Standards and Trade Development Facility

STDF - CABI - ICCO PROJECT:

"CocoaSafe": Capacity Building and Knowledge Sharing in SPS in Cocoa

in Southeast Asia (STDF/PG/381)

TRAINING OF MASTER FACILITATORS (TOMF)

TRAINING MANUAL

2014

ACKNOWLEDGEMENTS

This TOMF manual draws heavily from the following resources:

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PART 1

THEORY

1. GENERAL ASPECTS OF TOMF

1.1. BACKGROUND INFORMATION OF TOMF COURSE

Cocoa is an important economic crop of Indonesia, Malaysia and Papua New Guinea (PNG) and is an important source of income to thousands of smallholder farmers who depend on it for their livelihood. In PNG, it contributes about K200 million yearly to the government's agricultural export revenue. About 80% of cocoa is produced by smallholders, with 150,000 households depending on cocoa for their livelihoods.

The overall development goal of this project is to maintain and increase market access of cocoa exports from Indonesia, Malaysia and Papua New Guinea by improving practices along the supply chain to meet international standards of food safety. This will include:

(i) improving the quality of cocoa through capacity building in SPS,

(ii) promoting and facilitating knowledge sharing between stakeholder groups participating in the project, and

(iii) raising awareness among cocoa stakeholders beyond the project's immediate reach on food safety concerns in the whole supply chain (and how to address them).

The stakeholders targeted by the project will include smallholder producers, agro-dealers, processors and exporters, also involving national and regional authorities that are responsible for research relating to cocoa, and SPS issues. The project have several components of activities and under "*Component I. Enhancing the Capacity of Cocoa Stakeholders in Indonesia and Malaysia to Improve the Quality and Safety of Cocoa"* there would be 8 activities and 3 activities related to capacity building for extension officers, farmers, agrodealers and processors/sellers. The three relevant activities are:

Activity 1.1 Development of locally adapted curricula and training materials for training of master facilitators and facilitators: Tailored for key intervention points in the value chain

Activity 1.2 Training of master facilitators (TOMF): Organizing and conducting a Training-of-Master Facilitators (TOMF) course to train a core group of Master Facilitators (MF).

Activity 1.3 Training of facilitators (TOF): Master Facilitators organizing and conducting Training-of-Facilitators (TOF) courses to train a cadre of local Facilitators who can conduct Field Schools (FS) for farm group/cooperative leaders, local extension staff, agro-dealers, and traders & processors.

Of the above, the TOMF course constitutes the first activity to be undertaken, which aims at enabling farmers to effectively implement Cocoa IPM & Safety through increased knowledge and awareness. Its main role is to train a strong core group of MF and it cannot be over-emphasized that they will form the primary pillar with respect to capacity building of both Facilitators, farmers, agro-dealers and processors. This is because the MF constitutes the 'upstream' and unless they are well trained, the 'midstream' Facilitators who would undergo training with them will likely be weak as trainers. And the latter in turn would not be able to provide sound training to the 'downstream' farmers.

A typical TOMF course should ideally run for a full crop season to enable participants to experience the different growing stages of a crop and to learn how best to deal with the different problems that may occur over different time (hence different conditions) in a crop. Depending on the type of crop, it may range from 3-4 months for rice and some vegetables (e.g. cabbage) to about 6 months for cotton.
However, at times, because of logistical and other reasons, especially the limitation of resources, it is not possible to run the course over the full length of the crop season. Hence, a compressed course would need to be run instead, with curriculum designed specially to fit in with the shorter timing, as with the case of the current TOMF course for CocoaSafe in Indonesia and Malaysia.

1.2. SURVEY OF PARTICIPANTS' BACKGROUND

At the beginning of the FS, TOF and TOMF, a survey will be conducted to obtain the background information of the participants, such as gender, affiliations (research or extension government institutions, NGOs, private agencies, etc), positions, experiences and basic knowledge concerning Cocoa Safe. This will be gathered through a simple set of objective questions for the participants to complete. The information will also serve as benchmark information for comparison at the conclusion of the TOMF course when the impact evaluation is conducted. In the case of FS especially for farmers, ballot box tests will be used instead of questionnaires.

1.3. PARTICIPATORY INTRODUCTION OF PARTICIPANTS

The participatory approach will be used to introduce the participants of the TOMF. In doing so, the following steps and procedures will be adopted.

a) Because the current TOMF participants will be divided into 5 groups, 5 pictures based on the theme of CocoaSafe will be prepared. Each picture will be cut into 4-6 pieces (or more) depending on the number of participants per group. The cut pieces will then be mixed together.

b) Each participant will pick a cut piece of the pictures and look for other participants who have parts that will match to form the whole picture. When all participants have found their respective partners, they will all group around a table (each group to a table).

c) After gathering the necessary information of another group member, a participant in a group will introduce that person. Then the person who has just been introduced, introduces another person who in turn will introduce a third person. This goes on until every member of the group is introduced. Before introduction, each person will obtain as much information as possible of the person he/she is supposed to introduced, such as:
   1. Name
   2. Matters concerning work (place of work, position, experience and specialisation)
   3. Personal particulars (marital status, children if any, hobby, leisure activities, etc)

d) During the time of introductions, other participants can ask additional questions to seek more information.

1.4. GROUP FORMATION AND GROUP RESPONSIBILITIES

1.4.1. Group formation: In TOF and FFS, the Facilitators and farmers normally carry out the activities in small groups, each group having usually 4-6 members. Participants of the TOMF will thus function likewise. For logistical convenience and lesser costs, the current TOMF will have only 5 groups.

During the process of participatory introduction of the participants, the 5 groups would have been formed. However, it is possible that these groups may not have appropriate balance of gender or professional expertise, e.g. a particular group may have mostly males while another mostly females, or a group having members mostly from research institutions or from the same work organisation. In such a situation, it would be necessary to get volunteers to change to another group to obtain the desire mix of members.

When the grouping is finalised, members of each group will discuss among themselves to select a name for the group. Names that are appropriate would be those with beneficial attributes, e.g. peacock, hornbill, spiders, ladybird, dragonfly, etc. Each group will be referred by the chosen name throughout the training course.

1.4.2. Group responsibilities: During the training course, each group in turn will take responsibilities of the activities for the whole week (in the case of season-long training) or for the day (in a shortened training as in the current TOMF course). During the period when the group is tasked with the week/day responsibilities, the members of a group will take turn to discuss, plan and be responsible for the activities of the week (in season-long training) and for the day (in short training), as determined by consensus of the group. For each day, these would include:

- Recall the activities from previous day
- Keeping track of time to ensure the day’s activities are running according to schedule
- Recap the activities at the end of the day
- Discuss/plan and prepare the activities for next day at the end of each day

1.5. ROLES AND RESPONSIBILITIES OF MASTER FACILITATORS, FACILITATORS AND THE TARGET GROUPS (FARMERS, AGRODEALERS & PROCESSORS)

An important objective of the project is to develop a farmer participatory training and research (FPTR) program towards enabling the target groups to effectively implement cocoa IPM and safety through increased knowledge and awareness. This is to be achieved through three main focused areas of activities, which are (1) Training of Master Facilitators (MF), (2) Training of Facilitators, and (3) Training of target groups.

The following are the expected roles and responsibilities of the MF and Facilitators who will be involved in the training.

1.5.1. Master Facilitators: The initial core group of local MF will train a cadre of Facilitators who can conduct Field Schools (FS). These MF form the primary pillar with respect to capacity building of both Facilitators and the target groups. Essentially, they constitute the 'upstream' among the three groups – MF, Facilitators and Target Groups (TG). Unless MF are well trained, the 'midstream' Facilitators who are trained by them will likely be weak as trainers. And the Facilitators in turn would not be able to provide good training to the TG. It is thus crucial that the core group of MF must be properly trained right from the beginning and can play their role effectively.

The responsibilities and specific follow-up tasks of the MF would include:

- Organising and conducting Training-of-Facilitators (TOF) courses to train a cadre of local Facilitators who can conduct FS to train TG.
- Planning and preparing the TOF courses, including the operational/logistical requirements and preparation of needed training materials. Emphasis would be on helping Facilitators develop curriculum with technical contents suited for FFS-type training of farmers.
- In conducting the TOF courses, the MF would train Facilitators on the basics of Cocoa IPM and Safety Management, criteria for identifying suitable FS field sites, how to set up and run FS, enhancing facilitation (particularly group dynamics) and FS management skills, designing relevant FPTR discovery learning exercises and insect zoos, and how to help TGs undertake agro-ecosystem analysis (AESA). The TOF courses would be carried out using the hands-on participatory learning methodology in both the field and classroom. Where required, these would be supplemented by Power-point presentations to enhance the learning process of the Facilitators.
- Assist Facilitators to organize and conduct FS to train the TGs on Cocoa IPM and Safety Management. This would include guidance on planning and preparing FFS, advice on operational/logistical needs, field sites, curriculum and getting ready all training materials.
- In the conduct of FS by Facilitators, the MF (in pairs) would assist in overseeing the implementation of FFS, and provide guidance/suggestions on needed improvements where deemed necessary.

1.5.2. Facilitators: The cadre of Facilitators will conduct FS to train TGs on how to effectively manage pest and diseases of cocoa and its safety. They have to learn well on how to do this from the MF so as to be able to perform well their tasks of training farmers.

The responsibilities and specific follow-up tasks of the Facilitators would include:

- Identify and select appropriate FS training site (including study field) and the operational/logistical requirements, including the required supporting training materials, equipment and facilities.
- Develop the training curriculum and the training materials on pest and diseases of cocoa and its safety specific to conditions in Indonesia and Malaysia. The training materials would include technical aspects on cocoa production, post-harvest, rational pesticide use, cocoa quality, participatory and discovery learning exercises (including insect zoos), AESA and group dynamics.
- Organize and conduct the FS. The training would be carried out using the hands-on participatory learning methodology in both the field and classroom. Emphasis would be on discovery learning exercises.
- Facilitators will work in pairs to facilitate each FS, using non-formal education and adult training methodology. Training will be focused for TGs with active participation. The field will be used as the primary resource for discovery-based learning and Facilitators would ensure that the field environment and the available resources contribute to learning by the farmers.
- Facilitators will continue to assist FS-trained farmers through follow-up visits to monitor and to provide advice and update them on the latest information, including identifying new exercises to help them improve their crop management and post-harvest handling.

1.6. CURRICULUM OF TOMF COURSE, TOF COURSE AND FS

Each of the following – TOMF course, TOF course and the FS – has a different curriculum. However, there are many aspects which are common, except those of the TOMF course are more detailed and of greater depth than that of the TOF, and the latter more so than those of the FS. Besides the common features, both the TOMF and TOF courses also have additional aspects, with the former having more. Below are listed the main facets of the curriculum for the TOMF course, TOF course and the FS.

1.6.1. Training of Master Facilitators (TOMF) course

- Facilitation and non-formal education
- Basic technical subject matters (Cocoa crop, agronomic practices, IPDM & IPM and management measures, rational pesticide usage, cocoa quality and safety)
- Insect zoos (including their design and development)
- Discovery learning exercises and field studies (including their design and development)
- AESA (field monitoring, drawings and presentations)
- Group dynamics (including their design and development)
- Special topics
- Ballot box test (BBT) (including their design and development)
- Preparation and conduct of TOF (selection of Facilitators and site, logistical arrangements, development of TOF curriculum, organising graduation ceremony and related matters, such as awarding of certificates)
- Preparation and conduct of TOF-attached FS (selection of farmers and site, logistical arrangements, development of FS curriculum, organising of field day and related matters, such as awarding of certificates)
- Planning of TOF follow-up plans/activities (e.g. FS, farmer field research/studies)

1.6.2. Training of Facilitators (TOF) course

- Facilitation and non-formal education
- Basic technical subject matters (Cocoa crop, agronomic practices, IPDM, RPU, CPB biology, ecology, management measures, fermentation and storage)
- Insect zoos (including their design and development)
- Discovery learning exercises and field studies (including their design and development)
- AESA (field monitoring, drawings and presentations)
- Group dynamics (including their design and development)
- Special topics
- Ballot box test (BBT) (including their design and development)
- Preparation and conduct of FS (selection of farmers and site, logistical arrangements, development of FS curriculum, organising of field day and related matters, such as awarding of certificates)
- Planning of FS follow-up plans/activities

1.6.3. Field School (FS)

FS for Farmers (FFS)

- Basic technical subject matters (Cocoa crop, agronomic practices, IPDM, RPU, CPB biology, ecology and management measures, fermentation and storage)
- Insect zoos
- Discovery learning exercises and farmer field studies
- AESA (field monitoring, drawings and presentations)
- Group dynamics
- Special topics
- Ballot box test (BBT)
- Field day (drama, performance, exhibits, etc.)

FS for Agro-dealers (FSA)

- Basic technical subject matters (Cocoa crop, agronomic practices, IPDM, CPB biology, ecology and management measures)
- Rational Pesticide Use
- Regulation on pesticides and its residues
- Discovery learning exercises
- Group dynamics

- Special topics
- Ballot box test (BBT)

FS for Processors/Collectors (FSP)

- Basic technical subject matters (Cocoa crop, agronomic practices, IPDM, RPU, CPB biology, ecology and management measures, fermentation and storage)
- Cocoa storage and quality
- Regulation on pesticides and its residues
- Discovery learning exercises
- Group dynamics
- Special topics
- Ballot box test (BBT)

2. GENERAL INTRODUCTION ON COCOA

2.1. THE COCOA COMMODITY

Historians believe the Olmecs first discovered that the cocoa fruit was edible by observing rats eating it with gluttonous vigour. They soon realized the tree produced a fruit with a thousand flavours and nearly as many uses. The Olmecs (1500-400 BC) were almost certainly the first humans to consume chocolate, originally in the form of a drink. They crushed the cocoa beans, mixed them with water and added spices, chillies and herbs. They began cultivating cocoa in equatorial Mexico. Over time, the Mayans (600 BC) and Aztecs (400 AD) developed successful methods for cultivating cocoa as well. The cocoa bean was used as a monetary unit and as a measuring unit, 400 beans equaling a Zontli and 8000 equaling a Xiquipilli. During their wars with the Aztecs and the Mayans, the Chimimeken people's preferred method of levying taxes in conquered regions was in the form of cocoa beans.

For these civilizations, cocoa was a symbol of abundance. It was used in religious rituals dedicated to Quetzalcoatl, the Aztec god responsible for bringing the cocoa tree to man, to Chak ek Chuah, the Mayan patron saint of cocoa and as an offering at the funerals of noblemen.

Cocoa production advanced as people migrated throughout Meso-America but consumption of the drink remained a privilege for the upper classes and for soldiers during battle. By this time, the re-invigorating and fortifying virtues of cocoa were becoming widely recognized and embraced.

In 1502, Columbus got his first glimpse of cocoa beans on a native canoe during a stop-over in Nicaragua, but he did not appreciate its awesome potential value. The true importance of this "brown gold" was not recognized until Hernando Cortez drank it with the Aztec emperor Montezuma, and brought it back to the Spanish court in 1528 along with the equipment necessary for brewing the drink. Even then, it is unlikely anyone envisaged its ultimate importance as a world commodity.

In 1585, the first cargo of cocoa beans arrived on the Iberian Peninsula from New Spain, launching the trade in cocoa, and resulting in the establishment of the first chocolate shops, thus, ushering in a new era of rapidly growing demand for this mysterious nectar from the new world.

In the 17th century, markets in Europe were rapidly expanding and cocoa spread to most islands in the Caribbean and subsequently to mainland Venezuela and Colombia. In the same century, the Spanish succeeded in transferring a few live plants to Manila in the Philippines. Cocoa cultivation gradually spread southward through the East Indies, and ultimately also to Sri Lanka in the 19th century. Apart from this, early in the 20th century a series of introductions were made by the British into Sri Lanka from Trinidad, by the Dutch to Java and by the Germans to Papua New Guinea from various parts of Latin America. This gave rise to the cocoa industries of Papua New Guinea and Indonesia. Quite independently, Ecuador and the Province of Bahia in Brazil developed major cocoa areas in the 19th century, although the first planting in Bahia had been made in the mid-18th century. From Bahia, cocoa found its way to West Africa, where vast cocoa areas developed in the 20th century in Cameroon, Nigeria, Ghana and Cote d'Ivoire.

More than a millennium after its discovery, chocolate is now a big business. The USA alone, the world's biggest consumer, consumes between 1 and 1.4 million tons of chocolate every year, and the global trade in confectionery, of which chocolate has the lion's share, is estimated at about US$ 80 billion per year. Cocoa has become a vital export crop for many countries, particularly in West Africa, which produces over 65% of the world's cocoa. It is also a major foreign exchange earner for some Central and South American countries and for South and Southeast Asia.

Over 80% of all cocoa is produced by smallholder farmers. Cocoa provides employment in many rural communities and pays for school fees of farmers' children. Smallholder cocoa is grown mostly under shade trees and either inter-cropped or grown in a semi-natural agro-forestry setting and hence, is a particularly rich and stable habitat for many species (biodiversity).

2.2. COCOA PRODUCTION

World cocoa production is projected to grow at a rate of 2.2 percent a year, from 1998 - 2000 to 2010, compared with the 1.7 percent growth during the previous decade, and reach 3.7 million tonnes. During

the same period, Africa's share in the global production is expected to decrease slightly from 69 percent to 68 percent, while the share of the Far East is projected to remain at 18 percent and that of Latin America and the Caribbean at 14 percent.
In the Far East, production had grown rapidly over the past two decades, and this growth is likely to continue. Production in the Far East is projected to grow by 2.7 percent per year from 509 000 tonnes during the base period to 680 000 tonnes in 2010 reflecting the expected improvement in yields. The Far East is expected to replace Latin America and the Caribbean as the second largest cocoa producing region by 2010. Most of the production growth in Asia would come from Indonesia, the world's third largest cocoa bean producer after Côte d'Ivoire and Ghana. Production in Indonesia is projected to grow by 3.5 percent annually to 574 000 tonnes in 2010 and account for 16 percent of the global production by 2010, compared to 14 percent in 1998 - 2000.

Cocoa in the SE Asia region is an important source of income to thousands of smallholder farmers who depend on it for their livelihood. Indonesia is the world's third largest cocoa producer and exporter, after Côte d'Ivoire and Ghana, with an estimated cocoa production area of 1.65 million Ha with production of 440,000 tonnes during 2010/2011[1] of which 87% are produced by smallholders. There are approximately 500,000 cocoa smallholder farmers. Sulawesi is the main cocoa-producing area (966,000 ha, representing about two thirds of the countries output), while the remaining production is distributed between North Sumatra, West Java and Papua, with lower level production in Bali, Flores and other islands. Cocoa represents Indonesia's fourth largest agricultural export in terms of foreign exchange earnings. Exports from Indonesia include some fine flavour cocoa which is used for the production of speciality chocolates owing to its unique flavour and aroma characteristics. However most of the production is bulk cocoa mass of moderate quality, destined for North American, Latin America, EU and Asia-Pacific markets (Table 1). Importantly, the latter largely comprises export to Malaysia; imports of cocoa and cocoa preparations from Indonesia to Malaysia in 2011 were worth 476 million USD, of which 87% was in the form of cocoa beans (data source: UN Comtrade). Production in Malaysia has declined from 247,000 tonnes in 1990 to 16,000 in 2010 due to declining prices internationally, higher labour costs, loss of production due to pests and diseases, and a switch in relative competitiveness to other crops (particularly oil palm and pepper). The area under cocoa cultivation is now estimated at just over 20,000 ha, of which 95% is on smallholdings. However, Malaysia now aims to address this decline and enhance production in-country.

Most of the cocoa within the region is produced by smallholder farmers, who mostly form farmer groups. Productivity is typically low, with average to good quality of cocoa beans. In these systems best practice is rarely applied in cocoa production.

2.2.1 Cocoa in Indonesia

Indonesia's Cocoa Production and Export

The cocoa bean is one of the most important agricultural export products of Indonesia. In the past 25 years, the Indonesian cocoa sector has experienced massive growth, driven by rapid expansion of smallholder farmer participation. Indonesian smallholders contribute - by far - most of the national production, thus outperforming big state plantations and large private estates. The country currently has approximately 1.5 million hectares of cocoa plantations.

In Indonesia, the Government policies had encouraged expansion of production, and most of the increases during the last two decades were bulk cocoa coming from hybrid trees. While the expansion of production area in Indonesia has slowed since the late 1990s, yields in the country are still the highest among major cocoa producing countries. A close link between the world market prices and the producer prices in Indonesia also contributed to the country's high yields. Since the growers earn a high proportion of the market prices, they can invest in inputs, which in turn results in improvement in yields.

[1] Source: Indonesian Statistics of Estate Crops – Cocoa, 2010-2012.

Table 1. Cocoa exports from the project countries (2010/2011): beans & cocoa products (metric tonnes) (Source: ICCO Quarterly Bulletin of Cocoa Statistics).

	Indonesia	Malaysia	Papua New Guinea
Cocoa beans to:			
EU	963	200	5,716
Other Europe	5	0	0
Asia Pacific	239,851	4,570	39,557
Japan	239	11,856	0
NAFTA	23,226	4,283	1,523
Latin America	10,900	0	0
Other regions	0	0	0
Cocoa products to:	Indonesia	Malaysia	Papua New Guinea
Cocoa butter	64,342	126,955	0
Powder & cake	69,276	141,543	0
Paste/liquor	11,581	25,289	0
Chocolate products	17,295	42,631	0

Figure 1 Indonesia's main location of cocoa production: 1) Sulawesi, 2) North Sumatera, 3) West Java, 4) Papua New Guinea, and 5) East Kalimantan

The main Indonesian cocoa producing region is the island of Sulawesi which accounts for around 75 percent of Indonesia's total cocoa production. As Indonesia’s cocoa productivity per hectare has been lagging behind that of other cocoa-producing countries, the government started a five-year cocoa revitalization program in 2009 to boost production through intensification, rehabilitation and rejuvenation activities, covering a total area of 450 thousand hectares. Factors that are hampering progress in the cocoa industry are aging trees (planted in the 1980s), insufficient improved planting materials and little farm maintenance. More investment in this sector is needed to reach the government's one million tonnes annual production target by 2013-2014.

In terms of export, cocoa forms Indonesia's fourth largest foreign exchange earnings from the agriculture sector (after palm oil, rubber and coconut). However, the majority of Indonesia's cocoa export constitutes raw beans instead of processed cocoa, meaning that Indonesia loses out on added value revenues. The most important destination countries for Indonesia's cocoa beans are Malaysia, the USA and Singapore.

The table below shows Indonesia's national cocoa production and export.

	2010	2011	2012	2013
National Production (in tonnes)	575,000	435,000	500,000*	575,000*
National Export (in tonnes)	280,000	200,000	120,000*	

* indicates a forecast

Source: Indonesia Cocoa Association and Indonesian Coffee and Cocoa Research Institute

The table below indicates production forecasts of the world's top cocoa producers for the 2011-2012 season (the cocoa season runs from 1 October to 30 September).

Estimated Cocoa Production 2011/2012 (in Tonnes)

1. Ivory Coast	1,410,000
2. Ghana	860,000
3. Indonesia	**480,000**
4. Nigeria	210,000

Source: International Cocoa Organization (ICCO)

2.2.2 Cocoa in Malaysia

Malaysia's Cocoa Production and Export

In Malaysia, the first cocoa planted area was found in Malacca in 1778. Subsequently, the cocoa planting was started in a plotted area at Serdang Agriculture Station and Silam Agriculture Research Center, Sabah. The earliest cocoa commercialization started around 1933 to 1959 where cocoa types Amelonado was first planted at Jerangau, Terengganu. The planted area was 403 Ha.

Cocoa trial was further undertaken at Serdang, Cheras, Kuala Lipis and Temerloh from 1936 to 1940. However, cocoa was only actively planted after World War II. Cocoa officially came to Queen Hill, Tawau, Sabah in 1960. From then on, there was no turning back on the cocoa fever. It boom in the late 1970's and early 1980's.

Cocoa production areas in Malaysia have been reduced significantly and fell below the 100,000 Ha level in 2000 and since then, the crop area has been declining. By 2007, the area under the crop has decreased to about 31,000 Ha. The downward trend has been observed since the early 1990s when the outbreak of cocoa pod borer (CPB) and vascular streak dieback (VSD) disease coincided with the deterioration of country's macro-economic conditions where priorities have been given for expansions of urban areas and real estate development. In addition, farmers switched to production from cocoa to more lucrative crops, such as palm oil, in response to the fall in world cocoa prices during the 1990s. The cocoa production in 2011 and 2012 is less than 5,000 tonnes.

The estate cocoa area was located mainly in Sabah. In 2000, there were 22,439 Ha of cocoa planting under estates and these declined to about 7,000 Ha in 2007. Most of the cocoa areas were located in Sabah, 88% of the total in 2000 and 90% in 2007. The smallholding cocoa area amounted to 53,327 Ha in 2000 and 23,800 in 2007. Most of the area was also located in Sabah (60%), Sarawak (15%) and the balance in P. Malaysia.

The table below shows Malaysia's national cocoa cultivated area and production:

	2009	2010	2011	2012
National cultivated area (in hectares)	17,338	19,417	20,544	21,710
National production of cocoa bean (in tonnes)	18,152	15,654	4,605	3,645

Source: Malaysian Cocoa Board (MCB)

2.3. CONSTRAINTS TO COCOA PRODUCTION

Being an exotic crop in many cocoa producing locations, cocoa has contracted a number of serious 'new encounter diseases', which originate from the indigenous flora but to which exotics have no co-evolved defence mechanism(s). It has been suggested that when cocoa is in its natural habitat, in the upper reaches of the Amazon rain forest, it is to some extent protected from infection by a range of co-evolved natural beneficial. Exceptions to this rule of thumb are the serious disease threats in Central and South America in the form of witches' broom and frosty pod rot. Nevertheless, wherever cocoa is introduced, the crop is becoming increasingly susceptible to a wide range of diseases with which it has only recently come into contact. The most important constraints to cocoa production in Indonesia, Malaysia and PNG include the insect pest, cocoa pod borer (CPB) and the fungal disease, vascular streak dieback (VSD). CPB has had a devastating impact on cocoa production in Indonesia. It is estimated that by the year 2000 it had spread through the country causing yield losses worth approximately US$40 million per year. In Malaysia, a severe attack of CPB in the 1990's led to a decrease in production by 50,000 MT which may have played a major role in the virtual disappearance of cocoa from Peninsular Malaysia during the 1990s. VSD was first recorded in PNG in the 1960s were it caused severe yield losses. The development of resistant germplasm eventually allowed the disease to be controlled there has been a re-emerged in later years causing serious losses. VSD is now present in all cocoa producing countries in Asia and the Pacific and is a major problem in the commercial plantations of West Malaysia, Sabah, Sulawesi and East and West Java. Other constraints to primary production include a range of pests and diseases such as: *Phytophthora* black pod, mirids, stem borer, mistletoe, termites and weeds, Furthermore, through increasing global movement of plant material, there is a looming threat of introduction of other pests and diseases from the Americas and Africa which are not currently present in Asia and the Pacific.

In addition to problems related to crop health, farmers face a volatile world market, labour constraints, constraining land tenure systems, high costs of farm inputs and lack of access to credit facilities.

2.4. CONSTRAINTS TO EXPORT COCOA BEANS

DEFINITION OF GOOD QUALITY COCOA BEANS

The definition of good quality cocoa by FAO/WHO 1969 – Codex Committee on Cocoa Products and Chocolate are:
(a) Fermented, thoroughly dry, free from smoky beans, free from abnormal or foreign odours and free from any evidence of adulteration.
(b) Reasonably uniform in size, reasonably free from broken beans, fragments and pieces of shell, and be virtually free from foreign matter"

This includes production, harvesting, post-harvest handling, storage and shipping- all steps along the supply chain.

PRODUCE MORE COCOA AND PRODUCE SAFER!

Food safety is currently high on the agenda of many government and consumer organisations, particularly those in the Europe, Japan and the USA. More stringent legislation and regulations are being brought into force to protect their consumers' health from harmful contaminants and residues that can be present in foodstuffs. Cocoa beans and cocoa products have been highlighted as foodstuffs which may contain high levels of certain contaminants and residues. Therefore, cocoa producing countries must not only meet the more traditional quality requirements for cocoa such as physical and flavour attributes but also introduce measures to minimise the levels of harmful substances present in their cocoa to comply with new SPS standards on food safety. If these new standards are not met, there is the risk that future cocoa consignments will be rejected by importing countries. The introduction of contaminants and a decline in bean quality can occur at many different points along the cocoa supply chain: production, processing (harvesting, fermentation and drying), storage, transportation and manufacturing. Therefore all stakeholders along the chain, including those involved in production and post-harvest processing need to be aware of and comply with the regulations and food safety standards for cocoa to minimise the risk of the introduction of these contaminants and maintain market access. The main priority areas for contamination of cocoa include: pesticide residues, heavy metals, ochratoxin A (OTA) and polycyclic aromatic hydrocarbons (PAH).

Africa produces around 70% of the world's cocoa while production in Asia accounts for around 15%. Indonesia is the largest producer in Asia now the third largest producer in the world after the Ivory Coast and Ghana. Papua New Guinea produces a modest amount of cocoa on a world scale but is important to world production due to its fine flavour. Malaysia has become a major importer and grinder of cocoa beans but production has declined in recent decades due to pest and disease constraints and the high price of oil palm but a national government programme aims to increase production over the coming years. As the world demand for cocoa grows each year and chocolate consumption continues to rise important new markets are beginning to emerge, particularly in Asian countries such as China and India. This is an invaluable opportunity for Asian producers many of who are small-scale farmers, to meet the demand for cocoa within the region.

2.5. REGULATIONS ON FOOD SAFETY AND SPS

PESTICIDE RESIDUES

Cocoa is exposed to pesticides (insecticides, fungicides and herbicides) on the farm when they are applied to manage pests and diseases. Cocoa beans can also be exposed to pesticides during post-harvest processing, storage and shipping where it may be fumigated to control insect storage pests. Measures are therefore needed to minimise the levels of harmful substances in cocoa production arising from the use of pesticides, particularly as cocoa-producing countries face potential trade barriers as a result of increasing numbers of legislative and regulatory measures on SPS standards on food safety, enacted by cocoa-consuming countries.

To regulate pesticide residues in imported produce, standards set by Codex Alimentarius can be used as a reference for international trade although major markets such as EU, NAFTA (North American Free Trade Agreement) Japan and other countries outline their own maximum residue levels (MRLs). EU directive 91/414/EEC establishes active substances permitted in food stuffs for the European Union and regulation 396/2005 establishes harmonised MRLs for pesticides permitted in food and animal feed. This includes cocoa as an imported commodity, and if consignments are found to contain pesticide residues above permitted MRLs the shipments can be blocked at import. Cocoa bean and cocoa product consignments entering the EU are routinely checked for chemical residues by national authorities. MRLs for cocoa are in most cases set at the limit of detection (LOD) of the analytical method or at a default level of 0.01 mg/kg. Several active ingredients previously used in pesticides and still being used outside of the EU, are now prohibited for use in EU. Cocoa imported into EU must comply with the MRLs for active substances or batches may be rejected on entry. The MRLs are determined on the shelled beans (nibs).
In May 2006 the Department of Food Safety, Ministry of Health, Labour and Welfare (MHLW) of Japan introduced the following restrictions on pesticides in the "Positive List System for Agricultural Chemical Residues in Foods". MRLs in Japan are determined using 'whole beans' (with the shell), which causes confusion as limits set in the EU are determined using 'shelled beans' or 'nibs' (without shell). However, the MHLW are in the process of reviewing this practice for some pesticides to harmonize with EU methods.

Mitigation of pesticide residues for Good Agriculture Practices (GAP)

This will be covered in greater detail over the course and will need to comply with international and national standards:

- Only use registered pesticides/pesticides permitted in importing countries
- Use at recommended dose/timing

- Use correct nozzle
- Observe pre-harvest interval (PHI)
- Use personal protective equipment (PPE) when applying pesticides
- Reduce pesticide use, IPM approach
- Follow GAP, pruning to manage tree height etc.
- Avoid cross contamination

HEAVY METALS

Heavy metals such as arsenic, cadmium and lead are toxic to humans and animals. They accumulate in the tissues of the body and over time can cause damage to internal organs and can also be carcinogenic. Heavy metals are present in the environment and are taken up by plants. They can occur naturally in soils either from weathering of the bed rock or through volcanic activity; this may have implications for countries with volcanic soil such as Indonesia & PNG. Contamination can also occur through anthropogenic (manmade) activity such as mining, industrial activity and can be present in agrochemicals amendments such as fertilizers and pesticides. It is not fully understood how cocoa uptakes and stores heavy metals and if certain varieties accumulate more than others but there is a tendency for heavy metals from anthropogenic activities to be more soluble in water and therefore have a higher availability for uptake by plants.

Regulations for Heavy Metals

There are currently EU regulations for several heavy metals in food stuffs but this list does not yet include cocoa. Recently the EU's main focus has been on cadmium contamination and limits for cadmium in cocoa and cocoa products have been proposed and are expected to be published later this year (2014). Limits will be set for chocolate and cocoa powder but not raw cocoa beans. There will be a transition period of 5 years and the regulation is due to be enforced from 1 January 2019. It is likely that the EU will look to set similar limits for lead and arsenic in the future.

Mitigation of heavy metal uptake

Because uptake of heavy metals is poorly understood and they can occur in high levels naturally in some soil they are very difficult to mitigate against. The level of heavy metals in cocoa beans was thought to be linked to high levels in the soil, but latest findings prove more complex than this. Uptake of heavy metals may be dependent on cocoa variety grown, soil pH, water source and organic matter content of the soil. Higher levels of heavy metals uptake can also be linked to macro/micro nutrient deficiencies. Recommendations include using only approved inputs such as low cadmium phosphate fertilizers and approved soil tested areas.

