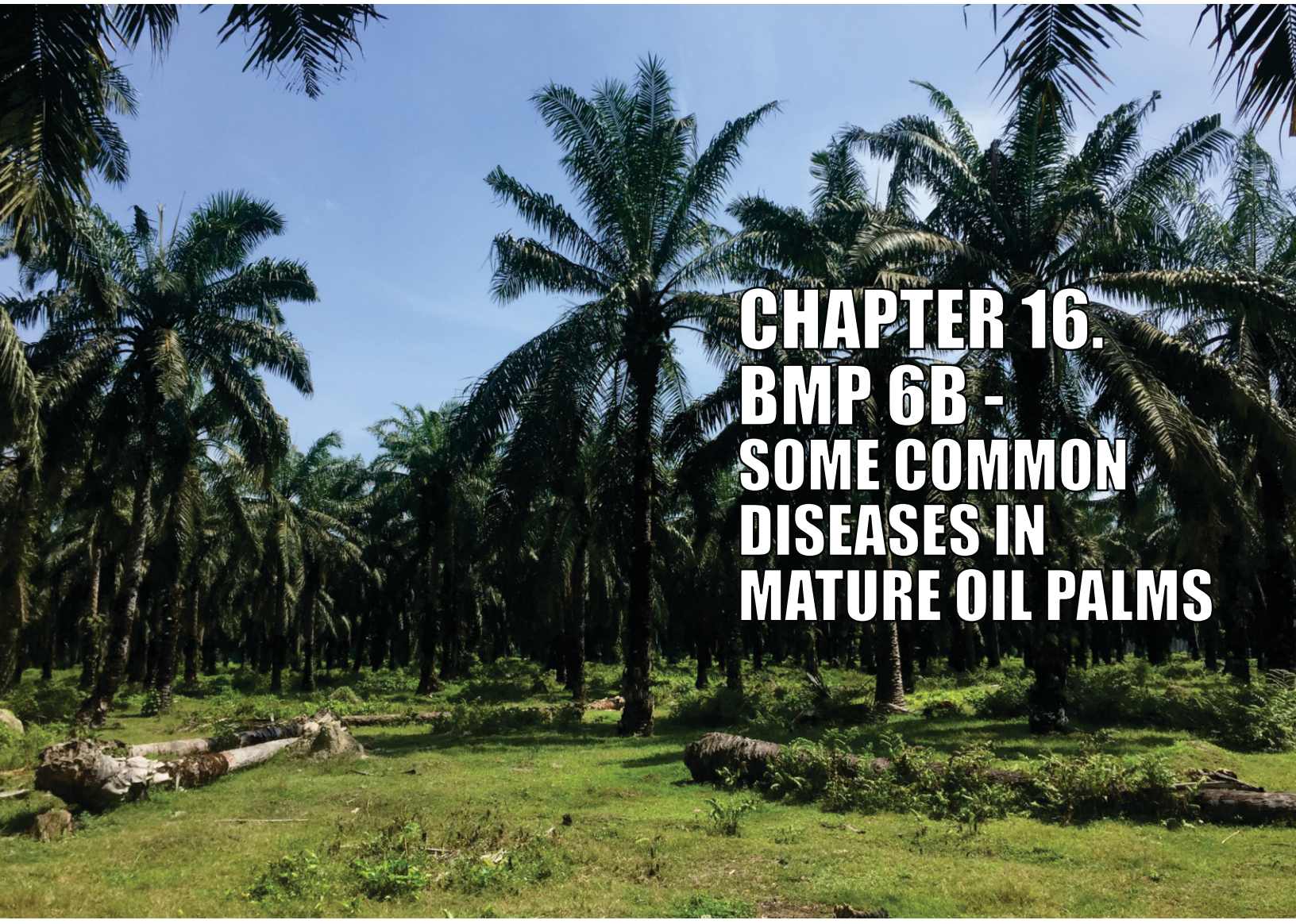
15.4.2 Natural enemies

Predatory birds (e.g., barn owl, Photo 15.13); snakes.

Photo 15.13 Barn owl caught a rat (Source: http://pom-zainal zakariah.blogspot.com/2014 /09/mypalmoil_29.html).

