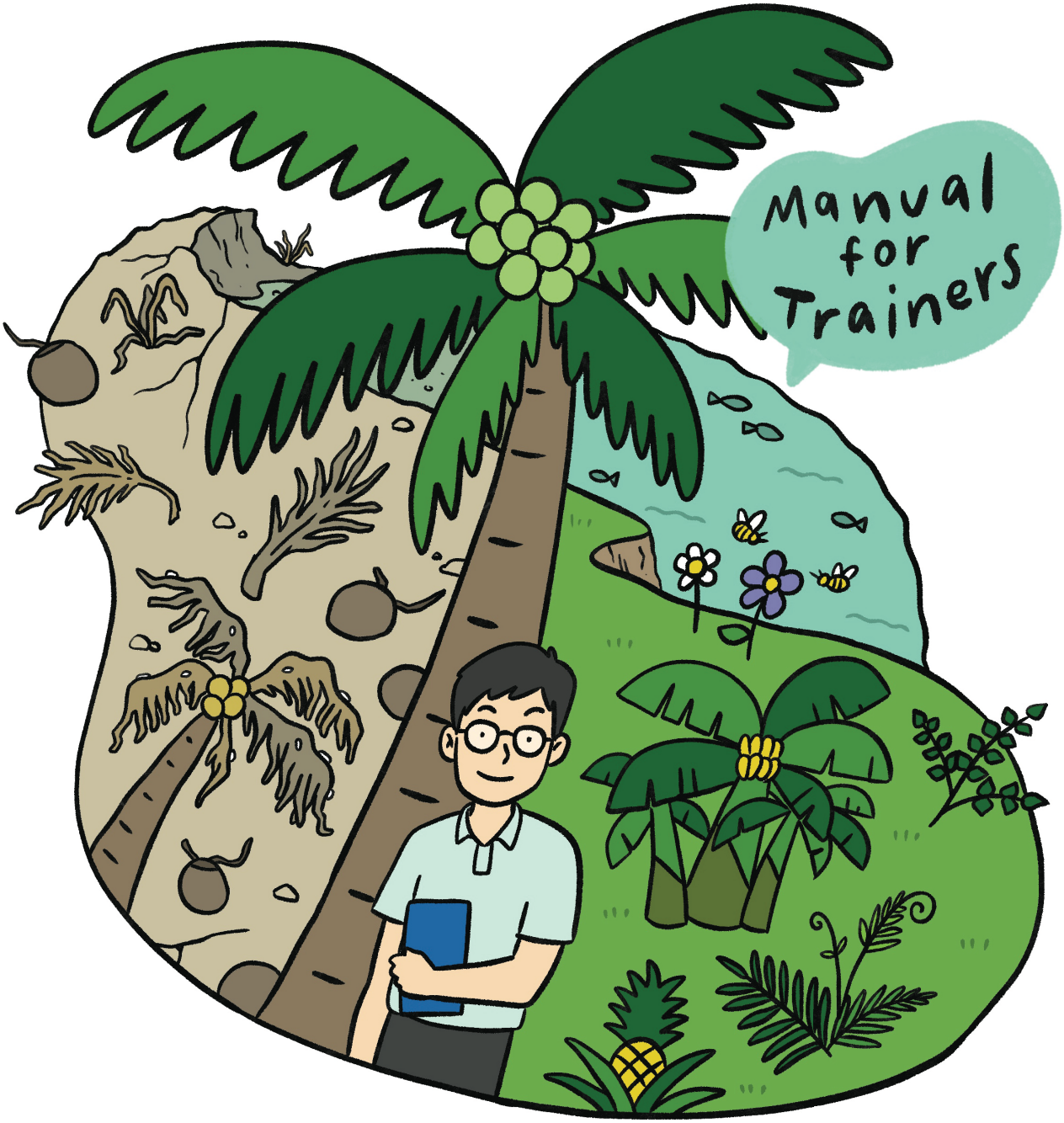
Regenerative Organic Agriculture Training for Coconut Farmers



DANONE ecosystem

HARMLESS HARVEST®

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

INTRODUCTION

Background

As global temperatures continue to rise and the associated impacts of a changing climate become more frequent and severe, our food supplies are increasingly under threat. Farmers are often one of the first to feel the impacts of weather changes: Unpredictable rainfall, temperature fluctuations, floods, droughts, and new pests can take a heavy toll on any farm in terms of yields and productivity. The most vulnerable are conventional farms, which rely on fertilizers and pesticides, neglect soil health and reduce diversity.

Fortunately, there are alternative farming practices, which help make farms become more resilient and sustainable. This can be done via building healthy soils that can soak up heavy rainfall and hold water for dry periods, strengthen farms through diversification, and by planning farms that can sequester or store carbon in its soils. These practices are part of regenerative organic agriculture, which is a holistic way of farming that restores the resources it uses, rather than exhausting them. Regenerative organic agriculture offers climate friendly solutions to ongoing problems that many farmers are experiencing; from single crop dependency, soil erosion to heavy reliance on chemical fertilizers, as well as buffer farms and reduce their vulnerability against climate impacts.

Agriculture is paradoxically one of the biggest contributors to climate change and one of the most exposed sectors to the impacts of climate change. This training was developed to support farmers in reducing the former whilst improving the latter in the long run.

Rehabilitate nature. Respect people. Revitalize farming.

Who developed this training?

This training was developed by the Regenerative Coconut Agriculture Project (ReCAP), which is funded by Harmless Harvest and Danone Ecosystem Fund. The project was launched in June 2020 and is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with the support of Harmless Harvest in central Thailand (Nakhon Pathom, Ratchaburi, Samut Sakhorn and Samut Songkram).

The contents of the training are based on existing knowledge from the Rodale Institute and training materials of the Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Harmless Harvest, and GIZ. Furthermore, the training materials were tested by selected ReCAP pilot farmers who were the first to adopt regenerative organic practices on their coconut farms in Thailand, and then adapted based on their experiences and lessons learned.

Why should farmers join this training?

Over five days, farmers will learn about:

1. Farming as a business: How to track their expenditures and income, manage market risks and diversify their income sources.

2. Soil health: How to keep their soils healthy and fertile through cover crops, intercrops, organic fertilizers, and help to trap carbon dioxide from the atmosphere and store it in the soil.

3. Healthy yields: How to control pests organically and take care of pollinators.

4. Climate change: How agriculture and climate change are intertwined and how to plan their farm according to regenerative organic practices.

Changing practices is not an easy task for many farmers. This training has been developed to make this transformation as easy as possible by offering hands-on guidance and know-how. In each of its modules, several choices are offered so that each farmer can decide what method is the most applicable to their farm.

Who should join this training?

The main target of this training are Nam Hom coconut farmers in Thailand who are interested to learn about sustainable farming, willing to shift their farms from monocultures to intercropping, and are keen to practice regenerative organic agriculture.

