

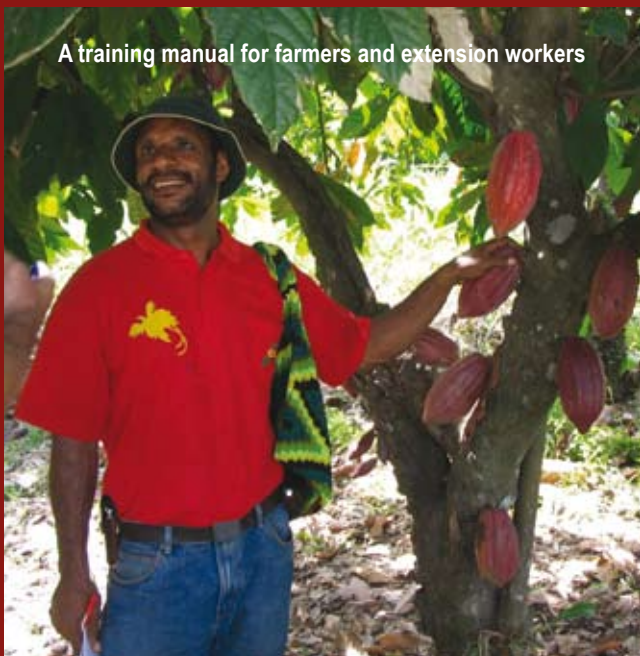


Australian Government

**Australian Centre for
International Agricultural Research**

Integrated Pest and Disease Management for Sustainable Cocoa Production

A training manual for farmers and extension workers





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Integrated Pest and Disease Management for Sustainable Cocoa Production

A training manual for farmers and extension workers

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2008



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Published by the Australian Centre for International Agricultural Research (ACIAR)
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Konam J., Namaliu Y., Daniel R. and Guest D.I. 2008. *Integrated pest and disease management for sustainable cocoa production: a training manual for farmers and extension workers*. ACIAR Monograph No. 131, 36 pp.

ISBN 978 1 921434 57 0 (print)
ISBN 978 1 921434 58 7 (online)

Technical editing and production management by Biotext Pty Ltd
Design by Design ONE
Photographs by David Guest, Rosalie Daniel and Smilja Lambert
Printing by Finsbury Green

Foreword

Cocoa is a major source of income for rural families and plays an important role in wealth generation and improving the quality of life in many tropical countries, including Papua New Guinea (PNG). However, the potential benefits of new planting materials available since the 1980s have not been realised. Improved management of mature cocoa stands could produce sustainable yields of more than 1,000 kg per hectare per year, but average yields remain at 300 kg of dry cocoa beans per hectare per year.

This booklet accompanies the 'Classroom in the Cocoa Block' training, which is part of a suite of projects funded by the



Australian Centre for International Agricultural Research (ACIAR) in PNG that strategically address knowledge gaps in cocoa production. New management approaches, based on sound agronomic practices and integrated pest and disease management (IPDM) strategies, have been developed to assist farmers to optimise their cocoa production. Farmers can expect significantly higher yields if these approaches are implemented completely and correctly.

A key feature of the development of the IPDM strategies is acknowledging that individual farmers and their families differ in their priorities and levels of access to resources. The aim is to demonstrate options and assist farmers in their choices of the most appropriate management level for their particular circumstances. The project 'Enhancing Papua New Guinea Smallholder Cocoa Production through Greater Adoption of Disease Control Practices' aims to develop pest and disease management options that make it possible to meet the PNG target of 100,000 tonnes of dry cocoa beans per year by 2012.

The principles underlying improved cocoa management in PNG apply to other regions as well, and ACIAR hopes this booklet and the accompanying training will be used widely.

A handwritten signature in black ink, appearing to read 'Peter Core'.