15.4.3 Control measures

- Hunting for nests (e.g., under frond heaps) and destroying them, including killing any rats found.
- Use poisoned baits to kill the rats; if this is done, check with the product supplier that it is safe for non-target organisms (such as the birds that may consume the poisoned rats).



CHAPTER 16. BMP 6B - SOME COMMON DISEASES IN MATURE OIL PALMS

Mature oil palm trees may become infected with many diseases. We describe here the two most common and serious diseases you may encounter in your fields:

1. Stem rot (due to *Ganoderma boninense*), and
2. Bunch rot (due to *Marasmius palmivorus*), and what you can do to manage them.

16.1 Stem Rot *(Ganoderma boninense)*

16.1.1 The disease

Stem rot is a common disease of oil palms – most commonly caused by *Ganoderma boninense.* There are 2 types of *Ganoderma boninense* stem rot:

1. Basal stem rot (i.e., it affects the base of the tree trunk); and
2. Upper stem rot (i.e., it affects the trunk at a higher point in taller trees).

16.1.2 The disease causal agent (pathogen)

Stem rot is most commonly due to *Ganoderma boninense*, a fungus that is naturally present in the soil in many areas, acting to breakdown dead trees. There are many types (or species) of *Ganoderma boninense*, most are not harmful to living oil palms.

16.1.3 Sources of disease in the field and how it spreads

- Old tree stumps – including rubber, coconut, and oil palm tree stumps – may be colonized by *Ganoderma boninense*, becoming sources of disease when roots of living oil palm trees come into contact.

- Buried tree logs – including coconut or oil palm – are also sources of disease.
- Other palm trees, and also legume cover plants, can be colonized by *Ganoderma boninense*.
- Volunteer oil palm seedlings may be infected in the same way as the planted trees; as they are younger and usually neglected, they may be more susceptible to infection – then they become hosts for the pathogen and help the disease spread in the field.

All of the above help to spread the disease by:

- Allowing *Ganoderma boninense* to colonize them and becoming potential sources of infection, and
- Allowing *Ganoderma boninense* to multiply, even to the point when fruiting bodies of *Ganoderma boninense* emerge from the colonized biomass.
- The *Ganoderma boninense* fruiting bodies can then produce millions of spores that will further spread the fungus in the field, as well as to neighbouring fields,
- The spores may also colonize upper parts of living oil palm tree trunks, leading to upper stem rot.

16.1.4 Disease impact and symptoms

Infected trees may die within 1-2 years from the time when symptoms of infection first appear. There is no treatment that can cure infected trees. The impacts of the disease are:

- Stunted growth of infected trees due to destruction of internal trunk tissues.
- Reduced yield of infected trees due to poor health.
- Loss of trees that die.

The initial symptoms of the disease are similar to water stress symptoms (see Photo 16.1):

- Multiple unopened spears,
- Yellowing of fronds, and
- Old (lower) fronds hang down like a skirt.

Photo 16.1 An oil palm tree with initial symptoms of *Ganoderma* infection (Source: C. Donough).

As the infection becomes worse, the tree will show the following later symptoms:

- New fronds become shorter until frond emergence stops,
- Even upper fronds will hang down,
- Production of FFB will stop.

The confirmation that a tree is infected with *Ganoderma boninense* is the production of the distinct *Ganoderma boninense* fruiting bodies on the infected tree trunk (see Photo16.2).

Photo 16.2 Fruiting bodies of *Ganoderma* on the trunk of an infected tree (Source: C. Donough).

When the fruiting bodies first emerge, they look like a white button (see Photo 16.3a). Then they grow into the characteristic plate-like fruiting bodies that are reddish to brown on top, and white underneath (see Photo 16.3b).