Training with ReCAP's Pilot Farmers on
Regenerative Organic Agriculture, October 2020

FOREWORD
DEPARTMENT OF AGRICULTURE

Nam Hom coconuts or aromatic coconuts are the economic crop of Thailand which is popular in domestic and international consumers. The major cultivation area is in the central part of Thailand including Ratchaburi, Samut Sakhon, Samut Songkhram, and Nakhon Pathom. Aromatic coconuts generated an export value more than 7 billion baht in 2021, and the export value is likely to continue to increase, with a taste that is unique to the geographic location and quality that meets the needs of the market.

Regenerative Organic Agriculture Training for Coconut farmers is a training course that will develop and increase the standard for Thai coconut farmers. Farmers can produce coconuts following the standard which is safe for farmers and consumers. The course also helps to preserve and restore the sustainable source of cultivation with environmentally friendly as well as increasing the potential of farmers to upgrade cultivation towards organic farming standards

The Department of Agriculture is very pleased in cooperation between the public and private sectors in the preparation and development of such a course, and provides support through the agronomist team of the department participating in project activities and being a guest speaker in farmers' training course and support academic information throughout the past operations. Upon completion of the training, the farmers who attend this training course are able to apply the acquired knowledge to adapt to their own coconut plantation to prepare for sustainable coconut production under the climate change environment.

Rapibhat Chandarasrivongs
Director-General
Department of Agriculture

FOREWORD
DEPARTMENT OF AGRICULTURE EXTENSION

Department of Agricultural Extension is the core agency to support farmers to pursue the agriculture career under the marketing – led production policy and access the green economy system (Green Economy), which develops the economic along with social development and maintains a balanced and sustainable environment. Therefore, DOAE together with the Deutsche Gesellschaft für Inernationale Zusammenarbeit (GIZ) GmbH, the Danone Ecosystem Fund, Harmless Harvest (Thailand) Co., Ltd. and the Department of Agriculture have organized the training course for lecturers and farmers on revitalizing organic coconut plantations or the Regenerative Coconuts Agriculture Project (RECAP) to increase the efficiency of the coconut plantations for generating a variety of income; soil rehabilitation; improving coconut plantations for farmers' better livelihood with regards to safety for themselves and consumers; reducing production costs as well as producing environmentally friendly products in the future.

Department of Agricultural Extension together with the network partners hope that this course guideline will provide the knowledge as a practical guideline to officials and farmers in order to increase the efficiency of sustainable coconut production as the vision of the Department of Agricultural Extension : *"Farmers are self-reliant and have well-being as well as increased income."*

Kemkaeng Yutidhammadamrong
Director-General
Department of Agricultural Extension

FOREWORD
HARMLESS HARVEST

At Harmless Harvest we are making a promise to our consumers and to ourselves: we are not perfect, but we wake up every day with the intention of doing less harm and more good.

So we came to Thailand more than 10 years ago because the Nam Hom Coconut is simply the best in the world and our consumers deserve more good.

Over these 10 years, we worked with thousands of Nam Hom coconut farmers, harvesters and farm workers. Together we learned how to make organic farming better, how to take better care of our coconut trees and our farms. We also chose to follow the guidance of Fair For Life because we are serious about social progress and about taking better care of our community.
Less harm, more good.

During our journey with the Nam Hom coconut farmers, we realized that our farms are not ready to fight climate change. During prolonged periods of drought, the farm yields drop, the trees are exposed to diseases and pest attacks, the income of the farmers is getting lower and their livelihood is at risk.

Yet some farms resisted much better than others. Their yields remained high, their farmers were able to better resist the lack of rain. Their secret? These farmers were applying some of the principles of the Regenerative Agriculture:

- Take care of your soil because it is feeding your trees and your plant.
- Always keep a green cover on your soil, otherwise it will dry under the sun and be exposed to erosion.
- Let your soil breathe, it will absorb more rain and stay moist longer.
- A healthy soil capture carbon emissions and can allow to revert climate change.
- Increase biodiversity to better fight diseases and pests.

So we spent the last 4 years researching these principles. We partnered with the best experts, professors of Kasetsart University in Kamphaeng Saen, GIZ, Danone Ecosystem Fund to define the ideal model for Regenerative Coconut Agriculture Project – ReCAP.

13 farmers from Ratchaburi, Samut Sakhon and Samut Songkhram joined us in this initiative. They applied these principles in their farms to confirm our recommendations were giving the good results we expected. They are all real pioneers, and I can't thank them enough for their commitment, dedication and hardwork.

This training manual regroups all the knowledge and good practices collected over the years, all the tricks and tips to be successful in your Nam Hom Coconut farm. We want to share this with absolutely everyone who wants to fight climate change and revert global warming. There is no time to waste: start preparing your farm and your soil today so you can be ready before the next drought.

I hope you will enjoy reading this manual and testing the recommendations on the field. Our team of agronomists is here to help you and to answer your questions.
Less harm, more good. Together.

Mathieu Chaumont
Director Sustainability, Sourcing & Supply Chain
Harmless Harvest Thailand

FOREWORD
DANONE ECOSYSTEM FUND

In 13 years of our existence, Danone Ecosystem Fund has impacted more than 5 million lives around the world and we are happy to support the transformation of Thai Coconut farmers towards Regenerative Organic practices. This transformation is needed to fight back the implication of climate crisis by strengthening the resiliency and livelihood of the local farmers and hence will impact positively in the entire value chains where Danone Group operates.

We believe in the power of co-creation and sustainability of the economic model. To achieve a best case co-creation, the project is combing the sharing expertise, co-management, and co-investment between GIZ, Harmless Harvest, and Danone Ecosystem Fund to build a project that will enables all ecosystem needed for the farmers to convert to a better practices in a long term. We also appreciate the support from Thai Government to always backs this initiative. We are fully endorse this training curriculum and materials as a key capacity building and building the confident for the farmers – not only for ReCAP's farmers but also can be utilized for all Thai farmers and the world.

Pierre Bou
Operational Director
Danone Ecosystem Fund

Agung Bimo Listyanu
One Planet Coordinator, Asia
Danone Ecosystem Fund

FOREWORD
DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ)

Farmers today are exposed to many uncertainties, thereby making it one of the riskiest occupations: from having to face fluctuating market prices, unpredictable climate conditions, to various pests and diseases – often at the same time. These risks have a direct impact on farm income, which has consequences on the wellbeing of the farmer and their family, and ultimately the future of their farms. There are no guarantees in farming, but there are ways for farmers to cope and manage risks.

This training curriculum was developed to offer Nam Hom coconut farmers in Thailand guidance on how to manage some of these risks. By attending the training, farmers will understand the problems associated with monocultures, the use of chemicals, climate change, as well as learn how to reduce the consequences by adopting regenerative organic farming practices. Over just a few days, farmers will be assisted in optimizing their farms through income diversification, restoring soil health, and creating healthier farms for the people whose livelihoods depend on it.

Building on the expertise of our partners, the Farmer Business School training curriculum of GIZ, as well as successful experiences from farmers, we offer farmers the best knowledge we have gathered to find ways on protecting their coconut farms from today's uncertainties, so that Thailand becomes the home of climate and farmer friendly coconuts for many generations to come.