Peter Core

Chief Executive Officer, ACIAR

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Acknowledgments

The IPDM technologies were developed with support from ACIAR Project ASEM/2003/015, AGIF Project 1048 and the following people:

- Philo Asia, Peter Bapiwai, Yoel Efron, Peter Epaina, Chris Fidelis, Paul Gende, Godfrey Hannet, Anton Kamuso, Wendy Konam, Elizabeth Maras, Susanna Namaliu, Jack Nideson, Paul N'nlau, Josephine Saul-Maora, Roslyn Tade, Henry Tangbil, John-Thomas Vano, Ricky Wenani, Olisha Wesley and David Yinil, from the Cocoa Coconut Institute Papua New Guinea, for their assistance in the research and extension, and the establishment of field sites
- Maia Wamala, from the Papua New Guinea University of Technology, for training of students in integrated pest and disease management technologies
- Smilja Lambert, from Mars Incorporated, for providing expertise throughout the project, and valuable feedback during the development of this manual
- Greg Johnson, from Horticulture 4 Development, for his involvement in the initiation of the project.

A close-up photograph of several cocoa pods, showing their characteristic ribbed texture and light brown color. The pods are arranged in a cluster, with some in sharp focus and others blurred in the background. The lighting is soft and natural, highlighting the organic shape of the pods.

1 Introduction

1.1 The cocoa cropping cycle

Cocoa (*Theobroma cacao*) is an understorey tree originating in South American rainforests. Flowering is initiated in response to seasonal changes. In Papua New Guinea (PNG), hybrid cocoa will begin flowering about 30 months after planting, while clonal trees may take only 15–24 months to flower. Full production is achieved when trees are 4–5 years old, and can be maintained for 20 years or more with good management.

At the end of the wet season (March), trees produce a flush of new leaves. Soon afterwards (April–July), flowers are produced. If pollinated, these flowers will develop into mature pods after 5–6 months. Therefore, the main harvest is during October–January, and up to 60% of the year's harvest comes from this crop.

A second growth flush (leaves followed by flowers) occurs at the start of the wet season (November), and the resulting mid-crop is harvested from April to July.

1.2 Integrated pest and disease management

Scientists at the Cocoa Coconut Institute of Papua New Guinea (CCI) have developed a series of low-, medium- and high-input options (involving pruning, pest and disease control, shade tree management and resistant varieties), which form the basis of integrated management strategies to reduce yield losses from pests and diseases in the cocoa crop.

Integrated pest and disease management (IPDM) is designed to balance and manage activities in relation to the cocoa cropping cycle (Table 1). While new planting materials are one component, IPDM technology is equally effective when it is applied to existing plantings of hybrid or clonal cocoa. IPDM is designed to maximise benefits to the farmer by improving the health of the cocoa plants.

The application of IPDM to the cocoa crop enables farmers to choose management strategies suited to their situations and needs. The use of an integrated management system reduces the levels of pests and diseases in the cocoa crop, reduces the inappropriate use of chemicals, provides alternatives for pest and disease management and improves the yield and quality of the cocoa, thereby increasing farmer income.

Higher yields will result because IPDM involves:

- improved planting material from CCI with higher yield potentials, enhanced disease resistance and structurally superior characteristics
- effective rehabilitation of existing, established cocoa trees
- timely pruning of cocoa and shade trees to improve light interception and airflow, and stimulate growth

- sanitation to reduce pests and disease inoculum
- interference with pest and disease cycles and vector movement
- weed control
- use of manures or fertiliser to improve cocoa nutrition.

Table 1 The cocoa cropping cycle

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Main crop												
Mid-crop												

Legend: Flowering and cherelle development
 Harvest period

Note: The dates in the cropping cycle are based on experiences in East New Britain Province and may vary slightly in other regions of PNG. Please speak with your local CCI or Department of Primary Industries (DPI) representative for more information.

In general, IPDM inputs (cocoa tree pruning, sanitation practices, weed management, fertiliser application and shade tree management) should be applied 3 months before flowering (main and mid-crops) to promote flowering and pod development rather than vegetative growth. Diseased pods should be removed during weekly harvests.

1.3 IPDM options

Research conducted by the pathology and plant breeding sections at CCI has led to the development of a selection of IPDM strategies for sustainable cocoa production by smallholder cocoa farmers. The disease management input options (Table 2) range from a low input to the more time-consuming and expensive high-input

level. The choice of options recognises variability in cocoa farmers' economic circumstances, family situations and aspirations.