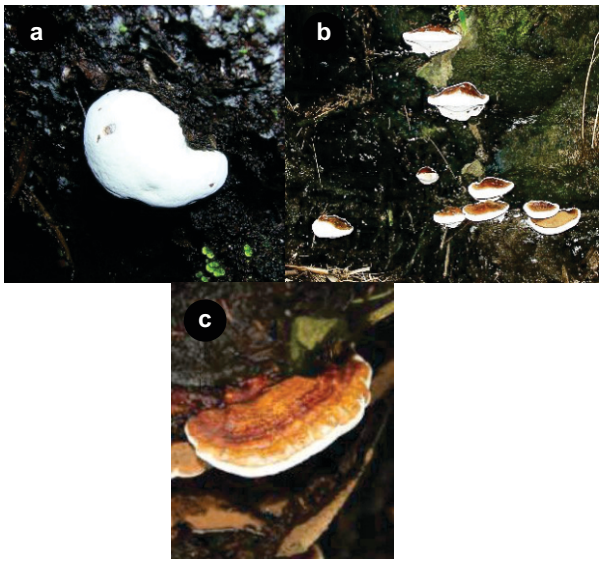


Photo 16.3 Ganoderma fruiting bodies: (a) white button-like when first emerge, (b) when mature, reddish to brown on top, with white edge and underside, (c) fruiting body from *Ganoderma boninense* on oil palm tree (Source: (a,b) C. Donough, (c) Indonesian Oil Palm Research Institute).

On one hand, trees showing presence of *Ganoderma boninense* fruiting bodies may still look healthy, but they are definitely infected. On the other hand, trees that exhibit all the symptoms previously described may not have any *Ganoderma boninense* fruiting bodies; when such trees die and fall over, infection can be confirmed by looking at the exposed internal trunk tissue where the trunk broke.

16.1.5 Avoidance and control

a) Walk through the field regularly to see if there is any tree showing infection symptoms

- Once an infected tree is identified, mark it (if it is still alive)
- If it is no longer productive or dead, refer to c) below for actions to take
- If it is still alive and productive, refer to d) below for actions to take
- Check the field for new infections at least once every 6 months
- If there are any potential sources of infection, see b) below for actions to take

b) Identify and destroy, or remove, all potential sources of infection from the field:

- Tree stumps and logs – in case of stumps, remove as much as possible of the roots
- Avoid burying logs – if not possible to remove, then cut up to hasten decomposition
- Remove & destroy volunteer oil palm seedlings
- If there are any *Ganoderma boninense* fruiting bodies on any of the above, destroy them

c) Infected oil palm tree that is dead or no longer producing bunches –

- Cut down the tree if it is not yet fallen, and dig out the root bole if it is still in the ground
- Dig a large hole (e.g., 1m x 1m x 1m deep) and leave it exposed for a few weeks, then backfill it with soil from a different place (if possible); do not attempt to plant a replacement seedling in this diseased spot
- Chop all the infected tree biomass into small pieces to hasten decomposition
- If there are any *Ganoderma boninense* fruiting bodies on any of the above, destroy them

d) Infected oil palm tree that is still alive and producing bunches –

- Remove all *Ganoderma boninense* fruiting bodies and destroy them – repeat when new fruiting bodies emerge as long as the tree remains alive and productive
- Mound up the base of the tree trunk with soil up to 1m above the ground – this may stimulate growth of new roots and keep the tree alive long enough for the bunches to be harvested
- Once all bunches have been harvested, treat the tree as described in c) above.

16.2 Bunch Rot *(Marasmius)*

16.2.1 The disease causal agent (pathogen)

Bunch rot is caused by *Marasmius palmivorus*, a fungus that is very common in oil palm fields, living on rotting palm tree tissues such as rotting fronds and bunches, especially when conditions are moist.

When conditions are conducive, the fungus can spread from the rotten tissues to colonize healthy tissues, including the frond bases and younger developing bunches.

Once the healthy bunches are colonized, the fungus can multiply quickly covering the developing bunches in a white mycelium (Photo 16.4) and causing the fruits and bunches to rot (see Photo16.5 below).

Figure 16.4 Bunch infected with *Marasmius*
(Source: Indonesian Oil Palm Research Institute).

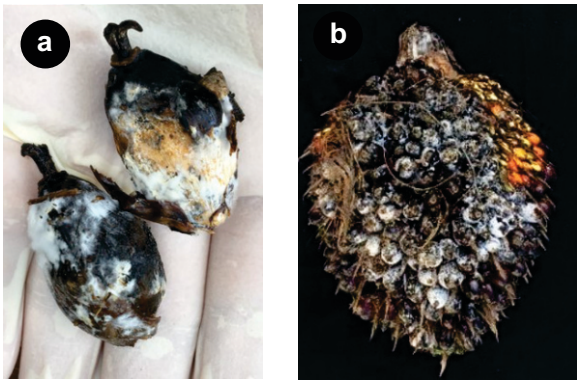


Photo 16.5 (a) Fruits and (b) bunch rotting due to *Marasmius* (Source: Maizatul-Suriza et al., 2021).