Dr. Matthias Bickel
Director Agriculture and Food
GIZ Thailand

Lisa Faust
Project Manager
GIZ Thailand

CONTENTS

SUMMARY OF THE MANUAL

The training consists of eight modules, of which topics are outlined in the table below with the estimated duration for each topic and module. At the end of the manual, you will find an annex on didactical methods to guide you, as the trainer, through good and effective practices of teaching.

Module 0	**Introduction and overview**	**1 h 30 min**
	1. Introduction of the training and the Handbook for Farmers	5 min
	2. Introduce yourself and your farm	15 min
	3. Aromatic coconut situation	35 min
	4. About ReCAP project	20 min
	5. Overview of the training program	10 min
	6. Summary and closing	5 min
Module 1	**Regenerative organic practices**	**1 h 30 min**
	1. Definition and importance of organic farming	10 min
	2. Greenhouse effect and global warming	15 min
	3. Regenerative organic certification requirements	20 min
	4. Case study	10 min
	5. Regenerative organic practices provide solution for ongoing problems	30 min
	6. Summary and closing	5 min

Module 2	**Soil health**	**4 h 30 min**
	1. Definition of soil health	5 min
	2. Soil health test	30 min
	3. Benefits of soil health	5 min
	4. Soil health principles	5 min
	5. Good practices to improve soil health: cover cropping, intercropping, and organic mulching	45 min
	6. Study visit: cover cropping in coconut farms	90 min
	7. Study visit: intercropping in coconut farms	85 min
	8. Summary and closing	5 min
Module 3	**Organic fertilizer**	**6 h**
	1. Importance of organic fertilizers	15 min
	2. Principles and methods of making organic fertilizers	30 min
	3. Application of organic fertilizers to aromatic coconut production	15 min
	4. Practice in making compost	90 min
	5. Practice in making vermicompost	90 min
	6. Study visit: producing and applying compost	115 min
	7. Summary and closing	5 min
Module 4	**Integrated pest management**	**6 h**
	1. Major pest insects in coconut farms	15 min
	2. Major diseases of coconut	10 min
	3. Integrated Pest Management	35 min
	4. Practice: how to rear *Bracon* wasp	120 min
	5. Practice: how to rear *Metarhizium*	175 min
	6. Summary and closing	5 min

Module 5	**Pollinators**	**2 h 45 min**
	1. Stingless bee	25 min
	2. Asian honeybee	20 min
	3. Study visit: stingless bee cultivation and colony division	115 min
	4. Summary and closing	5 min
Module 6	**Coconut farming as a business**	**2 h 45 min**
	1. Business components	15 min
	2. Business cycle	5 min
	3. Diagnosis and finding opportunity	40 min
	4. Planning, implementation and evaluation	45 min
	5. Exercises	55 min
	6. Summary and closing	5 min
Module 7	**Transforming your farm to a regenerative organic farm**	**3 h**
	1. Identify problem you found in your farm	30 min
	2. Regenerative organic solutions	30 min
	3. Activity plan of transforming your farm to ROC	40 min
	4. Draw and present your future farm	80 min

Manual guidance for trainers

Structure of Modules

Each module will be presented in the following structure:

- Outline of the module containing the objectives; the expected outcome of knowledge, skills, and attitudes that the participants will acquire; list of methods and training supplies needed; the estimated duration; as well as the key messages that the trainers should deliver to the participants
- Introduction on getting the participants' attention or linking to the previous modules
- PowerPoint presentations
- Activities and questions
- Closing session with module summary and Q&A
- Examples of exercises or guiding questions for practice sessions, i.e., hands-on trainings or study visits

Important Notes for Trainers

To support you as the trainer in conducting this training, three products have been developed: i) Manual for Trainers, ii) Handbook for Farmers, and iii) PowerPoint Presentations. The manual is for you as the trainer and offers guidance on how to teach the contents of this training to the farmers, with the use of the handbook and presentations. Please get familiar with all three products.

In addition to the manual, the trainer is clearly a main actor to deliver key messages of the training as well as handle overall facilitation and organization of the training. It is thus recommended that there should be a minimum of two trainers working together in a training: One focuses on delivering the contents, the other is responsible for preparation, logistics, and time management.

At the start of each module, trainers should inform the participants on what page the content of the module is in the Handbook for Farmers begins, so the participants will not get lost.

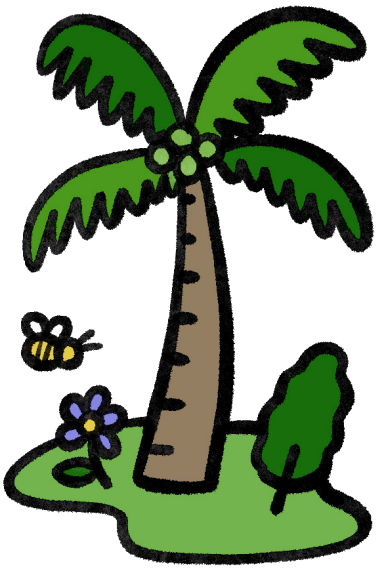
There are some guiding questions provided in each module, but trainers are highly encouraged to prepare their own set of questions. They are able to choose and adjust the set of questions according to the discussion topics and training duration. A sufficient number of copies of those provided questions should be prepared for group work, practices, and study visits.

The training should be conducted as a dialogue and an exchange of ideas, not merely as a series of lectures. It is suggested to limit the duration of inputs or presenting information to 15-20 minutes, follow up lectures with interactive questions, group discussions, exercises, or other learning-based activities. Trainers may initiate or encourage the exchange of information among participants and trainers because these interactive trainings, which include participants' involvement in the learning process, tend to be more effective than passive lectures. Actively engaged participants have likewise a tendency to retain, recall, and remember the essential information. Trainers can consult more details of the teaching methods in Annex B Page 260 in this manual.

Last but not least, do not forget to emphasize to participants that regular attendance and punctuality at the entire program is very essential to make this training effective.

Module 0

INTRODUCTION AND OVERVIEW



OBJECTIVES

To understand the purpose of the training and get an initial insight into the importance of regenerative organic agriculture. Participants are presented with the topics of the training to be covered.

ACQUIRED KNOWLEDGE

The participants:

1. Understand the importance of regenerative organic agriculture and how regenerative farming practices help make their coconut farms sustainable

2. Acquire necessary knowledge and skills about regenerative organic coconut farm to apply these practices to their own farms

ACQUIRED SKILLS

The participants can:

1. Differentiate between conventional coconut farms and regenerative organic farms

2. Apply the skills learnt during the training to their own farms

ACQUIRED ATTITUDES

The participants realize the importance of adopting the regenerative organic practices for sustainability and initially transform their coconut farms into regenerative organic agriculture.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Better farm management—farm transformation into the Regenerative Organic Certification (ROC) farms—will make aromatic coconut farming sustainable in two significant ways. Firstly, it will allow farmers to produce in safe conditions to both their health and environment. Secondly, farmers are likely to earn an extra income from the diversified crops and secure long-term incomes by improving soil health.