The outcomes of IPDM are to:

- improve tree health
- develop productive primary tree structure
- reduce pest and disease pressure
- develop disease-suppressive conditions.

Table 2 IPDM options for improved, sustainable cocoa production

Option	Input level	Activity
1	Low	Current practice
2	Medium	Sanitation Cocoa and shade tree pruning Manual weeding Weekly harvesting of all pods
3	High	Sanitation Cocoa and shade tree pruning Manual weeding Fertiliser/manure application Weekly harvesting of all pods
4	Maximum	Sanitation Cocoa and shade tree pruning Weed management (manual and chemical control using herbicides) Fertiliser/manure application Application of fungicides and insecticides Control of insect vectors Weekly harvesting of all pods

If you would like more information about the IPDM options, please contact your nearest CCI or DPI office.



2 Cocoa pruning

Correct pruning is very important (Figure 1). Poor pruning can reduce the yield of cocoa for many months and even years, and increase disease levels and weed growth.

Planting is usually done in the rainy season between November and March. The following information on the timing of pruning (Table 3) is related to the stage of development of the plant, rather than the season.

There are four key components to pruning cocoa trees:

1. formation pruning (Section 2.1, p. 13)
 - tip pruning
 - canopy shape pruning
2. chupon or water shoot pruning (Section 2.2, p. 15)
3. sanitary pruning (Section 2.3, p. 15)
4. structural pruning (Section 2.4, p. 16).



Figure 1 Correct pruning creates trees with an even, open canopy that allows air and sunlight to penetrate. This helps to prevent and reduce pests and diseases.

Table 3 Timing of pruning activities

Type of pruning	Activity	Time after planting or rejuvenation (months)											
		0	3	6	9	12	15	18					
Formation pruning	Tip prune		■	■									
	Canopy shape prune			■	■	■							
Chupon pruning				■		■		■		■		■	
Sanitary and structural pruning						■				■			
Shade pruning ^a						■				■			

^a Shade pruning refers to the pruning of the shade trees, not to the pruning of the cocoa tree (see Section 3 for more information about pruning shade trees).

2.1 Formation pruning

The aim of formation pruning is to shape the tree and form a cocoa canopy that promotes the development of secondary branches that bear more pods.

Formation pruning involves two phases. In the first phase, the tips of newly growing branches are removed to promote the growth of side branches. Four to five of these branches are selected and groomed into primary branches for the bearing life of the cocoa tree in the second phase of pruning. In canopy shape pruning, lower and hanging branches are removed. This promotes a well-shaped, strong canopy.

Phase 1 Tip pruning

Timing: 3–6 months after planting.

Method

1. Cut off the dominant growing tip to promote the upright growth of more side branches.
2. Prune back droopy branches to promote strong union of branches at an early age.

Phase 2 Canopy shape pruning

Timing: 6–9 months after planting.

Method

1. Cut back the lateral branches 40–60 cm above ground level (branches below knee height) to promote well-spaced main branches.



Figure 2 Formation pruning of the cocoa tree will promote the development of four to five branches as a primary structure.

2. Prune back droopy and low-hanging branches to form a circular canopy.
3. Leave four to five evenly spaced main branches from the jorquette (the point at which the stem fans out to branch) to promote canopy coverage (Figure 2).

Prune to develop a good primary tree structure and promote the development of secondary branches.

Precaution: Avoid pruning that will result in poor structure and canopy formation, and excess vegetative growth.

2.2 Chupon or water shoot pruning

Chupon pruning is applied to young plants to achieve structural strength and avoid excess branches. It is applied to mature plants to reserve nutrients for pod development and to improve light penetration and airflow.

Timing: Every 3 months.

Method

1. Prune all shoots below knee height where they meet the trunk (lower than 40–60 cm from the ground).
2. Prune most of the regrowth shoots within the primary formed structure.
3. Encourage chupons at the base of fallen and leaning trees to grow up to replace the old tree. Remove chupons that do not grow straight up.