16.2.2 Conditions that are conducive for bunch rot

- Presence of rotten bunches or fruits due to:
  - Infrequent and/or improper harvesting, or
  - Abortion (or failure) caused by external conditions (e.g., high soil acidity, or poor pollination)
- Tightly packed fronds (e.g., due to etiolation when tree spacing is too close)
- Presence of rotting old fronds (e.g., due to under-pruning).

16.2.3 Avoidance and control

Marasmius is too widespread in oil palm fields so it is impossible to eradicate. Therefore, control is based on avoiding conditions that are conducive for its spread:

- Ensure that your trees have a good sanitation, well pruned and free of rotten bunches or loose fruits by timely pruning and harvesting
- If there are trees that are etiolated due to close spacing, thin out some of them to allow the fronds of the remaining trees to spread out more and eliminate tight and humid conditions
- If your farm is on soil that can become very acidic (e.g., acid sulphate soil), ensure that measures are in place to avoid development of hyper-acidic conditions such as having structures in place to maintain water level in field drains or using the right fertilizer products that do not contribute to acidity or even reduce it.

CHAPTER 17.
BMP 7 -
RECORD KEEPING

Objectives of record keeping are:

- To know the actual FFB production of the field, and
- To document all the key field practices actually carried out in the field.

17.1 Why is it important to know the FFB production?

- The FFB produced is the source of income.
- FFB production is used to calculate fertilizer application rate (see **Chapter 10 BMP 4b Right Rate**).

17.2 How to assess FFB productivity?

- To know whether your field is performing well or not, you must make comparisons such as:
  - This year compared to last year for your own field, or
  - Your field compared to other fields in your community.
- To compare the FFB production this year versus last year for your own field, you can simply use the total FFB produced from the field.
- However, to compare your field to other fields, it's not so simple.
  - The fields may be different in size, therefore, the total FFB production from your field (as well as from the other fields) must be converted to 'kg per ha' so that the comparison is on the same basis. So, knowing the size of your field is important.

  - The "size of your field" means the area (in ha) planted with oil palm i.e., excluding any area used for any other purposes.
  - If your field includes mature and immature trees, the area of each one must be separated, because the FFB yield (kg per ha) is only from the mature area.

17.3 What are the key field practices which are important to document?

- The key field practices are the BMP in this Pocket Guide, which are:
  - Harvesting
  - Pruning
  - Fertilizer use (based on the 4R principles)
  - Groundcover management
  - Pests & diseases management

- The key field practices are the BMP in this Pocket Guide, which are:
  - Harvesting frequency influences FFB production (**Chapter 2 BMP 1**)
  - Pruning standard influences FFB production and harvesting efficiency (**Chapter 4 BMP 2**)
  - Fertilizer influences FFB production (**Chapters 7, 10-12 BMP 4a-4d**)
  - Groundcover condition influences FFB production and fertilizer efficiency (**Chapter 13 BMP 5**)
  - Pests & diseases management influences FFB production (**Chapter 14 BMP 6**).

17.4 How can the field records benefit you or your community?

If have good records, your data is useful for an agronomist or extension agent, or even yourself and/or your family members to analyse the productivity of your field.

- Such analysis can help to show how to increase the productivity of your field
- And if your records include costs of inputs (labour, material) and revenue from FFB sold, then the information can be:
  - Analysed to see how to increase the profitability of your field, and
  - Used to monitor and manage your cashflow
  - If other farmers in your community have similar records, the combined data will be helpful for extension agencies who are tasked to help your community.

17.5 Making decision based on specific information

Ultimately, the goal of record keeping is to allow you to make decisions for your oil palm field that is based on specific information from the field, rather than relying on general information that you may be able to find from various sources, e.g., standard fertilizer rates, which are most likely not 100% suited to your field.

17.6 GYGA daily diary

In the GYGA project, all participating farmers (i.e., members of the GYGA Club at each of the project sites) have been provided a Daily Diary format for recording information on key field activities – if you choose to continue using the format, it will capture all the key information you need for analysis of the FFB production and associated practices. However, if you prefer to make your own record format, then you can refer to the following notes for guidance on what should be recorded. An example format for monthly records is shown in Appendix 1.