METHODS

1. Lecture with PowerPoint presentation for approximately 90 minutes

2. Sharing experiences among the participants

LINKS

https://kisstheground.com/

https://regenorganic.org/

https://rodaleinstitute.org/

TRAINING DURATION

5 days (training duration may be adjusted)

TRAINING SUPPLIES, TOOLS, AND MATERIALS

1. PowerPoint (PPT) presentation
2. A notebook computer with PPT program
3. An LCD projector and a screen or smart TV
4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and guide questions and issues to be discussed in Module 0
5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 0, and blank pages for taking notes.
6. Flipchart
7. Markers

DURATION

Main topics	Time (min)
1. Introduction of the training and the Handbook for Farmers	5
2. Introduce yourself and your farm	15
3. Aromatic coconut situation	35
4. About ReCAP project	20
5. Overview of the training program	10
6. Summary and closing	5
Total time of training in Module 0	**90 (1 h 30 min)**

KEY MESSAGES

The importance of regenerative organic practices and how it helps the coconut farm to be sustainable.

LECTURE

OPENING
Get the Attention

1. Introduction of the training and the Handbook for Farmers

- Welcome and greet participants by introducing yourself and trainer team

- Explain the purpose of the training and the expected outcome

- Inform the participants that this training was developed by Danone Ecosystem Fund, Harmless Harvest Thailand and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) within the Regenerative Coconuts Agriculture Project (ReCAP)

- Explain how to use the Handbook for Farmers:

• The handbook consists of 8 modules.

• The overall content of each module is shown on Pages 7–9.

• Each module is composed of a lecture and guiding instructions for several agricultural practices, such as how to make organic fertilizer or how to rear *Bracon* wasps, which farmers can review and follow.

• Blank note pages are included at the end of every module.

2. Introduce yourself and your farm

- Activity: Draw your own farm

- Materials: Flip chart or paper, pens or pencils

- The trainer says "Let's start this module by drawing a picture of your current farm: how it looks like at the present. After this training, you will probably learn some ideas to make your farm better"

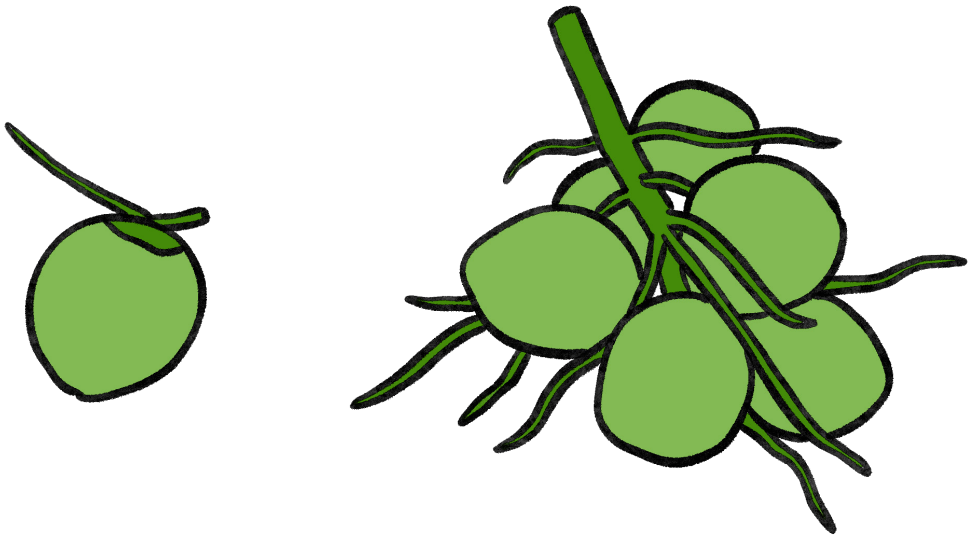
- Next Steps

• Distribute the prepared materials to each participant.

• Show the example of coconut farm drawing, which is on **Page 11 of the Module 0 in the Handbook for Farmers**

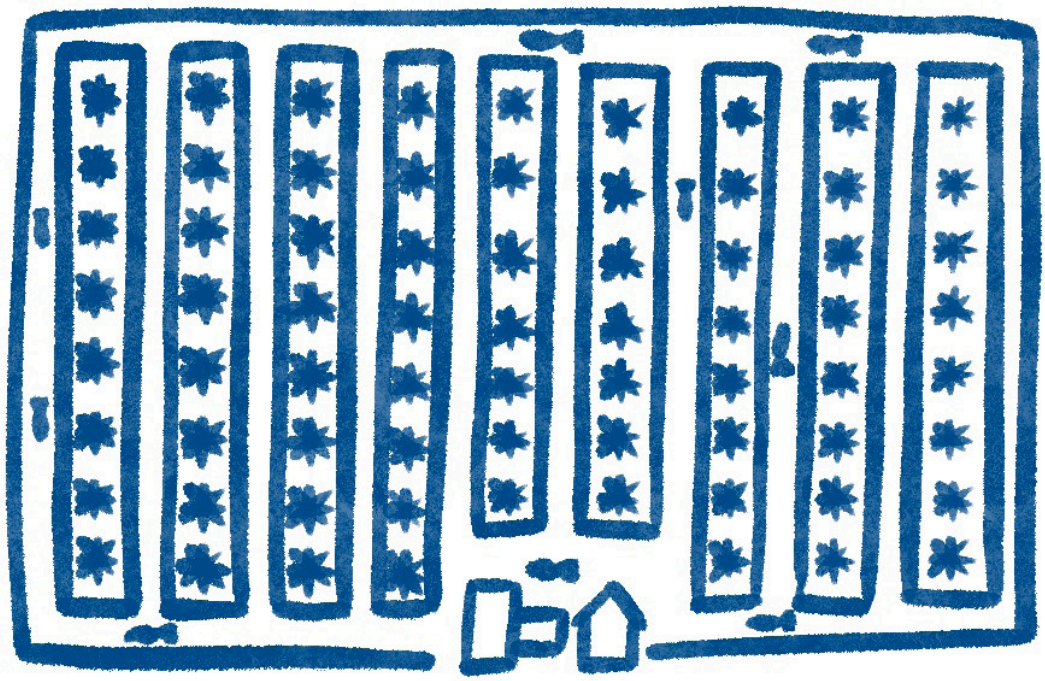
• Ask participants to draw their own farm on the next blank page, **Page 12 of Module 0 in the Handbook for Farmers**

• Remind participants that the farm drawing should display how they arrange their farm, including coconut trees, other crops, and farm activities, such as raising fish or chicken, as well as indicate the quantity. Simple symbols can be used to represent these details.



DO THIS

Example drawing: This picture is an example of coconut farm drawing, where the farmer has only coconut trees and fish in the farm.



- Give participants 15 minutes to draw. Meanwhile, the trainers are able to join and help them in drawing.
- Let each participant introduce themselves and explain their current farm with their drawing.