OCHRATOXIN A (OTA)

OTA is a toxic metabolite or mycotoxin produced by some fungi, mainly *Aspergillus* and *Penicillium* species. It is commonly found as a contaminant in coffee, cocoa, cereals and nuts. *Aspergillus ochraceus* is able to grow and produce OTA in cocoa beans during several stages of processing. OTA is relatively heat stable and can remain in the cocoa and manufactured chocolate. OTA is genotoxic and teratogenic and the toxic effects include kidney damage.

Regulations on OTA

EU has been in discussion about limits for OTA since 1999. The limits were set for some food stuffs in 2002, but currently no limits have been set specifically for cocoa. Chocolate is a minor source of OTA in the diet however, the EU may consider revising this in the future, if it feels there is an issue with OTA in cocoa.

Mitigation of OTA

- The organisms which produce OTA enter the pod through wounds on the surface of the pod which is frequently associated with machete, cutlass or 'parang' wounds during harvesting
- The easiest way to reduce levels of OTA is not to wound or damage the cocoa pod during harvesting
- Damaged pods should not be stored for more than 1 day and do not store undamaged pods for more than 1 week
- When harvesting, it is important to discard any rotten or damaged pods
- Dry cocoa to 8% moisture

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

PAHs are carcinogenic and genotoxic organic compounds that are composed of two or more fused aromatic rings. They are by-products formed during the incomplete combustion of fossil fuels. Contamination of cocoa by PAHs is usually the result of cocoa beans coming into contact with smoke when being dries in inefficient or poorly maintained diesel and wood dryers. PAHs are very soluble in oils and fats and can cause contamination of high levels in cocoa butter.

Regulations on PAHs

The EU has imposed maximum limits of PAHs in foodstuffs including cocoa butter. Previously benzo(a)pyrene was used to assess the PAH content in food however in 2011 the European Food Safety Authority (EFSA) concluded that it was not a suitable marker to calculate the level of PAHs present in food. A new regulation was introduced in 2011 (EC Regulation No. 835/2011) which uses a group of PAHs (HAP4 = benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene and chrysene) alongside benzo(a)pyrene to assess the PAH level in foodstuffs. New maximum levels of benzo(a)pyrene and HAP4 in cocoa butter are being phase in as follows:

- From 1 April 2013 to 31 March 2015 the limit is 5µg/kg for the benzo(a)pyrene and 35µg/kg for HAP4
- From April 1, 2015 the limit will be set at 5µg/kg benzo(a)pyrene and 30µg/kg for HAP4

Mitigation of PAHs

- Sun-dry cocoa when possible (sometimes difficult in the rainy season)
- Avoid smoke coming in contact with the beans
- Direct drying with wood or diesel fires are to be avoided
- Use indirect drying methods if natural drying is not possible
- Carry out regular maintenance of driers
- Ensure driers have functional exhaust system/chimney
- Effective removal of the shell can reduce levels of contamination

In summary, food safety and high quality cocoa beans should be a priority for all and not just the regulators. There is an urgent need to inform stakeholders along the cocoa supply chain about the importance of food safety issues. Maximise the production of high quality, safe cocoa in the region.

3. FOOD SAFETY & HACCP

Food can transmit disease from person to person as well as serve as a growth medium for bacteria that can cause food poisoning. In theory, food poisoning is 100% preventable. Thus, the need for food safety measures.

Food safety is a scientific discipline describing handling, preparation and storage of food in ways that prevent foodborne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. Smart business operators need to implement food safety systems to ensure safety between industry and the market and then safe between the market and the consumer. One of the food safety management systems is HACCP principles.

HACCP

Hazard Analysis and Critical Control Point or HACCP is a systematic **preventive** approach to food safety and biological, chemical and physical hazards in production processes. It is referred as the prevention of hazards rather than finishes product inspection.

HACCP is believe to originate from a production process used during World War II to monitor production of artillery shell's firing mechanisms (firing bombs), because one cannot test if the bomb works or not. It was finally developed into a logical tool for traditional inspection methods to a modern, science-based, food safety system in 1960s by NASA and Pillsbury. Pillsbury was given the contract to produce food for NASA space flights. The HACCP system can be used at all stages of a food chain, from food production and preparation processes, it focused only on the health safety issues of a product.

The HACCP principle is based on hazard analysis from contamination. The types of contamination can be generalised into 3 categories:-

1. **Biological hazard**– e.g. microorganisms like *E.coli*, *salmonella*, toxins, AFs (aflatoxins), *leptospirosis* in rat urine, birds droppings, etc.
2. **Chemical hazard** – e.g. pesticides, heavy metals like lead, cadmium & arsenide, smoke/ PAHs (polycyclic aromatic hydrocarbons), mineral oils, etc.
3. **Physical hazard** – e.g. stones/pebbles, glass, metals like screws, nuts, etc.

The following topics will be discussed to exemplify the food safety aspect of cocoa and using HACCP principles to evaluate the sources of possible contamination in each Food safety module/ topics:-

	Topics for Cocoa safe	**Food Safety Module (from ASEAN GAP)**
3.1	Crop management - Establishment of cocoa farm	Site history & management
	Raising Nursery	Planting material
3.2	Crop nutrition + Water	Fertilizers & soil additives
		Water
3.3	Crop protection & IPM	Chemicals - Agrochemicals
		Other chemicals
3.4	Worker safety & hygiene	Personal hygiene
3.5	Cocoa harvesting	Harvesting & handling produce
3.6	Post- harvest handling	Buildings & structures
3.7	Waste management	Cleaning & sanitation
		Storage & transport
3.8	Farm record keeping /Traceability	Traceability & recall
		Documents & records
3.9	GAP Training & Self check/ Self Audit	Training Review of practices

3.1 CROP MANAGEMENT

3.1.1 Establishment of cocoa farm – land preparation & site history

Q. Where to plant cocoa?

Importance

Farmers need to consider several factors before planting cocoa in a new area or existing area in order to make sure that they do not come into chemical and biological contamination while making the best use of the land.

Factors to consider include:

- What type of soil? Is there a risk to contamination from heavy metals like cadmium, arsenate that is in the soil? (eg certain type of volcanic soils, soils with high pH, etc.)
- If it was an existing farm – where there chemical or biological hazards left behind which can cause contamination to the produce?
- The location of any contaminated sites on the property, which are unsuitable for production, should be left unused or take remedial action to manage the risk, and this should be recorded. A map of the farm will help to document the site.

Action: To carry out Soil analysis for the soil in the farm.

3.1.2 Planting materials & nursery

Importance

Establishing a successful nursery requires that there is a reliable source of planting material (i.e. seed source or bud eyes) and water close to where the nursery is to be sited. The seed source can be a seed garden where improved planting materials are produced or from a bud-wood garden, for buddings. . Seedlings should be raised in the nursery for 3 to 6 months.

- Location of the nursery to have a gentle slope but level area – this allows for good drainage; during wet weather disease pressure could build up which requires more spraying of pesticides (fungicides). A well drain site will dry up faster, thus reduce the disease pressure, thereby, reducing the number of spray rounds and the amount of pesticides used.
- Look for a place closer to sources of water and planting materials
- If planting material is obtained from another farm or nursery, a **record** is kept of the name of the supplier and the date of supply.
- A record is kept of any chemical treatment used and the reason for use.
- In large scale nurseries, soils from previous year's seed beds may be contaminated by pathogens and so should be sterilized before use. This may be done by heating or fumigating and requires that the soil be removed and put back after it has been sterilized.

Action:- keep records of activities, especially use of pesticides in fumigation

3.1.3 Pruning

Importance

Cocoa trees grown from seeds tend to produce side shoots called "chupons" which is for growing tall. Under natural condition the cocoa seedling tend to grow tall to compete with other trees. The more chupons and branches a tree grows, the more energy (food) it uses up, thus competing with the pods, which can reduce the size and number of pods that reach maturity. For seedling cocoa trees, keep to one stem with three to four main branches.

Pruning leads to:-

- Height control – this can also reduce breeding ground for squirrels and rats.
- Increase air circulation – thus reduce diseases like horse hair blight, thread blight, pink disease, black pods, etc. At the same time remove dead and dying branches, mistletoes, mosses and epiphytes (this is referred to as sanitation pruning).
- Exposes the pods and makes it easier for pesticide application/ spraying. Less pesticides is used for **target spraying** on the pods for control of CPB, black pods, helopeltis mirids, etc. than blanket spraying on the tree. It saves chemical, time and money.

- Easier harvesting. You will get more profit from your farm if you harvest all pods on a regular basis. It is difficult to harvest pods that are very high up in an unpruned tree. Tall trees take more effort to prune than small trees, but it is worth the effort. If trees are too tall to prune (or even to harvest), consider rehabilitation options (see "Deciding to rehabilitate or renew a cocoa farm" and the technical bulletin on rehabilitation).

3.1.4 Shade trees management

The cocoa tree is a shade loving tree, it grows in the lower level of the jungle. Thus, shade trees have to be planted when growing the cocoa seedlings. However, as the cocoa tree grows and matures, the shade tree has to be reduced/ thinned down to allow more sunlight to reach the cocoa tree for pods production. There is a correlation between yield and shade - more shade less yield, or less shade more yield, but to a certain level. Too little shade can result in poor cocoa tree health and increase weed problem. The ideal level of light for cocoa trees is about 75% of full sunlight.
The shade trees can be thinned by physically chopping it down or ring bark. It can also be poisoned by using pesticides – aboricides /herbicides e.g. triclopyr

- To keep a record of any chemical treatment used and the reason for use.

3.1.5 Weed management (herbicides)

Weeds at the base of cocoa trees compete for nutrients, water and space and support the spread of pests and diseases. In immature areas, it also compete for light by over-shading the young cocoa seedlings. They can also restrict access during harvesting, pruning and other activities.
Weeds can be removed from around the base of the cocoa trees manually with a hoe or slashing, or by using pesticides, (herbicides). However, avoid bare soil by keeping a layer of dry leaves as a mulch.

- To keep a record of any herbicides treatments used and the reason for use.

3.2 CROP NUTRITION + WATER

3.2.1 Soil fertility

Because cocoa is a forest crop suited to forest soils, it is exceptionally demanding in its soil requirements. Most tropical forest soils consist of accumulated plant nutrients in the top few centimetres. When forests are cleared, the nutrients are rapidly released, giving the soil a high fertility for a few years. Hence, when planting cocoa in a field that has been used to grow other crops, farmers should remember to apply recommended mineral fertilizer or compost to the planting hole to improve soil fertility.

3.2.2 Soil management - Mulching and composting

Not all soils are suitable for cocoa cultivation. Cocoa trees grow well only in good quality soil. It is therefore important to select an appropriate site before establishing a cocoa farm. Or add mulch/ compost to the soil. To select a site look for the presence of earthworms in the soil since this gives an indication for humus soils. After the inspection for earthworm and humus, conduct a careful analysis of the soil in order to characterize the soil, also to monitor for heavy metals.

Note: in some cases, it is not advisable to mulch the cocoa pod husk back into the cocoa farm due to **heavy metal contamination** from the soil. Thus, mulching pod husk back into the farm will increase the heavy metal contamination.

3.2.3 Fertilizer management

i) Types of fertilizers

There are two main categories of fertilizers: those mined and made by factories (inorganic or chemical fertilizer) and those made from plant or animal products such as manure or compost (organic fertilizers).

From the food safety aspect, inorganic fertilizer can exposed chemical hazards like heavy metals – eg cadmium & arsenide, which comes from the soil where the fertilizer was mined.

As for organic fertilizer it can exposed micro-organisms like *E.coli*, salmonella and other toxins. Example, **chicken dung** could harbour *salmonella* and *E.coli*. It could also contain pesticides residue and heavy metals from the wood treated sawdust. There could also be antibiotic which comes from the chicken feed or medication. Thus chicken dung is not "organic", it is an industrial waste.

ii) Fertilizer application

Importance

- Do not carry out fertilizer application at the same time / or close to time of cocoa harvesting. This is to reduce the chance of getting fertilizer contamination with the cocoa pods and wet beans.
- Fertilize after harvesting or at least two weeks before harvesting.
- Be careful when applying fertilizers as some fertilizers can damage the trees or the leaves if they come in direct contact with them. If you want to fertilize the canopy directly, you can use 'foliar' fertilizer.
- There are also fertilizers that can be sprayed on, and are referred to as foliar fertilizer. This is usually for correcting nutrient deficiency or nutrient imbalance. The advantage of fertilizers that are applied on the leaves is that they are absorbed more quickly than those applied to the ground. However, safety to worker spraying must also be considered.
- Worker safety – use facemask when applying powder/dust type of fertilizer e.g. limestone dust or rock phosphate in powder/dust form. For spraying, please follow the safety aspect for pesticide application. Remarks: most fertilizers are now in granular form thus reducing the hazard of dust.
- Never mix ammonium-based fertilizers (ZA) with SP36 or other single fertilizers.
- Never allow children to be involved in applying fertilizers.
- Always store fertilizer in a dry place.
- Keep records of fertilizer use.

3.2.4 Water

Water is used in the nursery and for spraying purposes. It is not used in the processing process like fermentation. Sometimes it is used for watering the seedlings in the field, during dry weather. Thereby, not much risk of contamination to the cocoa beans.

The risk of chemical contamination to cocoa could arise from using ground water, which could have high amounts of heavy metals. Best to have the ground water analyses for presence of heavy metals and its concentration level of heavy metals, if present.

Action: To send ground **water for analysis** and a record of the analysis is kept.

- **Untreated sewage water is not to be use** during production and postharvest handling of produce.

3.3 CROP PROTECTION

3.3.1 Integrated Pest Management (IPM)

IPM is a system of crop management which includes all measures to control pests and assure growth of crops in order to get high yield with sustainable production and economic efficiency and to minimize the risk to human health and environment.

IPM based its measures by first Prevention, then Observations and lastly Intervention.

A. Prevention. Based on indirect measures, like growing a healthy crop with proper care, good planting material, timely and appropriate fertilization, crop husbandry and hygiene, preservation of beneficial insects.

B. Observation :- requires one to take an active role at monitoring/checking the crop regularly, to observe for possible pest and/or disease outbreak. To be able to diagnose the problem, and thus, take appropriate timely actions.

C. Intervention :- this is the direct measure to control the pest. It could be by:- cultural control, physical/mechanical control, biological control and/or finally by chemical control.

Intervention/ or Control measures are:-
1. Cultural control
2. Physical/Mechanical control
3. Biological control and/or finally
4. Chemical control

There are **7 basic rules to IPM**:-
1. Know the pest
2. Know the key beneficial and their impact.
3. Scout the crops, monitor pests and beneficial.
4. If intervention is required, select the most appropriate option (cultural, mechanical, biological, or chemical).
5. If chemical intervention is required, use the right product for each pest problem.
6. Use correct dosage and application technique.
7. Apply a resistance management strategy.

3.3.2 PEST & DISEASES

Plants provide up to 95% of the world's food supply, either directly or indirectly. Unfortunately, not only man is interested in plants. Uncountable masses of organisms compete with man for food. Such unwanted animals, plants, or other forms of living organism are called pests.
They cause injury, disease or destruction to man, to animals and plants, as well as goods.

Pest list – the following list is given in the Pest Data Sheet

PEST DATA SHEETS (PDS)	
1	**CPB - Cocoa pod borer (***Conopomorpha cramerella* Snellen)
2	**Mirids/ Capsids (*Helopeltis theivora* (Tea mosquito)**
3	**Stem borer (*Zeuzera coffeae*)** *Zeuzera coffeae* (Lepidoptera)
4	**Termites**
5	**White grub (***Phyllophaga* species)
6	**VSD – Vascular streak dieback (***Ceratobasidium theobroma)* *(formerly Oncobasidium theobromae* P.H.B. Talbot & Keane)
7	**Black pod (** *Phytophthora palmivora* (E J Butler))
8	**Pink disease** *Erythricium salmonicolor* (Berk. & Broome) Burds. (Formerly *Corticium salmonicolor* Berk. & Broome)
9	**Blight -** horse hair blight (*Marasmius crinis-equi*) and white thread blight (*Marasmiellus scandens*)
10	**Storage insect pests**

3.3.3 RATIONAL PESTICIDE USE

Types of chemical/ pesticides sprayed
- Carefully read the label and instructions on dosage and timing of application or ask an extension worker for information. Remember, if you use more than the right dose you are wasting money, . If you are not sure what dosage to use on your farm best, use the recommended dosage given on the label.

Problems with pesticide use:

- Many cocoa farmers in Indonesia, Malaysia and PNG use pesticides to reduce pests because several methods may be needed to control cocoa diseases and insect pests such as Cocoa pod borers (CPB), black pod and mirids.
- Many cocoa farmers abuse pesticides because they:
  - Use poor spraying equipment (badly maintained with unsuitable nozzles)

    - Do not have information about which pesticides to use, and
    - Do not properly protect themselves when applying pesticides (see "Spray dye exercise").
- As a result, many farmers waste a lot of pesticide and use more than necessary, with little effect on disease and insect pest infestation. The result is waste of labour and unnecessary expenditure.
- Lack of farmer protection when applying pesticides can lead to health problems and improper use of pesticides can cause damage to the environment, especially by killing off the good bugs and other animals in the ecosystem.

What is rational pesticide use?

- Rational pesticide use includes:
    - Selecting the most effective, but least poisonous pesticides
    - Improving how pesticides are applied
    - Improving when pesticides are applied.
- One of the primary objectives of rational pesticide use is to reduce farmers' dependence on pesticides, especially those pesticides that are highly poisonous and harmful to all insects, whether pests or beneficial.
- Pesticide use may sometimes be necessary, but it must be combined with sound crop and pest management practices and based on tree health observations.
- When farmers apply rational pesticide use principles, they may be able to reduce the amount of pesticides used, save money, increase their yields and protect human health and the environment from the negative effects of pesticides.

3.3.4 Decision steps for applying pesticides to cocoa in the field

1. **See if there is a problem**
   Question: Is there a problem on my farm?
   Action: Inspect your farm regularly for signs of insect damage or disease symptoms.

2. **Find out what you are trying to control – know your pest.**
   Question: What is causing the problem-- insects, animals, disease, not enough water, too much water, etc.?
   Action: Inspect the farm in more details to find the cause of the problem. Get advice from other farmers or an extension agent. If it is an insect or disease, identify which the specific insect or disease.

3. **Decide whether the problem is serious**
   Pesticides are expensive and could be harmful to you and the environment. Decide if the problem is serious enough -- or will become serious enough-- to justify spending time and money to control it.

   Question: Is the pest problem serious? Should I act now, or watch and wait?
   Action: For some pests like mirids, follow the guidelines which tell you how to decide when to use insecticides.

4. **Decide whether you need to use pesticides**
   Applying good farm sanitation practices can help to control pests. No one pesticide can control all pests. Before you use a pesticide, be sure it will control the pest that is damaging your crop.

   Question: Is using a pesticide the best way to control this pest? If so, do I have the right pesticide for the job?
   Action: Start by applying good farm sanitation practices. If you see no results, consider using pesticides. For some pests like mirids, follow the guidelines which tell you how to decide when to use insecticides.

5. **Select the right pesticide**
   Questions: Am I using a suitable product for cocoa? Is it on the recommended list for controlling the problem I have? Is there enough time to apply the pesticide before harvesting time?
   Action: Get advice from an experienced farmer, extension agent or agrochemical dealer on which product is best for your problem. Look over the list of recommended pesticides to see if the product is

on the list. Read the label on the container carefully.

6. **Apply the pesticide correctly and safely**

Questions:
- Have I been trained on how to use pesticides?
- Am I following all the instructions on the label?
- Am I using the right type of sprayer and nozzle?
- Am I wearing the right clothing and protective wear?
- Do I know how to take care of my spraying equipment?
- Do I know what to do after spraying (how to handle the equipment, empty containers etc)?

Action: Get training from an experienced farmer, extension agent or another source on how to apply pesticides correctly and safely.

3.3.5 Recommended pesticides

Pesticides are classified into 3 classes that tell how hazardous (poisonous) they are:

Class I - Extremely hazardous	DO NOT USE (For example Thionex or Endosulfan)
Class II - Moderately hazardous	Take great care when using
Class III - Slightly hazardous	Take care
Class IV - Unlikely to be hazardous	Take care

Cocoa that has been sprayed with class 1 and some in class 2, cannot be exported to Europe, the United States and Japan.

The government will decide which pesticide can be used in your country. However the following table indicates pesticides that are permitted for use on cocoa.

Permitted pesticides for cocoa

Common name	Active ingredient	Class indicating how poisonous the product is
Fungicides		
Kocide	Copper hydroxide	3
Nordox	Copper oxide	2
Ridomil 72 WP	Metalaxyl and copper oxide	2
Insecticides		
Confidor	Imidacloprid	2
Decis 25 EC	Deltamethrin	2
Akate Master	Bifenthrin	2
Actara 25 WG	Thiamethoxam	3

Reading pesticide labels

It is important to read pesticide labels (or have someone read it to you) because the label tells the name of the product, what the pesticide is used for, the ingredients, expiry date, how to mix, apply, store and dispose of the product, the pre-harvest interval and what to do in case of emergencies. Do not use pesticides that do not have a label or if you are uncertain of the origins.

Using pesticides more efficiently

There are three things that farmers can do to use pesticides more efficiently:

1. Select the least dangerous pesticides available

   Where possible, use products that control the pest you are targeting, without harming the good insects and other plants and animals. These are called specific pesticides.

   Read the label on the pesticide and ask:
   - Is it the best pesticide for my problem?
   - How safe is it? (see the above table of recommended pesticides)
   - How much should I mix into my spray tank?
   - Are there any other important precautions I should take?

2. Target the application of pesticides

   Make sure that the pesticides reach the part of the tree (pods, leaves etc) where it will have the most effect.

3. Better timing of treatments

   Apply the pesticides at the right time to have the most effect on the disease or pest. For some pests, mirids for example, instead of spraying on a calendar basis, you can use damage thresholds to decide when to spray.

3.3.6 Reducing pesticide residues in cocoa

What are pesticide residues?

When pesticides (fungicide, insecticide, herbicide) are applied to cocoa (or any other crop) in the field and during transportation and storage, some of the pesticide remains in the crop and is taken in the bodies of humans who eat the crop as food. The pesticide that remains in the crop after harvesting is called pesticide residue.

Regulations on pesticide residues

Eating chocolate that has a high level of pesticide residue is harmful to human health. To protect people's health, countries that eat a lot of chocolate (Europe, Japan, United States, etc.) have established guidelines on the maximum level of pesticide residue they allow in cocoa imported into those countries. All cocoa going to Europe, United States and Japan is now tested in those importing countries and in some African countries to see whether it contains the level of pesticide residues allowed. Cocoa which contain more than the maximum pesticide residue (MPR) allowed is rejected.

To ensure that cocoa from your country is not rejected because of high pesticide residues, farmers, traders, transporters and exporters need to follow set guidelines.

Guidelines for farmers

To avoid high pesticide residues, cocoa farmers need to:

- Apply the right pesticide (s) to solve the problem
- Apply only recommended pesticides
- Apply the pesticide in the right way.

- Apply the pesticide at the right time to effectively control the pest.

- Apply the pesticide before the pre-harvest interval (PHI): The pre-harvest interval is the minimum permitted number of days between the last spray and harvest. The PHI is different for different pesticides. For example, the PHI for some fungicides is one month.

Applying pesticides safely and effectively on cocoa farms

Basic sprayer maintenance and repair

- Use a robust sprayer. A cheap sprayer may not save you money in the long run if it does not last long.
- Using plain water, check pump operation – does the nozzle produce a spray? If not, check diaphragm/piston, valves, seals and make sure filters are not blocked.
- Check all hose clips, unions and seals for leakages before starting to spray. Use plumber's tape (Teflon or similar) and/or cut up old bicycle inner tubes to make repairs if spare parts are not available. Check seals, gaskets, hoses etc. regularly (2-3 times per season) for wear.
- Does the nozzle produce a fine spray? If not, it may be worn. Does the nozzle/lance/trigger valve leak? If any do, repair with plumber's tape or rubber seals.
- Check straps and fixings to make sure they are comfortable and not broken. Repair/replace as necessary. This is important and can make spraying much easier.

Good practices when mixing and applying pesticides

- Select your target – what are you trying to control? Where does the spray deposit need to go?
- Select the right nozzle for the job. For a sprayer fitted with variable hollow cone nozzle, decide what setting should be selected. Squirting high targets with a jet is usually wasteful. Remember, the high flow rate leads to bigger droplets, causing a greater risk of run-off (dripping from pods or leaves). When there is run-off, most of the pesticide will end up on the soil surface, rather than on the pods or branches where you need it!
- Calibrate the right amount of water (volume rate) and pesticide. How many trees per tank load? How many tank loads (thus litres) are required to spray the whole farm?
- Use proper application technique. Be systematic about treating trees. Are all the pods being sprayed effectively?
- Watch for dripping from the pods or leaves. This means you are wasting pesticide.
- After spraying, clean out the sprayer thoroughly first with water and then use a small amount of soap. Don't forget to wash yourself and your clothes thoroughly.
- **Never** allow children to mix or apply pesticides. They should not even be around when these activities are taking place, as they are more likely to be harmed by exposure to pesticides than adults.

Safe pesticide use

Farmers are most likely to be exposed to pesticides when:

- Mixing and loading. Farmers must handle concentrated pesticides to measure the amount they need. Then they must dilute it and pour it into the application equipment.
- Using hand-held application equipment. Farmers must walk near spray mists and dusts. If they are treating a large area, they might walk through or very near an area they just treated. If they touch treated plant parts, some of the pesticide might transfer onto them or their clothing
- Using equipment not designed for the job. Farmers who do not have sprayers might be exposed to pesticides when using the wrong kind of devices to apply pesticides to plants.
- Cleaning equipment

3.3.7 Applying pesticides safely and efficiently on cocoa farms – PAT (Crop Life)

a. Introduction to Crop Life

b. The Plant Science Industry
c. GAP standards – CoC, IPM, IRM, ACF, Container management
d. Responsible use – 5 Golden rule, SDS, PPE.
e. Use of PPE
f. Sprayer equipment's.

3.4 Workers/ Farmers safety –PPE for spraying pesticide

- Wear protective clothing when using pesticides including gloves, long trousers and sleeves, closed shoes, an eye or face shield and a hat

- Wear rubber/plastic gloves to protect your hands. Use gloves that are long enough to protect the forearms as well as the hands and make sure that there are no holes in the gloves. Do not use cloth or leather gloves as these materials absorb pesticide. Do not use cloth-lined gloves as the lining will absorb pesticides. Wear the shirt over the gloves when mixing, filling the applicator, applying pesticides and when cleaning up to prevent the liquid from running down your arm and into the glove. Wear the shirt inside the gloves when spraying upward.

- Eye and facemask protect the eyes and mouth. Wear a mask when mixing and applying pesticides. Putting a handkerchief over your mouth will not protect you from the pesticide.

- Wear boots during all parts of pesticide application to protect your feet. Make sure to wear the trousers over the top of the boots and not tucked into the boots when mixing and filling the applicator.

- Do not eat, drink or smoke when using pesticides
- Only use recommended pesticides
- Use a good quality sprayer that does not leak. Check your sprayer for leakage before spraying

- Be aware of wind conditions and direction when you spray to protect yourself from pesticides

- After use, bury pesticide containers in a pit at least 50 m from water sources (rivers, streams, bore holes, dams etc) and as far as possible from children's play areas and domestic animals. Put flattened containers in layers or 10-15 cm deep and cover.

- Avoid reusing pesticide bottles. It is difficult or impossible to rinse all of the pesticide residue out of a container.

- If a pesticide container is re-used for drinking water or for preparing food, it might cause people who drink the water or eat the food to become ill -- or even die!

- After spraying, clean out the sprayer with soap and clean water
- Wash yourself and your clothes
- Wash your clothes for spraying separately from your house hold clothes.

3.5 COCOA HARVESTING, POD STORAGE AND POD BREAKING

Importance of correct harvesting practices

- Harvesting is the start of the post-harvest process that determines the quality of the beans to be sold, which will be used by the cocoa and chocolate industry. Getting any of the post-harvest steps wrong can lead to poor quality beans.
- If you harvest too early, or too frequently, you are likely to collect unripe pods. Pods that are still green or partly green have more solid pulp (with less sugar content) and the beans may be hard to break up. Unripe pulp gives rise to clumps of beans and leads to poor fermentation.
- Harvesting early in the season and at the end can mean that you will not have not enough pods/beans to make a good fermentation heap
- Harvesting too late leads to the pulp drying up, and in extreme cases, the beans may start to germinate. Lack of pulp will not give a good fermentation. Also, germinated beans will not ferment well,

and the hole caused by the emerging shoot will allow mould inside the bean.
- Before fermenting, you can store unopened pods for no longer than 5- 7 days as storage allows the pulp to increase in sugar content, which causes faster fermentation. Storing pods for longer than 7 days may allow mould to damage the beans and/or encourage the beans to germinate.

Farmer practices

- Some farmers harvest pods too early for various reasons including the desire to sell their cocoa quickly to get money. This leads to poor fermentation. Other farmers delay harvesting due to lack of labour, waiting for the rains to stop or for other reasons. Harvesting late may lead to poor fermentation and loss of beans as a result of mould and germination. Leaving over-ripe pods on trees also encourages disease.
- Some farmers damage the beans when using a machete for pod breaking by cutting too deeply. Damaged beans should be thrown away.
- Children should never use machetes to break pods, as they may injure themselves. They may be involved in pod breaking after school, using a short stick.
- Many farmers store pods for too long which may cause the beans to start to germinate.
- Damaged pods that are stored could turn mouldy or the beans get aflotoxin.

3.6 POST- HARVEST HANDLING

3.6.1. FERMENTATION

Importance

- Fermentation is necessary to begin the process of developing the cocoa/chocolate flavour needed by chocolate manufacturers. Cocoa/chocolate flavour fully develops when fermented beans are roasted. When you roast unfermented beans, the beans taste horrible !
- Proper fermentation is important because it stops germination and gives the beans a good taste after roasting.
- Flavour development begins when the temperature of the beans is raised to a high enough level during fermentation.
- The level of heat required to start the flavour development process only occurs in fermentation heaps with at least **20 kg** of wet beans. The temperature does not get high enough to start flavour development in a fermentation heap with a smaller quantity of beans.
- Ferment beans for a total of 5-6 days.
- Fermented cocoa must be dried. Drying cocoa beans reduces the growth of mould and helps improve the flavour. Dried cocoa beans are easier to store and to transport.
- A properly fermented and dried bean should be brown in colour when you cut the bean in half.

Fermentation process

- Fermentation begins as soon as the cocoa beans are exposed to environment and microbe predominantly yeast started to growth on the pulp leads to the production of alcohol and organic acids with concomitant of temperature increment.
- Optimal productions of cocoa flavour precursor will only occurred when the beans are slightly acidic and the temperature is raised to more than 42^0C during fermentation.
- If the temperature does not reach 42^0C, the beans will not ferment to produce the flavour pre-cursor but decay process will take place.
- Sufficient depth of fermentation heaps is required to ensure enough heat generated during process and it depending on the fermentation technique applied. (If heap fermentation is applied, at least 25 kg of wet beans needed. Whereas, shallow box need as low as 7 kg of wet beans).
- Ensure the fermentation heap is covered properly either using banana leaves, clean gunny or cloth, as long as it can prevent heat from released to environment.
- Ensure the fermentation container to have sufficient perforation for good drainage during sweating.
- Turning of fermentation heap should be done at least once to allow good aeration and ensure beans are mixed evenly.
- Duration of fermentation is depending on pre-harvest practice, quantity of beans and fermentation

technique applied. However, Malaysian Cocoa Board recommended using Shallow box for five days with a single turning on third day.

- Fermentation process should be terminated when:
  - Cocoa beans are dry, separated from each other, blotted and reddish in colour.
  - Temperature of fermenting mass starts decreases.
  - Smell of acetic acid/vinegar diminished
  - Cut test shows that the colour of cocoa beans faded or bleached and surround by brown.

Figure 2 Cut test of good fermented beans

3.6.2 DRYING

Drying process

- Drying is a continuation of fermentation process. During drying, the reddish colour of cocoa beans will be changed to fully brown, as well as reduce the bitter and astringent taste.
- Fermented cocoa must be dried right after the fermentation process complete by spreading the beans on the appropriate surface, preferably on elevated platform.
- The thickness of the spread must be limited to 'one bean thickness' especially on first day of drying to ensure optimum sunray penetration, as well as preventing the beans from continually fermenting which will producing over-fermented and blackish.
- Drying process will reduces the moisture content of fermented beans from about 55-60% to about 7.5% so that preventing moulds from growing and good for storage.
- During drying the beans must be turned periodically for every 2 to 3 hours to ensure beans uniformly dried as well as preventing overheated.
- During turning, the husk fragment or placenta is separated from the mass to obtain clean and high quality dry beans.
- Protect cocoa beans during drying from rain and dew. The cocoa beans should be heaped and covered at night or during rainy weather to avoid re-wetting.
- Do not mix cocoa beans at different drying stages. Use specific identification for each one of them to identify each drying stage.
- Sufficiently dried beans will produce crackle sound when lightly squeezing.
- Drying process could be carried out either naturally or artificially or a combination of both.

Natural or sun drying

- Sun or natural drying is a simple, effective and an economic type because heat of the sunray is used to warm the surface of the exposed beans.
- Sun drying is a highly recommended due to its slow drying rate and also produces better quality beans but not favourable when peak harvesting periods coincide with rainy season.
- The fermented beans are spread on the cement or ground and as hygienic practice, the drying area layered with clean mat or canvas and protected from trespassing of livestock.
- The fermented beans should be dried away from strong smelly sources such as smoke, copra or even rubber.
- In addition, the drying area should receive maximum sun exposure during most times of the day, to speed up the drying process of cocoa beans.
- Shaded or blocked areas should be avoided to ensure the good air circulation and sufficient intensity of light.
- Inefficient of air circulation and insufficient light intensity especially at night or humid area will

promoted growth of moulds.