17.7 What are the minimum records that should be kept?

The following are arranged in order of relative importance

a) Field basic information
   - Field location
   - Field size (ideally only the part planted with mature oil palm trees)
     - *This data is important for calculating the FFB productivity of the field (see 17.2 above)*
   - Year of planting of the oil palm trees
   - Actual number of oil palm trees in the field
     - *If any replacement trees are planted, ideally record separately their number planted for each year of replacement planting*
     - *This data is needed for fertilizer application rate calculation*

b) FFB production and harvesting
- Actual date of each occasion of harvesting
  - *This allows the interval (how many days?) between successive harvest occasions to be monitored; the interval influences FFB production*
- Record the FFB weight on each date of harvesting
  - *Summing up the FFB production over one year and dividing it by the field size allows you to calculate the annual FFB yield per hectare*
- Record the total amount of money you received for the bunches sold
  - *Summing up the amount of money received for FFB sold over one year and comparing it to your total cost for the year will show the profit that you earned from the field*
- Record the cost of harvesting (i.e., what was paid to the hired labour, or to your family member(s) who did harvesting)
  - *This information is part of your cost of producing the FFB*

c) Fertilizer use
- Actual date of each application for each fertilizer
- Actual name and type of the fertilizer applied, including the nutrient contents as written on the fertilizer bag(s)
  - *Ideally, an image of the fertilizer bag should be captured in your handphone for reference*
- Actual quantity of the fertilizer that was applied – in total number of bags per field
  - *It's good to collect and count all the empty fertilizer bag after application is completed.*

- Total cost of the fertilizer applied. This should include:
  - *Cost of the fertilizer, and*
  - *Cost of labour for fertilizer application (i.e., what was paid to the hired labour or to your family member(s) who did the fertilizer application)*
  - *If there is a separate cost for transportation of the fertilizer to the field, this should also be recorded*
  - *This information allows you to know, or estimate, the total cost of each round of fertilizer application – so you can better plan your cash flow.*

d) Other field and tree maintenance activities
- These activities include:
  - *Pruning,*
  - *Weeding (including trunk weeding), and*
  - *Pests & diseases management*
- In certain situations, other activities may also include:
  - *Field drainage (may include water level control in drains),*
  - *Slope management (may include harvesting platforms, silt pits, contour terraces),*
- For each activity, the following should be recorded:
  - *Date of work done,*
  - *Definition or description of the work done,*
    - *For weeding, e.g., circle weeding, woodies uprooting, etc*
    - *For pests & diseases, e.g., rat baiting, trunk injection, etc*

- *Material used (if any) – definition, quantity, cost*
- *Labour used (if any) – number of persons, total time spent on the work*

17.8 Using field records to calculate yield, production cost and gross profit

Using the records above, you can calculate your annual FFB yield, production cost and gross profit – see example in Table 17.1

Table 17.1 Monthly & annual summary of (a) FFB yield and revenue, (b) cost of harvesting, fertilizer, upkeep, (c) total field cost, and (d) gross profit for a typical field (Source: data from GYGA Club Riau).

Month	FFB Yield (kg/ha)	FFB revenue (IDR/ha)	Harvest cost (IDR/ha)	Fertilizer cost (IDR/ha)	Upkeep cost (IDR/ha)	Total Field cost (IDR/ha)	Nett Revenue (IDR/ha)
Jan-20	896	1,487,582	140,639	27,858	18,271	186,768	1,300,814
Feb-20	694	1,074,870	109,488	6,874	724	117,086	957,784
Mar-20	875	1,180,446	134,500	-	8,683	143,183	1,037,263
Apr-20	919	1,192,650	144,130	11,758	56,682	212,570	980,080
May-20	1,095	1,116,733	167,511	6,392	482	174,385	942,348
Jun-20	1,185	1,274,993	184,660	-	19,959	204,619	1,070,374
Jul-20	1,344	1,673,465	212,800	-	30,029	242,829	1,430,636
Aug-20	1,358	1,887,586	207,035	34,491	26,001	267,527	1,620,059
Sep-20	1,428	2,166,537	219,397	48,179	21,587	289,163	1,877,374
Oct-20	1,390	2,217,869	214,885	23,034	12,542	250,461	1,967,408
Nov-20	1,346	2,399,812	205,745	22,817	1,749	230,311	2,169,501
Dec-20	1,217	2,226,839	188,971	-	10,372	199,343	2,027,496
Total	**13,746**	**19,899,382**	**2,129,761**	**181,403**	**207,081**	**2,518,245**	**17,381,137**