Questions from trainer:

Why do you participate in this training and what do you expect after the training? (These should be written on a board)

Possible answers from participants:

"To make my coconut farm better", "To get better price for the coconut", "Want to change to organic farm for better health"

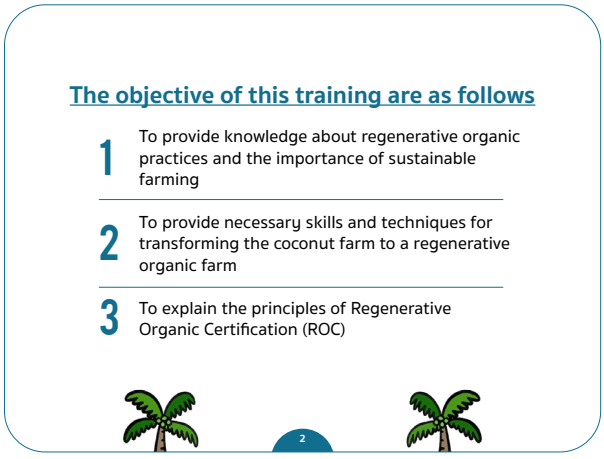
Expected outcome

- The trainer and the participants get acquainted.
- The trainer knows how the participants' farms look like and what their needs are.

Start the module

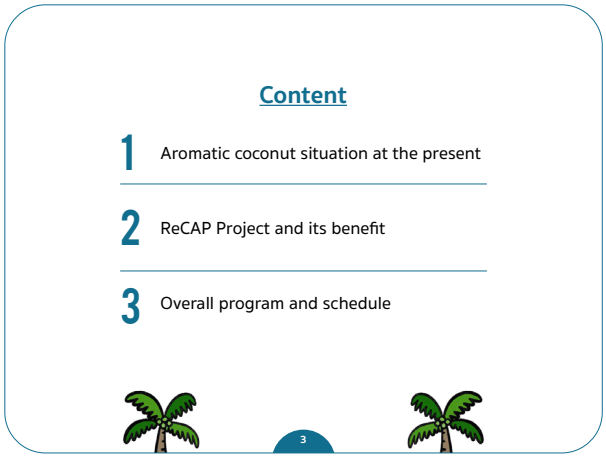
This training is set up because of the present situation of coconut farming that many coconut growers increasingly mismanage their farm, especially by using a lot of chemicals, in order to achieve high yields. This practice will destroy the land and badly affect farmer health and environment in the long term.

> See Page 10 in the Handbook for Farmers



The objectives of this training are as follows:

1. To provide knowledge about regenerative organic practices and the importance of sustainable farming.
2. To provide necessary skills and techniques for transforming the coconut farm to a regenerative organic farm.
3. To explain the principles of Regenerative Organic Certification (ROC).



In this module, we will talk about

1. The situation of the aromatic coconut at the present, coconut business and opportunities, as well as challenges of making a sustainable farm
2. The ReCAP project and the benefits of joining this training
3. Overall program, schedule, and essential details of this training

Question from trainer:

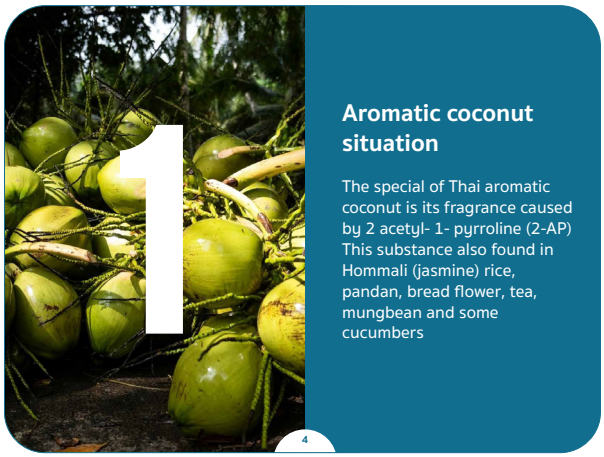
What is the difference between aromatic coconut and other coconuts?

Possible answers from participants:

"It has a special fragrance."

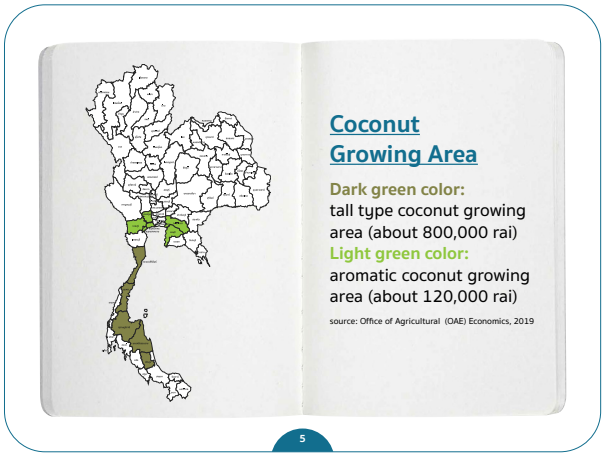
Then the trainer can explain how the fragrance comes from.

3. Aromatic coconut situation



As all of you have already known that aromatic coconut is not only tasty and nutritious, but it also has special fragrance produced from the substance called 2-AP.

The 2-AP content can be found in many other fragrant plants and flowers, such as jasmine rice, pandan, tea, mung bean and some cucumbers.

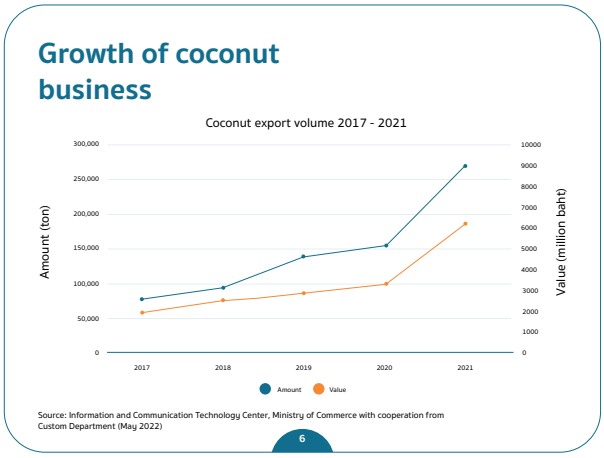


Coconut trees can grow all around Thailand, but the main area is in the southern part, especially **in Prachuap Khiri Khan province (dark green color), where most of the coconuts are the tall type** for oil and coconut milk industry.

- Growing area of the tall-type coconut is decreasing from 1.3 million rai (2013) to 800,000 rai (2017), mainly due to invasion of the coconut hispine beetle and cheaper price of the imported coconut.

Meanwhile, **the dwarf-type coconut**, including aromatic coconut also known as young or green coconut, are mainly grown in the central part of Thailand, namely **Ratchaburi, Samut Sakhon, Samut Songkram, Nakhon Pathom, Chachoengsao and Pathum Thani (light green color).**

- Growing area of the dwarf-type is 120,000 rai (2017) as the amount of the growing area seemingly increases in every part of Thailand.