- The drying area can be covered from rain either by using canvas, tarpaulin or zinc.
- Alternatively, fermented beans can be sun dried on elevated platforms built from bamboo or wooden to prevent contamination. Platforms have the advantage in accelerating drying rate through increasing good air circulation.
- Drying of beans will takes between 3 to 7 days to complete and depending on the weather conditions. Prolong drying may lead to mould growth.

Artificial drying

- Artificial drying is useful when the harvesting season frequently coincides with the rainy season.
- The dryer use firewood, diesel and gas as heating source. However, usage of firewood is strictly prohibited due to smoke contaminated.
- Smoke contamination not only interfere cocoa flavour but also significantly contribute to polycyclic aromatic hydrocarbons (PAHS) contamination in beans. PAHs are organic compound is a carcinogen, which potentially cause formation of lung cancer.
- Usage of diesel and gas are still can be considered, as long as they do not directly come into contact with the beans.
- During drying, the temperature of hot air should be maintained at below 60^0C in order to prevent deactivation of enzymes during tanning process.
- A properly fermented and dried bean should be brown in colour when you cut the bean in two.

Table 1 Relationship between colour, degree of fermentation and flavour

Colour of beans	Degree of fermentation	Flavour on roasting
Brown	Fully fermented	Strong cocoa flavour, balance of acidity, astringency and bitterness
Brown/purple	Partly fermented	Good cocoa flavour, higher acidity, astringency and bitterness
Purple	Low fermentation	Low cocoa flavour, strong acidity, astringency and bitterness
Greyish or black	Unfermented	Absence of cocoa flavour, predominantly acid, astringent and bitter. Overall sour flavour

3.6.3 Quality/ Grading

Quality certification of dried beans

- Malaysian Cocoa Board has implement the certification since 2010 to ensure ;
- Good beans produced by cocoa grower or processor
- Fair trade practice among the cocoa traders are based on Malaysian Standard
- Quality requirements of cocoa beans (MS 293:2005) as follows:
  - The cocoa beans shall be from ripe pods and adequately fermented, free from smoky smell, free from objectionable or foreign odour and free from any evidence of adulteration.
  - The cocoa beans shall be evenly dried throughout. The moisture content shall be less than or equal to 7.5%.
  - The cocoa beans shall be reasonably uniform in size.
- The consignment shall be free from bean clusters and reasonably free from double bean.
- The consignment shall contain less than or equal to 2% waste by weight.
- The consignment shall be free from insects including mites.
- The consignment shall be free from foreign matter.

- The grading specifications are given in Table 2.

Table 2 Grade specifications of the cocoa beans

Standard Malaysian Cocoa Grades	Bean Count (100g)	Mouldy beans (% max.)	Slaty beans (% max.)	Insect damaged and germinated beans (% max)
SMC 1	<=100	<= 3	<= 3	<= 2.5
SMC 2	>100 <= 110	<= 3	<= 3	<= 2.5
SMC 3	> 110 <= 120	<= 3	<= 3	<= 2.5
NOTES : 1) SMC denotes Standard Malaysian Cocoa. 2) All percentages in the grade specifications are by count. The percentage given in the last column applies to all the mentioned therein, taken together.				

- The degree of fermentation for cocoa beans consignments shall be referred to Table 3.

Table 3 The degree of fermentation for cocoa beans consignments

Fermentation level	Category
>60% of the cut bean is fully brown	Good
45% - 60% of the cut bean id fully brown	Moderately good
< 45 % of the cut bean id fully brown	Fairly good

3.6.4 Packaging

- Before dried cocoa beans are packed, they must be sorted to remove flat beans, slaty beans, shrivelled beans, black beans,mouldy beans, small and/or fused beans, germinated beans, beans with insect damage, etc.
- Ensure the facilities and equipment that are related with sorting process are regularly inspected, maintained and cleaned, in order to avoid physical damage to cocoa beans that make them more susceptible to contamination and deterioration and to prevent the introduction of new contamination and undesirable materials.
- An appropriate degree of personal hygiene should be maintained by all personnel.
- The dried cocoa beans that will be stored must be properly identified by lots at the farm level or in out-of-farm warehouses, in bulk or in clean bags under appropriate storage conditions.
- Cocoa beans should be packaged in clean bags which are sufficiently strong and properly sewn or sealed to withstand transport and storage and which are suitable for food contact use and discourage pest infestation.

3.6.5 Farm storage

- The bagged cocoa beans must be placed in warehouses or storage sheds that are weatherproof, well aerated, cleaned, free from dampness and insect pests and away from smoke and other doriferous materials that could contaminate the cocoa.
- The design and structure of the warehouses or storage sheds should be adequate to maintain dryness and uniformity of the stored dried cocoa beans.
- The cocoa bags should be arranged on pallets and away from walls, to allow good air circulation.
- The stored beans should not be exposed to direct sunlight nor stored near heating sources, to avoid the possibility of temperature differentials and water migration.
- Cleaning and maintenance programs should be implemented.

- Storage facilities should be periodically inspected, cleaned and repaired.
- The moisture content of the stored cocoa beans should be periodically checked and kept below 7.5% by re-drying.

3.6.6 Transporting/ shipping

- Transport of cocoa beans also requires the adoption of practices to avoid re-wetting, to maintain temperature as uniform as possible and to prevent contamination by other materials. The main requirements here are:
  - Cover cocoa bean loading and unloading areas to protect against rain.
  - Before receiving a new cargo, the vehicles must be cleaned from residues of previous cargo.
  - The vehicles must have floor, side walls and ceilings (in closed vehicles) checked for the presence of points where exhaust fumes or water from rain can be channeled into the cocoa cargo.
  - Tarpaulins and plastic canvas used to cover the cargo should also be regularly checked to ensure that they are clean and without holes. The vehicles should also receive regular maintenance and should be kept in good condition.
  - Reliable transport service-providers that adopt the recommended good transportation practices should be selected by operators

3.7 WASTE MANAGEMENT

3.7.1 FARM SANITATION

Importance

- Farm sanitation means removing unnecessary or unwanted things from the farm. This includes:
  - Dead, diseased or damaged pods
  - Dead leaves, branches and trees
  - Weeds
  - Mistletoe
  - Chupons
  - Piles of cocoa husks
  - Stagnant water

- Removing damaged, diseased and dead pods, dead branches and decaying tree stems regularly helps to reduce diseases.
- Removing mistletoes improves tree health, as these plants reduce the amount of food and water getting to branches and pods.
- Weeds, such as grasses and ferns that grow on the tree, compete with cocoa trees for nutrients and water from the soil. Weeds also increase humidity in the farm. Too many weeds on a farm make it more difficult to remove dead and diseased pods, branches etc. that may carry pests and diseases.
- Moss holds moisture that increases the risk of black pod disease and tree canker. Because moss covers the bark of the stems and the tree, it stops flowers from growing on the bark, which reduces the number of pods produced.
- An epiphyte is a type of plant that grows on another plant or object but is not rooted in soil. These plants do not drain the water, energy or nutrients from cocoa trees, as they get nutrients from the air and other sources. Some mosses and ferns are epiphytes. Epiphytes are only a problem when they cover the bark and stem of a tree, stopping flowers from growing or when they create high levels of moisture on tree stems that encourage black pod diseas
- Where black pod disease is a problem, cocoa husks should be moved away from the farm. Those husks can be used to make compost somewhere else and used as fertiliser on the cocoa farm. Where black pod disease is not a problem, cocoa husks can be spread around the cocoa trees where they will decay and fertilise the trees.
- Cocoa trees standing in pools of water will often become unhealthy. Stagnant water may also encourage the spread of black pod disease. Remove stagnant water by digging small drainage canals.

Farmer practice

- Many farmers are not aware of the need to remove unnecessary or unwanted things from their farms. For example, some farmers only weed once instead of the recommended least twice per year: during the rainy season, and after the short dry season.
- Some farmers do not remove chupons because they believe that more stems and branches will give them higher production. These farmers do not realize that extra stems and branches compete with cocoa pods for water and food. The result is lower production.
- Other farmers do not prune their trees because they believe that pruning harms the trees. Some believe that tall trees are stronger and healthier. These farmers do not know that shape pruning is only done at the beginning of the rainy season when there is no risk of stress on the trees.
- Other farmers do not do farm sanitation practices because they do not have enough labour.

3.7.2 Pesticide waste – empty containers (Crop life: ref 3.3.7)

3.8 FARM RECORD KEEPING /TRACEABILITY

This section contains examples of documents and record forms that are required to implement various practices in the food safety module. The record forms are examples only and can be modified to suit the use. ASEAN GAP specifies the information that has to be documented and the records to keep. The examples are given below:-

1	**Farm plan**
2	**Risk assessment record**
3	**Planting material record**
4	**Chemical inventory**
5	**Spray record**
6	**Postharvest/ Storage chemical record**
7	**Chemical authorisation form**
8	**Fertilizer record**
9	**Harvesting and packing record**
10	**Job responsibility and training record**
11	**Cleaning and pest control plan**
12	**Corrective action report**
13	**Personal hygiene instructions**
14	**Self- assessment checklist**

Traceability

Each farmer can be considered as a production site and can be identified by a name or code. The code is placed on the site and recorded on a property map. The code is recorded in all documents.
The packed cocoa beans are clearly marked with the identification code to enable traceability of the produce to the farm or site where the produce is grown.

3.9 GAP TRAINING & SELF CHECK/ SELF AUDIT

Farmers and workers are trained in their area of responsibility relevant to GAP and a record of training is kept.

As a self-check measures, all practices should be reviewed at least once a year to ensure that they are done correctly and actions are taken to correct any deficiencies identified.
A record is kept of practices reviewed and corrective actions taken.

4. STEPS TO PLAN, ORGANISE AND CONDUCT TRAINING OF FACILITATORS

- To plan, organise and conduct TOF and Field Schools (FS) there are several aspects and steps to be considered and taken.
- Paying attention to them will ensure a successful outcome of the training activities.

Training-of-Facilitators by Master Facilitators (MF)

MF involved should meet to discuss the steps and chart out details of the specific work plans, including identifying which team member is responsible for which tasks, how and when the tasks will be performed as well as the expected outputs.
The main steps are:

4.1. Preparatory meetings with related agencies
4.2. Plan and prepare relevant curriculum (including needed training materials)
4.3. Plan and prepare operational/logistical requirements
4.4. Organise and conduct the TOF course
4.5. Discuss and plan TOF follow-up activities and the conduct of FS

Below are described in more details the above primary steps 4.1 to 4.5:

4.1. PREPARATORY MEETINGS WITH RELATED AGENCIES

The primary objectives are to explore, discuss and develop an overall plan for whatever proposed TOF courses with relevant stakeholders in a particular location, area or region, such as:

1. Number of TOF courses to carry out over a specific period (including the timeline)
2. Which specific areas/locations (including estimated number of Trainers) to be trained and the venue(s) for conducting the TOF courses
3. Which stakeholders would be involved and their commitments
4. Sources of funding
5. Identify potential participants to be trained as Facilitators
6. Decide on 1st TOF course to be conducted (which MF to be involved, appropriate training site, participants, timing, budget and other requirements (materials, logistics, etc.)

4.2. PLAN AND PREPARE RELEVANT CURRICULUM (INCLUDING TRAINING MATERIALS)

All care must be given to prepare well the curriculum contents because they are what Facilitators must know and would adopt to train farmers, agro-dealers and processors in FS. Preparing the curriculum well is thus crucial. The specific tasks are:

- Prepare the TOF curriculum well ahead and as complete as possible, including the relevant practical. Ensure the contents include at least the following:

    1. FPTR and What is FS (training process and key features, aims, principles, benefits)
    2. How is FS conducted (e.g. weekly ½ day activities over the crop period for FFS)
    3. Basics of the main growth stages of cocoa as well as their key pests/diseases and associated natural enemies.
    4. Relevant insect/disease zoos and experimental studies (with case examples on how to design them)
    5. Agro-Ecosystem Analysis (AESA) – aims and how (field monitoring, drawing, and presentation)
    6. Group dynamics
    7. Special topics
    8. Non-formal education and facilitation
    9. Need for record keeping and report preparation
    10. Organising field day
    11. Pre- and post-TOF course evaluation
    12. FS follow-up activities
    13. How to plan, organise and conduct FS

- Ensure all training materials required of the above curriculum are also prepared ahead before conducting the TOF

4.3. PLAN AND PREPARE OPERATIONAL/LOGISTICAL REQUIREMENTS

Besides getting ready the training curriculum and training materials, it is necessary to ensure all other operational/logistical requirements are also in place, such as:

1. TOF training venue, including the necessary operational and organisational support
2. Participants properly identified and informed of the TOF course well ahead
3. Accommodation for participants and other support requirements
4. Study field sites and support materials
5. Transport and other logistical requirements where relevant
6. Others that will ensure smooth running of the TOF and its successful completion

4.4. ORGANISE AND CONDUCT THE TOF COURSE

- MF conducting the TOF should have a check-list to ensure all TOF materials and needed support logistics are all in place ahead of the course.
- Visits to training venue and study field sites prior to training should also be made to help correct any deficiencies.
- (If necessary, MF should arrive at least 1-2 days ahead of the course to ensure any last-minute requirements are not over-looked).
- For the TOF course, all participants should be provided with:
    - An outline of the TOF course programme
    - TOF course materials (hand-outs, etc.)
    - Field kit (list and double-check to confirm contents)

Important: [The TOF processes for learning technical knowledge are generally similar to those activities in an FS, being discovery-based learning *via* structured participatory exercises. If these exercises are well carried out and discussed in TOF, the Facilitators will have gained the knowledge and skills needed to conduct the same an FS. MF must therefore pay particular attention to the participatory/discovery exercises and the processes involved when conducting the TOF].

4.5. Discuss and plan TOF follow-up activities

After the TOF course, the newly-trained Facilitators are expected to proceed with planning and implementing follow-up activities, such as:

- Plan, prepare and conduct FS
  Note: During the TOF, MF should discuss with them and together help develop a plan and the list of FS requirements.
- Make efforts to continuously improve themselves not only in technical subject matters but also other various skills that would help them improve their FS-related activities (such as skills in facilitation, communication, management, organisation, reporting, etc). These are usually achieved through personal involvement in organising and conducting as many FS as possible as well as active participation in in-service or refresher TOF courses that may be organised from time to time by both MF and experienced Trainers.

PART 2

DISCOVERY LEARNING SERIES

PRACTICAL

SFFS EXERCISE 1: Cocoa Cropping Calendar - Crop Cycle

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A cropping calendar is an important tool in farmer field schools as it serves as the guideline for activities carried out in the farmer practice plot. A cropping calendar must therefore depict current farmer practice and NOT recommended practice. For the ICPM (Integrated Crop & Pest Management) plot, there is no cropping calendar, as decisions on the implementation of practices are based on regular field observations and the discoveries made over the course of the field school.

OBJECTIVES

- To develop farmers' capacity for making valid comparisons of their current practices with ICPM (integrated crop and pest management) practices
- Where appropriate, to introduce the topic of child labour in an unthreatening manner (see the protocol "An introduction to child labour issues")

NOTE: This exercise should be done twice: during community sensitization and during the first or second FFS session.

MATERIALS

- Flip chart paper
- Markers (three colours)

PROCEDURE

A cropping calendar is a representation of all cocoa production tasks performed during a season. It is depicted as a timeline (X-axis) divided into monthly periods, with drawings of crop stages at the top of the matrix. Tasks are listed along the negative Y-axis, and the times these are applied are indicated as horizontal bars.

Ask participants to list all activities done in cocoa production. As this calendar will be used to implement practices in the farmer practice plot of the farmer field school, it is important to be specific and detailed. Go through the entire cocoa production cycle, including land preparation, seedling management, planting, weeding, removal of chupons, pruning, spraying, harvesting, fermentation, drying, storage etc.

Have participants fill out the calendar in as much detail as possible using different colours to indicate what work is done by men, women and children.

Example of a cropping calendar

	Activities	1	2	3	4	5	6	7	8	9	10	11	12
1	Land preparation			■	■								
2	Nursery preparation	■											■
3	Planting in the nursery					■	■						
4	Transplanting					■	■						
5	Gap filling					■	■						
6	Removal of chupons					■	■						
7	Fertilizer application												
8	Weeding						■	■	■	■	■	■	
9	Spraying cocoa pod borer	■	■	■	■	■							
10	Spraying Helopeltis	■	■	■	■	■							
11	Spraying black pod								■	■			
12	Harvesting	■	■	■					■	■	■	■	■
13	Pod breaking										■	■	■
14	Fermenting										■	■	■
15	Drying										■	■	■
16	Bagging										■	■	■
17	Weighing/selling										■	■	■

In addition to the calendar, which indicates the frequency of activities, write the following information on a separate sheet of paper:

- Type of fungicides/pesticides applied
- Quantity of fungicide/pesticide applied per hectare/acre
- Type of sprayer used
- Pruning practices and frequency
- Shade management and frequency
- Type of sanitary harvesting done and frequency
- How farmers dispose of diseased pods

When doing a cropping calendar with FFS participants, the calendar should reflect the actual practices of the farmer owner or the common practice in the area (to be decided by participants) rather than practices that would be implemented if farmers had the resources.

SFFS EXERCISE 2: Cocoa Ecosystem

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In the cocoa garden there are a number of "levels" or habitats in which insects live. One way to think of these is in terms of a vertical stratification. The top level is in the branches and leaves of the shade trees. The second level is on the cocoa trees. The third level in the shrubs and weeds and the forth level is in the surface of the soil. Each of these habitats has different species of organisms.

Each insect has unique to its habitat. The characteristics and function of insect are influenced by their habitat. Most insects that live in the soil function as natural enemies or decomposers. All insects that live in the top level have are very dynamic and move among plot. Plant feeders usually live in the cocoa canopy.

OBJECTIVES

To explain the different types of habitats found in a cocoa ecosystem and the types of organisms that live there.

TIME: 2 hours

MATERIALS

- Cocoa garden
- Sweep net
- Plastic bags
- Large paper
- Pens
- Glue.

PROCEDURE

<u>Preparation</u>

Use the following questions as discussion topics:

- How many habitats can be seen in the cocoa field?
- What kind of insects and other organisms can be found in each of these habitats?.
- What is the relationship between these habitats? Do they overlap and inter-relate?

Action

- Divide into four groups. One group should focus on one habitat.
- Have them first stand and observe their habitat. Then slowly begin to look closer.
- Collect organisms that they find in the habitat.
- Draw pictures of these organisms. Then have each group place them (the drawing) on a large piece of paper which has the rice ecosystem drawn on it with four habitats clearly defined.
- Discuss the relationship between these organisms.

Discussion

- What kinds of insects/spiders and other organisms were found in each habitat?
- Are the organisms in one habitat related to another? Do insects and other organisms change their habitat during their life cycles?
- How does the energy cycle relate to these habitats and organisms?

Follow up

- Continue to observe the ecosystem, concentrating on each habitat. Identify the functions of the organisms that were found.

SFFS EXERCISE 3: Cocoa Food Web

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The life cycles of insects are well known. Some insects have complete life cycles (metamorphosis) and some insects have incomplete life cycle. A food web is the interaction among plants, plant feeder, and their natural enemies. A food web is simple an arrangement of names linked together by lines that indicate our understanding that one group feed on or parasites another groups.

Energy from one level of the ecosystem moves to other levels along a chain of interactions within the food web. As an insect goes through its life cycle, it can play a different role within a food web.

OBJECTIVE

To explain life cycle and food web chains for several insect pests.

TIME: 2 hours

MATERIALS

- Large paper
- Drawing pen
- Reference on natural enemies of herbivores

PROCEDURE

Preparation

Open discussion by asking:

- What is the meaning of life cycle?
- How many kinds of life cycles do insects have?
- What is the meaning of food web in the ecosystem?
- How do life cycles and food webs relate to each other?

Action

- Each group should choose a pest/natural enemy to analyse (e,g. CPB, Helopeltis, Stemborers, white grub, mealybugs, ants, others)
- Draw a large circle and draw in the general stages for the insect around the circle.

- On the drawing, draw the natural enemies that attack a particular stage of the insect.
- For the natural enemies, write the stages of the natural enemy life cycles.

Discussion

- What would happen to natural enemies if there were no insect pests? Do we think insect pests can become beneficial at low populations? Why are they important?
- What will happen if we spray broad-spectrum pesticides?

Follow-up

- Analyze other pests/natural enemies

SFFS EXERCISE 4: Ballot Box Test

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This exercise evaluates participants' knowledge at the start and end of the FFS, which enables facilitators to assess the impact of training. It can be adapted for illiterate participants by having literate participants or non-participants read the questions out loud.

Usually an FFS has a pre- and post-test. This is a field-based test in which 20 to 25 "balloting" stations (e.g bamboo stakes, trees or boards with three small boxes and a multiple choice question attached) are placed around the edge of a study field. The boxes have small slots in their tops through which ballots are entered. The ballots are usually cardboard paper "coins" that are numbered. Each participant is given an identifying number from one to twenty-five. Participants are given a set of 25 paper "coins" with their number inscribed. The paper could have the name of the farmer on it, but this is not really necessary because we are not testing the individual but rather we want to find out how many farmers knew the correct answer and how many did not.

Participants then go from station to station and place their coins in the boxes that are lettered according to the choices associated with each question. Farmers answer each question by choosing between 3 answers. Usually the questions are designed in such a way that they can measure:

- Understanding of ecology and natural control mechanisms.
- Ability to identification of pests, natural enemies, diseases, and damage symptoms.
- Knowledge of crop management methods

The questions might include: identification of the roles of various insects (the insects should be in clear plastic bags or bottles attached to the question); damage on cocoa plants (a string should run from the question and be attached to the damaged area on a nearby plant); other relevant field questions that can be readily seen and identified with live samples. No drawings or pictures are used and no abstract questions are asked that cannot be based on a live sample.

Example questions

- Show one insect pest and three (3) different natural enemies. The farmers have to indicate which natural enemy can help control that pest.
- Show one insect pest and the type of crop damage. The farmers have to indicate what and how the damage the insect caused.
- Show one fruit damage and list three organisms, one of which is the cause. The farmers have to indicate which organism causes the damage.
- Show a predator (e.g. spider or ants) and list three possible answers, one of which is correct and the others not (e.g. aphid and caterpillar). The farmers have to indicate which is a natural enemy.

In general, the pre- and post-tests should cover the same material and be of the same relative difficulty. The tests are usually conducted as part of the first and last meetings of an FFS. The results should point out weak areas of knowledge (in the case of the pre-test) or the learning needs of participants. The post-test, when compared to the pre-test can be used to indicate improvements in knowledge among FFS participants and to determine needs for follow-up activities.

The ballot box test at the beginning of an FFS is not really about testing the farmers' knowledge, but rather a way of showing them the gaps in their knowledge as a way of preparing them for what they can expect to learn during the coming FFS sessions. The results of the test may be immediately used to start discussions about these topics.

EXERCISE

As practical exercises, members of each group will discuss among themselves to plan and construct two ballot box tests. Test materials may be collected from the field for the preparation. Upon construction, the ballot box tests are to be presented for comments by other groups.

Sample ballot box questions:

(Correct answers are indicated in bold)

Category	Sample	Question	Answers
Recognising pests	Vial with mirid adult in alcohol	What is this?	a. A farmer's friend **b. A farmer's enemy**
	Tie a rope to connect with cocoa pod with black pod symptom	What is this symptom caused by?	a. A bacteria b. A virus **c. A fungus**
	Vial with stem borer larva in alcohol	What is this?	a. A farmer's friend **b. A farmer's enemy**

	Tie a rope to connect with cocoa pod with mirid symptom	What is this symptom caused by?	a. A disease **b. An insect** c. Rain
	Tie a rope to connect with cocoa pod with black pod symptom	What is this symptom caused by?	**a. A disease** b. An insect c. Rain
	Tie a rope to a tree with initial symptom of die back	What will eventually happen to this tree?	a. Recover **b. Die**
Recognising beneficials	Vial with spider in alcohol	What is this?	**a. A farmer's friend** b. A farmer's enemy c. A neutral
	Vial with yellow weaver ant in alcohol	What is this?	**a. A farmer's friend** b. A farmer's enemy c. A neutral
	Plastic bag with praying mantis	What is this?	**a. A farmer's friend** b. A farmer's enemy c. A neutral
	Vial with syrphid fly larva in alcohol	What is this?	**a. A farmer's friend** b. A farmer's enemy c. A neutral
Crop physiology and nutrition	-	What should a farmer expect one campaign after maintenance pruning?	**a. Less black pod** b. More black pod c. No change in black pod disease
	-	With heavy shade, what do you expect?	a. Short trees b. Medium trees **c. Tall trees**
	-	With no or light shade, what do you expect?	a. Less black pod b. Less mirids **c. More weeds**
	-	Which is the fastest method of regenerating cocoa?	a. Raising and planting seedlings b. Budding
	-	What is a major source of nutrients for the cocoa tree?	a. Animal droppings in the farm b. Rain water **c. Leaf litter**
		Tall (3m) cocoa trees better than short (1m) cocoa trees because:-	a. Produce more pods b. Easier to harvest **c. Spray more pesticides**
Pesticide use and spray application	Tie rope to black pod infected pod	What would you use to control this problem?	**a. Fungicide** b. Insecticide c. Mix of fungicide with
	Tie rope to mirid infected pod	What would you use to control this problem?	a. Fungicide **b. Insecticide** c. Mix of fungicide with

	Make drawings of farmers that are protected to various degrees against pesticide poisoning	Which of these farmers is well protected from pesticide poisoning?	a. Long-sleeved shirt, shorts, flip-flops b. Long-sleeved shirt, long pants, boots **c. As in b. but add hat, mouth cover and gloves**
	Time for harvesting	When is the time to spray for CPB & black pod control?	a. Just before harvesting? **b. After harvesting cocoa pods.** c. No difference – anytime can.
	Fan nozzle for application	This nozzle generally used for:	**a. Weeding** b. Insecticide & Fungicides c. Whatever pesticide
	Cone nozzle application	This nozzle generally used for:	a. Weeding **b. P&D spraying** c. Whatever spraying
		For mirid control at the early part of the cocoa season (February, March) what type of sprayer should preferably be used?	**a. Knapsack sprayer** b. Pressurised sprayer c. Mist blower
		How can one improve the efficacy of a fungicide application?	a. Spray until run-off **b. Add adjuvant/sticker**
Cocoa quality	-	What is the optimum number of days for fermentation?	a. 3 days **b. 6 days**
		What is the best method to dry cocoa?	a. Sun-drying on jute mats on soil **b. Sun-drying on bamboo matted platform with a plastic cover**
Regeneration		What should a farmer do when he experiences declining cocoa yields over several years?	a. Abandon the farm b. Replant **c. Make a decision after considering present yields, age and number of the trees, the cost of different methods that can bring existing trees into better production**
Child labour	-	What is the minimum age a person should be to apply pesticides?	a. 15 years **b. 18 years**
	-	What kind of cocoa farm activities can under-15 year- olds do?	a. Open pods with machete **b. Collect cocoa pods using a small pail**

	-	Which of these activities can a 12-year old help out with on a cocoa farm?	a. Cut ripe cocoa from trees **b. Turning dry beans** c. Collect cocoa pods using a
HIV/AIDS		What causes HIV/AIDS?	a. Witchcraft **b. A virus**
		How do people get HIV/AIDS?	a. From sharing a glass with an infected person b. From touching an infected person c. **From having sex with an infected person or coming in contact with blood from an infected person**

SFFS EXERCISE 5: Getting to Know Each Other

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To develop a suitable atmosphere for learning, FFS participants need to know details about each other at the start of the training. They also need to identify indicators to help them monitor change related to the application of new practices and knowledge. At the same time, facilitators and FFS program managers need to have detailed information on participants to monitor who they are training.

PARTICIPATORY INTRODUCTION OF PARTICIPANTS

OBJECTIVES

- To enable participants to know more about each other
- To allow participants to develop their own indicators for monitoring change related to application of new practices learned from the FFS
- To provide FFS facilitators and FFS program managers with detailed information on participants for monitoring and planning purposes.

The participatory approach will be used to introduce the participants of the TOMF.

PROCEDURE

Because the current TOMF participants will be divided into 5 groups, 5 pictures based on the theme of Cocoa Safe will be prepared. Each picture will be cut into 4-6 pieces (or more) depending on the number of participants per group. The cut pieces will then be mixed together.

- Each participant will pick a cut piece of the pictures and look for other participants who have parts that will match to form the whole picture. When all participants have found their respective partners, they will all group around a table (each group to a table).

- After gathering the necessary information of another group member, a participant in a group will introduce that person. Then the person, who has just been introduced, introduces another person who in turn will introduce a third person. This goes on until every member of the group is introduced. Before introduction, each person will obtain as much information as possible of the person (see questions below):

The questions for “getting to know each other” are as follows:

No	Question	What to write
1	Name	Name of the person
2	Sex	Male / female
3	Which village are you from?	Name of village
4	Are you married?	Not married, married, widowed
5	How old are you?	Age in years
6	Level of education	Did not go to school / primary / secondary / above secondary
7	Can you read and write in English?	Yes / No
8	Do you belong to a local organisation(s)?	Yes / No
9	What type of organization(s)?	Farmer organization, church group, savings and credit group, other types of groups (can have more than one answer)
10	How are you related to the owner of the cocoa farms that you are working on?	Farm owner, wife of owner, sharecropper
11	How many cocoa farms do you own / work on?	Number of cocoa farms
12	How many hectares (or acres if appropriate) do you have in cocoa that produced last year (this should include all farms owned)?	Exact hectares / acres of all farms combined
13	How old are most trees on your farm(s)?	0-5 years; 6-12 years; 13-15 years; 26-30 years

OBSERVING CHANGE (PARTICIPATORY MONITORING)

Once the “getting to know each other” exercise is completed, ask participants to suggest a list of things (indicators) that we think will tell them whether they have benefited from attending the field school. Indicators should be things that can be observed.

List the indicators on a flip chart. Include the following indicators, if not mentioned:

- Increase in cocoa yields (amounts harvested)
- Reduction in amount of fungicide used
- Reduction in amount of insecticide used

These indicators will be observed on the FFS learning plots (ICPM and farmer practice) as well as on the participants’ own farms. Point out which of the indicators identified are part of the AESA and which are not. Agree on how you will collect information on those indicators that are not part of the AESA and how each participant will monitor the indicators on their own farms. Agree how often, how and when the group will report on the results from their own farms.

Mention that to tell whether change has taken place, it is important to compare the situation before and after the training took place. Together with participants, develop questions for each indicator proposed by participants. These questions will be used to measure the situation of each participant before the training. It is important to collect information from the last cocoa-growing season. List the questions on a flip chart.

AESA EXERCISE 1: Agro-Ecosystem Analysis

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OBJECTIVES

- To analyse field situation from observations, make drawings of findings, and discuss management actions required
- To study crop agro-ecosystem for informed decision-making
- To understand various interactions among components in the crop ecosystem and appreciate their balance

WHAT YOU NEED

- Field of crop
- Polythene bags
- Vials
- Alcohol
- Cotton wool
- Hand lens
- Sweep nets
- Notebooks, pencils, sharpeners and erasers, colour markers and crayons
- Poster paper (flip charts/newsprint) and markers
- Flip-chart backing board and masking tape
- Ruler and tape measure
- Cutlass/knife

ACTIVITIES

Into field for AESA observation

- The FFS learning field typically has 2 treatment plots (One treatment is farmers' practice (FP), the other is IPM practice (with decisions on crop management made based on the AESA findings). Data are collected from the 2 treatment plots to learn about their impacts (IPM versus FP).

- Each week, the farmer participants (in separate small groups of 4-6 people each) enter the FFS learning field (usually in early morning).

- Each sub-group selects one person to record all data called out by sub-group members making the observations. (Recording to be rotated among group members on different ASEA days).

- Each sub-group moves diagonally across each plot to select/tag 5-10 plants for plant agronomic observations throughout the FFS. **[Activity A. Conditions of Plants].**

- Each sub-group also chooses 5-10 trees randomly each week for AESA observations on pests/natural enemies**. [Activity B. Situation of Pests/Natural Enemies].**

***For each randomly selected plant [Activity B]*:**

- Carefully observe and count all insects you can find, both pests and natural enemies. [Collect insects (you cannot recognize in vials/plastic bags) back to meeting place for other sub-groups to help identify. Also, look for signs of insect damage on plants

- Carefully observe 5 leaves and fruits (if available), taken at random. Observe and record how many leaves and fruits are diseased. Name the diseases if you know, otherwise collect them back to meeting place for other sub-groups to help.

- Count the number of trees where major pests and diseases are found.

- Record number and species of weeds around the plant. If not sure of weed, collect it back to the meeting place for other sub-groups to help.

On each of the tagged plant [Activity A]:

- Record general condition of plant (healthy, moderately healthy, weak).

- Record weather conditions (sunny, cloudy, going to rain, drizzle, etc) at time of making observations.

- Record/estimate ground cover (leaf litter, bare, others).

- Record/estimate soil moisture levels (high, medium, low). Check if there is soil erosion, including health of the soil (structure, organic matter, etc.).

- Estimate and record the shade coverage (heavy, medium, light, or un-shaded or in % shade) and average distance between trees.

- Estimate and record canopy diameter, tree trunk circumference, average number of main branches for buddings, average height of branching, and the extent of ground cover (leaf litter, bare, or others).

- At flowering stage, estimate % flowers and count number of cherelles (small fruitlets) on the plant. Count number of pods (>10 cm or 4 inches), unripe and ripe pods (fruits). If too many, take samples and estimate the average %.