- FFB yield is expressed in kg per ha (as shown in Table 17.1 above)
  - Annual yield = total for 12 months (can be Jan- Dec, or any 12 consecutive months)
- Note that monthly yield varies within a year – for example in Table 17.2 below:
  - There is a low period of yield, with the lowest yield during Feb-2020 for both the typical field (i.e., with more or less average yield for the location) as well as the good field (i.e., within the top 10% for the location), and

  - There is a high period of yield, with the highest yield in Sep-2020 in the typical field, and in Jul-2020 in the good field.
  - This type of low-high yield pattern each year is normal.

Table 17.2 Monthly & annual FFB yield of a typical & a good field (Source: data GYGA Club Riau).

Month	Typical field FFB Yield (kg/ha)	Good field FFB Yield (kg/ha)
Jan-20	896	2,137
Feb-20	694	1,710
Mar-20	875	2,056
Apr-20	919	2,309
May-20	1,095	2,837
Jun-20	1,185	2,510
Jul-20	1,344	3,336
Aug-20	1,358	2,991
Sep-20	1,428	3,144
Oct-20	1,390	2,881
Nov-20	1,346	2,791
Dec-20	1,217	2,296
Total	13,746	30,998

- What is a good yield or poor yield?
  - Often farmers tend to think in terms of average monthly yield – e.g., if the average expectation is 1,000 kg/ha per month, so:
    - In months when the yield is below 1,000 kg/ha, there is anxiety, and
    - In months when the yield is above 1,000 kg/ha, there is satisfaction.
  - This way of thinking can be misleading –
    - Because of the natural low-high yield pattern as explained above.
    - Months with yield below 1,000 kg/ha may be due to the natural low period, but
    - When the yield for a month is above 1,000 kg/ha, there may be high losses if harvesting is poor, because in good fields, the yield during the peak period may be over 3,000kg/ha per month (see Table 17.2).
    - Note that in the good field, there is no single month with yield below 1,000kg/ha
  - To assess whether FFB yield is good or poor, it's better to use annual (i.e., 12-month period) yield in "kg per ha".

17.9 Extra records and activities that are helpful for improving performance

The following extra records and activities are also helpful if you are interested in more detailed analysis of the productivity of your field with the aim to improve performance.

a) Field basic information
   - A map of the field
     - This can be hand-drawn sketch map
     - The map should be updated whenever there is a change in field size and/or number of trees.
   - Type/source of planting material (e.g., certified seeds from PPKS)
   - Previous crop planted on the land (e.g., rubber)

b) FFB Production and harvesting
   - Record the total number of harvested bunches on each date of harvesting
     - If you do harvesting by yourself, it should be easy to just record how many bunches you cut
     - If someone else is harvesting your field for you, it should be just as easy for them to inform you the number of bunches they cut
     - Knowing the number of harvested bunches is useful if your field is prone to bunch stealing – especially if harvesting is done by someone else for you.

- Do harvest audit on the day after harvesting is done – to assess the amount of unharvested or uncollected bunches / fruits
  - This is especially important if harvesting is done by someone else (e.g., hired labour)
  - The bunches and fruits left unharvested or uncollected may not be recoverable by the next occasion of harvesting – so it is a loss to you, especially if you have invested in inputs like fertilizer in the past that helped the trees produce those bunches / fruits
  - During the harvest audit, also count the number of fresh cut bunch stalks on the trees
    - > The number of fresh cuts should be the same as the reported number of harvested bunches
    - > If it is higher, it means stealing occurred and you will know how many bunches were stolen
- If you use hired labour for harvesting, or even if harvesting is done by yourself and/or your family members, ideally record the following –
  - Number of harvesters (i.e., all persons doing some activity related to harvesting e.g., cutting bunches, collecting loose fruits, carrying bunches to collection point, stacking fronds pruned during harvesting), and
  - Time spent on harvesting (i.e., starting time and completion time –

so that the number of man-hours spent on harvesting can be calculated).