Value of exported aromatic coconut seems to increase every year, possibly implying that the demand for the aromatic coconut is still high. One reason behind the increase is probably the consumer health trend in which nutritious and safe food is highly demanded.

In 2018-2021, aromatic coconut has ranked 4th of Thailand's most exported fresh fruits

Most exported fresh fruits	Value (million THB)			
	2561	2562	2563	2564
Durian	30,187	45,481	65,631	109,205
Longan	17,219	8,783	16,844	23,133
Mangosteen	7,271	16,704	15,021	17,090
Aromatic coconut	**2,557**	**2,884**	**3,394**	**6,200**
Mango	2,017	1,854	1,953	2,935
Rambutan	170	293	172	240
Pineapple	281	246	156	229

Source: Information and Communication Technology Center, Ministry of Commerce with cooperation from Custom (May, 2022)

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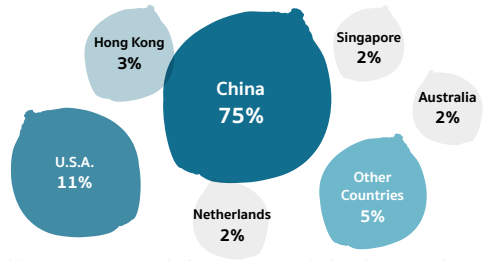
Aromatic coconut regularly ranks in Thailand's top ten fruits with highest export value. In 2018-2021, it had ranked fourth following durian, longan and mangosteen, respectively.

Aromatic coconut markets: 80% export

most of them are nonorganic



Source: OAE, 2020 http://www.ops3.moc.go.th/infor/HS/export/export_commodity/default_Sr12.asp?hscode=08011910&sr_hscode=#

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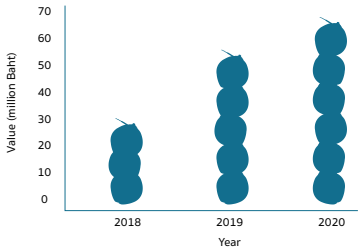
The main market of aromatic coconut is export market accounting for 80% of the fruit produced. Most of them are nonorganic. This is in contrast to the global trend that organic food business is booming continuously. Later we will talk about the growing of organic food and you will understand why we should change our coconut to be organic.

Coconut products are exported in various forms, such as the whole coconut fruit, trimmed coconut, polished coconut, or coconut water.

Thai coconut importing countries include China (75%), USA, Hong Kong, Australia and many countries in Europe, e.g., the Netherlands.

Organic aromatic coconut export



Source: OAE, 2020. Export statistic http://www.ops3.moc.go.th/infor/HS/export/export_commodity/default_Sr12.asp?hscode=08011910501&sr_hscode=# 24 September 2020.

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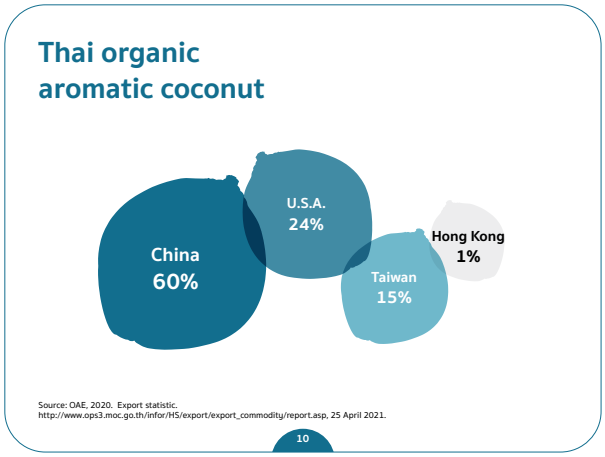
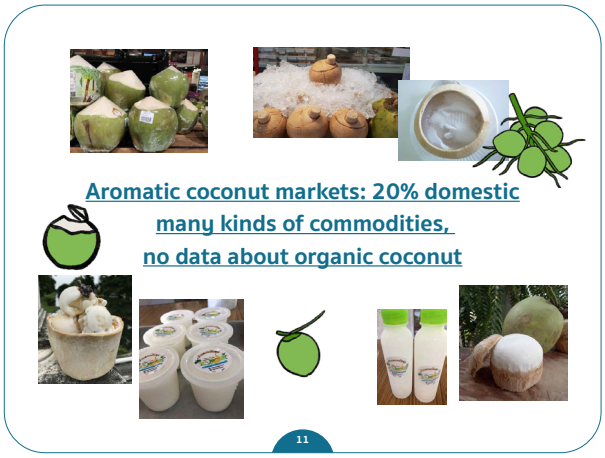
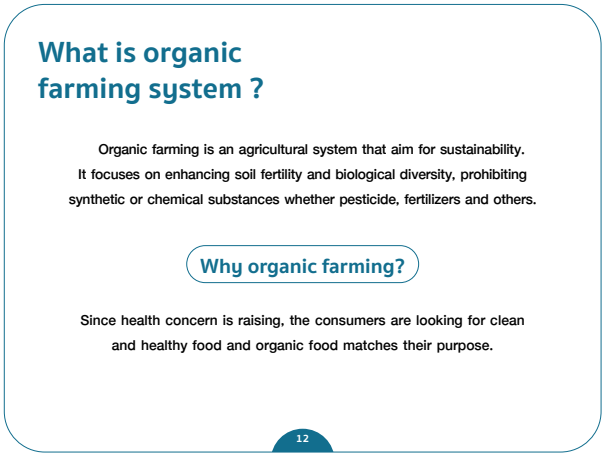
For organic coconut export, their value increased from 20 million THB in 2018 to almost 50 million THB in 2019. In 2020, despite the pandemic, the export value of organic coconuts is almost 60 million THB. This could be evidence to show the popularity of organic aromatic coconut.



At the present, China is the biggest importer of organic aromatic coconut from Thailand, followed by USA. There are also other countries, such as Taiwan and Hong Kong that have imported our organic aromatic coconut, but the import value is not in a large scale.



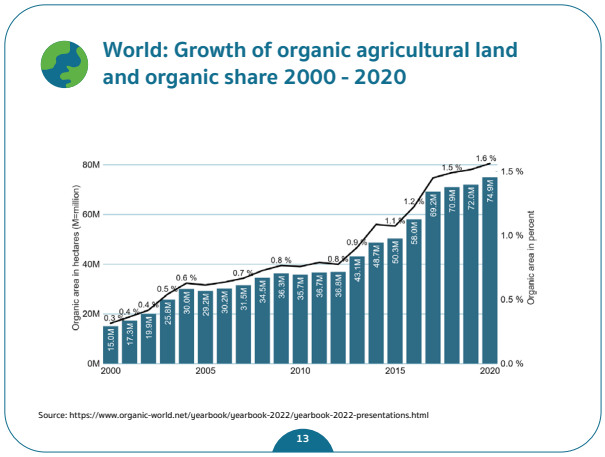
The domestic market absorbs only 20 % (2020) of the coconuts produced. The coconuts go to wholesale markets (such as Talad Thai, Simummuang Market in Pathum Thani, Monkol Pathom Market in Nakhon Pathom, and Srimuang Market in Ratchaburi), fresh markets, modern markets, and mobile fruit vendors. The products are whole green fruit, trimmed or polished coconut, toasted coconut, coconut juice, ice-cream, pudding, etc.