2.3 Sanitary pruning

‘Sanitation’ or cleanliness helps to increase sunlight and airflow, and to prevent and reduce pest, disease and weed problems (Figure 3). This improves tree health and promotes pod development. Sanitary pruning is carried out at the same time as structural pruning, and when diseased branches are seen in the cocoa block.

Timing: Every 5–6 months.

Precaution: When pruning chupons and shoots, make sure that the whole chupon is removed back to the main stem and that no stumps or ends remain.

Method

Prune in the following order:

1. low-hanging and drooping branches below 1.2 m in height
2. chupons and small unproductive twigs
3. all infected and damaged branches
4. interlocking branches, leaving a gap of 20–40 cm between branches
5. leading branches to maintain a tree height of 3.5 m
6. central incision: prune very lightly at the centre of the canopy
7. side incision: prune a few small branches on the side of the tree canopy to create a gap
8. removal of any pod mummies.

2.4 Structural pruning

Structural pruning aims to promote the continued development of four to five main branches as the primary structure. This pruning stimulates the replacement of old and infected branches on mature trees with new growth. This maintains the productive area, while opening the canopy and allowing ventilation within and between trees (Figure 3). Aim to maintain a well-rounded canopy.

Timing: Every 5–6 months.

Precautions: Do not prune trees that do not have active leading branches. Avoid pruning productive branches, particularly in the centre of the tree. Height control pruning is applied only to active growing trees that exceed 3.5 m. Pruning should not leave a gap in the side of the tree greater than your outstretched arms (1.5 m).

Method

Prune in the following order:

1. Height control

Prune leading branches at a height of 3.5 m to maintain reachable height for harvesting. Apply only to trees of more than 3.5 m (two people) tall.

2. Ground clearance

Prune low-lying and droopy branches to achieve a clearance of 1.2 m from the ground.

3. Develop the mid-canopy

Prune a small v-shape in the middle of the canopy in the east–west, and then north–south directions.



Figure 3 Prune to establish a tree with four or five main branches at the jorquette.

Correct pruning increases ventilation and helps to reduce humidity, thereby making conditions less suitable for pests and diseases.

A close-up photograph of several cocoa beans, showing their characteristic oval shape and textured surface. The beans are light brown and are set against a bright, slightly blurred background of more beans and leaves, creating a warm, golden-yellow tone.

3 Pruning of shade trees

Good shade management will promote healthy growth of cocoa trees and improve their yield. Too little shade results in poor cocoa tree health and weed problems. Too much shade increases pest and disease problems. Both will result in low cocoa production.

The ideal level of light for cocoa trees in PNG is about 75% of full sunlight. The cocoa trees should intercept about 50%, while a further 25% of sunlight should hit the soil.

Shade can be provided by many types of trees, but in PNG the most common shade trees are coconut or gliricidia (*Gliricidia sepium*). Managing coconut shade involves regularly removing leaves that fall into the cocoa trees. Gliricidia management is described in the following section.

3.1 Management of gliricidia shade

Timing: In July and December (5–6 months after structural pruning) and during normal sanitary pruning rounds.

Method

Prune in the following order:

1. Canopy reduction

Prune heavy canopy branches to reduce the weight of the gliricidia canopy.

2. Debarking

Remove bark from around the trunk at shoulder level and cut out conducting tissues of the surface from which the bark has been removed.

3. Regrowth pruning

Three months after debarking, groom two or three regrowths and remove the rest.

Six months after debarking, leave one of the first regrowths and debark the rest.

Leave two of the new regrowths from the main branch (selected after 6 months) and remove the rest. Repeat as a cycle.

A close-up photograph of several cocoa pods, showing their characteristic ribbed texture and light brown color. The pods are arranged in a cluster, with some in sharp focus and others blurred in the background.

4 Weed control

Weeds include grasses, broadleaf plants, vines and other trees that grow in the cocoa block. Weeds at the base of cocoa trees compete for nutrients, light, water and space and support the spread of pests and diseases. They also restrict access during harvesting, pruning and other activities. Weeds can be removed from around the base of the cocoa trees manually or by using chemicals (Figure 4). The choice of weed control depends on the resources available, and whether or not you want to grow organic cocoa.