- ***This information combined with the bunch number allows you to calculate the productivity of harvesting work – so that you may be able to improve the efficiency of the work.***

c) Fertilizer use

- Do a field audit after fertilizer application is completed (either same day or next day) to record the actual number of trees that received fertilizer
  - This is especially important if fertilizer application was done by someone else for you, so that you will know whether the work was properly done
  - NOT all trees may have received fertilizer if:
    - > The application tool used was inappropriate, or not calibrated or wrongly calibrated, or
    - > The person(s) applying the fertilizer are inexperienced
- Do a census of visible nutrient deficiency symptoms
  - This census can be done at least once or twice a year
  - It will provide helpful information about which nutrients are lacking in your field, which may still occur even if you are applying fertilizers regularly

- The focus can be on symptoms that are clear i.e., Potassium (= kalium, K) deficiency, Magnesium (Mg) deficiency, Boron (B) deficiency, and N:K imbalance (white stripe) – see **Chapter 8 Deficiency symptoms** for more detail

- If you use hired labour to apply the fertilizer, or even if it was done by yourself and/or your family members, ideally record the following:
  - Number of workers/persons involved (i.e., all persons doing some activity related to fertilizer application e.g., transporting fertilizer bags, applying fertilizer, collecting and counting empty fertilizer bags), and
  - Time spent on fertilizer application (i.e., starting time and completion time – so that the number of man-hours spent on fertilizer application can be calculated)

- ***This information combined with the total quantity applied allows you to calculate the productivity of fertilizer application – which will vary according to the quantity applied – this is important for future planning of this important activity.***

- If you have access to rainfall information that is relevant to your field, it is also good to record it because it can be helpful for planning a future schedule for fertilizer applications (see **Chapter 11 BMP 4c Right Time**).

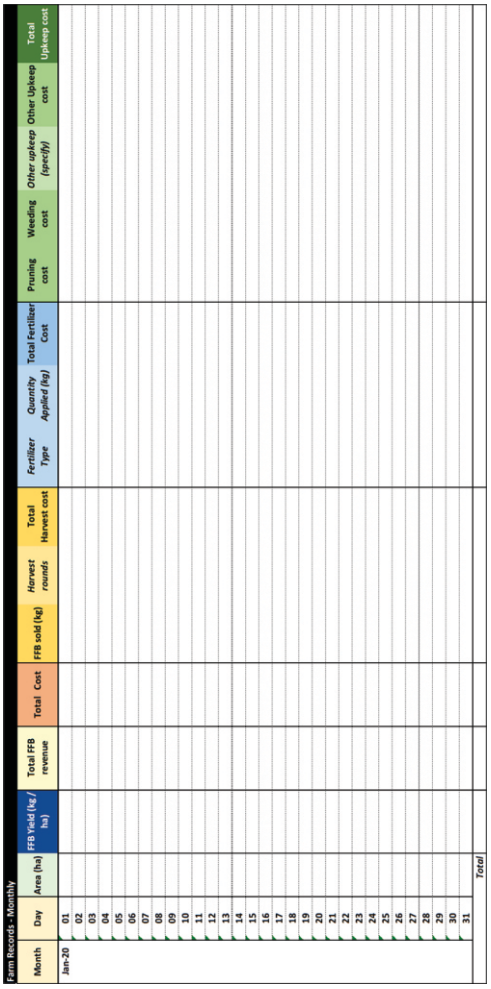
- Relevant rainfall information means –
  > Information from your local weather station (if there is one), or
  > Information from a rain gauge installed & operated by your village / community
- The information to be recorded are –
  > Quantity of rainfall (in mm), and
  > Days of rain
- If the data is from your local weather station, it is likely to be in monthly totals
- If the data is from your own community rain gauge, it should be daily data

d) Chemical use

Certification standards (e.g., ISPO) may also require the following records:

- Storage, treatment and disposal of used containers or leftover material or residues
- This may include other chemicals used (e.g., petrol or diesel) that may pollute the environment if not properly handled.