It is advisable to also do a rapid field walk per plot to check for any unnoticed problems.

Agro-ecosystem drawing

In a shaded area close to the field, or meeting place, draw all the main observations on a flip chart paper. The plant should be drawn in its present state of growth, with the sun or clouds symbolizing the weather conditions. The following is a format commonly used.

Sub-group name: (or you can make a drawing) **Type of plot:** IPM or FP

Date: **Week AESA No:**

General information	**Agronomic data**
• Buddings or seedlings • Plant variety(ies): • Approximate age of plants: • Estimated shade coverage (heavy, medium, light, or un-shaded): • Average distance between plants: •	• Average % of flowers: • Average number of cherelles: • Average number of unripe pods/fruits: • Average number of ripe pods: • Estimated canopy diameter: • Plant circumference: • Average number of main branches: • Average height of main branching: • Ground cover (leaf litter, bare, others): • Soil moisture (high, medium, low): • Soil health (structure, organic matter, others):

Weather: (Draw the weather condition at the time you make your observations)

Left (of the plant)	**Draw one large picture of the plant**	**Right** (of the plant)
Draw insect pests and symptoms of diseases found. Also indicate their abundance.	At the base around the tree, draw the weeds found. Also indicate species and numbers.	Draw the natural enemy species found, with indication of their abundance.

Analysis

Observations	**Possible causes**	**Group recommendations**
1.		
2.		

AGRO-ECOSYSTEM ANALYSIS (AESA)

- In AESA, comparisons are made between numbers and types of pests, and the natural enemies in relation to growing condition of the plant.
- Conclusions are drawn about the present overall situation compared to the previous AESA.
- Observations of specific problems are listed in AESA drawing with the possible causes and recommendations on follow-up actions.

Agro-ecosystem decision-making

(The following are some guide questions for decision-making)

- The final outcome of the AESA is the decision-making.

- Discuss within each sub-group what management decisions to take. *(For example, given the relative pest and natural enemy populations, disease levels, do we need to spray or are there other management options?).*

- If you do need to do something, decide also on:
  - How and when do you do it?
  - Consider what would be the impact on the agro-ecosystem? *(For example, if you opt to spray a pesticide, what chemical should you use? Is it necessary to spray the whole field? Is it necessary to spray the whole plant? What will happen to the natural enemies if you spray? And what knock-on effects would you expect if the natural enemies were to be killed by the spraying).*

- What is the condition of the soil? What is the structure of the soil? If it is poor, how to improve it? Do we need to take measures against soil erosion? If so, how?

<u>The decisions for actions by the small group can include</u>:

- There is a balance in the relationships of natural enemies to pests. So, no need to spray.

- There is a need to make insect zoo to determine how these natural enemies control the pests. *(The objective of insect zoo is also to help farmers observe and understand the insect-crop relationships, the insect pest status, and to gauge the potential impacts of natural enemies).*

- The field is clean. So, no weeding is necessary.

- The soil moisture is enough for normal growing of the plants. Watering is not needed.

- Do nothing and continue to observe the field.

<u>Recommendations</u>: Each sub-group should fill into the decision-making portion under '*group recommendations*' in the AESA drawing.

<u>Presentation</u>: Each sub-group appoints a representative to present its findings and conclusions to the whole group. This permits further questioning, discussion and refinement. Sometimes, the decision made by a sub-group is modified or rejected in the whole discussion. From the discussion, a consensus is reached as to what action(s) (if any) should be taken and when, e.g. specific pest control measures, weeding, fertilising, or other management operations.

***How can AESA be used*?**

Sometimes, it is not possible to answer straightaway all the questions that arise. In such a situation, one should use the AESA to identify topics/experimental exercises/insect-disease zoos that the FFS needs to study or to obtain ideas on which IPM or integrated crop management (ICM) methods should be tried.

AESA EXERCISE 2: Identifying and Collecting Healthy Ripe Pods, Diseases, CPB-infested pods (include half-ripe) & Rodent Damaged Pods in the Field

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OBJECTIVES

- To be familiar with what is healthy ripe pods, diseased; CPB infested and rodent damaged cocoa pods.
- To collect enough pods of each category to use as material for CH Exercise 2.
  (Note: unripe pods are not harvested in order not to lose crop, but half-ripe/premature ripening pods due to severe CPB attack are harvested under CPB category.)

WHAT YOU NEED

- Harvesting knives
- Machetes
- Harvesting poles
- Secateurs
- Weighing scale
- Cocoa plots, one with good height control and pruning and the other without.

ACTIVITIES

1. In your respective groups, go into the cocoa plot with good height control and pruning. Mark out 10 trees in the plot. Harvest all mature ripe pods from each of the trees. Record the time taken to carry out the harvesting. Bring out all the pods to the side of the road. Separate the pods into healthy, diseased, CPB infested (include half-ripe) and rodent damaged pods. Record the numbers. Use the pictoral guides in this manual to help you in the sorting. You will have to split open pods to confirm that they are infested. For the healthy ripe pods, split them open and record weight of wet beans obtained.
2. Repeat the same for the cocoa plot with poor height control and pruning.
3. **Optional**, in place where there are no differences in height control, separate the pods from the top canopy/ side branches and the bottom trunk pods for this exercise.
4. Record all data for summarisation of total counts and means.
5. Make drawings of what you understand to be healthy ripe, diseased, CPB infested and rodent damaged pods.

QUESTIONS FOR DISCUSSION

1. What are the total and mean number of cocoa pods of each category (i.e. healthy ripe, diseased, CPB infested and rodent damaged pods) collected from the plot with good sanitation and without?
2. What is the yield in terms of total and mean weight of wet beans from the plot with good sanitation and without?

3. **Optional**: What is the yield in terms of total and mean weight of wet beans from the low main branches and pods from the canopy/ side branches?
4. What is the total and mean time taken to harvest pods from 10 trees in the plot with good sanitation?
5. Prepare a poster to present your findings.

CH EXERCISE 1: Pruning and Canopy Height Control

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OBJECTIVE

To understand the importance of pruning and canopy height control for effective control of CPB infestation.

The side benefits/effects of pruning on chemical control – better target and reduce pesticides usage.

WHAT YOU NEED

- Harvesting knives
- Machetes
- Harvesting poles
- Secateurs
- Weighing scale
- Cocoa plots, one with good height control and pruning and the other without.

ACTIVITIES

6. This is a continuation of AESA Exercise 1. Data of AESA Exercise 1 that is important for this exercise are the total and mean number of each category of pods taken out, yield in terms of weight of wet beans harvested and time taken to carry out the harvesting.
7. An additional activity here would be to repeat the harvesting of AESA Exercise 1 with each group taking the plots and the same trees of another group. This serves as a check on how many pods are left behind by the previous group. Pods collected from this follow-up harvest should be similarly categorised into healthy ripe, diseased, CPB infested and rodent damaged pods.
8. Record all data for summarisation of total counts and means.

QUESTIONS FOR DISCUSSION

1. What are the total and mean number of cocoa pods of each category (i.e., healthy ripe, diseased, CPB infested and rodent damaged) collected from the plot with good sanitation and without in the follow-up harvest? (or top canopy vs bottom trunk).
2. From this and data from AESA Exercise 1, what can you say about the importance of pruning and canopy height control for effective control of CPB infestation?
3. In terms of chemical control, how does pruning and canopy height control contribute to pesticide usage?
4. Prepare a poster to present your findings.

CH EXERCISE 2: The Role of Shade and Spacing in Determining the Architecture of Cocoa Trees and Yield

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In many parts of Africa, farmers allow cocoa trees to grow into a large bush with three jorquettes. Many trees are overly tall (15-20 m). This exercise allows farmers to understand how shade and light influence the shape of the young cocoa tree and how this affects farm management. Over-shading also affects yield.

OBJECTIVE

- To understand how spacing, shade and light affects the shape of young cocoa trees
- To understand the importance of pruning young cocoa trees to give them the right shape
- Shape of budded trees – need to be managed/ supported from young stage.

TIMING

When there are pods on the trees

LOCATION

Mature cocoa farm (4 years and older) with wide spacing (more than 3 meters) and tall trees

MATERIALS

- 4 standard pruners
- 8 poles (assuming there will be 4 small groups)
- String measuring 90 m marked every 3 m
- Tape measure
- Flip chart paper
- Markers

NOTE: Before the exercise, visit the farm to identify 4 areas for the exercise (2 with wide spacing and 2 with 3 m by 3 m spacing) and mark out 5 trees in each of the 4 areas

PROCEDURE

Divide the participants into small groups of 5-6 participants. Assign two groups to an area with widely spaced trees (more than 3 meters apart) and the other two groups to an area with trees planted at normal spacing (3 meters apart). Ask each group to do the following in their assigned area of 5 trees:

1. Measure the size of the stems with the string
2. See if the standard pruner can reach the top of the trees
3. Diameter of the crown (stretch a pole from one end of the furthest branch to the other end and measure the distance; do the same in the other direction)

4. Measure the spacing between cocoa trees
5. Count the number of mature pods and get the average for the 5 trees (total number of pods divided by 5)

Ask each group to report their observations and write them up on the flip chart. Facilitate a discussion comparing the results from the two areas of the farm using the guide questions.

QUESTIONS FOR DISCUSSION

1. Are the cocoa trees grown from seeds or buddings?
2. Are all the cocoa trees of the same height and stem size?
3. What has caused some of the cocoa trees to be taller?
4. What has caused some of the stems to be very small (less than 10 cm)?
5. What is the spacing in the area where the cocoa is not too tall and has normal size stems?
6. What is the spacing in the area where the cocoa is tall and has small stems?
7. Is there a difference in the average number of pods in the areas with tall trees and trees of normal height?
8. What is the correct spacing for cocoa trees?
9. What are some disadvantages of tall cocoa trees?
10. What height should a cocoa tree be?
11. How do you ensure that cocoa trees grow to the right height?
12. What have you learnt from this exercise?

CH EXERCISE 3: Role Play on the Importance of Soil Fertility for Cocoa Production

………...

OBJECTIVE

- To make farmers aware of the long term implications of not using fertilizers in terms of yield, long term soil fertility and potential for replanting cocoa
- To make farmers aware of the implications of soil mining
- To make farmers aware of the nutrient content of fertilizers and their effects on the cocoa plant
- New awareness of presence of heavy metals in cocoa beans which could have come from soil and/or fertilizers

TIMING

At the start of the rainy season before conducting other exercises on fertilizer use

MATERIALS

- Prepared script of the role play
- Flip chart
- Markers

PROCEDURE

Organize participants for the skit. You may need to practice this skit with participants who have important speaking roles before the session. You will need the following volunteers:

- 1 participant to be the storyteller
- 1 participant to be the cocoa farmer, (3 farmers),
- 2 participants to be cocoa trees
- 3 participants to be soil organic matter
- 3 participants to be microorganisms
- 1 participant to be phosphorus (P)
- 1 participant to be potassium (K)
- 1 participant to be nitrogen (N)

You may have to modify the story to your own situation. It will also be important to develop local terms for technical terms such as soil organic matter, microbes, nitrogen, phosphor and potassium.

SCRIPT

Story teller: A cocoa farmer owns a cocoa farm that was planted by his grandfather 50 years ago. Lately he has noticed that his yields have reduced from 4 bags to 2 bags per acre (10 bags to 5 bags per hectare). He notices that his farm has more pests and disease, the same number of young pods but more pods die when growing and there are holes in the canopy. He visits his farm every day but is worried about the situation. One day while working on his farm, he falls asleep under a tree. He begins to dream. In his dream he is able to hear trees and other natural things talking.

Cocoa tree 1: I am old and sick. Although my owner is a good farmer who manages his farm well, he does not pay any attention to the soil. Year after year, he harvests my pods and takes them away but does not return anything to the farm to make me stronger.

Cocoa tree 2: I get all my food from the soil. The soil is made up of many things such as nutrients (food), air, water, microorganisms (very small things in the soil that help move the nutrients to my roots). If the soil is not fertile, I too will not be healthy. Oh, if we could only make this farmer see all the things that I need from the soil to be healthy.

Cocoa tree 1: My pods and beans contain a lot of the nutrients from the soil. But when the farmer harvests them, he takes them away from the farm. Year after year, he harvests my pods and takes them away but does not return anything to the farm to feed me and make me stronger.

Soil organic matter: Maybe all of us can help the farmer to understand what makes a fertile soil. We are the things in the soil that come from plants and animals. This includes things like leaves, the bodies of dead animals and insects and worm shit. We are an important part of the soil.

Microorganisms: Let me introduce my family. We are microorganisms, very small things that live in the soil. We are friends of the farmer. We help to break down dead matter in the soil into smaller and smaller pieces that can be used by the roots of the trees for food. Some of us help protect the plant roots from attack by diseases and pests.

Story teller: The farmer begins to understand that soil is not dead but is a living thing. Suddenly three other characters join the group.

Potassium: I am potassium, an important food that is needed to make a plant healthy. There is a lot of me in cocoa beans and especially in pod husks. I am very important for moving nutrients around the tree, for making the tree able to fight pests and diseases and for pod growth. I am the most important nutrient.

Nitrogen: That is not true. I am nitrogen and I am more important because I am needed for strong growth of the cocoa tree, flowering, leaf growth and development of the beans. I help the plant to take in sunlight and use it as energy. I am found in the air and the soil but only in small amounts that are not enough for growing plants including cocoa trees. If there is too little of me in the soil, cocoa trees don't grow very fast. One way to increase the amount of nitrogen is to use chemical fertilizers that contain nitrogen.

Phosphorous: None of you are as important I me. I am phosphor, another plant food found in the soil. In cocoa, I help the beans and the roots to grow well.

Story teller: Suddenly another character jumps into the discussion.

Soil PH: Excuse me, let me talk too. Soil can change from being less acidic to more acidic. When soil gets more acidic, it stops the nutrients in the soil from being taken up by plants. As the farmer farms year after year, harvesting pods and taking them away from the farm without putting any food back into the soil, the soil becomes more and more acid. After many years, this situation causes the soil microbes to suffer and the nutrients I need cannot easily travel to my roots.

Cocoa tree 1: All of you stop arguing. I need nutrients from the soil in the same way that humans need food. If a human only eats palm soup and fufu with no meat (insert name of a local dish) every single day for his whole life, he will get sick. Also, after some time he will finish eating all the yam (plantain etc.) he planted. Humans need to eat different types of foods such as meat, fish, vegetables and fruits to be healthy. Trees too need to get different types of nutrients from the soil. Therefore all the nutrients are important but in different amounts.

Nitrogen: There are different types of fertilizers that provide the important soil nutrients. Some are made from plant or animal products such as manure and compost. Some fertilizers from the shops are made up of phosphorous and potassium. Others include nitrogen as well. There are also single nutrient fertilizers such as Urea and TSP (triple super phosphate). Good quality fertilizers also include other nutrients that a cocoa tree needs.

Farmer: I did not know all these things. Now that I understand the different kinds of plant foods needed for my cocoa to be healthy, I will start applying fertilizer to my cocoa trees.

Cocoa tree 2: But how will you choose which fertilizer is right for your farm? There are many types of fertilizers.

Cocoa tree 1: Another thing you need to know is that when the situation has been left for some time, it may take a lot of fertilizer and money to improve the soil.

Story teller: The farmer wakes up from his dream. The next day he goes to the shop to buy fertilizer.

QUESTIONS FOR DISCUSSION

1. How many participants use fertilizer on cocoa? On other crops?
2. Why don't some farmers use fertilizer on cocoa?
3. What does applying fertilizers do to a cocoa tree?
4. What are the advantages and disadvantages of using manure or compost on a cocoa farm?
5. What are the microorganisms found in manure that can cause food poisoining?
6. What types of mineral fertilizers are available in this area?
7. How do you choose which fertilizer is right for your farm?
8. Any complains about heavy metals in your cocoa beans in your area?

CH EXERCISE 4: The Effects of Fertilizers on Young Cocoa Plants

Cocoa farmers often are not aware of what effects chemical fertilizers have on different parts of the cocoa trees. This exercise allows them to observe these effects on young cocoa plants and to draw conclusions about the advantages of chemical fertilizers.

OBJECTIVE

To show farmers the effects of fertilizers on the young cocoa plant

MATERIALS

- 10 cocoa seedlings 4-5 months old of the same age and size, preferably from the same pod planted in large polybags (larger than the usual type to allow for vigorous growth)
- A good compound fertilizer, preferably one suitable for young cocoa plants
- Record sheet (see attached)

TIMING

At the start of the rains after completing the fertilizer role-play protocol

PROCEDURE

Part 1

Introduce the topic of fertilizer use and explain the purpose of the exercise. Divide the participants into 2 groups of 5 each. One group should be label "Seedlings with fertilizer" and the second group "Seedlings without fertilizer". Label each plant in both groups with the numbers 1-5. For example; "seedling with fertilizer 1", "seedling with fertilizer 2" and so on.

Apply fertilizer to the seedlings in the first group, making sure to put the fertilizer away from the plant stem but nearer the bag. Keep the seedlings in a well-shaded area in the FFS farm. Agree with the participants who will be responsible for watering the seedlings and for making observations and keeping records.

Apply fertilizer a second time at the start of pod production (late August-early September).

Part 2

Monitoring

Every session until the end of the FFS, observe the following on the two groups of seedlings:

- Vigor (strong, moderate, poor)
- Health of leaves (healthy, not healthy)
- Insect attack (high, moderate, low)

Once a month, the facilitator should check to make sure that participants are keeping the records. The record keeper should make a short report every month to the rest of the school on the difference between the two groups of plants, if any.

At the end of the experiment, cut off the poly bags, shake off the soil and dip the roots in water. Observe the spread of the taproot and the peripheral roots. Facilitate a discussion comparing the two groups of plant on the other observations.

QUESTIONS FOR DISCUSSION

1. Are there differences between the two groups of plants in terms of vigour, health of leaves, incidence of insect attack? If so, how are they different?
2. During which month (s) did the biggest difference occur? Why?
3. What have you learned from this exercise?

RECORD SHEET FOR MONITORING THE EFFECTS OF FERTILIZER ON COCOA PLANTS

	Vigour														**Other observations**
	Sessions														
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
With fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															
Without fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															

	Health of leaves Sessions														
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
With fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															
Without fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															
	Insect attack														
	Sessions														
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
With fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															
Without fertilizer															
Seedling 1															
Seedling 2															
Seedling 3															
Seedling 4															
Seedling 5															

CH EXERCISE 5: The Effects of Fertilizers on Mature Cocoa Plants

Cocoa farmers often are not aware of what effects chemical fertilizers have on mature cocoa trees. This exercise allows them to observe these effects and to draw conclusions about the advantages of chemical fertilizers.

OBJECTIVE

To show farmers the effects of fertilizers on the cocoa tree

MATERIALS

- 15 cocoa trees outside of the ICPM plot (this plot is referred to as the fertilizer demo plot)
- 15 cocoa trees in the ICPM plot
- 15 cocoa trees being observed in the FP plot
- A good compound fertilizer, preferably one specially produced for cocoa trees
- Record sheet (see attached)

TIMING

At the start of the rains after completing the fertilizer role-play protocol

PROCEDURE

Introduce the topic of fertilizer use and explain the purpose of the exercise.

Apply fertilizer to the trees in the fertilizer demo plot at the start of the rainy season (April- May). Depending on the type of fertilizer, apply fertilizer a second time at the start of pod production (late August-early September).

Monitoring

When doing AESA each time, monitor the trees in the three plots (ICPM, FP and fertilizer demo plot) for the following:

- Number of immature, large pods on tree (>10cm pods; count only below 2 m)
- Number of healthy ripe pods harvested for use (Harvest whole tree)
- Number of unusable large pods attacked by black pod and removed (whole tree)
- Number of unusable large pods attacked by rodents and removed (whole tree)
- Size of pods

At the end of the training cycle, compare the following between the FP,ICPM and fertilizer demo plots:

- Amount of beans harvested
- Number of beans per pod
- Ease in removing beans
- Proportion of flat beans

QUESTIONS FOR DISCUSSION

1. What differences do you observe between the three plots?
2. How can we explain these differences?

Record sheet for monitoring fertilizer trials

1. a) Facilitator(s):______________________________ b) (School) location____________________c) Date______/_____/____ (dd/mm/yy)

	ICPM PLOT				FARMER PRACTICE PLOT				FERTILIZER DEMO PLOT			
Cocoa pods and input monitoring	a) Trees 1	b) Trees 6	g) Trees 11-15	h) Total 1-15	e) Trees	f) Trees 6-10	g) Trees 11-15	h) Total 1-15	e) Trees	f) Trees 6-10	g) Trees 11-15	h) Total 1-15
1. Number of immature pods (>10cm) on tree stem below 2 m)												
2.. No of healthy ripe pods harvested (whole tree)												
3. No of blackpods (whole tree) & remove												
4. No of rodents damage pods (whole tree) & remove												
6. Fungicide (Record quantities of material applied, e.g.100 g of $CuSO_2$ (copper	a1) Type b1) Qty sprayed:_____c1) Units________				A2) Type b2) Qty sprayed:_____c2) Units________				a2) Type b2) Qty sprayed:_____c2) Units________			
7. Insecticide((Record quantities of material actually applied, e.g. 20ml of deltametrin x no. of	a1) Type b1) Qty sprayed:_____c1) Units________				A2) Type b2) Qty sprayed:_____c2) Units________				a2) Type b2) Qty sprayed:_____c2) Units________			
8. Fertilizer (Record quantities of fertilizer applied measured in kilograms, e.g. if one-fourth of a fifty kg bag, then = 12.5 kg	a1) Type b1) Amount applied (all trees)_______kg				A2) Type b2) Amount applied (all trees)_______kg				a2) Type b2) Amount applied (all trees)_______kg			

9. Time of pod setting			
10. Size of pods			

CDP EXERCISE 1: Impact of Humidity and the Role of Diseased Pods in Spreading Black Pod

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Awareness of the impact of humidity and the role of diseased pods in spreading black pod disease encourages cocoa farmers to improve farm sanitation.

OBJECTIVE

To demonstrate the impact of humidity on black pod disease development and the role of diseased pods in spreading black pod

MATERIALS

- 3 plastic bowls/containers with lids
- Knife
- Tissue paper
- 3 healthy green cocoa pods
- Actively sporulating cocoa pods (infected pods with disease seeds =spores) If you cannot find sporulating cocoa pods, take an infected pod and put it in a plastic bag with wet tissue and keep it in a shaded place for a day or two until white powdery spore masses form
- Water
- Labels and marker
- Notebook and pen

PROCEDURE

Place tissue paper at the bottom of three plastic bowls. Wet the tissue paper in two of the three bowls with water to create a humid atmosphere. Label one bowl “infected”, the second bowl “control with no water” and the third bowl “control with water”.

Put a healthy green pod in each of the three bowls. With a knife, cut two small portions of the actively sporulating infected pod (portion of pod with white powder – seeds of the disease). Place one each of the cut diseased portion on the pods in the bowls labeled “infected” and “control with no water”, making sure that the diseased surface is in direct and close contact with the healthy pod. Cover the bowl labeled “infected” and “control with water” to create a humid environment. Leave the bowl labeled “control with no water” open.

OBSERVATIONS

Observe the set up daily for 5 days.

- Check for growth of emerging infected areas on the pods. Measure the diameter of the infected areas, noting how many cm it grows each day.
- Check for development of white powdery spore masses.

QUESTIONS FOR DISCUSSION

1. Is there a difference between the growths of emerging symptoms in the three bowls? If yes, why? What does the difference mean for black pod development in a cocoa farm?
2. Is there a difference in the starting time of sporulation between the bowls? If yes, what does this mean for the spread of black pod disease in a cocoa farm?
3. Are there any methods to reduce humidity in a cocoa farm? If yes, what kind of impact would you expect on the development of black pod if humidity is reduced?

CDP EXERCISE 2: Cocoa Disease Infection Study

This exercise has been developed for black pod but can be applied to other cocoa pod diseases

OBJECTIVE

Better understanding of the role of rain in transmitting black pod and the importance of phytosanitary harvest in controlling the disease

MATERIALS

- 3 large plastic bowls/containers with lids
- Knife
- Tissue paper
- 3 healthy green cocoa pods
- 1 actively sporulating cocoa pod (infected pod with disease seeds =spores). If you cannot find sporulating cocoa pods, take an infected pod and put it in a plastic bag with wet tissue and keep it in a shaded place for a day or two until white powdery spore masses form
- 3 clean soft paint brushes
- Dry, clean stick
- Water
- 2 cups
- Labels and marker
- Notebook and pen

PROCEDURES

Line the bottom of the three plastic bowls with tissue paper. Wet the tissue paper in 2 bowls with a similar amount of clean water to maintain a humid atmosphere. Wash and dry the 3 healthy cocoa pods. Put a pod in each of the three bowls. Label one bowl "infected", the second one "control with no water" and the third bowl "control with water".

Take the sporulating cocoa pod and wash the white powder of the sporulating area into one cup with the aid of the paintbrush. Label the cup "infected water". Stir the suspension in the 'infected water' cup with the dry stick for 5-10 minutes and leave for 30 minutes.

Fill another cup with clean water and label the cup "clean water". Using the paintbrush, put drops of the "infected water" on the healthy pod in the "infected disease zoo". Using the other clean paintbrush, put drops of the "clean water" on the healthy pod in the "control with water disease zoo". Using the third clean paintbrush, add spores on the pod contained in the "control with no water" disease zoo. Cover the bowls labelled "infected" and "control with water' to create a humid environment.

OBSERVATIONS

Observe the set up daily for 5 days. Check for:

- Growth of emerging infected areas on the pods, noting how many days after set-up you can see these emerging.
- Development of white powdery spore masses, noting how many days after set-up you can see these emerging.

Guide questions for discussion

1. Why did we include an uninfected "control" disease zoo (bowl 3)?
2. Why did we include a control disease zoo with no water?
3. How long did it take for the symptoms to develop in the infected disease zoo?
4. How long did it take for the spore masses to develop?
5. Can we tell how long the disease cycle takes?
6. What do the results tell us about disease development in a cocoa farm?
7. What have you learned from this exercise?

CDP EXERCISE 3: Role of Soil in the Spread of Black Pod Disease

Farmers have many misconceptions about how black pod disease spreads and may not know that soil can play a role in spreading it.

OBJECTIVE

To demonstrate the potential role of soil in the spread of black pod disease.

MATERIALS

- Six healthy cocoa pods
- 250 g. of soil taken from a farm heavily infected with black pod (take a sample from the top 5 cm)
- 2 large plastic bowls/containers with lids
- 5 litres of cool, boiled water

ACTIVITIES

Place the soil sample in bowl no. 1. Place 3 pods in the soil in bowl 1. Pour 2.5 litres of water over the soil and the pods, making sure that the pods are half covered by the water. Cover the bowl.

Place the remaining 3 pods in bowl no. 2. Pour 2.5 liters of water over the pods and cover the bowl.

OBSERVATIONS

Check the set-up daily for 5 days for:

- Growth of infected areas, noting how days after set-up these infected areas emerge
- Development of white powdery spore masses, noting how many days after set-up these emerge

QUESTIONS FOR DISCUSSION

1. What does this exercise show about how black pod spreads?
2. How other factors are important in the spread of black pod?
3. What can farmers do to prevent the spread of black pod on their cocoa farms?
4. What lessons have you learned?

CDP EXERCISE 4: Black Pod Disease Zoo in the Field

This exercise allows farmers to discover that black pod development is slowed down when shade is reduced from heavy to light. A similar exercise can be used to compare disease development on different cocoa varieties (instead of selecting pods in differently shaded areas, select pods of different varieties).

OBJECTIVE

To show the impact of reducing shade on black pod development

MATERIALS

- Cocoa farm with areas of heavy and moderate/light shade where there are pods at an early stage of black pod infection
- Waterproof markers
- Ruler
- Tags/labels

PROCEDURE

Walk through the cocoa farm. Identify an area with heavy shade and an area with light shade. Divide participants into groups. Ask each group to identify 5 pods of the same size and stage that have initial black pod symptoms (e.g. 1 spot of about 5 cm in diameter per pod) in both the area with heavy shade and the area with light shade. Make sure to select sizable pods.

Label the identified pods, noting on each label the date, the area (heavy shade or light shade) and the name of the group of participants. Trace with the waterproof marker the periphery of the black pod rotted surface.

OBSERVATIONS

Observe the labelled pods after 5-7 days. Measure, using a ruler:

- How much the black pod rot has grown beyond the traced periphery.
- The diameter of the white sporulating area.

- Compare observations between the heavy shaded and light shaded areas

QUESTIONS FOR DISCUSSION

1. Is there a difference in growth of the black pod rot areas? Why?
2. Is there a difference in sporulation of the black pod? Why?
3. What do the answers to above questions mean for the spread of black pod in a farm with heavy shade compared to light shade?
4. Are there any other advantages/disadvantages of heavy shade in a cocoa farm?
5. Are there any other advantages/disadvantages of light shade in a cocoa farm?
6. Which cultural methods are available to slow down the spread of black pod disease? Which of these shall we apply to the ICPM plot in our field school?

CDP EXERCISE 5: Insect Zoo 1 – Symptom Development

Some insects are pests, feeding on plant parts. Some feed on insect preys, others live inside other insects, while others come from weeds or neighbouring crops, and are simply resting on the crop. This insect zoo demonstrates the symptoms of insect pests on cocoa pods and/or cocoa seedlings in polybag.

OBJECTIVE

To study insect feeding patterns and understand which insect causes which damage symptoms

MATERIALS

- Small plastic vials or empty water bottles containers
- Plastic bags
- Plastic buckets (transparent if available), large enough to hold cocoa pods of various sizes
- Cocoa pods, leaves and chupons
- Tissue paper
- Camel or fine hair brush
- Labels
- Muslin cloth or fine mesh screen
- Rubber bands/pieces of string
- Hand lens
- *Optional*: insect collection box and pins

PROCEDURE

Introduce and discuss the concepts of pests ("enemy of the farmer"), natural enemies ("friends of the farmer") and neutral ("a visitor"). Very early in the morning, have participants carefully collect unknown and known insects from the FFS plot using a sweep net or by capturing them in plastic vials/bottles. Be careful when handling the insects that you want to study, as they won't feed if they have been roughly handled. Ask participants to study the insects and give the local name of each. Discuss what insects might feed on.

To set-up zoos, line the plastic buckets with tissue paper to avoid condensation. Put one cocoa pod and/or some leaves and chupons in each bucket and label each bucket with the (local) name of the insect that you want to study. Put different insect species in different "zoos". Participants can be divided into groups to observe the different zoos.

To find out whether an insect is a pest, put it on a cocoa pod or a sapling (young cocoa tree) in a bucket and cover the bucket with muslin cloth / screen, secured with a rubber band / piece of string. Keep the buckets out of direct sunlight. Observe whether the insect feeds and the feeding symptoms. Check again after some time; how long does the insect survive?

Another way to build an 'insect zoo' is to sleeve cocoa pods or branches on the tree in the field with plastic bags that have screen windows (make sure that there are no holes in the plastic or screen windows). Insert the insects that you want to study and observe the zoo daily.

At the end of the exercise, participants should present their observations to the wider group.

It is a good idea to build up a reference collection of some pests and natural enemies during a field school training cycle. To make a reference collection, pierce or glue studied, dead insects on insect pins or fine tailor pins (pierce the pin through the thorax--the middle part of the body). Add a small paper label with details of the collection date, place and crop. Very small insects may be kept in glass vials with alcohol.

OBSERVATIONS

- Have participants record the local names of the insects that were collected, the location where they were collected and describe their observations on poster paper.
- Participants should explain in presentation session:
- Insect(s) collected
- Where they collected them
- What they fed on
- Whether they changed development stages
- How long they remained in certain development stages They should illustrate their observations with drawings.

QUESTIONS FOR DISCUSSION

1. Did the insect feed in the zoo? If no, why not (was the insect damaged, not hungry, or is the insect not a cocoa pest)?
2. How long did the insect survive in the zoo?
3. Was the insect a 'friend' of the farmer, a 'visitor' or an 'enemy' of the farmer?
4. How could the information about feeding patterns help you in managing pests?

CDP EXERCISE 6: Insect Zoo 2 – Symptom Development - CPB

Insect/disease zoos are usually small observational studies made by farmers (with help from facilitators) to learn specific aspects of the pests or their natural enemies, e.g. life stages, nature of injury and damage symptoms, specific behaviour (e.g. oviposition) of natural enemies, etc. They can be considered either as special topics or additional studies to support the understanding of some bigger issues. Usually, they are focused on locally identified pest problems, although they may also deal with general topics such as plant-insect relationships, pest-natural enemy relationships, disease transmission process, etc. In general, they help to increase farmers' understanding of ecological principles in the crop agro-ecosystem.

Most farmers are unaware of concepts such as predation and parasitisation, even though these may be naturally present in their farms. These are good subjects for participatory and discovery through insect zoo observations, where farmers can discover processes not easily observed in the open field.

Similarly with diseases, many disease zoos have been developed to help farmers learn about disease symptoms and development, including the various modes concerning how diseases are spread (e.g. seed, soil, and insect vectors).

A) BREEDING OUT CPB PUPAE FROM FIELD-COLLECTED PODS

OBJECTIVE

To breed out CPB pupae from pods infested with CPB larvae.