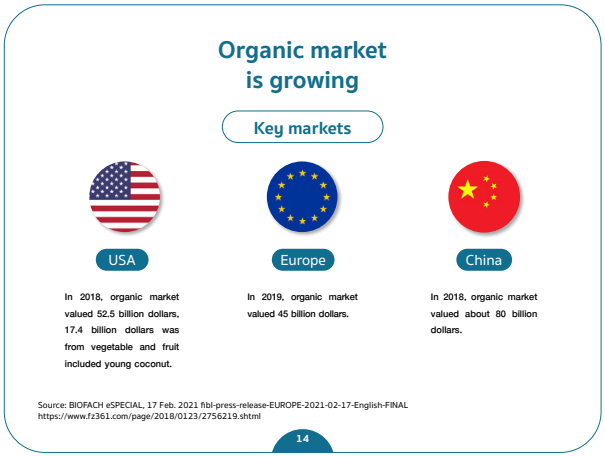
Since the demand of organic products, including coconut, is rising, we should understand what is meant by organic agriculture.

Organic agriculture is an agricultural system that aims for sustainability. It focuses on enhancing soil fertility and biological diversity, as well as prohibiting synthetic or chemical substances, namely pesticides, fertilizers and others.

The increasing demand for organic products is resulted from consumers' rising health concern. They need uncontaminated food, especially without toxic chemicals. In addition, environmental concern is another reason behind this demand trend. They believe that consuming organic products helps protect the environment because organic system bans the use of chemicals.



This slide shows the growth of organic agricultural land that has increased around the world, from 0.3 % in 2000 to 1.6 % in 2020.



Organic market also increases enormously especially in main organic market like USA, Europe and China.

USA: In 2018, organic market valued 52.5 billion dollars, 17.4 billion dollars of which was from vegetable and fruit, young coconut included.

Europe: In 2019, organic market valued 45 billion dollars.

In China: In 2018 organic market valued about 80 billion dollars.

You will see that there is a big opportunity for organic product, including coconut.

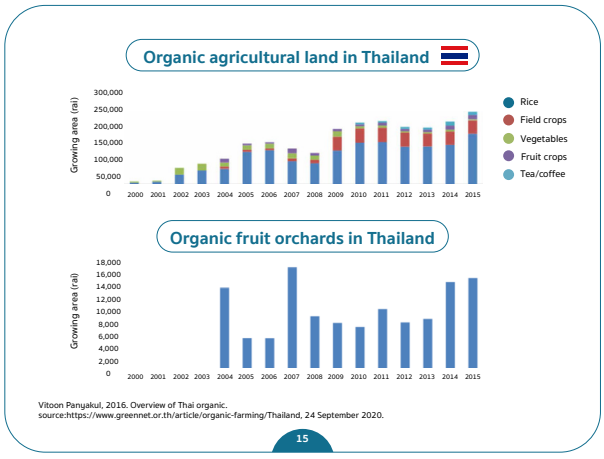
Question from trainer:

Do you think we have organic agricultural land in Thailand?

If yes, how many percentages of the agricultural land in Thailand is organic?

Possible answer from participants:

Should be “Yes, we have, but it still less than 1 %.”



As shown in the upper graph, the organic agriculture land in Thailand has seemingly increased. Mainly crops grown in the organic farming are rice and vegetables.

In addition, there are also some fruits organically grown in the farm. Though the fruit crops are not as much as others, they seem to be increasing.

Thai policy about organic food

Thai government realizes that organic market is continuously increasing and Thailand gained 3,000 million THB in value from organic products, 2,000 million THB of which was from export in 2020.

Thus, the government set up strategy between 2017-2022 with the budgets of 1.9 billion THB. The expected outcome in 2022 are the organic land will increase to 1.3 million rai with 80,000 farmers.

Source: https://www.thaigov.go.th/news/contents/details/34980 ,6 April 2021

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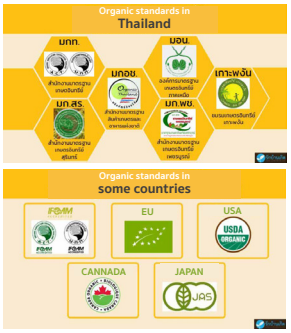
Thai government realizes that organic market is continuously increasing and Thailand gained 3,000 million THB in value from organic products, 2,000 million of which was from export in 2020.

Thus, the government set up a strategy for 2017-2022 with the budgets of 1.9 thousand million THB with the expected outcome in 2022 of increasing organic farming areas to 1.3 million rai with 80,000 farmers.

Organic standards by various organizations



https://actorganic-cert.or.th/th/contact/

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Organic agriculture has different practices and standards. The level of the organic standards varies by their strictness. While some standards are only for domestic markets, others are recognized worldwide. Among these, ROC, which stands for “Regenerative Organic Certification,” is the one supporting the creation of this training material.

The details about ROC are explained in Module 1.

Challenge for Organic system

1. Where organic system is not developed yet, farmers can lack availability of supply to produce according to organic principles.
2. The customers are not always aware of the advantages of organic goods – it should be advertised more.
3. Most farmers lack knowledge about the correct practices of the organic agriculture. Since from the past, the focus was on conventional agriculture.
4. Organic products need to be officially certified (time, cost) vs conventional product in order to guarantee to the consumers the production methods and quality of the product.

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Even though the demand for organic products is increasing, there are many obstacles to achieving organic agriculture:

1. Where organic system is not developed yet, farmers can lack availability of supply to produce according to organic principles.

2. The customers are not always aware of the advantages of organic goods – it should be advertised more.

3. Most farmers lack knowledge about the correct practices of the organic agriculture as their focus has been on conventional agriculture for a long time.

4. Organic products need to be officially certified (time, cost) vs. conventional product in order to guarantee to the consumers the production methods and quality of the product.

Question from trainer:

Do your coconut palms provide lower yield in some periods?

Possible answer from participants:

Should be "Yes."

Challenges in aromatic coconut business

1. Low yield in some season even the demand is still high.
2. Inappropriate farm management (too much chemicals, monocropping, no soil cover).
3. More and more competition.

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If focusing on aromatic coconut farming, there are also several challenges for which we need to be acknowledged and prepare ourselves.

The first and explicit challenge is the low yield, which usually occurs around March to May. However, the low-yield period is unpredictably shifted in some years. The causes of the low yield are probably the poor health of coconut trees, or the failure of pollination and fertilization, weather condition, etc.

The second challenge is the inappropriate farm management that includes 1) using too much chemical substances, such as fertilizers, herbicides, insecticides, etc., which are harmful to farmer's health; 2) growing a single crop without cover crops or intercrops, which is likely to pose risks both to soil health and to the farm business, especially when the coconut price fluctuates; 3) no farm recording and accounting possibly leading to increased loss and decreased profit as farmers cannot accurately calculate their expense and income.