Appendix 1.
Sample Format - Monthly Records



Farm Records - Monthly																				
Month	Day	Area (ha)	FFB Yield (kg / ha)	Total FFB revenue	Total Cost	FFB sold (kg)	Harvest rounds	Total Harvest cost	Fertilizer Type	Quantity Applied (kg)	Total Fertiliser Cost	Pruning cost	Weeding cost	Other upkeep (specify)	Other Upkeep cost	Total Upkeep cost
Jan-20	01															
	02															
	03															
	04															
	05															
	06															
	07															
	08															
	09															
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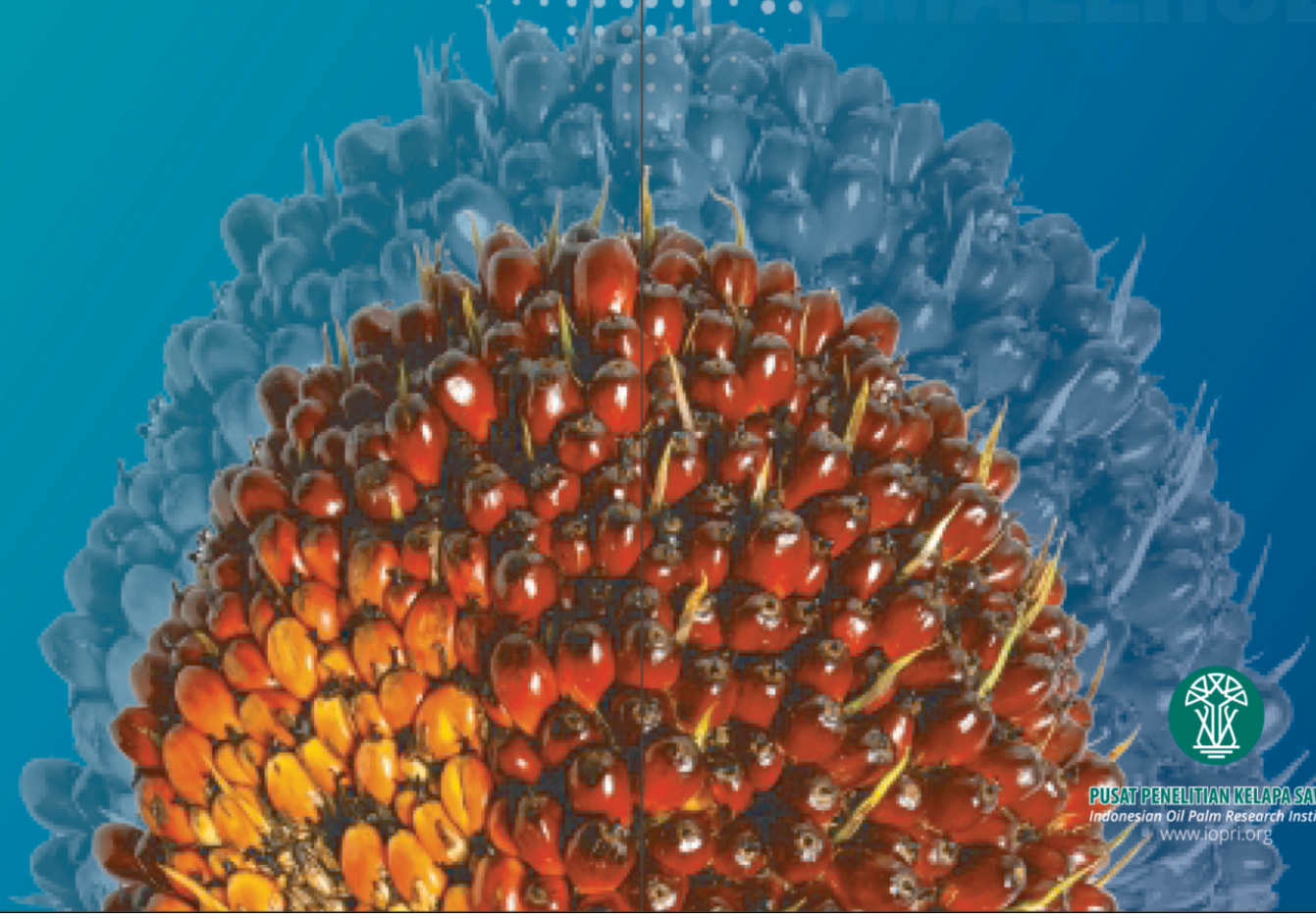
POCKET GUIDE
INDONESIAN OIL PALM SMALLHOLDERS



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EXTENSION