Remove weeds from underneath the trees to:

- reduce pests and diseases
- increase water and nutrient availability
- improve access to trees.



Figure 4 Ring weed to remove weeds 1 m from around the base of the cocoa trees.

4.1 Weed control without chemicals

Timing: Every 1–2 months.

Method

Options include:

- manual slashing
- manual ring weeding 1 m around the base of each tree (Figure 5)
- manual strip weeding 1 m each side of trees in the row
- mulching with cocoa leaves, but not within 20 cm of the trunk
- pruning the shade canopy to allow approximately 25% light interception.



Figure 5 Ring weed 1 m around the base of trees.

4.2 Weed control with herbicides

Herbicides provide a more expensive, but less time-consuming, alternative to manually removing weeds from around the cocoa trees.

Timing: One month before applying fertiliser, 4 weeks and 8 weeks after applying fertiliser.

Method

Depending on the weed management preferred, either:

- strip spray along rows

OR

- ring spray around tree base to the drip line with either Roundup (Table 4) or Paraquat (Table 5).

Table 4 Roundup mixture

Chemical	Volume	Action
Roundup (Glyphosate Duo)	80 mL (1/4 of a drink can)	Weeds start to dry after 4–5 days
Li-700 (surfactant)	10 mL (2 full soft- drink bottle-caps)	Helps mixture to stick to weeds
Water	15.1 L	Solvent
Total	16 L	

Note: These mixtures are appropriate for a 16 L Mata knapsack spray tank fitted with green polyjet nozzle.

Table 5 Paraquat mixture

Chemical	Volume	Action
Paraquat (Gramoxone)	100 mL (1/4 of a drink can)	Weeds die within 1 day
Water	15.9 L	Solvent
Total	16 L	

Note: These mixtures are appropriate for a 16 L Mata knapsack spray tank fitted with green polyjet nozzle.

Precaution: Always wear gloves when handling herbicides because they are toxic!



5 Fertiliser and manure

Fertilisers and manures provide extra nutrients for vigour and improved health, leading to increased pod production in well-managed mature cocoa. Fertilisers should be applied at the end of each harvest period to promote flowering. The most common fertilisers are urea and NPK (nitrogen, phosphorus, potassium). You can also use composted chicken manure or other animal manures. Manures also improve the soil and are required for organic cocoa production.

5.1 Urea

Urea assists root development and vigour in young cocoa. In mature cocoa, it promotes new vegetative growth and flower production. Urea is applied after pruning.

Timing: Every 5–6 months.

First application: end of February or start of March, or immediately after pruning.

Second application: end of August or beginning of September, or immediately after pruning.

Rate: 50 g (2 tablespoons) per mature tree; 5 g (1 teaspoon) per young tree.

Method

1. Ring weed 1–1.5 m around the base of trees one week before applying fertiliser.
2. Apply fertiliser one to two steps (1–1.5 m) away from the trunk by dropping the fertiliser on the soil.
3. Cover the soil with leaves.

5.2 Nitrogen, phosphorus, potassium

NPK assists mature plants to nourish the cherelles and develop pods to ripening.

Timing: Every 5–6 months, after harvest.

First application: February or March, or immediately after harvest of pods.

Second application: August or September, or immediately after harvest of pods.

Rate: 120 g (8 tablespoons) per tree for mature trees; 10–20 g (1 tablespoon) per tree for younger trees.

Method: As for urea.

5.3 Composted (old) chicken manure

Make sure the chicken manure is fully composted (at least 3 months old) and no longer has a strong smell. Chicken manure can be used instead of NPK.

Timing: Every 5–6 months, after harvest.

Rate: Up to one bag (10 kg) per tree.

Method: As for urea.

A close-up photograph of several cocoa pods, showing their characteristic shape and texture. The pods are light brown and appear to be attached to a branch. The background is a soft, out-of-focus yellowish-green.