MATERIALS

- Several infested cocoa pods freshly collected from the field
- Transparent rearing jar or container (sufficiently large to keep the pods)
- Muslin cloth
- Rubber band
- Some soil
- Some cocoa leaves (fresh or/and dried)

PROCEDURE

1. Collect several cocoa pods with signs of CPB infestation (e.g. uneven ripening)
2. Place some soil in the rearing container
3. Place the cocoa pods in the container
4. Place some cocoa leaves on the soil or/and over the pods. Double check to make sure the leaves are clean and do not contain any insect on them
5. Cover the mouth of the container with muslin cloth, securing it with rubber band
6. Observe the container daily to check whether CPB pupae can be found on the leaves. If so, also check for exit holes if they are present on the pods
7. At the end of the study, split open the pods to examine the conditions of the inside

QUESTIONS FOR DISCUSSION

- Can you find any CPB pupae on the leaves? If so, where did they come from, and why do you think so?
- What are the implications?
- How is the condition of the inside of the pods? Please describe.

B) BREEDING OUT CPB ADULTS FROM FIELD-COLLECTED CPB PUPAE

OBJECTIVE

To rear out CPB adults from field-collected pupae.

MATERIALS

- Some cocoa leaves with CPB pupae collected from the field
- Transparent rearing jar or container (to keep the leaves for observation)
- Muslin cloth
- Rubber band
- Some soil

PROCEDURE

1. Collect some fallen cocoa leaves with CPB pupae from the ground in the field
2. Place some soil in the rearing container
3. Place the leaves in the container
4. Cover the mouth of the container with muslin cloth, securing it with rubber band
5. Observe the container daily to check whether CPB adults can be found in the container. If so, also check what have remained on the leaves

QUESTIONS FOR DISCUSSION

1. Can you find any CPB adults? If so, where did they come from, and why do you think so?
2. What are the implications?
3. What did you find remaining on the leaves? Please describe

CDP EXERCISE 7: Insect Zoo – Predation Exercise

Farmers do not always recognize the role of predatory insects in controlling other insect pests. Sometimes mistaken knowledge can lead farmers to use pesticide that kill beneficial predatory insects.

OBJECTIVE

To discover the importance of beneficial insects and their role in controlling pests

NOTE*: This exercise may be done after the insect zoo on symptom development to identify which of the insects used in that exercise are predators.*

MATERIALS

- Small plastic vials, empty water bottles containers or plastic bags
- Plastic buckets (transparent if available), large enough to hold cocoa pods of various sizes
- Cocoa pods and leaves
- Tissue paper
- Camel or fine hair brush
- Labels
- Muslin cloth or fine mesh screen
- Rubber bands/pieces of string
- Hand lens
- Optional: insect collection box and pins

ACTIVITIES

In the previous session, explain the objective of the exercise and ask participants to collect insects from their own farms either the night before the session or early in the morning before the session. Ask participants to study the insects and give the local name of each. Discuss what the insects might feed on: cocoa or other insects.

To set-up zoos, line the plastic buckets with tissue paper to avoid condensation. Put one clean cocoa pod and/or some leaves in a bucket and label each bucket with the local name of the insect you want to study.

Place an expected predatory insect (a “natural enemy” or “farmer’s friend”) together with an expected prey insect in a “zoo” (for example, lady beetles with aphids or praying mantis with a leaf feeding caterpillar). Make sure that you don’t put different species of predators together as they might attack each other. Label each bucket with the local name and number of insects in each zoo.

OBSERVATIONS

Divide participants into 3 groups to observe the “zoos”. Each “zoo” should be kept by one participant, in a place out of direct sunlight, and observed regularly every day for 3-5 days for the following:

- Number of surviving pests and preys in each zoo
- Development of pest symptoms in the zoo with predators and the zoo without predators

At the end of the exercise, groups should describe and draw their observations on poster paper and make a presentation to the whole school.

QUESTIONS FOR DISCUSSION

1. Was the studied insect(s) a 'friend’ of the farmer or an 'enemy’ of the farmer?
2. What do you expect might happen to the farmers’ ‘friends’ when insecticides are used to control pests?
3. How can you conserve farmers’ ‘friends’ in the field?

CDP EXERCISE 8: Insect Zoo – Life Cycle Development

Increasing farmer knowledge about the life cycle of insect pests will lead to better integrated pest management approaches against insect pests. This exercise should focus on CPB and mirids, given their economic importance in Indonesia, Malaysia and PNG.

OBJECTIVE

To study insect life cycles, recognize and learn about their development stages

MATERIALS

- Small plastic vials or empty water bottles containers
- Plastic bags
- Plastic buckets (transparent if available), large enough to hold cocoa pods of various sizes
- Tissue paper
- Camel or fine hair brush
- Labels
- Muslin cloth or fine mesh screen
- Rubber bands/pieces of string
- Hand lens
- Optional: insect collection box and pins

ACTIVITIES

1. Carefully collect eggs or larvae of mired or CPB or other cocoa pests by capturing them in plastic vials/bottles.
2. To set-up zoos to study life cycles, line the plastic buckets with tissue paper to avoid condensation. Put one cocoa pod and/or some leaves in each bucket and label each bucket with the (local) name of the insect that you want to study. Participants can be divided into groups to observe the different zoos.
3. Rear the collected insects in the zoos until the adult stage. Feed the larval stage on appropriate food (leaves, pods, stems) every day and observe them during development. Monitor the duration of each development stage. It is important to always keep checking the tissue paper lining the buckets; when it is wet, replace it with dry tissue paper.
4. Another way to build an 'insect zoo' is to sleeve cocoa pods or branches on the tree in the field with plastic bags that have screen windows (make sure that there are no holes in the plastic or screen windows). Insert the insects that you want to study and observe the zoo daily.
5. At the end of the exercise, participants should present their observations to the wider group.

OBSERVATIONS

1. Have participants observe the insects in the zoo as often as possible, or at least every two days. They should try and describe a complete life cycle.
2. Participants should note and explain the following in presentation sessions:
3. Name of insect
4. Where collected
5. What they were feeding on
6. Whether they changed developmental stages
7. How long they stayed in each developmental stage
8. What takes place in each developmental stage (is it moving, is it still feeding, is it laying eggs)
9. Participants should illustrate their observations with drawings of each development stage. They should try to do a complete cycle.

QUESTIONS FOR DISCUSSION

1. What did you learn about the insect you studied in the insect zoo?
2. How can the information about duration of development stages help you in pest management?

CDP EXERCISE 9: Determining MIrid Damage Threshold for Essential Insecticide Application

………...

In many cocoa-growing communities, farmers spray against mirids following a calendar-based schedule, without considering whether there is a need to spray or not. This practice is often uneconomical and not environmentally friendly. The use of damage thresholds in deciding when to spray ensures that insecticides are applied only when they are needed. This approach helps to protect the environment from avoidable contamination and saves farmers money.

OBJECTIVE

To help farmers understand the concept of mirid damage threshold, its application and its benefits

NOTE: This exercise should be conducted after the protocol on insect zoo symptom development to ensure that participants can recognize mirids and their various damage symptoms

MATERIALS

- Cocoa field (at least 1 ha) with sections obviously infested with mirids and sections free of mirids
- Record book
- Pens
- List of recommended insecticides for mired control and their current local market prices
- Guidelines on deciding whether to spray or not (see below)

ACTIVITIES

Before the FFS session, facilitators should walk through the FFS farm (beyond the FFS plots) to identify locations with obvious mirid damage. Divide the farm into 4-5 equal parts (each part with at least 100-200 trees) with different levels of mirid infestation.

Facilitate a discussion on the importance of mirids as a pest. Ask participants what they do to control mirids.

Ask participants to list the mirid damage symptoms they know. These should include: fresh mirid lesions on pods, fresh lesions on chupons and fan branches, pockets of dry/wilted chupons or fan branches, formation of stag heads and fresh cankers on trunks/branches or the presence of nymphs/adult mirids. Note that farmers may not be able to recognize some of these symptoms as mirid damage. If they are able to identify mirid lesions either on pods, chupons or fan branches, this should suffice as the other symptoms occur only in very severe damage situations.

Lead a discussion on the concept of threshold by asking the following questions:

- Is it necessary to spray insecticide every time you notice mirids or mirid damage symptoms damage on your cocoa trees?
- How do we determine whether we need to spray and how much to spray?

Agree on the definition of damage threshold as the level of mirid damage at which it makes economic sense to spray insecticide.

Divide the farm into 4-5 equal sections (each section having about 100 trees) with different stages of mirid damage. Divide participants into as many groups as you have divided the farm.

Have each group do the following:

- Count the total number of trees in section and mark each tree with palm branches. They should keep a score of the number of trees with mirid damage symptoms by pulling off the palm leaves on infected trees or on trees with mirid damage symptoms. The number of palm leaves in your hand gives a sensitive measure of the level of damage as a percent of trees.
- After counting the palm leaves pulled off the trees, each group should calculate the percentage of infected trees as follows:

$$\text{Percentage of mirid damage} = \frac{\text{Number of infested trees}}{\text{Total number of trees in the section of the farm}} \times 100$$

- Count and record the number of mature and immmature pods on all the trees.

Calculate the proportion of ripe pods as follows:

$$\text{Number of mature pods} = \frac{\text{Number of ripe pods}}{\text{Total number of pods}} \times 100$$

Using the following guideline for mired damage, each group should decide if they need to spray or not:

- Less than 5% damage: do not spray
- 5-25% damage: Spot spray
- Higher than 25% damage: blanket spray

Consider the proportion of mature pods in making the decision to spray. If a high proportion (more than 70%) of pods in the section of the farm are mature, do not spray. Do not spray also if harvesting is due in less than 13 days or if more than 85% of crop is already harvested.

Bring participants together for group presentations and discussion.

Using the list of recommended insecticides and their local market prices, ask participants to estimate what it will cost if they were to spray each type of insecticide on the plot each group worked on. Each group should also estimate the monetary value of cocoa beans that will be lost in each plot if they do not spray. Take into account the mature and immature pods in determining the losses. Estimate the weight of the dried beans and the farm gate price.

QUESTIONS FOR DISCUSSION

1. What differences exist in the level of mirid infestation within each plot and between the plots?
2. What are the advantages or disadvantages of using damage thresholds to make a decision about spraying?
3. At what stage can spraying save an infected pod from further damage?
4. If you spray now in the plot that you observed, are you likely to save the infested pods from damage?
5. What have you learned from this exercise?

RPU EXERCISE 1: Deciding to Apply Pesticides on Cocoa

OBJECTIVES

To train farmers on the steps in making the decision to use pesticides

TIMING

Before any exercise on pesticide use

MATERIALS

- Flip chart paper
- Colored pencils or markers
- Sheets of paper (8 ½" x ll" or larger) with writing (and pictures) describing pesticide use decision-making (see methods section.)
- Samples of protective clothing (rubber boots, gloves, face mask, hat, goggles, long sleeve shirt)
- Optional: Pesticides containers (empty and rinsed, clean)

PROCEDURE

Ahead of time, prepare sheets of paper with each of the 6 decision-making steps (see technical bulletin on reducing pesticide residues in cocoa). Each sheet should list one or more questions a farmer should ask before deciding to use a pesticide. If possible, draw a picture to represent the step.

DECISION STEPS

1. **See if there is a problem:** Is there a problem on my farm?
2. **Find out what you are trying to control:** What is causing the problem-- (insect, animals, disease, not enough water, too much water etc)?
3. **Decide whether the problem is serious:** Is the pest problem serious? Should I act now, or watch and wait?
4. **Decide whether you need to use pesticides:** Is using a pesticide the best way to control this pest? If so, do I have the right pesticide for the job?
5. **Select the right pesticide:** Am I using a suitable product for cocoa? Is there enough time to apply the pesticide before harvesting time?

6. **Apply the pesticide correctly and safely:** Have I been trained on how to use pesticides? Am I following all the instructions on the label? Am I wearing the right clothing and protective wear?

Arrange the 6 sheets of papers in any order (but not in the above order) on the ground on stick them up on cocoa trees. Ask farmers working in small groups to put them in the right order and to discuss what action a farmer should take at each step. Ask 2-3 groups to report their discussion.

Review the decision steps to make sure farmers are aware of all of the questions they need to ask themselves at each step.

Safe pesticide use

Lead a session on the precautions that farmers should take when using pesticides using the guide questions for discussion. Demonstrate how to wear boots, gloves and facemask. Using the flip chart and a table like the one below, discuss the disadvantages of using personal protective equipment and how these can be lessened.

Personal protective equipment	Part of the body protected	Advantages	Disadvantages
Boot			
Gloves			
Long sleeves			
Hat			
Face mask			

Discuss how to care for spraying equipment, what to do after spraying and how to dispose of empty pesticides containers.

QUESTIONS FOR DISCUSSION

1. What should farmers do to use pesticides safely?
2. What should a farmer wear when applying pesticides? What parts of the body do these items protect? When should each item be worn?
3. Where should you put your trousers when wearing boots during spraying? Why?
4. Where should you put your long sleeve shirt during spraying? Why?
5. What are some disadvantages to wearing protective equipment? How can we overcome these disadvantages?
6. After spraying, what should a farmer do next?
7. Why is it important to wash your body and clothes after spraying?
8. What should you do with empty pesticide containers?
9. Why is it important to bury pesticide containers away from water sources? How far should you be from water sources?
10. Why should you not reuse empty pesticide containers?

RPU EXERCISE 2: Understanding Pesticides Regulations

OBJECTIVE

- To raise awareness of international/national requirements related to pesticide use on cocoa
- To improve farmers' knowledge of recommended pesticides
- To raise awareness of maximum pesticide residues
- To raise awareness of the concept of pre-harvest interval

TIMING

Before any exercise on pesticide use; preferably at the same time as "Deciding to apply pesticides on cocoa"

MATERIALS

- Flip chart/markers
- List of recommended pesticides
- 2-3 different types of pesticide which indicate the pre-harvest interval on the labels

ACTIVITIES

A) Understanding pesticide regulations

Start a discussion on the effects of pesticides on human health. Lead a short review session on alternatives to pesticides.

Introduce the topic of pesticide regulations at national and international level. Introduce the concept of pesticide residues, maximum pesticide residue and pre- harvest interval and regulations developed by cocoa importing countries.

Explain pesticide classes. Write the list of recommended pesticides on the flip chart. Mention pesticides in class 1 that cannot be used.

Outline the various things farmers need to do to respect to ensure that their cocoa meets international pesticide regulations:

- Apply the right pesticide (s) to solve the problem
- Apply the pesticide in the right way
- Apply the pesticide at the right time to effectively control the pest

- Apply the pesticide before the pre-harvest interval (PHI)

QUESTIONS FOR DISCUSSION

1. What is a pesticide?
2. Do pesticides affect our health? What effect do they have? Are they good or bad?
3. Have you or someone you know ever gotten sick from using pesticide?
4. What are the different ways pesticides enter our bodies?
5. Besides using pesticides what can we do to reduce pests in cocoa farms?
6. Explain the idea of pesticide residues in your own words.
7. Should a farmer apply pesticides on cocoa just before the harvest? Why or why not?
8. What is the pre-harvest interval for these pesticides?
9. Are all pesticides poisonous to humans to the same degree?
10. Name some pesticides that should NEVER be used on cocoa but are sold in this area. What would happen if they are used?
11. What are the 4 actions that farmers should do to make sure their cocoa does not have a high level of pesticide residues?
12. What would happen if farmers in this country continue to spray their cocoa like they normally do (or ignore the pesticide regulations)?

B) Reading pesticide labels

Show a pesticide bottle to one farmer, without allowing him/her to read the label. Ask the farmer to explain how to use the pesticide. Give the bottle to another farmer, asking him/her to read the label. Discuss the difference between how the farmer who did not read the label and the farmer who read the label would apply the pesticide.

Discuss what information pesticide labels provide by examining the other two pesticide containers. Information to mention includes:

- Brand name
- Product type (fungicide, insecticide, herbicide)
- Manufacturer's name and address
- Ingredient statement (chemical name and ingredient)
- Active ingredient (the chemical(s) that kills the pest)
- Common name
- Net content (amount a container holds or weighs)
- Expiry date
- How to apply the product
- How much product to use
- When the product should be applied
- How often to apply the product
- How soon a crop can be used after an application
- When people and animals can re-enter a treated area after application
- What to do if there is an accident

QUESTIONS FOR DISCUSSION

1. Why is it important to read pesticide labels?
2. What information do pesticide labels provide?
3. What should you do if you cannot read a pesticide label?

RPU EXERCISE 3: Calibration and Performance Sprayers

Cocoa farmers are often not aware of the implications of nozzle performance and flow rates for high expenditure on pesticides. Less wastage of pesticide during spraying and more attention to nozzle settings can save farmers money.

OBJECTIVE

To raise farmers' awareness of nozzle performance and how spraying can be wasteful

NOTE: This protocol should be covered in two sessions.

MATERIALS

- Two sprayers belonging to participants (or to the school)
- **Either** two different types of nozzles if available on the local market **OR** similar variable cone nozzles at two different settings: wide cone and jet
- 2 buckets
- 2 litre measuring cup
- Rolls of kitchen wiping paper or poster papers that have a smooth reverse side
- Watch (measuring seconds)
- Non-toxic dye, preferably red dye (use 1 tablespoon per 15 litres)
- 30 litres of water

PROCEDURE

<u>Session 1</u>

A. Learning objective: To show differences in flow rate between nozzles

Divide participants into two groups and give each group a sprayer. Ask group 1 to fill the sprayer with water and set the nozzle at a wide cone setting. Ask a volunteer to spray into the two-litre measuring cup for 2 minutes. Repeat the procedure to make sure the measurement is accurate. Calculate the flow rate in ml/min by dividing your readings by 2. Record your results.

Ask group 2 to fill the sprayer with water and set the nozzle at a narrow jet setting. Ask a volunteer to spray into the two-litre measuring cup for 2 minutes. Repeat the procedure to make sure the measurement is accurate. Calculate the flow rate in ml/min by dividing your readings by 2. Record your results.

Ask each group to change the nozzle setting (group 1 should now use narrow jet setting and group 2 should use wide cone setting) and repeat the exercise.

B. Learning objective: To introduce the problem of “run-off”

Divide a section of the FFS plot into three sections of about 25 trees each. Divide participants into three groups, allocate one sprayer to each group and select one participant per group to spray. Place paper around the base of the trees in the three sections of the farm.

Ask each group to mix water with the dye and fill up the sprayer tank. Ask spray operators to spray trees according their normal methods until the tank is empty. Discuss the results using the guide questions.

QUESTIONS FOR DISCUSSION

1. Is there a difference in the number of trees sprayed per tank load between different operators? What is the reason for this?
2. What is the difference in the amount of run off and the amount of liquid on the paper between the operators? What accounts for this difference?
3. Are there intermediate settings that are more appropriate? If so, repeat the exercise using that setting and evaluate.

<u>Session 2</u>

Learning objective: To show how wastage can be reduced with improved spraying technique

Mix two batches of 15 litres of water with the dye and fill tanks with the water and dye mixture. Select a large area (with more than100 cocoa trees), preferably in an area outside the FFS plots. Cover the base of 25 trees with paper.

Divide participants into two groups. Group 1 should set the nozzle on wide cone setting. Group 2 should set the nozzle on a narrow-jet setting. Ask a volunteer from each group to spray the 25 trees, each using farmers’ normal practice. If it is common practice to use variable nozzles in the narrow-jet “squirting” mode to reach higher branches, ask the operator from group 2 to spray pods at shoulder height.

OBSERVATIONS

Each group should observe:

- The amount of leakage from the tank and lance assembly (trigger valve, joints, etc.)
- Rate of operating pump lever (if using a knapsack sprayer)
- The amount of run-off from pods
- The amount of liquid falling on the paper
- Amount of residue in each tank after spraying

QUESTIONS FOR DISCUSSION

1. Does the output of a nozzle change with different settings? If yes, why?
2. Is the output of the different nozzles similar at similar cone angle settings?
3. Did the operators operate the pump lever at the same rate? What difference does this make?
4. What have you learned from these exercises and how will you apply what you learned?

RPU EXERCISE 4: Improved Spraying Practices for Mirid Control

Cocoa farmers who do not spray at the beginning of the season often mix insecticides with fungicide sprays for black pod control during the rainy season, sometimes making up to 16 applications. Farmers can control mirids more effectively by reducing mirid populations at the beginning of the season with 2-3 targeted sprays for control of eggs in soft tissues and early instar nymphs.

OBJECTIVE

To improve targeting of insecticide spray procedures for mirid control and raising awareness of insecticide safety issues.

TIMING

Multi-stages. This protocol should be done after a mirid insect zoo and the mirid damage threshold protocol.

MATERIALS

- A “typical” cocoa farm (FFS plots)
- Two manual sprayers
- Sufficient insecticide for two tanks (no class I or II formulations) and insecticide information sheet
- Protective clothing for two operators

ACTIVITIES

Start a discussion about the timing of mirid attacks (remind participants of mirid insect zoo observations) and the most suitable parts of the cocoa tree to spray during the key mirid seasons. Discuss what insecticides and tank mixtures farmers normally use, the reasons for their choice and the safety of the insecticides.

Divide participants into two groups: one to cover the FP plot and the other to cover the ICPM plot. Ask the FP group to spray the plot as usual.

Ask the ICPM group to inspect the plot and spray according to action threshold

OBSERVATIONS

In addition to the normal observations made during each AESA, record the following observations:

- Quantities of pesticides (both insecticides and fungicides) used in the two plots during the season using the input record sheets
- Number of sprays in each plot and costs

QUESTIONS FOR DISCUSSION

1. At what times of the year do mirids attack cocoa?
2. Which parts of the plant are attacked at the different times?
3. Which parts of the plant are attacked at this time?
4. Which insecticides are available and recommended by pesticide salespeople? How dangerous are they?
5. Is mixing of insecticide and fungicide necessary at this time? Why or why not?

RPU EXERCISE 5: Pesticides Specificity

Farmers may not be aware of the disadvantages using chemical pesticides. They may not know that in addition to the target, pesticides kill beneficials such as natural enemies and antagonistic fungi.

OBJECTIVE

To evaluate the effect of pesticides on the survival of natural enemies

MATERIALS

- A cocoa farm, preferably unsprayed
- Plastic bags and small containers to collect insects
- Small soft brush
- Tissue paper
- Cocoa leaves
- 4 buckets (preferably transparent)
- 4 pieces of muslin or mosquito screen cloth with rubber bands, to cover the buckets
- Labels
- Marker
- Notebook,
- Pen
- 4 small hand sprayers (0.5 l), shared between groups
- Water
- Small amounts of different insecticides (including broad spectrum and selective, if possible, a bio-pesticide and botanical e.g. neem)
- Gloves and masks

ACTIVITIES

Prepare 4 hand sprayers before the FFS session. If a sprayer has been used before, wash it thoroughly with soap. Fill the first hand sprayer with water. This will be a control. Prepare and fill 3 hand sprayers with commonly used pesticides at field rate concentration. Use gloves and masks. Label the hand sprayers to avoid confusion.

Collect several cocoa leaves (3 per spray treatment). Spray each set of leaves with a selected spray solution and let the leaves dry. Use gloves and masks.

Transfer the dried leaves to the buckets (one leaf per bucket) using gloves. Label the buckets. Divide participants into 4 groups. Each group should have one bucket of each spray treatment (4 buckets in total). Try to get the leaves to lie flat on the inside surface of the bucket.

Have participants collect pests (for example, mirids or leaf eating caterpillars), predators (for example, spiders or syrphid larvae) and unknowns or neutrals from the cocoa farm. Try not to touch the insects by using brushes to collect them in jars or bottles. Carefully transfer them to the treatments so that there is one of each species per bucket. If possible, use the same insect species in all treatments and make sure they are of similar size. Cover the bucket with the muslin/mosquito screen cloth and secure with a rubber band.

OBSERVATIONS

- Check and record the conditions of the insects hourly for 4 hours, after 8 hours and after 24 hours.
- Count the number of dead insects. It may be necessary to touch the insect with a pen or pencil to determine if it is dead. If it does not walk off in a normal manner, then record it as dead.

QUESTIONS FOR DISCUSSION

1. What happened to the insects in the different jars? Why?
2. Did you observe any differences in the behaviour of the insects?
3. Which of the insects would you prefer on your farm? Why?
4. What happens in the field when a farmer sprays against a certain pest?
5. What will happen in a field 1,2, 3 weeks after spraying?
6. What other options do you have, besides the spray solutions tested, to manage cocoa pests, while conserving natural enemies

RPU EXERCISE 6: Spray Dye Exercise

Cocoa farmers may not be aware of the health dangers they face when spraying pesticides. Awareness of these dangers may encourage them to better protect themselves and maintain and repair their spraying equipment.

OBJECTIVES

- To create awareness of farmers' direct exposure to pesticides when spraying
- To demonstrate drift to non-target organisms
- To initiate discussion on wastage during spraying

MATERIALS

- Various knapsack sprayers, including a farmer's sprayer
- Buckets
- Measuring can
- Water
- Non-toxic dye, e.g. food colorant, preferably red
- White flip chart paper or paper kitchen towels or toilet paper
- Masking tape
- Cocoa farm
- A few volunteers

PROCEDURE

Prepare 5 litres of dye solution for each sprayer.

Wrap up the volunteers completely (except for the eyes) in white flip chart paper and/or paper kitchen towels or toilet paper, securing with masking tape. Ask each volunteer to fill his/her sprayer with the dye solution and then spray cocoa trees for 10 minutes as though using a pesticide.

Ask the rest of the participants to watch and make notes.

After spraying, remove the sprayer and observe how much dye is on each part of the sprayer's body (none, a little, a lot.

Examine the sprayed cocoa trees and observe how far the spray has drifted and whether or not there is run-off from the cocoa pods.

Measure back the amount of dye solution in each of the sprayers and check which sprayer has been most economical in its output.

QUESTIONS FOR DISCUSSION

1. How much spray has ended up on the operator?
2. What are the dangers of pesticide contamination to the health of the person spraying?
3. What sort of protective clothing should farmers wear when applying pesticides (discuss hats, shoes, boots, long sleeved shirts etc)?
4. How far did the spray drift? Under what conditions would the drift be greater? Under what conditions would it be less?
5. Was there any run-off? What does this mean with regard to cost of application and spray efficiency? What does this mean for the cost of spraying? How can farmers improve the efficiency of sprayers?

RPU EXERCISE 7: Botanical Pesticides Screening

OBJECTIVE

To show farmers a method for evaluating botanical pesticides

MATERIALS

- A hand sprayer
- Water bottles (cut off)
- Muslin or mosquito screen tissue
- Rubber bands
- Markers
- Camel brush
- Tissue paper
- Sweep-net
- Plastic bags for collecting insects
- Water
- Plastic gloves
- Masks
- Protective clothes
- A pair of boots
- Several potential botanical pesticides (e.g. neem seeds, papaya leaves)
- Cocoa leaves
- A measuring cup
- Soap

PROCEDURE

In the previous session, start a discussion on what botanical pesticides participants use or know about. Discuss the composition of each pesticide identified by participants, how effective it is and what possible negative effect, if any, it may have on human health. Ask participants to bring a sample of two or three botanical pesticide mixtures (200 ml) to the next session

The day of the session, pluck healthy mature cocoa leaves (5 per botanical pesticide to be tested and another five to serve as control). Place the leaves on the ground, about 5 meters apart. Using the hand sprayer, spray each set of leaves with one insecticide and the last set with water. Be careful to prevent any cross-contamination. Wait until the leaves dry up.

Have participants collect different kinds of insects and place in plastic bags. Be sure to collect what farmers think of as pests and natural enemies. Place one treated leaf with three insects of the same species in a water bottle. Cover the water bottles with muslin cloth and clamp with rubber band. Label each bottle with the name of botanical and insect. Repeat with all the leaves.

OBSERVATIONS

Make hourly observations noting differences in insect behavior and death by type of pesticide and insect species.

QUESTIONS FOR DISCUSSION

1. What differences do you observe between the different bottles (treatments)?
2. Did you observe any differences between the behaviour of the insects?
3. Did the botanicals kill all insects exposed to them or only some insects?
4. Which botanical would you prefer to use on your farm? Why?
5. Is it possible to control pests while conserving natural enemies? How?
6. What did you learn from this exercise that you can apply to your own farm?

RPU EXERCISE 8: Pesticides Resistance Role-Play

When pesticides are used on a frequent basis, there is risk of build-up of pest resistance against pesticides. Serious outbreaks of pests have been documented in several countries after intensive use of chemicals, resulting in the reduction of natural enemies, and meanwhile building up pest resistance to pesticides. At the same time, farmers tend to increase the frequency and dosage of pesticide application when crop health problems persist. As farmers get caught in the 'pesticide treadmill', costs of production escalate. This role-play shows how the build-up of pest resistance reduces the effectiveness of insecticide.

OBJECTIVE

To understand how insect populations become resistant to insecticides.

MATERIALS

- Tissues to cover noses of "super insects"
- 1 hand sprayer filled with water ("poison sprayer")
- 6 chairs or stools to represent cocoa trees (you can decorate them with leaves and pods)
- Prepared script of the story

PROCEDURE

Organize participants for the mime role-play. You will need the following volunteers:

- 1 participant to be the Story Teller
- 1 participant to be the Farmer (who will keep the "poison sprayer" with him/her)
- 7 participants to be "Ordinary Insects"
- 14 participants to be "Super Insects" who cover their noses with tissues

A group of "observers" (all remaining participants) will take notes.

Ask the "Ordinary Insects" to stay on one side and the "Super Insects" on the opposite side. The middle area is the cocoa farm. You may draw a boundary on the ground for the two sides of the "farm" using chalk. Put 6 chairs or stools as cocoa trees in the area representing the farm.

The storyteller starts reading the script, while the acting participants mime the role-play (instructions in *italics*).

Script

Storyteller: "In the first week of the cocoa season, a farmer went to his farm and found five insects. He complained bitterly about the presence of these insects because he regularly sprayed the farm in the last season. He did not know it, but one of these, a Super Insect, was resistant to the pesticide that he usually used. All the others were Ordinary Insects".

(1 Super Insect and 4 Ordinary Insects go into the farm and settle, feeding on the cocoa trees. After that, the farmer comes in and acts as though he is observing the crop and complaining about the insect population)

Storyteller: "The farmer became very worried that his cocoa pods would be eaten by the insects, and he decides to spray poison immediately. He went home to get his poison sprayer and sprayed the farm. One lucky Ordinary Insect managed to escape the poison by hiding behind a cocoa pod."

(The farmer brings the poison sprayer into the farm and sprays all except one Ordinary Insect. All Ordinary Insects die while the Super Insect covers his nose with a tissue. He/she shows to the public how his nose cover protects him/her and smiles)

Storyteller: "All but one of the Ordinary Insects died of the poison but the Super Insect happily survives because of the resistance he/she has against the poison. Now the Farmer was happy, so he went away for a week. In that week, the surviving insects gave birth to babies. Each adult insect makes 3 babies so that in the next generation, there were 3 Ordinary Insects and 3 Super Insects. After mating and making babies, the adult insects died."

(Surviving insects get babies by inviting 3 more Ordinary Insects and 3 more Super Insects into the field, then fly away and die)

Storyteller: "The next week the farmer came to the field and found 6 insects. Of course, he did not know that among the 6, there were 3 Super Insects that were resistant against poison. Again he was worried and he decided to spray. This time he mixed the poison a bit stronger and took care to cover all areas of the trees where the insects could be hiding."

(Farmer looks around carefully and sprays all insects, not excluding anyone)

Storyteller: "All Ordinary Insects died of the poison spray but the Super Insects survived."

(Ordinary Insects die, while the Super Insects again show their nose covers to the public and smile)

Storyteller: "Again the remaining insects (3 Super Insects) make babies. As before, each adult made 3 babies, flew away and died. Because the parents were Super Insects, the 9 new babies were all Super Insects".

(Surviving Super Insects get babies by inviting 9 more Super Insects into the field, then fly away and die. Farmer takes the poison sprayer, looks around carefully and sprays all the insects, not excluding anyone. The Super Insects again show their nose covers to the public and smile. The farmer looks puzzled.)

STORYTELLER: "WHAT SHOULD THE FARMER DO NOW?"

(End of the role-play. All players stand up and all observers clap)

QUESTIONS FOR DISCUSSION

1. What did you observe in the role-play?
2. Why did some of the insects die during the spraying? Why did some not die?
3. How many insects died out of how many in each generation?
4. How and why did the numbers change between the generations?
5. What do you think would have happened if the farmer continued spraying pesticides?
6. What else could the farmer try to do?

CQ EXERCISE 1: Impact of Pod Maturity on Fermentation and Cocoa Quality

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Several factors account for the poor quality of cocoa produced by some farmers. These include poor pesticide application, poor fermentation and drying methods and harvesting pods at the wrong time. Farmers harvest cocoa pods at the wrong time for many reasons including the desire to get income quickly, lack of knowledge about the quantity of fresh beans needed for fermentation and the relationship between harvesting time and quality.

OBJECTIVE

Improve understanding of the maturation stages of cocoa pods and the physical aspects of cocoa quality

MATERIALS

- Flip chart paper
- Markers
- 30-40 kg of fresh cocoa beans, preferably of the same variety, collected from the following types of pods:
  - Immature, green pods
  - Ripe pods, that is, pods that are half or 3/4 yellow
  - Over ripe pods, that is pods that are orange
  - Overripe pods attacked by black pod disease

    Note: It is preferable to use beans from participants' own farms rather than from the FFS plots so as not to affect the harvest data

- Materials usually used for fermentation
- Fresh banana leaves
- Four trays
- 1 very sharp pocket knife
- Labels for the four fermentation lots
- Materials usually used for sun drying, for example, a cement or raised platform

PROCEDURE

At harvest time, tour the FFS plot with participants, asking them to point out which pods are ready for harvesting and which are not.

Return to a central place. List on a flip chart the factors farmers consider when deciding when to harvest. Discuss to what extent each factor provides flexibility for harvesting later.

Cover the four lots of beans to be fermented with the banana leaves and place heavy objects on top of each pile.

Ferment and dry as usual for the specific varieties.

After drying, randomly select 100 seeds from each lot and put them on the four trays. With the pocketknife, cut each bean longitudinally and observe physical aspects.