6 Block sanitation

Cocoa diseases and insect pests spread because of poor block management. Insects play an important role in the black pod (*Phytophthora*) disease cycle.

Sanitation promotes tree cleanliness and improves hygiene. The most important part of sanitation is to harvest all pods weekly during the rainy season and fortnightly during the dry season.

Timing: Ongoing.

6.1 Tree cleanliness

6.1.1 Black pods

Black pods need to be removed from the cocoa block to reduce the spread of inoculum and the incidence of disease (Figure 6).

Method

1. When harvesting ripe, healthy pods, also remove:
 - black pods
 - dry cherelles

- rodent-, bat- or bird-damaged pods
 - parasitic plants and vines
 - weeds around the base of the cocoa tree
 - ant tents.
2. Bury the diseased and damaged pods; add chicken manure, plant material or cocoa prunings before covering with soil.



Figure 6 *Phytophthora* causes black pod of cocoa. Infected pods have dark lesions (see the pod on the left). *Phytophthora* is spread between pods by insects such as ants and flying beetles or by moisture (e.g. by raindrops). Infected pods act as sources of inoculum and must be removed from the cocoa block. The inoculum can sometimes be seen as white fluff on the cocoa pod (see the pod on the right).

6.1.2 Diseased and damaged parts

All diseased and damaged tree parts are removed to reduce disease inoculum and pests.

Method

1. Remove all diseased and damaged:
 - chupons
 - new flushes and leaves
 - branches.
2. Prune all chupons, leaves and branches infected with vascular streak dieback (VSD), *Phytophthora* (canker) or pink disease.

6.1.3 Cankers

Cankers are infected spots that appear as dark sores on the bark of branches and trunks (Figure 7). Cankers can be the source of *Phytophthora* infections all year round. Control of cankers reduces disease pressure.

Light scraping of dark, cracked or weeping bark will help identify cankers.

Timing: Every 6 months.

First application: February.

Second application: August.

Remove and bury all black pods and damaged pods to reduce the spread of black pod disease.



Figure 7 Canker due to *Phytophthora* on the cocoa trunk can be seen when the bark is scraped away with a knife. The infected tissue appears darker than the healthy tissue.

Method

1. Prepare a mixture of copper fungicide and insecticide (Table 6) in a container with a lid. This is enough to treat 10 big (6-year-old) trees, or 20 smaller trees.
2. Stir with a stick or shake to mix.
3. Locate the infected spots.
4. Scrape the spots to view the spread of canker (Figure 8).
5. Use a paintbrush to collect some solution and paint directly onto the trunk to cover the canker spot (Figure 9).
6. Stir the mixture regularly to keep the copper suspended.



Figure 8 Scrape cankers with a knife.

Table 6 Mixture for treatment of canker

Chemical	Amount	Action
Copper Nordox	60 g (4 tablespoons)	Prevents spread of <i>Phytophthora</i>
Nuvan	30 mL (2 tablespoons)	Kills longicorn larvae
White oil	30 mL (2 tablespoons)	Assists mixture to stick to bark
Water	1 L (3 drink cans)	
Total	1,000 mL	

Precaution: Always wear gloves. Copper Nordox and Nuvan (Dichlorvos) are poisons and should be handled with care.



Figure 9 Paint scraped cankers with the fungicide mixture.

6.2 Ground cleanliness

6.2.1 Leaf litter and mulch

The leaves act as mulch and:

- reduce rain splash onto the trunk
- reduce vector activity
- help minimise canker
- improve soil drainage and moisture
- stimulate microbial activity
- provide nutrients to the roots of the cocoa tree.

Method

1. Leave the fallen cocoa leaves on the ground, but clear a space of 20 cm around the base of the tree.
2. Remove weeds from 1 m around the base of the trunk.

A close-up photograph of several cocoa pods, showing their characteristic ribbed texture and light brown color. The pods are slightly out of focus, with some in sharp focus in the foreground.