OBSERVATIONS

- Take a handful of dried beans from each lot and squeeze between your fingers. Note which beans make a cracking sound.
- Observe and compare the difference in colour between the different lots of cocoa.
- Observe and compare the physical aspect of the cut seeds, and determine the number / percentages of:
    - Brown/purple or purple, compact beans
    - Germinated beans
    - Flat beans

QUESTIONS FOR DISCUSSION

1. Are there colour differences between the beans from the different lots? What is the difference?
2. Which lots have the worst quality beans?
3. What do you think explains the defects that you observe?
4. Do the differences between the lots of cocoa affect price? How?
5. What have you learned from this exercise?
6. What is the ideal amount for a fermentation heap? Why is the amount in a fermentation heap important?
7. What can farmers who harvest small quantities at a time do to increase their fermentation load?

CQ EXERCISE 2: Drying Cocoa on a Raised, Covered Platform

Proper drying is important for ensuring good cocoa quality. While drying on cemented floors is common among cocoa farmers in West Africa, the process can be improved through simple technologies such as using raised, covered platforms.

OBJECTIVE

To dry cocoa faster and protect drying cocoa from contamination, dew and rain

MATERIALS

- Cemented floors (at least 2 m x 2 m size)
- 2 raised platforms (at least 2 m x 2 m size raised 1.2 m from the ground and made of finely woven rafters/palm fronds). One of the platforms should be equipped with two 1.70 metres high stands that support the traverse beam for a black plastic sheet to be used in covering the beans at nights and when it rain. (See pictures below)
- About 100 kg. of well fermented cocoa beans
- 3 cocoa beans mixing paddles
- Flip chart and markers
- 1 black plastic sheet

PROCEDURE

Introduce the subject of drying and the objectives of the exercise.

Ask participants to form three groups. One group will work with drying on cemented floor, another will work with drying on a raised platform without a cover, while the third group will work on the raised platform with a black plastic sheet for covering at night and during rains.

Ask each group to spread out at least 25 kg of beans (with a thickness of 3-4 cm) to dry using the relevant method. During the first two days, each group should mix the beans every hour, and, three or four times per day thereafter. Ensure that the group working with the covered platform covers the beans with the plastic sheet if it rains and at night.

After spreading out the beans, facilitate a discussion of the benefits, ease of use and potential problem of each drying method.

Over the next two weeks, each group is responsible for drying the beans until they are fully dried. Groups should note any problems or observation related to the drying process, as well as the time it takes to fully dry the beans.

After 2 weeks, ask each group to report on the method they observed. Facilitate a discussion by the whole school on the three methods.

QUESTIONS FOR DISCUSSION

1. What are the differences between the three drying methods used?
2. Which method dried the beans faster?
3. Which method best protects the beans from contamination or damage?
4. How much does each method cost? Which method is easier and cheaper to use?
5. What are the limitations of each method and how can they be overcome?

CQ EXERCISE 3: Alternative Fermentation Method

………...

This exercise provides an alternative to the traditional method of fermentation that involves heaping beans on soil, covered with cocoyam or plantain leaves. The traditional method can cause rotting of beans as the cocoa 'sweating' cannot easily drain off. Some farmers report that box fermentation shortens drying time. In some areas, the fermentation box is rotated among farmers, which reduces the investment costs for each participating farmer.

OBJECTIVE

To learn another method of fermenting cocoa beans

MATERIALS

- Harvested cocoa pods, ready for opening
- Fresh cocoyam or plantain leaves to cover cocoa beans during fermentation
- Paddle to turn fermenting bean heap
- Box made of local wood (see picture), with slits in the bottom through which cocoa sweating can drain off

Discuss and record the locally common method of fermentation on a flip chart.

Open the cocoa pods in the usual fashion. Make two fresh bean heaps, one for the locally common fermentation and one for fermentation in a trough.

Start fermenting both heaps according to the below procedures A and B.

Heap A. Ferment one bean heap according to the locally common fermentation as recorded on the flip chart. Observe the heap when fermentation is complete. Dry the beans separately, labelled 'Heap A'.

Heap B. Deposit the other heap in the trough. Push the beans into a corner of the trough and cover them completely with one layer of the fresh cocoyam or plantain leaves. After 2 days, take off the leaves and put them aside for re-use after turning the heap. Turn the heap with the paddle. Re-cover the heap with the same leaves. Repeat this process after another 2 days. On the 6th day, remove the leaves for observation and take out the fermented bean mass for drying separately, labelled 'Heap B'.

OBSERVATIONS

Observe both heaps at the end of the fermentation process. Record the number of days needed to dry the fermented beans from Heap A and Heap B.

QUESTIONS FOR DISCUSSION

1. What is the difference between the two different methods of fermentation?
2. Are there any rotting beans in either of the heaps?
3. Is there any difference in drying times? If yes, why?
4. What is the difference in cost between the local and alternative fermentation method?
5. Are there any other modifications possible to improve the fermentation or drying process?

CQ EXERCISE 4: Drying Cocoa Beans Using an Improved Solar Dryer

Proper drying is important for achieving good quality cocoa beans. Using a raised, covered platform overcomes problems associated with drying beans in areas of high rainfall and humidity.

OBJECTIVE

To compare the effectiveness of three methods of drying cocoa beans in terms of speed of drying and level of contamination by mould.

MATERIALS

- Cement floor (with a surface area of at least 2 m by 2m) or any other commonly used drying method
- 2 raised platforms (a surface area of 2 m by 4 m raised to a height of 1 m from the floor and made of well woven palm fronds or of raffia). See photo below for the design of the improved solar dryer
- 1 transparent tarpaulin made of size 6 plastic
- About 100 kg of well fermented cocoa beans
- Flip chart board
- Flip chart papers
- Markers

PROCEDURE

Introduce the topic of drying cocoa and explore what methods farmers know about and use and what problems they face with this activity. Explain the objective of the exercise.

Divide the participants into three groups to work on the following drying methods:

Group 1: Drying on a cement floor or the common method used in the area

Group 2: Drying on an open, raised platform

Group 3: Drying using a raised platform with transparent plastic tarpaulin meant to cover the cocoa throughout the drying period.

Mix the fermented cocoa beans and divide the amount into three lots of at least 25 kg each. Give one lot of beans to each group. Request each group to spread out the cocoa beans, 3 to 4 cm thick, on the assigned drying area. During the first two days of the exercise, each group should turn the beans every hour, while on the subsequent days the cocoa beans should be stirred three or four times per day.

After spreading out the cocoa beans, discuss on the advantages, ease of use, cost and any difficulties associated with each drying method. List the points on the flip chart.

During the following two weeks, each group will be in charge of completely drying the cocoa beans. Ask each group to note the following:

- Number of days to dry the beans
- Number of mouldy beans
- Problems faced
- Other observations

After 2 weeks, ask each group to report their finding to the rest of the school. Facilitate a discussion on the three methods used.

QUESTIONS FOR DISCUSSION

1. What are the different ways to dry cocoa beans? What are the common practices in this area?
2. What are some problems you face when drying cocoa beans?
3. Which method dried the beans fastest? Why?
4. Which method is best for protecting cocoa beans from contamination?
5. What is the cost of each method? Which is cheapest? Which is most expensive?
6. Which method requires the most labour? Which requires the lease labour?
7. Which method is easiest to use?
8. What are the main differences between the three drying methods?
9. What are the disadvantages of each method and how can these shortcomings be overcome?

FEATURES OF THE IMPROVED SOLAR DRYER

- Surface area of platform: 2m by 4 m
- Height of platform: 1m from the floor
- Lowest level of the roof (pillar): 1.5 m
- Height of central beam: 3m, that is 1.5m from the platform

PART 3: Appendix

PEST DATA SHEETS OF MAJOR IMPORTANT PESTS

REFERENCES FOR PRACTICAL

COCOA POD BORER (CPB)

***Conopomorpha cramerella* Snellen**

IMPORTANCE

Cocoa pod borer (CPB) causes losses to cocoa by boring through the wall and into the pod, feeding on the pulp of bean and placenta of the pod. Damage to the funicles of pods results in malformed and undersized beans, in severe infestation it produce small flat beans that are often stuck together. It also causes the pod to yellow or ripen unevenly and prematurely. The beans from seriously infested pods are completely unusable, and over half the potential crop can be lost in heavy infestations. In light infestations, there may be no economic loss but control is still needed to prevent the development of more serious infestations.

Live pod borers are tough and can disperse over long distances. The CPB is also a pest of ' rambutan' a tropical fruit.

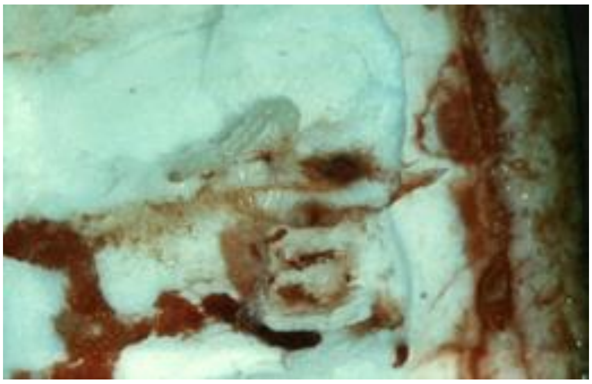
PEST DESCRIPTION

Eggs

The CPB lays tiny yellow-orange eggs. It is oval based and disk-like shape eggs. The eggs can be seen with the naked eye and measure about 0.5 x 0.2mm in size. There are mosaic pattern on the egg surface. The eggs are laid singly anywhere on the pod surface although there appears to be some preference for the pod furrows. On hatching (six to nine days), eggs become translucent, the shell being whitish but darkened inside by faeces.

Larvae

On hatching, the first larva stage (instar) is translucent white in colour and about 1 mm long. It tunnels through the floor of the eggshell and burrows through the husk. Once inside the pod, it tunnels in any direction and feeds randomly. The tunnels are filled with brown faeces. In younger pods, early-instar larvae can penetrate the developing beans, causing malformed and undersized beans. The feeding causes the pod to yellow or ripen unevenly and prematurely, causing confusion on ripeness standards for harvesting. The larval stage takes 14-18 days to complete. Late larva stages are about 1 cm long and creamy coloured while still inside the pod, but greenish after they emerge to pupate. Once outside the pod, larvae crawl or lower themselves by a silk thread to a suitable site for pupation.



Pupae .The pupation site could be in a furrow of the pod, or on green or dried leaves and other debris. Once the larvae have identified the pupation sites, they spin oval-shaped cocoons and enter a short prepupal stage before forming pupae. The pupa is recognisable as an encasing of a light-brown waterproof silken membrane tightly drawn over a depression on a pod surface or leaf. The pupa measures about 8mm and takes 6-8 days to complete	
Adult The adult is a small brown – greyish moth, about 7 mm in length. It has a wingspan of about 12 to 14 mm and has bright yellow patches at the tips of the forewings. The moths have very long antennae, which are swept backwards in their natural resting position. In flight the moths look like large, slow-flying mosquitoes. An adult female can produce 50-100 healthy eggs in its lifetime of about a week.	

ECOLOGY

Eggs are laid on pods more than 5 cm in length. The entire larval stage takes 14-18 days to complete, with 4-6 instars. The great majority of the larvae emerge from pre-maturely ripened cocoa pods. The larvae then tunnel out through the pod wall, leaving an easily identifiable exit hole.

The pupal stage normally takes 6-8 days to complete. The pest is therefore most likely to be transported by man to other cocoa-growing areas through movement of pods, leaves and other objects in or to which larvae and pupae are attached.

The moths are most active at night; mating and egg-laying takes place at this time. A female can normally produce 50-100 eggs in her lifetime. The moths are not known to fly long distances, and long-distance movement of CPB must almost certainly take place through movement of infested pods.

During the day, adult moths normally rest underneath horizontal or near-horizontal cocoa branches. The adult has a protective coloration that blends with the resting place making them difficult to spot. Adult longevity is generally about one week, but they can live up to 30 days. In total, the entire life cycle takes about 1 month to complete.

MANAGEMENT

Regular and complete removal of ALLl pods (*Rampassen*)

In the early days of the 20th century, regular and complete removal of all pods, or *rampassen*, was considered to be the only feasible control method. Research on the life cycle and oviposition habits of pod borer in the early 1980s confirmed that removing all pods longer than 6-7 cm from a field for 6 weeks would break the life cycle of the insect, as female moths will not usually lay eggs on younger pods. Also, the young pods do not have mucilage to feed the CPB,. The main setback for *rampassen* is the migration of female moths from uncontrolled cocoa farms, unless communal action is taken. Also, without appropriate pruning, complete elimination of a population of pod borer through *rampassen* is difficult.

If pods are picked at the earliest stage of ripeness, then almost 90% of the larvae will still be inside the pods. If pods are broken quickly and the husks destroyed, buried or covered with transparent plastic, the larval death rate will be very high and a good degree of control can be achieved. Alternatively, unbroken pods can be kept in plastic bags for several days, either to contain emerging larvae or to kill them through over-heating inside the bag. The interval between harvesting should be 14 days or less. An alternative would be to abandon harvesting during the low crop, and at the first sign of the rising crop to begin very intensive complete harvesting for several months. The economic implications of both alternatives would need to be tested in farmer trials.

Mechanical Control

In pod borer infested areas in the southern Philippines, some cocoa has been planted at very high densities as hedges with access for small tractors between pairs of rows. Trees are kept to a low height so that all harvesting can be done within easy reach. Mechanisation allows frequent, regular harvesting, and the hedge-like structure of the crop (1-m squares within the double rows, and 2-3 m between rows for mini-tractor access) allows thorough complete harvesting. Under this system, infestations of pod borer were at insignificant levels during the late 1980s, without any other form of control.

The idea of sleeving pods with bags of plastic or other materials to prevent egg-laying originated in Indonesia. Thin plastic bags, with open bottoms for ventilation, are placed on very young pods (less than 7 cm long) and left throughout the pod maturation period result in virtually complete protection from pod borers. The main problems are that bags are sometimes placed too late, or that insufficient ventilation may result in rots. In addition, this method is labour intensive. The economics of this method will depend on cost of labour versus cocoa yields.

Biological Control

Ant species, the large black ant (*Dolichoderus* sp.) and the weaver ant (*Oecophylla smaragdina*) are known to prey on larvae at emergence from the pods and on pupae, and disturb adults. However the best predator ant was actually the small 'sugar' ants (*Iridomyrmex* spp.) Predation by ants is almost a constant 40% of pupae each month. Ants can be augmented and manipulated to colonise areas within a cocoa garden. However, this needs care and patience to get it right.

Mass rearing and release of parasitic wasps has been tried. *Trichogrammatoidea* sp. gave good levels of control. *Ceraphron* and *Ooencyrtus* species were also tried but the cost was prohibitive. None of these parasitic wasps have established themselves successfully enough to be more than good local control agents.

The fungus *Beauveria bassiana* has been used very effectively to control larvae. Larvae that were infected on emergence from pods died during pupation. Other fungi have also been used very successfully. However, these compounds are difficult to find, as they are not usually commercially produced.

Chemical Control

Blanket spraying is not effective in the long term as populations of other pests, that are not normally a problem, can explode. Chemical sprays are subject to strict regulation for suitability, safety of the operator, and safety for the environment. The use of chemicals is not permitted in organic cocoa farming.

INTEGRATED PEST MANAGEMENT

The most immediate reductions in cocoa pod borer are likely to come about through integration of cultural control, viz. *rampassen*, and rational pesticide use. Both of these rely on well-pruned trees kept to a height low enough to collect and/or spray all pods. Longer-term control may be improved by grafting or replanting with hard-walled clones. Further releases of exotic natural enemies may provide additional partial control, if suitable parasites can be found.

CROP LOSSES

Over half of a crop can be lost due to heavy infestation.

PREFFERED SCIENTIFIC NAME

Conopomorpha cramerella Snellen

TAXONOMIC POSITION

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Arthropoda

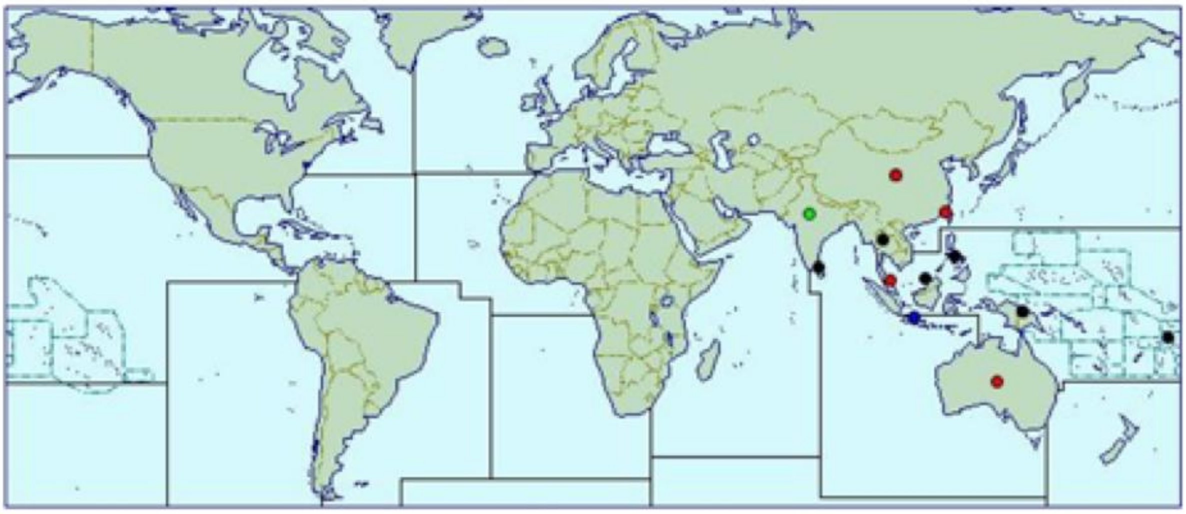
Subphylum: Uniramia

Class: Insecta

Order: Lepidoptera

Family: Gracillariidae

DISTRIBUTION MAP



● = Present, no further details ● = Widespread ● = Localised
● = Confined and subject to quarantine ● = Occasional or few reports
● = See regional map for distribution within the country

Crop Protection Compendium 19/03/2014

MIRIDS (Capsids) Sap sucking bugs
Helopeltis spp.

IMPORTANCE

Mirids and Capsids describe the same types of insects that feed on cocoa and belong to the family Miridae. The term Mirid is commonly used in Asia and the Americas whereas Capsid is the common term in Africa. In Malaysia, common names are Mosquito Bug and Bee Bug.

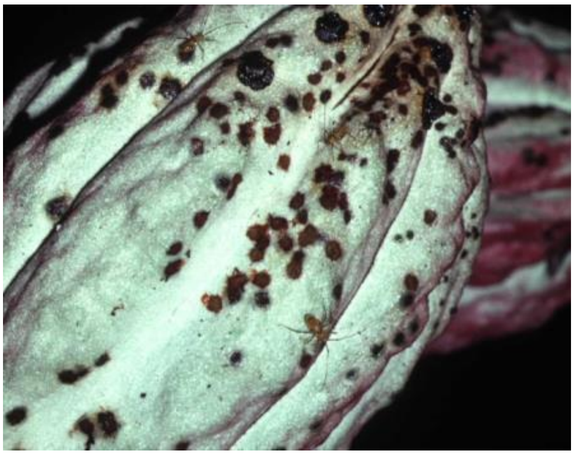
These insects attack by using their needle-like stylet (mouth part) to pierce the surface of the cocoa stems, branches and pods. Mirids suck out the sap and also inject toxic saliva (spit) into the plant and the internal tissues die.

Mirids are described as the most injurious and widespread of insect pests. On cocoa, there are forty or more species that can be described as 'Mirids'. *Helopeltis* species are the most important in Asia

DESCRIPTION

Mirids are good flyers and are active during the warm hours of the day. Feeding by sucking plant juices causes small water-soaked areas that quickly turn black.

The lesions on pods are circular, while the lesions on stems are usually oval and of a larger size. Soft and hard stem tissues are attacked, with feeding on soft stems resulting in wilting and terminal death and allowing entry of wound fungi.



ECOLOGY

The life cycles of the various Mirid species are very similar. Single or small groups of eggs are buried in the skin layers of pods, pod stalks, chupons and fan branches. Incubation periods of most Asian *Helopeltis* species vary with locality and season, but are generally 6-11 days. Two breathing structures project from each egg above the plant surface and are just visible to the naked eye.

Mirids do not have a pupal stage, but have five successive juvenile larva instars (nymph) stages, a process which takes on average 18-30 days. The nymphs increase in size with each moult and the last moult produces a winged adult. The adults are 7-12mm long and very slender. *Helopeltis* have long legs and antennae while in other genera the legs and antennae are more thickset.

The rate of larval development of the five instars is affected by climatic factors such as temperature and humidity, and by food quality. The average lifespans (first to fifth instar) are 9-19 days.

Adult lifespan and fertility vary between 6 and 30 days depending on local conditions and availability of pods and young shoots for feeding. There is a continuous cycle of generations through the year. In Malaysia, populations of *H. theivora* peak in October and are lowest in April/May. *Helopeltis* populations do not do well under conditions of heavy rain, high winds and low humidity.

MANAGEMENT

Integrated Pest Management

Cultural techniques (installing temporary shading in young plantings, upkeep and sucker removal in farms and the maintenance of a complete canopy) have been routinely applied, as a sole control practice or in addition to the rational use of pesticides, with the aim of minimizing pest damage to cocoa plantations. A number of trees are known to serve as alternate hosts of Mirids, including *Cola* sp., other *Theobroma* sp. and *Adansonia digitata*. These should not be used as shade trees in cocoa farms.

Biological control

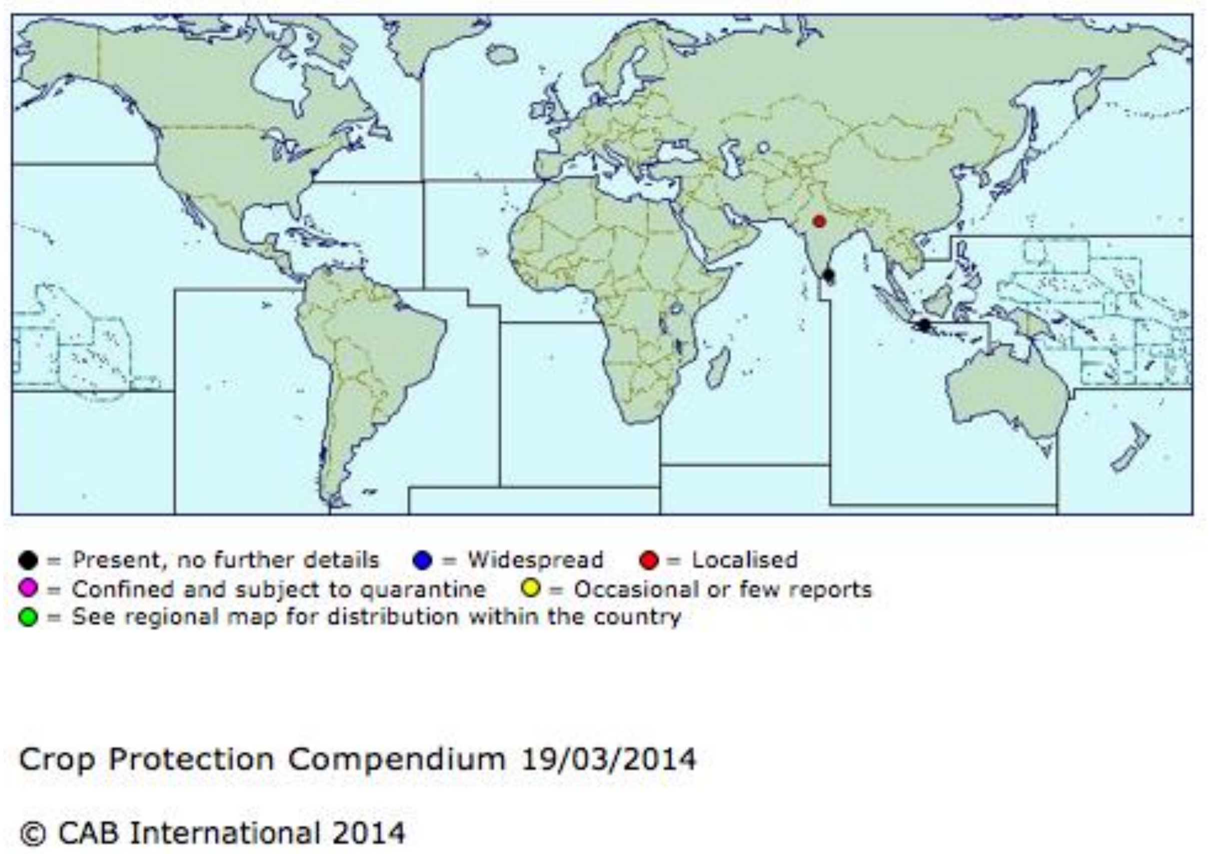
Since 1900, cocoa planters in Indonesia have been aware that damage is less when cocoa trees are colonised by ants, notably *Dolichoderus thoracicus* which is not aggressive to plantation staff. This ant has been deliberately released into some cocoa farms as a control measure. The introduction of ants has been developed as a component of integrated pest management in Indonesia (against *H. antonii* and *H. theivora*) and in Malaysia (against *H. theobromae*). The area to be colonised is first treated with ground applications of insecticides to suppress antagonistic ants and then colonies of *D. thoracicus* are introduced.

Mealybug species, which do not cause damage to cocoa pods, are also introduced to provide honeydew and encourage the ants to remain in the farm. The proximal ends of the cocoa pods are left on the trees at harvest to conserve the mealybugs. However, in areas with Cocoa Swollen Shoot Virus, this practise should be avoided as mealybugs can transmit CSSV! The litter layer on the ground is also conserved to provide nesting sites for the ants. Another ant (*Oecophylla smaragdina*) is equally beneficial, but it is aggressive and so is not liked by cocoa workers.
High levels of parasitism have been demonstrated by some egg and nymph parasitoids. Egg parasitoids of the genus *Telenomus* and the mymarid *Erythmelus helopeltidis* are particularly promising, as are the nymphal parasitoids of the genus *Leiophron*. Other predators such as assassin bugs and spiders are not specific to Mirids however, as part of a healthy system, have a role in control.

Chemical control Chemical applications remain the primary method of controlling mirids. Cocoa-producing countries launched national mirid control campaigns as early as 1958-1960. Annual eradication of the pest by chemical control was ensured by State companies under the authority of the Ministries of Agriculture in Ghana, the Cote d'Ivoire, Cameroon and Togo. This is possible for state and private companies, but for small holders chemical application using appropriate equipment is too expensive. Insect eradication operations start at the beginning of rising mirid populations, coinciding with the peak cropping periods. Complete treatment consists of two rounds one month apart. The second round is intended to reach young instars, which were not affected by the first spraying. Research on reducing the flow rate (Low Volume Treatment) has been undertaken and the results have been extended. This rational chemical control programme against mirids has been a success in West Africa.	
PREFFERED SCIENTIFIC NAME *Helopeltis* species	**Taxonomic position** Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Hemiptera Suborder: Heteroptera Family: Miridae

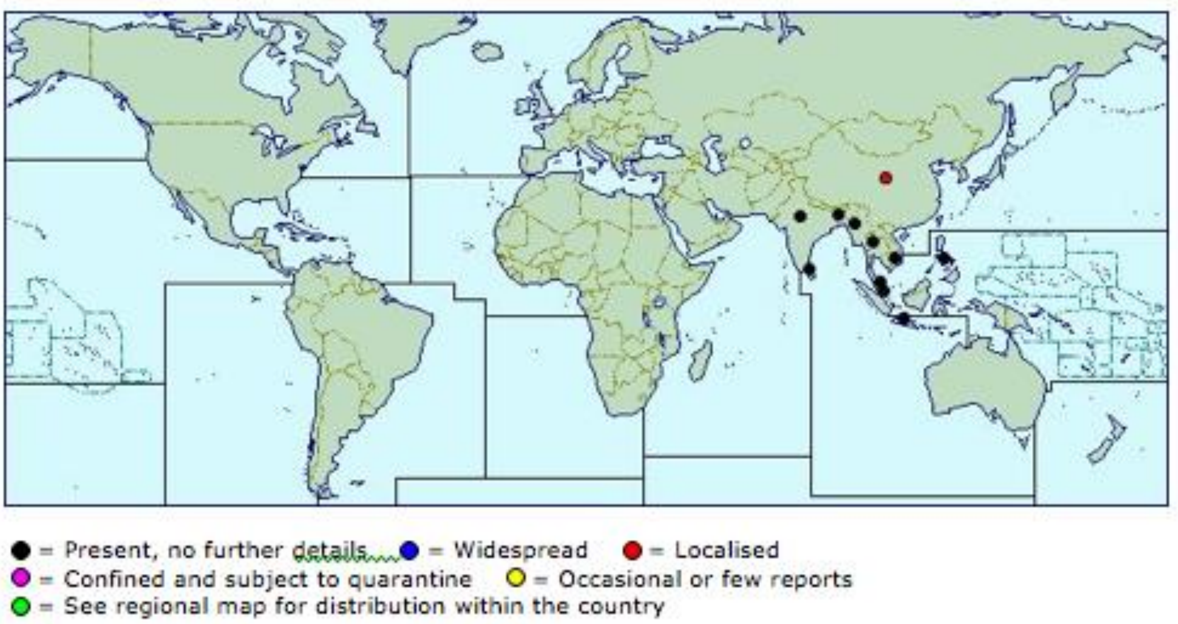
DISTRIBUTION MAP

Helopeltis antonii **(Tea bug)**



DISTRIBUTION MAP

***Helopeltis theivora* (Tea mosquito)**



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STEM BORER
Zeuzera coffeae (Lepidoptera)

IMPORTANCE

Zeuzera coffeae (Lepidoptera) attacks many other hosts apart from cocoa and is found in South East Asia and Papua New Guinea. In parts of Indonesia, stem borers are increasingly becoming a pest.

Pantorhytes species (Coleoptera) are found usually in the islands of New Guinea and the Solomons, although one species is found in Cape York Peninsula of Australia. Six *Pantorhytes* species are primary pests and at least eight others have been associated with stem boring damage of cocoa.

Other stem boring insects occur but these are of local or minor importance.

SYMPTOMS

The larvae attack stems that are from 1.5-20.0cm in diameter causing damage to seedlings and mature trees. The tunnel bored by the larva has a single entrance hole at its base and it runs length-ways inside the stem and is not normally longer than 30cms. The entrance hole is the same width as the tunnel.

Stem borer larva in length-ways tunnel inside stem, when the larva is active inside, a sticky sap dribbles down the bark causing a distinctive dark water stain. In thin stems the tunnel is simple but in larger stems several tunnels may start from one entrance hole. Stems of medium thickness may have side tunnels in the form of a loop. Tunnel entrances in cocoa taproots have been found as deep as 20cms below the soil. Sometimes the bark of the trunk and larger branches splits lengthways at a point not more than 30cms above the entrance hole. Such cracks are superficial but considerable amounts of sticky sap can escape.

Attack by stem borers allows many diseases to gain entrance into the cocoa tree, such as *Phytophthora* species, which will cause extensive stem and trunk cankers and often lead to sudden wilt and rapid death. This process is worsened by successive prolonged wet seasons.

ECOLOGY

Zeuzera coffeae adults are called leopard moths because of the pattern of dark bluish spots on a translucent white background on the forewings.

Sticky strings or groups of pale yellow eggs are laid on small stems and branches. No attempt is made to hide them in bark cracks. After about 10-11 days the eggs turn dark yellow-red before hatching. The larvae stay together and spin a communal web. From this web each larva lowers itself on silk threads. The threads are caught by the breeze and act as 'parachutes' and the larvae can be carried considerable distances. The death-rate is very high at this stage, but a larva lucky enough to land on a suitable host bores into the bark. Early tunnels may be formed in thin stems (petioles), which are later deserted for thicker stems. In cocoa the larvae tunnel up to 30cms along the centre of a branch and finally makes a cross tunnel before pupation. The pupa sticks out of the entrance of the cross tunnel before emergence.

MANAGEMENT

Cultural control
Pruning of infested branches does reduce stem borer populations but is labour intensive. Hand picking of adults and removal of larvae using pieces of wire can achieve good results but it must start as soon as infestation is spotted. Also unfortunately this method can cause serious damage to the trees if not undertaken very carefully and its use should be strictly limited.

Planting of barrier crops such as dense stands of taro or sweet potato or *Pueraria* species has also been suggested. The stands should be at least 15 m wide and established early for new plantings, removing alternative host plants is also recommended.
Leucaena glauca has also been recommended as a barrier crop, however if left unmanaged it can become a pest because of its rapid growth and its ability to crowd out native vegetation.

Biological control
In Java, larvae of *Z. coffeae* are parasitised by *Bracon zeuzerae* (Hymenoptera). In Malaysia, *Eulophonotus myrmeleon* larvae are parasitised by a *Glyptomorpha* (Hymenoptera). However, none of the many parasites and predators of *Pantorhytes* has shown any promise of providing natural control.

Live larvae are less likely to be found in trees foraged by the ants, but the introduction of ants into cocoa orchards is difficult.

The fungus *Beauveria bassiana* infects larvae of *Z. coffeae* but there is no commercial product available at present.

Woodpeckers will frequently peck out borers.

Chemical control
There is no effective chemical control that does not involve using highly toxic and expensive chemicals.

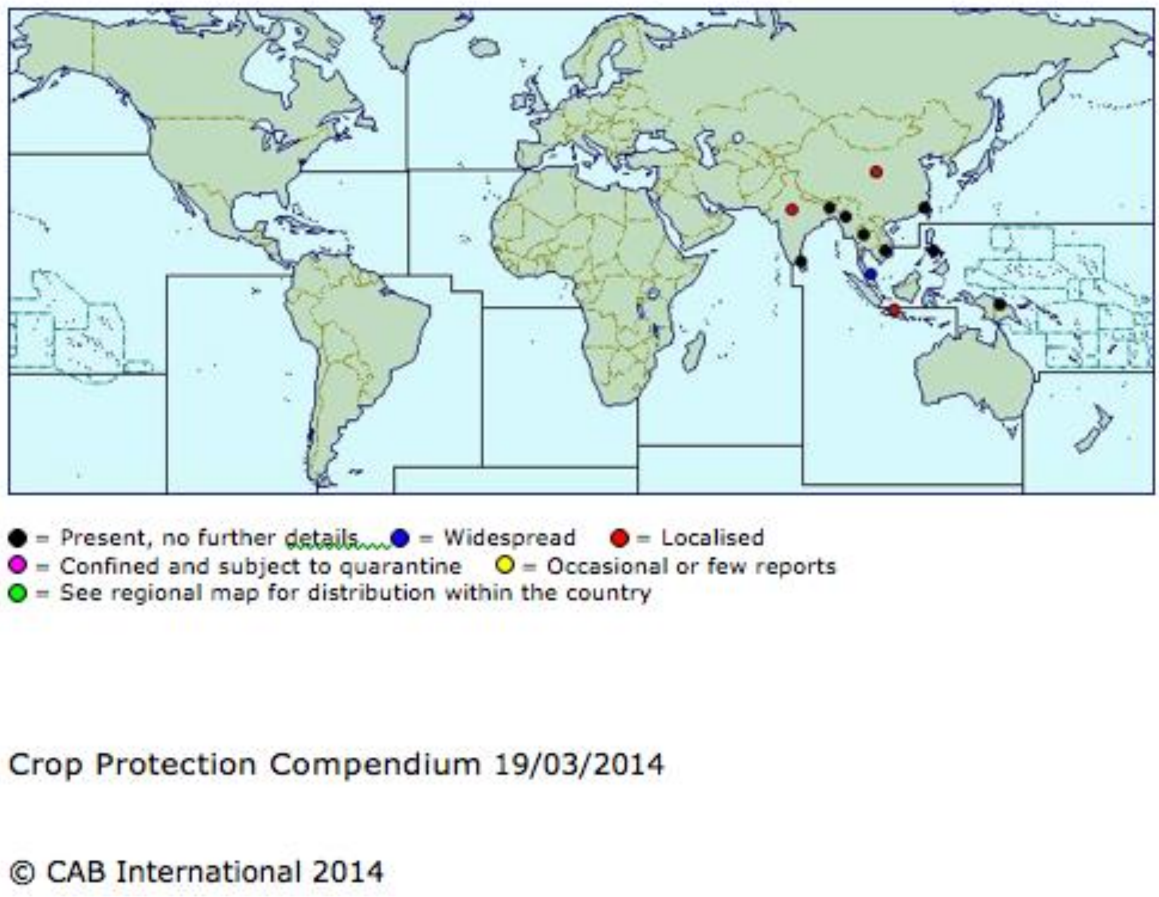
Spraying highly toxic chemicals kills parasitic wasps such as Ichneumons (Hymenoptera). Spraying stopped at the end of 1961 and by the end of 1962 the populations of *Zeuzera* declined dramatically following the increase of parasitic wasps.

CROP LOSSES

Uncontrolled outbreaks can cause severe losses to due to damage to the pod bearing branches.

PREFFERED SCIENTIFIC NAME	**Taxonomic position**
Zeuzera coffeae Nietner	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Lepidoptera Family: Cossidae

DISTRIBUTION MAP



TERMITES (White Ants)

IMPORTANCE

Termite attack on living cocoa wood usually goes unnoticed until much damage has been done and the trees have wilted. Termites that make runs over the surface of the bark will also carry spores, especially those of Black Pod disease. This fungus also causes cankers on the bark and stems. The chewing damage caused by termites also allows other wood-rotting fungi to enter. In addition, Termites will attack the shade trees causing the same type of damage as on cocoa.

On the other hand, some termites play an important role in breaking down plant material (stems, leaves, etc.) and facilitate nutrient recycling. They can also improve soil aeration and drainage through their tunnelling activities.

DESCRIPTION

Seventeen species of termite are of major importance in cocoa farms worldwide; other species occur but are of limited local importance usually during dry periods or drought. There are three families of termites that cause problems in cocoa around the world.

The family Kalotermitidae [K] includes dry and damp-wood termites that are able to maintain themselves in cavities in wood and make nests that have no connection with the soil. Nests are small, there is a soldier caste and the nymphs carry out the work, as there are no workers.

The Termitidae [T] are wood-eaters and mostly live underground or in mounds and four-fifths of all termites belong to this family. Rhinotermitidae [R] are an underground species that mainly attack dead and decaying wood and only occasionally invade living tissue.

Accurate information on termite management for farmers and extension personnel is very limited.
There are very few specialists able to identify tropical termite species that may be of economic importance and this has resulted in a large number of incorrect, doubtful or incomplete identifications.

Determining what species is attacking cocoa or any other crop is almost impossible and so the important factor is: are the termites I can see actually doing any damage to the crop – have the termites invaded and eaten the roots and collar?

Species identified in New Britain and Papua New Guinea that have caused problems are :

***Neotermes papua* and other species [K]**

Several species attack cocoa through dead solid wood on the branches or through roots. The termites then attack the healthy wood and are usually well established before discovery. Weakened branches or trees can fall in wind or heavy rain. *Leucaena glauca* shade trees are also attacked by *N. papua*.

***Nasutitermes princeps* [T]**

Nests are found in healthy trees and cause primary attack.

ECOLOGY

Termites attack cocoa trees in two different ways. Young plants in nurseries or the fields are attacked mostly in the collar area; the tap and other roots and the stem base. This usually happens in the dry season and, if the attacks are not noticed, the tree can be the victim of a severe and sudden wilt. The same type of damage occurs on chupons that are produced from the base of mature trees.

In mature trees the dry-wood termites attack injured and dying wood. Damp-wood termites damage living wood and these invade from wood in parts of the tree that have been damaged by other insects or disease.

The underground tunnels leading out from nests can be as long as 50m. The area of land that one termite colony can exploit is extensive.

MANAGEMENT

Management of termite infestation varies according to the type of termite and there are three general approaches, cultural, biological and chemical control.

Cultural control

Deep ploughing or hand tilling breaks open underground nests and exposes termites to drying-out and predators. A traditional method for mound-building termites has been to break open the nest and remove the queen. Flooding nests washes away or drowns the termites. Burning straw suffocates and kills the colony.

Keeping plants healthy makes them less susceptible to attack clearing weeds removes competition for soil nutrients.

Removing plant debris from farms can reduce the potential termite food supply and lead to starvation of the colony. Please note that this could also lead to the termites attacking the crop as their alternative food supply has been removed!

Mulching either increases or decreases termite numbers depending on whether the mulch has termite-repelling properties. Different compositions of any mulch must be tested, as effectiveness will depend on the species of termite present locally. Various parts of plants that termites find poisonous or unpleasant have been mixed with mulches and scattered around plants. These have been successful on a small-scale but have not been tried on a large scale.

Wood ash heaped around trees is said to prevent termite infestation of coffee and date palm and to protect seedlings. It is mixed into nursery beds or applied as a top layer on the soil. The benefit of using ash to repel termites is knowledge that has been collected from farmers.

Biological control
Ants are the greatest enemies of termites and under natural conditions limit their numbers. In Uganda a traditional practice of using dead animals, meat bones and sugarcane husks to poison Macrotermes mounds was used to develop baits for predatory ants and was tested for termite control in maize. The protein-based baits attracted significant numbers of ants and more nests established near maize plants, which reduced the termite damage and increased yield.

Chemical control
Some controlled-release formulations of non-persistent insecticides (e.g. permethrin – WHO Class II, and deltamethrin – WHO Class II) can be used as barriers in the soil around roots. These are effective and long-lasting but are not cost-effective for the majority of small-holders. Home-made botanicals from neem, wild tobacco and dried chilli have been used to control termites in the field and in storage warehouses.

CROP LOSSES

Can be severe in neglected and unloved cocoa orchards, as infestation is not noticed until it is too late.

PREFFERED SCIENTIFIC NAME	**Taxonomic position**
Just call them Termites!	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Isoptera

WHITE GRUBS
Phyllophaga spp.

IMPORTANCE

White grubs are considered to be a minor pest of cocoa, however during favourable weather conditions, very severe outbreaks can occur. Adult beetles are defoliating pests and damage a large number of fruit crops, including cocoa and forest trees as a result of feeding on apical buds and tender leaves.

There are three larval stages, but only the third has economic importance.

DESCRIPTION

Note: *It is very difficult to give morphology of all-important species, a generalized morphological character of different stages of Phyllophaga species are described.*

Egg
Freshly laid eggs are white, oval (about 3.22 mm in length and 1.9 mm in width) but after the third or fourth day the eggs become spherical, smooth, 2 mm in diameter. Prior to hatching they become brownish black and the egg swells up to 4 mm in diameter.

Larvae
The newly hatched larva is creamy-white in colour with a brown head, the head length and width being 4 mm and 3 mm, respectively. The first-instar larva measures 10.1 mm in length. The second-instar larva is about 25.5 mm in length and head capsule is 5.6 mm in width. The shape and colour resembles the first instar but the last abdominal segment becomes more swollen and darker. The third instar is slightly yellowish, creamy-white in colour, and on average 41 mm in length. The head length and width being 8 mm and 7 mm, respectively. Powerful mandibles, antennae 5-segmented, the last segment with one dorsal and two ventral sensory spots. Thoracic segment are distinct, the fore legs shorter, the hind longer and the middle pair in between.

Pupae
The newly formed pupa is light yellow and gradually changes to brown towards the transformation to adult. It measures 27.3 and 14.2 mm in length and width, respectively.

Adult
The freshly emerged imago is white in colour and with lapse of time it becomes dull brown with light-brown abdomen and dark-brown legs, antennae 10-segmented, apical 3 segments form lamellate club; fourth segment of maxillary palp oblong, prolonged margin serrated. Hind tibiae with spring ridge. Male slightly smaller than female. The average beetle widths are 23 and 12 mm, respectively.

ECOLOGY

White grubs are fat, fleshy and wrinkled, whitish or cream in colour and with the body 'C'-shaped. The legs are well developed and often hairy. The head is large, mouth parts are turned downwards (hypognathous) and heavily sclerotized, yellow-brown or red-brown in colour, and with powerful, exposed jaws (mandibles). All three larval stages live in the soil and feed upon living plant roots, and ingesting quantities of soil and organic matter. The presence of living roots and soft, friable, well-drained and slightly acid soil are crucial to the survival of most young larvae.

Cocoa seedlings and plants derived from grafts and budding have a tap root that penetrates deep into the soil whereas rooted cuttings have fibrous roots that favour the survival of the grubs. Fibrous roots and suitable soil conditions provided by some pastures and host plant parts on which grubs normally feed also favour the survival of grubs. In addition to suitable soil conditions, the closeness of adult food plants ensures that adult beetles frequently lay eggs nearby.

Eggs hatch at 6-13 days and the larvae immediately burrow into the soil and begin feeding on organic matter and small roots. Larvae are extremely vulnerable at this stage and even slightly unfavourable environmental conditions may cause up to 75% mortality. Third-instar larvae, which cause most damage to host plants than earlier instars, are present from the end of June or July until October. Full-grown larvae burrow deeper into the soil and form a cell in the first compact soil they encounter, usually at a depth of 20-30 cm. This takes place from August onwards and is completed by all individuals by November.

Pupation normally takes place in February or March in field conditions. The pupal stage lasts 30-40 days at 23-25°C soil temperature at 30 cm below the surface of an undisturbed soil. Pupal mortality may be as high as 25% in disturbed soils.

The adult matures and remains inactive until the cell is broken by rainfall soaking the soil and emergence is usually synchronized with the first seasonal rains in May. Emergence takes place at dusk between 17.45 and 18.45 h at 27-30°C. Females crawl or fly to a low branch or other support, where they hang with the tip of the abdomen sticking out. Males emerge shortly afterwards and after a short searching flight, mate for 10-15 minutes, hanging upside down from the female genitalia. At the end of this time both sexes fly off in search of food. After a feeding period, which lasts from one to several hours, beetles fly a short or longer distance before dropping to ground where they burrow into the soil to lay eggs or rest until the following night. The eggs are deposited singly, 5-15 cm deep, depending upon the softness of the soil. Repeated mating and continued feeding are necessary to ensure a high egg laying potential. The egg laying period ranges from about 50-100 days and high egg laying potential varies from 0-140 days.

Adult flight is the main means of movement and dispersal to previously uninfected areas and a suitable environment for the survival and multiplication of the pest.
Mating, dispersal flights and egg laying behaviour are broadly similar for most species. Most of the species complete their cycles in one year.

MANAGEMENT

Integrated Pest Management
It is not possible to control white grubs by adopting a single control technique. The management programme should be practised in the endemic localities or an area campaign basis by involving all of the following recommended control techniques: summer ploughing, application of insecticide on the adult host plant, installation of light traps for the control of adult beetles and conservation of natural enemies and their field application. IPM programmes combining the control components below have been devised and implemented, especially in India in field crops.

Cultural Control
Cultural techniques are useful in reducing the number of larvae as well as adult populations. In endemic areas summer ploughing of susceptible crop fields near cocoa orchards exposes the larvae which can then be eaten by birds. The application of nitrogenous fertilizers in susceptible crops grown near cocoa orchards, especially ammonia and urea, at high doses kill the first-instar larvae. Planting of resistant crop varieties also help to reduce white grub populations, especially in sugarcane if such crops are grown near cocoa orchards.

Mechanical Control
Light traps can be used for collecting adult beetles at night. Blue light is the most the most attractive to the adult beetles if blue light is not available then white light should be used. Other colours are much less attractive to the adult beetles. The beetles can also be collected by shaking the host plants however this action will prove very difficult with fully grown trees and may only be of use for seedlings and young trees. The fallen beetles are collected and destroyed by putting them in water containing kerosene. Host trees can be pruned to attract and concentrate the beetles on a limited number of host plants. The branches of these host plants can be transplanted in the endemic area to attract the adult beetles and the beetles picked up by hand from the branches and destroyed.

Biological Control
A number of fungal, bacterial and nematode biological control agents which attack white grubs have been tested in laboratory and field trials in different parts of the world. The results have usually been very good however no biocontrol commercial product has been manufactured.

Chemical Control
Insecticides are an important tool for immediate relief of white grub infestations. This method should be approached in the endemic localities to bring the population below the economic threshold level. Effective control is possible if the chemical is applied when the larvae are tiny or young, as older larvae are very hardy and move to a great depth in the soil. Insecticides that can give control are carbamate (e.g. carbosulfan or carbofuran) and/or organophosphate insecticide in the form of granules. Apply this to the soil at the time of planting and again 90 days later, coinciding with larval activity. To use permitted/registered pesticide in the respective country.

Pheromonal Control
This has been tried in Japan on one white grub species, however commercial availability is limited and expensive.

Regulatory Measures
Phytosanitary measures should be enforced to limit further spread of *Phyllophaga* by international transport of infested plant material.

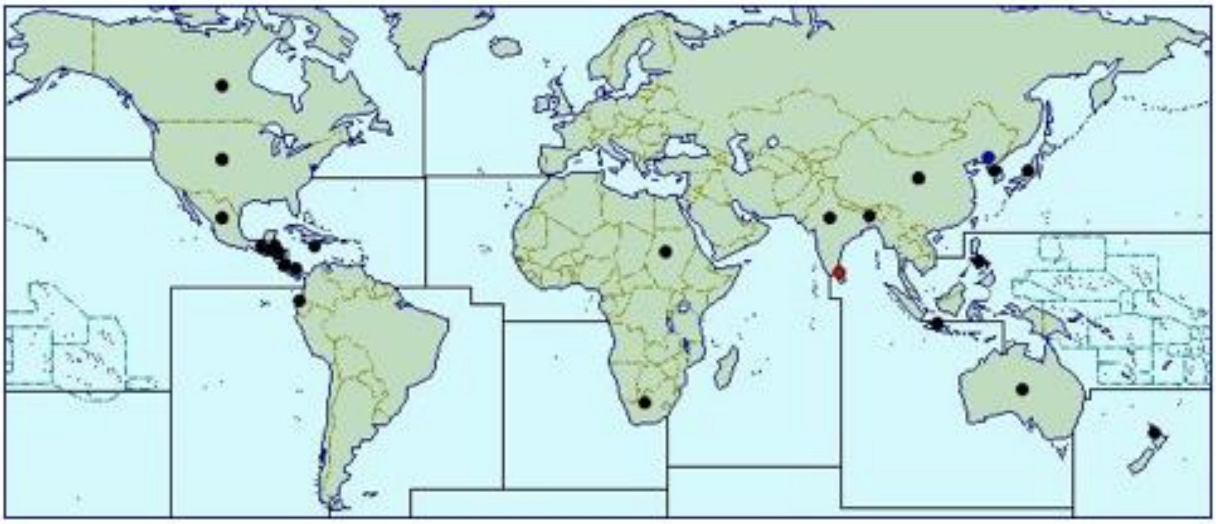
CROP LOSSES

Crop losses in hosts such as sugarcane in Mauritius can be up to 80% with huge populations (50,000 – 60,000 per acre) of white grubs in the soil. Potatoes in India have as much as 85% loss.

The severity of the damage depends on the white grub species, the host crop, the numbers of grubs and adults and favourable weather conditions.

PREFFERED SCIENTIFIC NAME	**Taxonomic position**
Phyllophaga species	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Coleoptera Family: Scarabaeidae

DISTRIBUTION MAP



● = Present, no further details ● = Widespread ● = Localised
● = Confined and subject to quarantine ● = Occasional or few reports
● = See regional map for distribution within the country

Crop Protection Compendium 19/03/2014

VASCULAR STREAK DIEBACK (VSD)
Ceratobasidium theobroma

IMPORTANCE

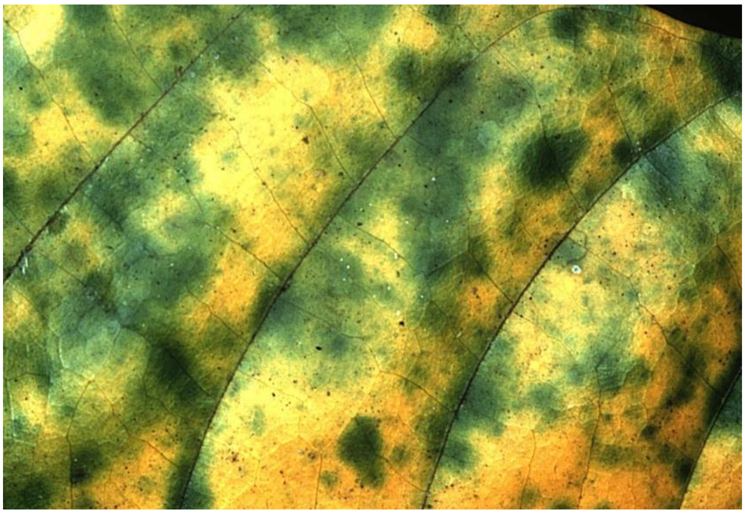
The disease is found in most cocoa growing areas in South East Asia. There is strong evidence that the fungus evolved on an indigenous host, as yet unidentified, in South East Asia/Melanesia and transferred to cocoa introduced to the region.

In Papua New Guinea, VSD is seen as being most damaging during the establishment phase of cocoa, when infection is likely to penetrate the main stem and kill the plants, whereas in Malaysia and Indonesia, the disease is also regarded as dangerous to mature trees. Seedlings that become infected before jorquetting (less than 10 months old) are the most susceptible to the disease. The younger the seedling is at the time of infection, the greater its chance of being killed.

DESCRIPTION

Infection always occurs through young flush leaves at a growing point with the fungus growing down the stem. Seedlings have only one growing point and are killed by the infection. After the jorquette is formed, the infection may progress into the main stem and kill the plant. Once trees are mature they have thousands of growing points, all of which can be infected. The disease does not progress into the larger branches of mature trees except perhaps in the most susceptible material, within which it can spread to the trunk causing the tree to die. There are no visible symptoms during initial fungal growth within the plant.

However, the most characteristic initial symptom, which can easily be seen, is the yellowing (chlorosis) of one leaf, usually on the second or third flush behind the tip, with scattered green patches about 2 – 5 mm in diameter. This appears after a few weeks in young seedlings compared to 2-3 months in branches on mature trees.



Within a few days, this leaf is shed and adjacent leaves turn yellowish in the same way, are subsequently shed and this leaves a characteristic gap in the leaf architecture on infected branches. Very characteristic symptoms are the blackening of the vascular bundles of the remaining leaf scar, giving three black spots. Die-back of the growing tips is also characteristic of the disease (hence name). Brown streaking is visible when stems are split.

Eventually, leaf fall occurs up until the growing tip of the flush subsequently dies, followed by the rest of the seedling or branch. The fungus may spread internally to other branches or the trunk. If the trunk is infected, the tree usually dies. The disease development from the initial infection to death of a growing tip takes usually 5 months on a mature tree, but only a few weeks in a young seedling. The disease often peaks 3 to 5 months after high seasonal rainfall.

When an infected leaf falls during wet weather, fungal strands may emerge from the leaf scar and develop into a spore forming body, which is evident as a white, velvety coating over the leaf scar and adjacent bark. In dry weather, leaf scars quickly become hardened and this prevents the emergence of the fungus.	

ECOLOGY

Formation of spores and sporulation occurs mainly at night, after the spore producing bodies have been wet by afternoon rain. Onset of darkness is also a stimulus for sporulation. Sporulation occurs for an average of 10 days on attached branches, on detached branches only for 2 days. Extended periods of leaf wetness are required for infection and even longer periods of bark wetness are required for spore body formation and sporulation.

Spores are dispersed by wind and rapidly destroyed by sunlight. Therefore, effective spore dispersal is probably limited to the few hours of darkness and high humidity following their discharge. Spore dispersal is probably further limited by the dense canopy of cocoa and shade trees in plantations. As a result, disease spread from older, infected cocoa into adjacent younger, healthy populations, occurs along a steep gradient, with very few primary infections occurring beyond 80 m from diseased cocoa. The VSD fungus can colonise the vascular system of pods: this has some potential importance for quarantine, with the possibility of transmitting the disease via infected pods distributed for seed. However no infection was ever detected in seed and the possibility for seed transmission has been discounted. Similarly, infected budwood does not graft and it is highly unlikely that infection will occur.

The fungal spores have no dormancy and free water is required for germination and infection. Spores germinate within 30 min if leaves remain wet, but do not grow further once the water evaporates. It appears that, as with sporulation, infection requires very particular conditions that are difficult to simulate in the laboratory. In tests, 3-week-old seedlings were inoculated which caused symptoms after 6-9 weeks. Inoculation of 6-month-old seedlings caused symptoms after 10-12 weeks. Peaks in disease occurrence in the field are often observed to occur 3-5 months after seasonal rainfall peaks. The fungus penetrates young (up to 10 cm long), unhardened leaves. After penetration, the branch or seedling grows for another 3-5 months (two or three growth flushes) before the fungus has ramified sufficiently to induce disease symptoms in the penetrated leaves. This incubation period explains the occurrence of the first symptoms on the second or third flushes behind the growing tip.

Infection rate is closely related to rainfall incidence and hence the disease is most common in wetter regions. Experience in Papua New Guinea indicates that 2500 mm rainfall per annum is required for VSD to be destructive.

MANAGEMENT

Host plant resistance

In Papua New Guinea, during the VSD epidemic in the 1960s, a natural selection took place, only trees with some resistance to the disease survived. Growers tended to replant with seedlings derived from survivors of the epidemic, which were likely to be more resistant. Excellent resistance now occurs in most cocoa types, except for Amelonado, which appears rather susceptible. Resistance has remained stable for 30 years in Papua New Guinea.

Much fully resistant material is now available in many of the affected countries in the region and its widespread planting has reduced the disease to minor importance under most planting conditions. The resistance is likely to be partial, as resistant varieties still become infected, but there are fewer infections per tree, the pathogen grows more slowly and sporulates rarely. Also, infections do not spread from lateral into main branches.

Cultural control

Healthy seedling raising

Seedlings should be raised well away from infected areas to ensure that stock transplanted into the field is initially disease-free. Nurseries should be protected by growing seedlings in a shade house or under a plastic shelter, which keeps the leaves dry for all but a few hours after watering. Covering nurseries with roofs also stop spores falling on the young cocoa seedlings.

Sanitation

Monthly inspection and pruning of infected stems with the first sign of yellowing has been practised in Papua New Guinea and Malaysia. Pruning prevents the disease from spreading within individual plants and also lowers the inoculum level. Pruning can be effective when combined with moderate levels of resistance, but it is often ineffective when inoculum levels are high and planting materials susceptible. Pruning should be conducted to 30cm below discoloured veins (the area with brown streaks when the stem is split) although in practice this may not always be possible in young seedlings. In older trees, pruning can result in complete recovery, but may also lead to an uneven stand. In Java, incidence of tree infection was kept below 1 % in mature stands when every two weeks over a period of 2 years, trained teams detected and pruned out infected branches.

Structural pruning

Opening up the canopy by pruning to increase air circulation and hence reduce the humidity is also crucial as that can help avoid spore formation, sporulation and infection.

Phytosanitary measures

Whole plants or cuttings from areas infested with VSD should not be used. When clonal material is required, it should be supplied as budwood from disease-free areas where possible. Budwood from plants grown in infested areas should be sent to an Intermediate Quarantine Station in a disease-free area and budded onto rootstocks raised from seed collected from a disease-free area. An extremely strict quarantine procedure instituted in Papua New Guinea in the 1970s enabled successful in-country transfer of superior clones from the infected cocoa area in New Britain to the disease-free islands of the North Solomons and New Ireland.

Chemical control

Protective fungicides are unlikely to be effective against this disease as infection occurs during wet weather when protective chemicals will tend to be washed from the trees. Also, infection occurs into rapidly expanding leaves. Chemical control has therefore been investigated primarily to protect young seedlings in the first year of field planting when disease pressure is high.

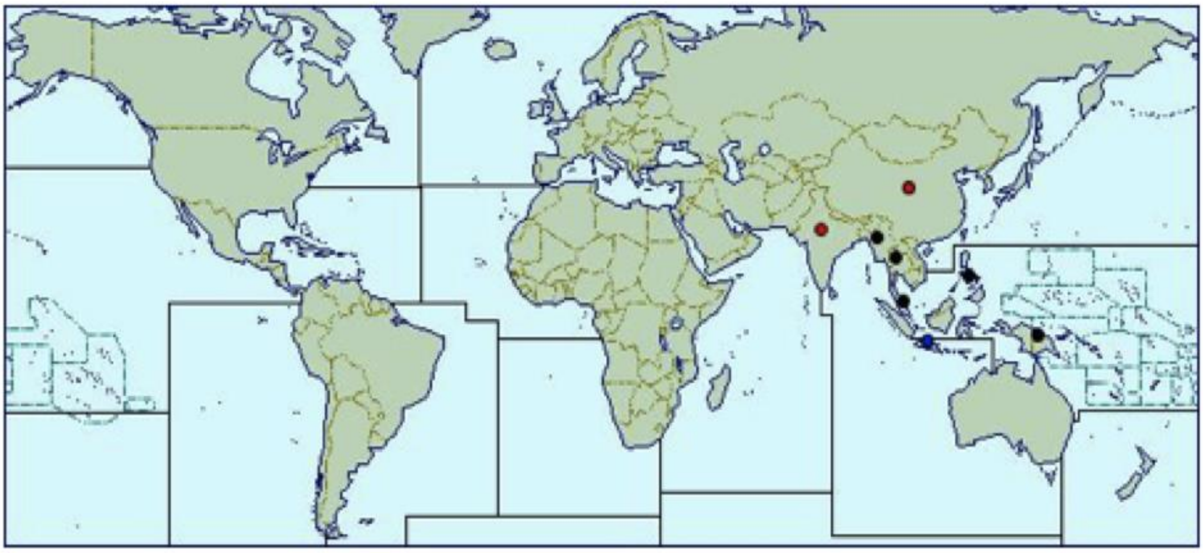
Some triazole fungicides have shown promise, for example as soil drenches with the systemic fungicides triadimefon (WHO class III) or triadimenol (WHO class III) in Malaysia. Seeds are not known to transmit the disease, but a precautionary dip in a triazole fungicide could be used. Tebuconazole (WHO Class III) was the most effective systemic triazole fungicide tested as monthly foliar sprays in Papua New Guinea, but proved to have a growth hormonal effect in seedlings.

CROP LOSSES

Seedlings less than ten months old are most at risk and 100% death can result from infection. In older trees of susceptible clones the outer branches are killed first, then the remainder of the tree over time. Losses can be considerable if susceptible clones are still in production and care and management of the orchard is neglected.

PREFFERED SCIENTIFIC NAME	**Taxonomic position**
Ceratobasidium theobroma (formerly Oncobasidium theobromae P.H.B. Talbot & Keane)	Domain: Eukaryota Kingdom: Fungi Phylum: Basidiomycota Subphylum: Agaricomycotina Class: Agaricomycetes Subclass: Agaricomycetidae Order: Ceratobasidiales Family: Ceratobasidiaceae

DISTRIBUTION MAP



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Crop Protection Compendium 19/03/2014

BLACK POD DISEASE

Phytophthora palmivora (E J Butler)

IMPORTANCE

Of all cocoa diseases world-wide, Black Pod causes the largest loss of production. Globally, seven fungus-like organisms have been identified as causing Black Pod disease of cocoa, but the one causing the major problem in South East Asia is *Phytophthora palmivora*. This organism also infects over 200 other plant species in tropical and sub-tropical regions.

SYMPTOMS

The disease begins with the appearance of a small translucent spot, about two days after infection. The spot turns a chocolate brown colour, then darkens and expands rapidly until the whole pod is covered.

The pod becomes completely black, in about 14 days and internal tissues, including the beans, shrivel to form a mummified pod. Mummified pods are major sources of Black Pod infection.

Thin white / yellow cottony threads grow on the pod surface starting at the point of infection and this becomes denser as the disease progresses.

Microscopic capsules are produced from the cottony threads and these capsules contain the spores. Spores are the method of spreading the disease and can be likened to seeds in plants, as this is the most common method of spreading a plant.

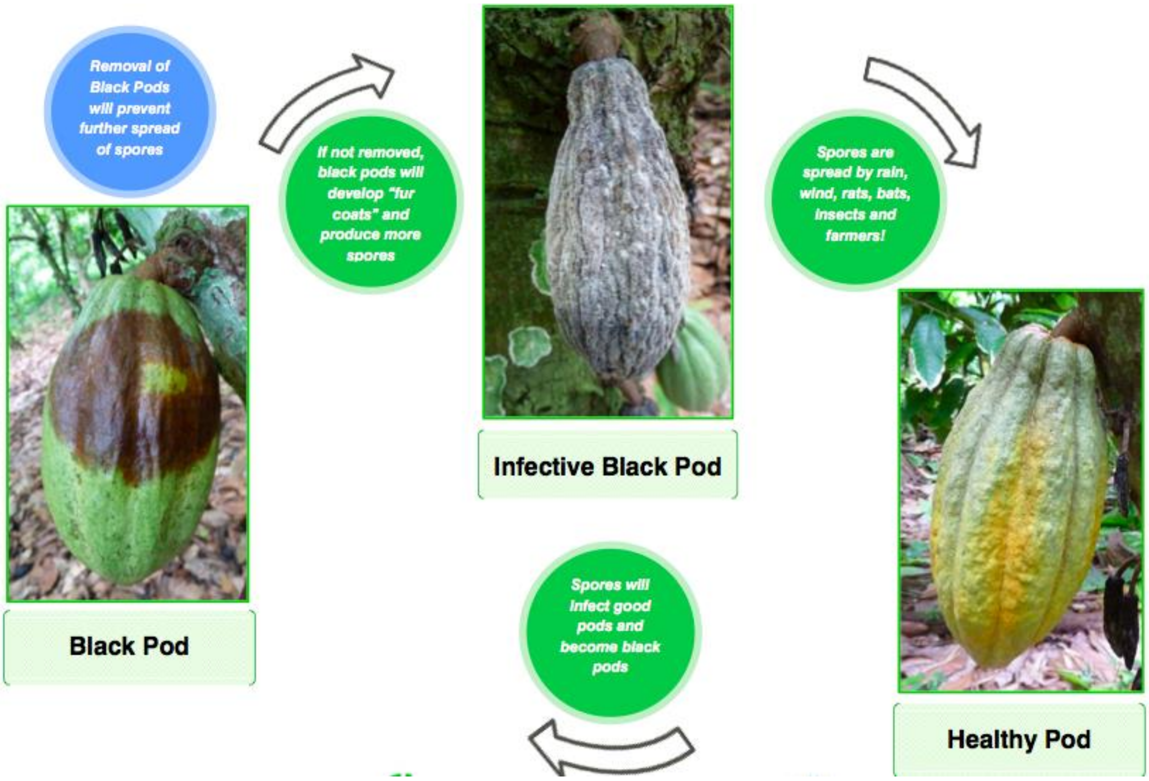
The spores are released from the capsules by rain splashing onto the pod surface and the spores are carried in rain droplets to infect other parts of the cocoa tree.

The disease also infects the stem, flower cushions and chupons. Infection produces cankers, which may girdle the trunk and cause sudden death. These cankers are seen as slightly sunken patches of bark, sometimes with a red sticky ooze seeping through the bark cracks. Removal of the bark reveals a discrete, spreading, reddish lesion in the vein tissue that usually does not penetrate deep into the wood.