7 Insect vector control

Flying insects, termites, ants and mirids spread black pod disease. Diseased pods are preferentially and rapidly colonised by flying beetles and other insects. The removal of infected pods and pod mummies in regular sanitation procedures will reduce the amount of inoculum available for the insects to carry. Sanitation and insecticides can be used to control insect vectors in the cocoa block. Ant tents should be scraped off the tree trunks using a knife. This will reduce the amount of soil being carried into the canopy.

7.1 Manual control of vectors

Timing: September (after the major pruning), and every 3 months as required.

Method

1. Scrape ant tents off the trunk and branches of the cocoa tree as shown in Figure 10.
2. Bury black cocoa pods and pod husks and cover with leaves, chicken manure and soil.

7.2 Chemical insecticides

Timing: Every 5–6 months.

First application: January, before canker treatment.

Second application: August, before canker treatment.

Method

1. Prepare a mixture of 10 mL Actelic (2 teaspoons) and 5 L of water in a knapsack sprayer.
2. Apply to trunk and all woody pod-bearing branches, particularly where pod/cherelle or cushion canker was noticed.
3. Apply to ant-tent pathways and infected pod husk heaps.



Figure 10 Scrape ant tents off the tree to prevent infested soil moving up the tree.

A close-up photograph of several cocoa pods, showing their characteristic ribbed texture and light brown color. The pods are arranged in a cluster, with some in the foreground and others slightly out of focus in the background. The lighting is soft and natural, highlighting the organic shape of the pods.

8 Cocoa pod borer

Cocoa pod borer (*Conopomorpha cramerella*, CPB), a moth that lays eggs on the surface of cocoa pods, has recently been found in East New Britain and West Sepik provinces. The larvae burrow into the pod and eat the pulp (Figure 11). Pods ripen unevenly, and the beans clump together. CPB has the potential to devastate PNG cocoa crops.

The most effective control of CPB is regular and complete harvesting of ripe pods. All prematurely or unevenly ripened pods and those pods that are infested when cut open should be removed and buried.

Check with CCI for the latest CPB management recommendations.

If you see CPB, it is important that you report it to your local DPI or CCI officer immediately.



Cocoa pod borer is a small moth. It occurs as larvae (like a worm) in its juvenile stage (left) and as a moth (below left) in its adult stage. The moth is about 1 cm long.



Cocoa pod borer can be recognised by uneven ripening of the pod and by small holes that the insect makes to enter and exit the pod.



When the pod is cut open, the cocoa pod borer larvae can be seen. The beans are often clumped together.

Figure 11 Check cocoa pods for uneven ripening on the outside and clumped beans and internal browning.

Remove and bury all unevenly ripened pods, and infested cocoa pods and husks.

Abbreviations and glossary

Ant tent	The dirt pathway built by ants as they carry soil and materials up the tree trunk.
Black pod	Disease caused by the microscopic organism <i>Phytophthora</i> , which causes lesions on the cocoa pod.
CCI	Cocoa Coconut Institute of Papua New Guinea
Cherelle	The young cocoa pod.
Chupon	Vertical branch of the cocoa seedlings. More chupons can develop below the jorquette. It is desirable to shape the cocoa tree by periodically removing new chupon growth.
Cocoa cropping cycle	The annual growing cycle of the cocoa tree.
Cover crop	A temporary vegetative cover that is grown to provide protection for the soil and the establishment of plants. Undersowing the cocoa trees with a crop will help to stabilise the soil and reduce weeds.
CPB	cocoa pod borer
DPI	Department of Primary Industries
IPDM	integrated pest and disease management
Main crop	Cocoa has two main harvest periods. In East New Britain, the main crop is harvested between October and January.
Mid-crop	The second harvest of cocoa in East New Britain occurs between April and July.
NPK	nitrogen, phosphorus, potassium fertiliser
PNG	Papua New Guinea
Pod mummy	Dehydrated black pods that develop as a result of infection by <i>Phytophthora palmivora</i> (black pod). The mummified pods are covered in sporangia and can act as a source of inoculum for further infections.
Sanitation	Removing diseased and damaged cocoa pods and branches from the cocoa block. Diseased pods should be buried.
Vector	Organism that carries <i>Phytophthora</i> and spreads black pod disease and canker.

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