The significance of stem canker is probably underestimated. Canker reduces tree vigour and carrying capacity of pod numbers, and so reduces yield. Cankers are often associated with stem or bark borer attack as these insects appear to be attracted to cankers.

The disease organism can also cause seedling and leaf blight.

LIFE CYCLE



ECOLOGY

Pods are susceptible at all stages of development and infection can occur on any part of the pod surface. Under humid and rainy conditions, a single infected pod can probably produce up to 4 million spore-producing capsules. Water is required for these organisms to spread from the source of infection and these can be pods, stem cankers, soil and roots. Very humid conditions cause the disease to develop and spread very quickly.

The Black Pod disease (*Phytophthora palmivora*) survives in mummified pods and in cankers, and in infected pods and other cocoa debris for less than 10 months depending on ground cover.

Rodents, such as rats and squirrels can also carry the spores around the cocoa trees. Rapid, long distance dispersal of the disease is primarily by man, often on contaminated harvesting and pruning tools and in contaminated soil on shoes.

MANAGEMENT

Cultural methods work by making it more difficult for the disease to spread through the crop.

Field inspections should begin at the start of the rainy season. After 2-3 days of continuous rainfall, check for and remove primary infections on all pods no matter how small the pod. Infected plant material needs to be disposed of carefully, composting is an effective method but it must be done properly otherwise it could be a future source of infection. Burning of infected material should only be used as a last resort it is very expensive for fuel and damages the environment. Regularly harvest ripe, healthy pods to prevent post-harvest losses, as even minor infections will cause spoilage of the beans inside the pod.

Seedlings should be planted properly spaced this provides a good air-flow and reduces humidity. Reduced humidity lessens the chances of water being available for spore spread.

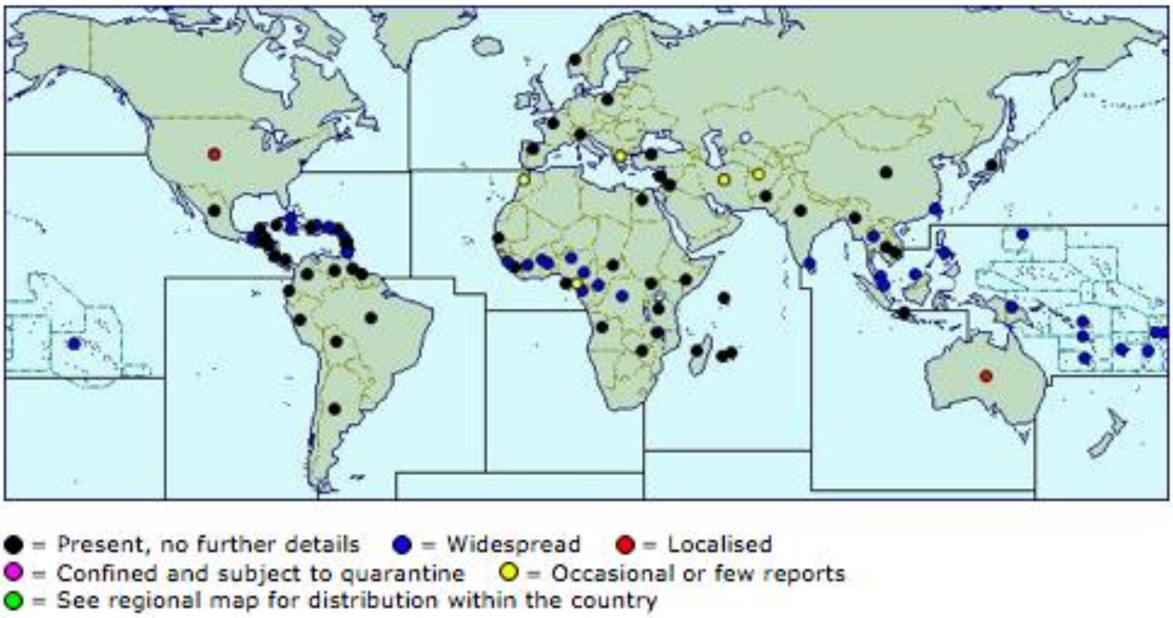
Good pruning of the tree canopy is essential – but take care not to make gaps in the canopy as this could aggravate Mirid infestations in some areas. Cultural control alone can be very effective against Black Pod disease if conducted properly.

Weed regularly, particularly at the beginning and during the wet season to increase air-flow and reduce humidity in the cocoa farm. Remove soil tunnels on the surface of cocoa trunk built by ants. This removes two sources of infection: spores carried in infested soil and those carried by the ants. When establishing new cocoa farms, try to avoid areas that are known to have Black Pod disease infested soil.

Mulches may also reduce splash borne inoculum from the soil onto pods borne low down on the trunk.

CROP LOSSES Heavy infection with Black Pod disease can result in 100% loss of pods. Stem canker is suspected to cause about 10% of trees.	
PREFFERED SCIENTIFIC NAME *Phytophthora palmivora* (E J Butler) E J Butler	**Taxonomic position** Domain: Eukaryota Kingdom: Chromista Phylum: Oomycota Class: Oomycetes Order: Peronosporales Family: Peronosporaceae

DISTRIBUTION MAP



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PINK DISEASE

Erythricium salmonicolor (Berk. & Broome)

IMPORTANCE

The disease can cause significant losses, ranging from the loss of individual branches to death of the whole tree if the main stem is affected. Young trees 2-6 years old in cocoa are particularly severely affected. Pink disease is considered one of the main threats to new timber plantations in Indonesia.

The fungus rarely causes death of mature trees, but can kill young trees.

DESCRIPTION

The fungus infection in cocoa is usually first seen as a sparse white silk-like web (mycelium) on the bark surface. The surface web is easily overlooked, particularly where the bark is wet.

The web spreads mainly along the underside of the branch and pink/white blisters (pustules) appear through cracks in the bark and through the pores of the swollen lenticels, about 1-8 cm behind the leading edge of the infection. The fungus silk-like threads (hyphae) penetrate the branch, causing progressive death of tissues furthest from the origin of the infection. Leaves furthest from the infection turn light green in the interveinal areas and then scorch brown from the leaf margins. The affected leaves remain attached to the plant for a long time, giving an appearance similar to that of a broken branch.

The fungus produces two types of spore depending on the life cycle stage. One spore type (the basidiospore) is produced from a basidioma, the characteristic pink/white or pink/orange crust that develops mostly on the underside of the branch. Although it can develop to encircle the entire stem it can sometimes reach 2 m in length. The crust is initially smooth, but cracks and becomes paler as it ages.

The other spore type (the conidia) is produced from orange/red blisters (pustules) scattered over the bark surface.

Long black streaks of coagulated latex or gums appear on infected branches of cocoa and open wounds develop as the bark forms cankers and splits.

ECOLOGY

Growth of the hyphae is seasonal and favoured by rain; the fungus survives dry periods in dormant cankers.

Spores (basidiospores) from basidioma
Development of the basidioma and release of spores depends on regular heavy rainfall. Release of spores start after the basidioma has become thoroughly wetted some 20-80 minutes after the start of rain. High humidity or heavy dew is not sufficient. Spore release continues for up to 14 h after rainfall has ceased. Optimum temperature for growth of pink disease is 28°C.

Spores are dispersed by rain splash and wind, spores being most numerous when rainfall is light and of short duration. The number of spores deposited is higher on unshaded crops than shaded because the leaves of the shade trees trap the spores. However, the ultimate disease incidence may not be lower in shaded tree crops, because many shade trees are hosts to pink disease and shade conditions would prolong spore viability.

Spores germinate and penetrate through undamaged bark. In water, germination of spores starts 60-90 minutes after release and 100% germination occurs after 210 minutes. However, 100% relative humidity (RH) is not sufficient to start germination. Spore viability is reduced by low humidity; no spores remained capable of germination after 24 h at 70% RH, compared with a germination rate of 36% among those kept at 100%. Most spores are unlikely to remain viable for more than 24 h in the field. Plant defence reactions include the formation of tyloses to plug the vessels and the production of phenolics in the ray parenchyma and axial parenchyma contiguous to the vessels.

Spores (conidia) from blisters (pustules)

The importance of the conidial stage in disease dissemination varies among different crops. Conidia were recorded on less than 3% of infected cocoa branches in Western Samoa. Conidia remain viable for around 20 days under dry conditions, but high humidity is required for their germination. The fungus threads can spread between trees through physical contact between branches. The fungus remains viable in infected branches for a considerable time after the branch is removed from the tree.

MANAGEMENT

Cultural control

The wide host range of the pathogen makes local exclusion and eradication extremely difficult, as cross-infection can occur. Effective cultural control can be achieved by frequent pruning rounds and burning of infected debris providing the disease can be recognized in its earliest stages, but this is usually best combined with fungicide treatment. The pink encrustation and conidial pustules of the fungus remain viable for a considerable time after infected branches are removed from the tree.

Chemical control

Fungicides reported to show activity against pink disease include copper formulations (e.g. Bordeaux mixture, copper oxychloride, copper carbonate); tridemorph paints in an ammoniated latex base; triadimefon granules; chlorothalonil paints in a latex/bitumen base.

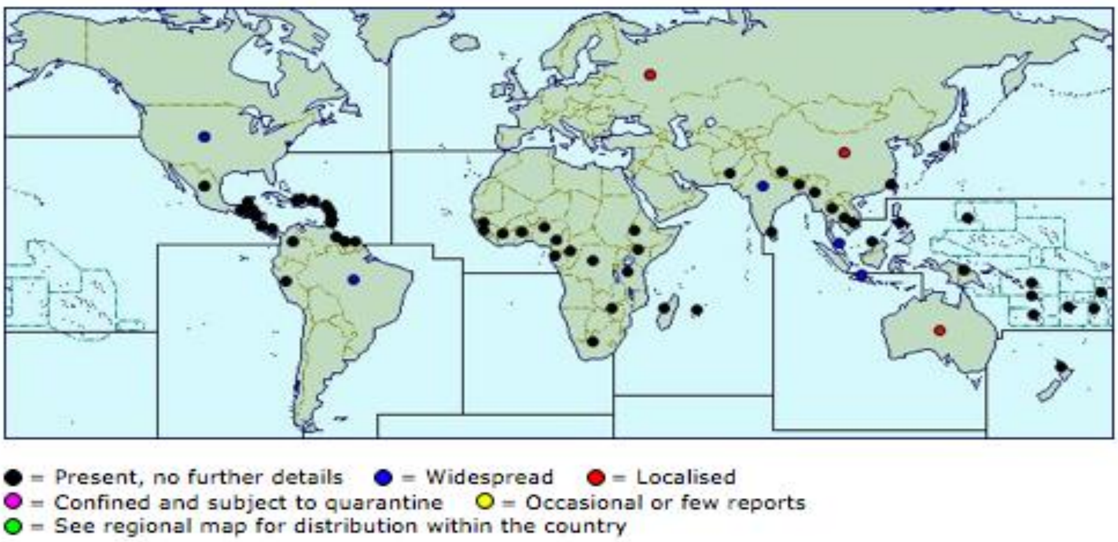
Pre- and post-monsoon application direct to trunk and branches with a specially designed spray lance proved most efficient. Application of sulphur/lime slurry gave the most economic control in Kalimantan.

CROP LOSSES

Disease incidences of 80% or more have been reported in cocoa.

PREFFERED SCIENTIFIC NAME	**Taxonomic position**
Erythricium salmonicolor (Berk. & Broome) Burds.	Domain: Eukaryota Kingdom: Fungi Phylum: Basidiomycota Subphylum: Agaricomycotina Class: Agaricomycetes Subclass: Agaricomycetidae Order: Polyporales Family: Corticiaceae
(Formerly *Corticium salmonicolor* Berk. & Broome)	

DISTRIBUTION MAP



Crop Protection Compendium 19/03/2014

BLIGHTS

Horse hair blight (*Marasmius crinis-equi*)
White thread blight (*Marasmiellus scandens*)

IMPORTANCE

Hawar bebenang hitam or horse hair blight (*Marasmius crinis-equi*) is of little economic significance on cocoa, and is not known to cause noticeable crop loss. The disease is generally associated with poorly maintained trees.

Hawar bebenang putih or white thread blight (*Marasmiellus scandens*) is of little economic significance on cocoa when it is kept under control. The disease is associated with poorly maintained plants already weakened by poor field management, other pests and diseases. The disease can usually be adequately controlled using cultural methods.

DESCRIPTION

HORSE HAIR BLIGHT

Hawar bebenang hitam forms an irregular network of black mycelial hair-like strands entangling the leaves of the branches. These strands are loose hanging from branches or leaves. Leaves that are so entangled are easily detached.

THREAD BLIGHT

Hawar bebenang putih fungus forms a network of white mycelial strands that grow across the leaves, petioles and branches. The infected leaves are shed from the branch and are held together by the fungal threads and dense mycelial pads.

ECOLOGY

On cocoa, horse hair blight is similar to white thread blight, the disease is more common in unattended fields where field sanitation practices are poor and infrequent. The likely means of spread of the disease are through fallen infected twigs and spores of the fruit bodies.

The fungus fruiting bodies are produced during long periods of continuous rains, sometimes in chains along the black strands. Fruiting bodies or basidiomata are small with the upper surface a light brown and growing from the branch or on short black stalks.

The occurrence of white thread blight is higher in plantations with poor cultural practices, especially when the normal rounds of sanitation pruning are not maintained and shade is too dense.
The disease spreads mainly by the fungus threads (hyphae) growing from leaf to leaf or along branches within a tree, and from tree to tree through infected fallen branches from tall shade trees. The disease also spreads through airborne basidiospores released from basidiomata formed during wet weather.
The disease might also be spread by a hemipteran bug, *Usingeria mirabilis*.

MANAGEMENT

These minor diseases only become a problem if cocoa orchards are neglected or poorly maintained. The disease is associated with poorly maintained plants already weakened by poor field management and other pests and diseases.

Both diseases are adequately controlled through regular sanitation pruning rounds. Infected and dead branches must be removed from the canopy.

CROP LOSSES

Horse hair blight is of little economic significance on cocoa, and is not known to cause noticeable crop loss.

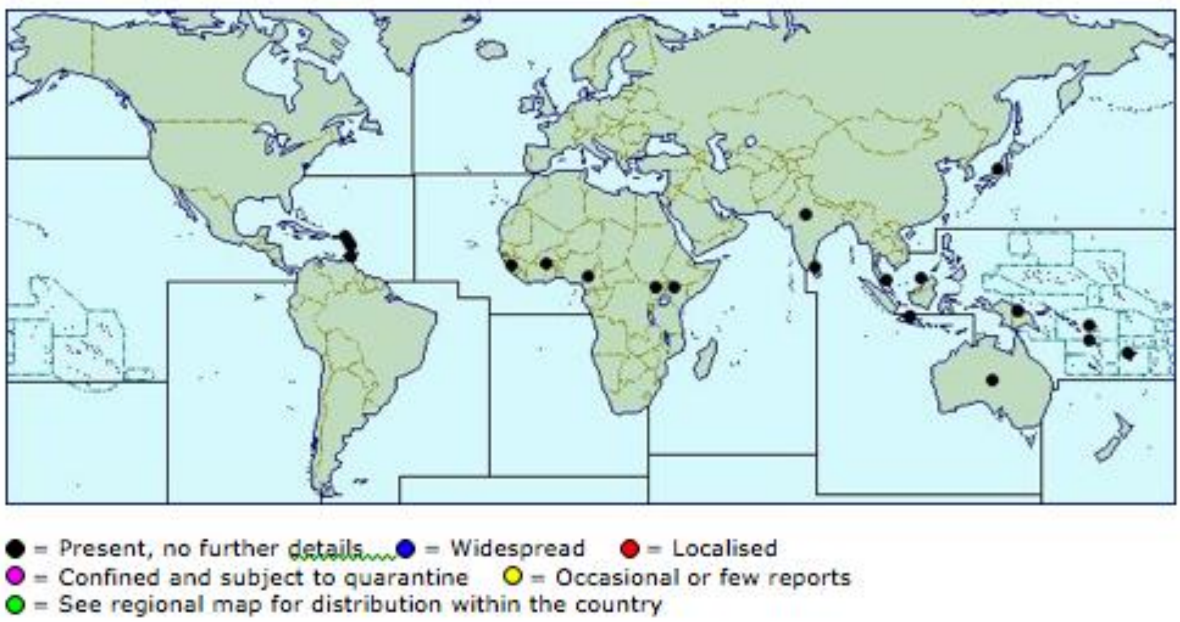
White thread blight is of little economic significance on cocoa when it is kept under control.

PREFERRED SCIENTIFIC NAME	**Taxonomic position**
Marasmius crinis-equi F. Mueller ex Kalchbr	Domain: Eukaryota

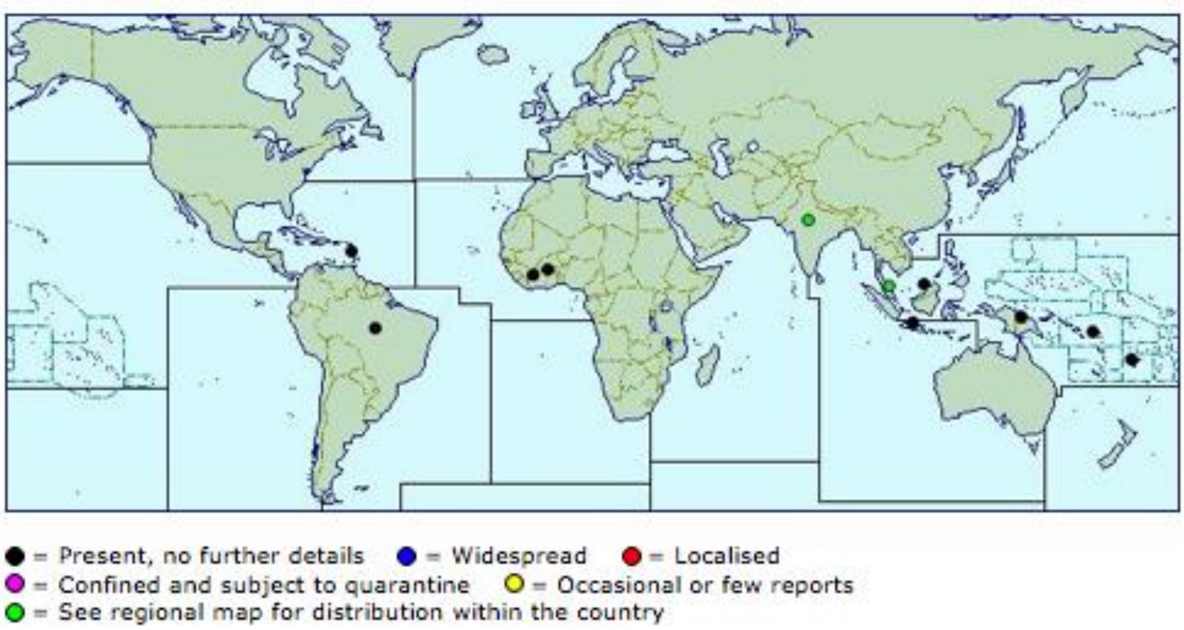
Horse hair blight; Hawar bebenang hitam	Kingdom: Fungi Phylum: Basidiomycota Subphylum: Agaricomycotina Class: Agaricomycetes Subclass: Agaricomycetidae Order: Agaricales Family: Marasmiaceae
Marasmiellus scandens (Massee) Denis & D.A. Reid Thread blight; Hawar bebenang putih	Domain: Eukaryota Kingdom: Fungi Phylum: Basidiomycota Subphylum: Agaricomycotina Class: Agaricomycetes Subclass: Agaricomycetidae Order: Agaricales Family: Marasmiaceae

DISTRIBUTION MAP

Horse hair blight (*Marasmius crinis-equi*)



White thread blight (*Marasmiellus scandens*)



Crop Protection Compendium 19/03/2014

STORAGE INSECT PESTS

IMPORTANCE

Insect pests have the ability to infest dried fermented cocoa beans and other stored commodities. The attack usually starts in the holding warehouse and can continue to escalate during transport to the final destination if conditions are right for the insects to multiply. Losses can be significant as the actions of the various pests can cause loss of weight, contamination by insect faeces and introduction of fungus contamination. All or any of these infestations can result in low prices or complete rejection by the buyers.

These insect pests are common in tropical and subtropical regions. Some such as the flour beetle are also found in warm temperate regions.
Four of the most common are:

- Cocoa moth
- Flour beetle
- Rice moth
- Tobacco beetle

DESCRIPTION

Cocoa moth
(*Cadra cautella*, formerly *Ephestia cautella*)

Up to 300 slightly sticky eggs are laid by the female in the first 3-4 days after mating but few, if any, in the remaining 4 or 5 days of life. At 30°C the eggs hatch in approximately 3 days. There are normally five larval instars and under good conditions (32.5°C and 70% RH) the larvae stages are completed in about 22 days. In heavy infestations the mature larvae leave the commodity in search of pupation sites, such as the walls of the store or the spaces between bags. Before pupation, the larva produces a cocoon; this is both thinner and looser than that of the rice moth. The pupal stage is completed in about 7 days. Under good conditions, development from egg to adult takes 29-31 days. The limiting levels of moisture at 30°C are 20 and 90% RH and development is only possible within a range of 15 to 36°C.

Adult emergence from the cocoon usually occurs during the late afternoon. Flight activity and egg-laying show a major peak at around dusk and a minor peak just before dawn.

Flour beetle or red flour beetle
(*Tribolium castaneum*)

Females lay up to 450 eggs in stored commodities. The incubation period of the eggs is between 5 and 12 days. All insect stages infest the stored commodity. The larvae are fully grown in 27-29 days and are 6mm long. Pupation occurs in stored commodity and the pupa does not produce a cocoon. Adults emerge from the pupa in 3-7 days.

The developmental period from the egg to the adult stage is about 20 days under optimum conditions of 35°C and 70% RH, but may be as long as 141 days at 25°C and 70% RH.

There may be between four and seven generations in 1 year, depending on weather conditions, and one generation may take 1-4.5 months. The adults may live for as long as 18 months, depending on weather conditions.

Adults fly in large numbers in the late afternoon and are active from October to May. Beetles fly in the field between 16.00 and 19.00 h on relatively calm days, and at temperatures above 26°C.
Migrating adults represent a serious potential for re-infestation of stored grain.

Rice moth (*Corcyra cephalonica*)	**Tobacco beetle** (*Lasioderma serricorne*)
Sexual activity usually begins shortly after adult emergence; females apparently mate only once during a 1- or 2-day period after emergence and if no mating occurs in this period the females are then not inclined to mate. There is a pre-egg laying period of about 2 days. Egg-laying mainly occurs during the night; the eggs are rather sticky and are usually deposited on the food or among sack fibres. The greatest number is laid on the second and third days after emergence, although egg-laying may continue throughout life. At 30-32.5°C, eggs take about 4 days to hatch. They are adversely affected by very low humidity and few eggs hatch below 20% RH. Optimum conditions for larval development are 30-32.5°C and 70% RH, at which the period from egg hatch to adult emergence is only 26-27 days. There is considerable variation in the number of larval instars; however, it would appear that males generally have seven and females have eight. The last-instar larvae pupate on store structures, on or between bags, or within the food. The adults emerge through the front end of the cocoon, where there is a line of weakness. The sex ratio is believed to be 1:1. The adult moth is nocturnal and is most active at nightfall. Its flight is rather slow and clumsy; flight is not powerful but can be sustained. The moths rest away from draughty places, on shaded store structures or surfaces of bag stacks; they are thus most commonly found in dark, sheltered corners of a store. The rice moth can tolerate conditions of less than 20% RH on sorghum and millet. This can give the insect an advantage in dry conditions. 	Each female lays up to 110 eggs loosely on the commodity. On hatching, the larvae often eat their eggshells. At first the larvae are quite active and will move around on, or bore into, the commodity, feeding as they go. They will move much more deeply into a loosely packed commodity than into one that is tightly packed. There are 4-6 larval instars. As the larvae grow they become less active and finally they make a pupal cell out of fragments of food and waste materials. The pupal stage lasts for about 9 days at 32-35°C. The generation time varies between 25 and 120 days depending on temperature, humidity and food. Development can take place between 20 and 37.5°C, and at humidities down to 25% RH. The adults live for 2-6 weeks and do not feed. The adult is an active flier, especially in the late afternoon and evening. The tobacco beetle does not tolerate cold and adults are killed by exposure to temperatures of 4°C for 6 days and few eggs survive for 5 days at 0-5°C 

MANAGEMENT

Sanitation and hygiene

Cleanliness in the storage warehouse is one of the most important weapons in the war against storage pests. After the commodity has been shipped the store walls and floor must be swept clean of all rubbish and spilt commodity. Household bleach can be used to wash the walls and floors, bleach is a strong chemical, and protective clothing and gloves must be worn when using it.

Old sacks must be discarded in a refuse tip away from the store or burnt. If in a good condition and can be reused, then the sacks must be thoroughly washed in detergent and dried in strong sunlight.
Cracks in the floor and walls of the store must be filled so that adult insects do not have anywhere to hide. Wooden pallets that are used to keep the storage sacks off the floor must be scrubbed clean and laid out in strong sunlight to dry.

Pheromone traps
Commercial traps are available and are very useful for monitoring during storage. These give an early indication if insects have started to infest the store. Traps should be used in conjunction with regular inspection of the store.

Chemical fumigation
This is very, very expensive and can only be undertaken by a licensed operator / company. Methyl bromide at one time was the chemical of choice but its use is now only permitted under very limited circumstances internationally. Other chemical fumigants such as phosphine and sulphuryl fluoride can be used in large commercial stores however strict international limits are placed on residues of these chemicals in commodities.

LOSSES

Losses in store can be considerable. The commodity can be rendered totally unsaleable because of damage by insect feeding and contamination by insect faeces. Moulds (fungi) grow over the surfaces and into the commodity causing rotting and introduce mycotoxins. Mycotoxins are poisons produce by the mould and can cause illness or death in people or animals that eat the contaminated commodity.

PREFFERED SCIENTIFIC NAME	Taxonomic position
Cadra cautella Walker (formerly *Ephestia cautella* Walker) Cocoa moth	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Lepidoptera Family: Pyralidae
Tribolium castaneum Herbst Flour or red flour beetle	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Coleoptera Family: Tenebrionidae
Corcyra cephalonica Stainton Rice moth	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Lepidoptera Family: Pyralidae
Lasioderma serricorne Fabricius Tobacco beetle, cigarette beetle	Domain: Eukaryota Kingdom: Metazoa Phylum: Arthropoda Subphylum: Uniramia Class: Insecta Order: Coleoptera Family: Anobiidae

PART 4

RECORD KEEPING

REFERENCES FOR PRACTICAL

EXAMPLES OF DOCUMENTS AND RECORD

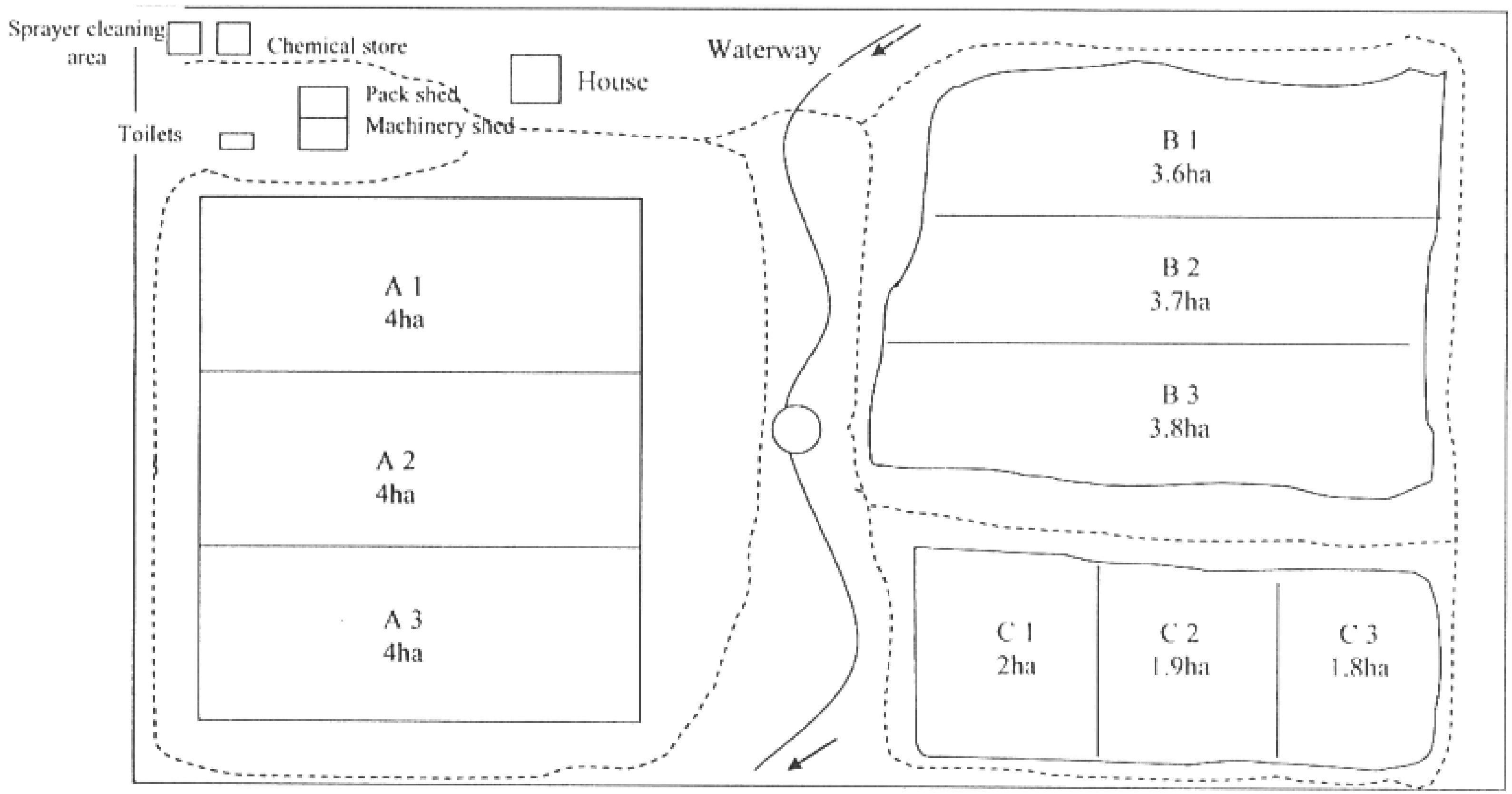
This section contains examples of document and record forms that are required to implement various practices in the food safety module. The document and record forms are examples only and other methods and formats can be used. ASEAN GAP specific the information that has to be documented and the records to keep, but does not specify how to document information and keep records.

The example documents and record forms contained in this section are:

- Farm plan
- Risk assessment record
- Planting material record
- Chemical inventory
- Spray record
- Postharvest / Storage of chemicals record
- Chemical authorization form
- Fertilizer record
- Harvesting and packing record
- Job responsibility and training record
- Cleaning and pest control plan
- Corrective action report
- Personal hygiene instructions
- Self-assessment checklist

Farm Plan

Farm ____________ **Grower** ____________



Risk Assessment Record

Business/Grower Name:

Contamination source	Crop	Assessment S = significant; NS = not significant	How is the risk managed?	Signature	Date

Planting Material Record

Business/Grower Name:

Date	Crop	Variety	Supplier (name and address)	Quantity obtained	Location where planted

Chemical Inventory

Business/Grower Name:

Date purchased	Name of product	Quantity	Place of purchase	Batch no. (where available)	Manufacture /expiry date	Method and date of disposal

Stocktake	Date: Name:	Date: Name:

Spray Record

Business/Grower Name: **Crop/ Variety:** **Year:**

Date/ Time	Block/ Row	Crop stage/ target	Product	Dilution rate	Application rate	Equipment / method used	Date safe to harvest or WHP	Comments/ weather conditions	Operator

Postharvest Chemical Record

Business/Grower Name:

Chemical	Tank Size	Tank Mixing Rate		Application Method
		Fresh	Top-up	

Date	Time	Chemical	Fresh (F) or Top-up (T)	Comments	Signature

Chemical Authorisation

This chemical storage shed is to be kept locked at all times.

………………………………… is responsible for the use and storage of all chemicals used on this property, and the training and supervision of all staff who are required to use chemicals.

The following staff have authorisation to use chemicals:

Authorised Person	Manager's Signature	Date

Fertiliser and Soil Additives Record

Business/Grower Name:

Year:

Date	Crop/ variety	Block Row	Product	Supplier of product	Application rate	Comments	Operator

Harvest and Packing Record

Business/Grower Name:

Crop / Variety	Planting date	Block ID	Harvest/ packing date	Batch code	Amount packed	Destination / Consignment No.	Comments (eg. quality, temperature)

Job Responsibility and Training Record

Business / Grower Name:

Name	Chemical Application	Fertilising	Pruning	Harvesting	Fermentation and drying	Grading and packing	Pest control	Personal hygiene	Repairs and maintain	Self assessment checklist

C = attended farm chemical user course
3 = performs job and training completed

33 = performs job, training completed and has responsibility for area

Cleaning and Pest Control Plan

Business/Grower Name: Date:

Area / equipment cleaned	Frequency	Responsibility	Method

Corrective Action Report

Business/Grower Name:

Date	Problem and cause	Action taken to fix problem	Signature/ date when problem fixed

Personal Hygiene Instructions

All staff:

Wash your hands with soap and water and dry your hands on a single use disposable paper towel before handling fruit

After Visiting the toilet
Handling animals
Smoking
Handling waste food and rubbish

Cover cuts and sores with clean, waterproof dressings.

Inform the manager if you are suffering from gastric illness, hepatitis and other infectious diseases.

Do not smoke, eat food, or spit in produce handling areas.

Signature of employee: ______________________ **Date:** ______________________