The third challenge is the higher competition in coconut market as the result of the higher demand for coconut that leads to the increased number of coconut producers in the domestic and global levels.

Challenge 1
Low yield in some periods Fruit drop

Fruit drop occurs around 6 weeks after bloom, usually 60-70% but sometimes can be more (Krisanapook et al., 2016)

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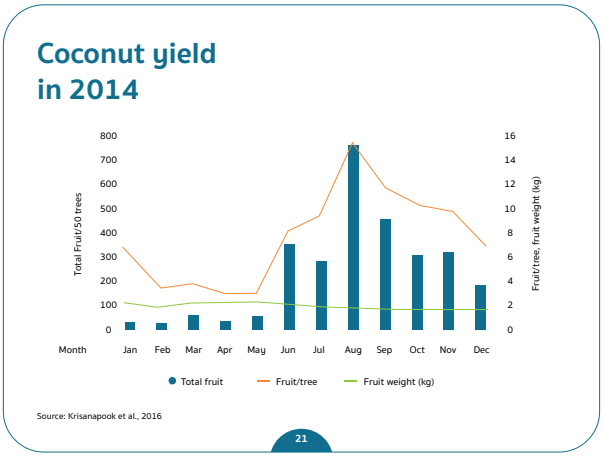
Challenge 1: Low yield in some periods

Low yield is one of the most important challenges for aromatic coconut production. Generally, the low-yield period occurs in the dry season around March to May.

One cause of the low yield is fruit drop. In a coconut farm, usually 60–70% of the total coconuts are the fruit drops. This percentage is sometimes increased. The fruit drop is resulted from the tree condition and the poor pollination.



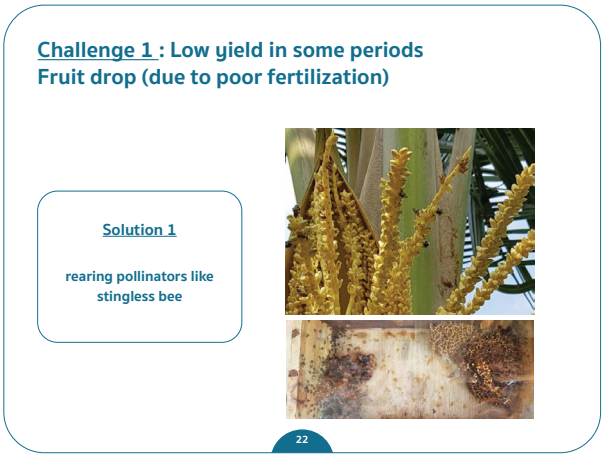
This picture shows an experiment on coconut yield in 2014. In the experiment, it was observed that, of the 50 coconut trees aged 20 years old, grown in the moderate-managing farm, the monthly yield was very varied, with the low yield clearly appeared in dry season.

Question from trainer:

Do you have any solutions concerning the discussed problem? How could we solve it?

Possible answer from participants:

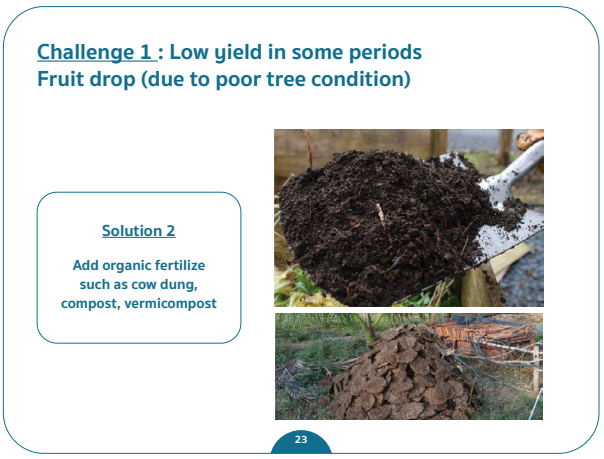
Use pollinators (insects) to increase pollination rate. Keep coconut trees healthy by applying fertilizer.



Solution 1:

A possible solution to the low yield is pollination. Pollinators, covering several species of insects, especially bees, are needed in the pollination process and often used to solve the low-yield problem. Stingless bee is one of the bee species that helps pollinate coconut crops more successfully.

The topic of bees and pollination will be detailed in Module 5.

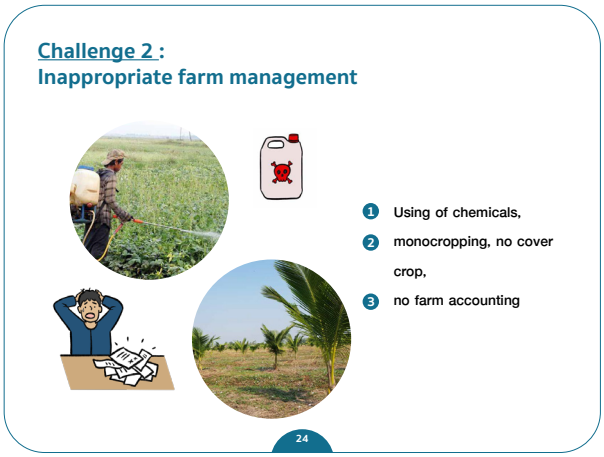


Solution 2:

In addition to the pollination, health of coconut trees has a significant effect on coconut yields. It is likely that healthy coconut trees produce good yields. Regular application of organic fertilizer, namely compost or animal manure, is a method to keep the coconut trees healthy.

How to make your own organic fertilizer will be discussed in Module 3.

Besides, adequate irrigation is necessary for coconut trees and growing cover crops will keep the moisture in the soil longer than bare soil. Cover crops in coconut farms will be discussed in Module 2.



Challenge 2: Inappropriate farm management

The first inappropriate practice for coconut farming is **using chemicals** in your farm as these synthetic substances are harmful to the farmers' health as well as the consumers'.

The second unsustainable farm management is growing only coconut in your farm. This **monocrop farming** results in soil erosion, lower soil fertility, and risk of income loss due to the solely dependence on coconut products.

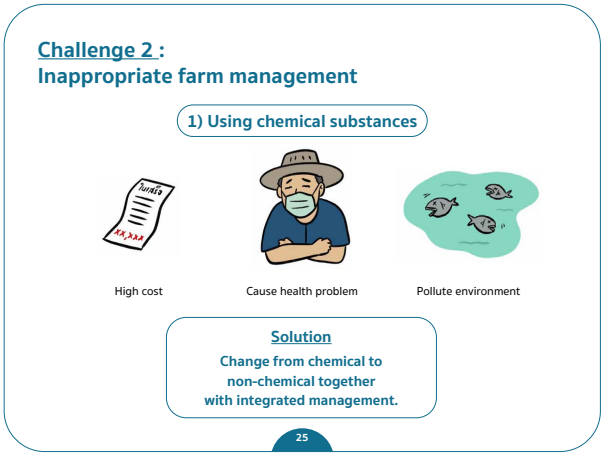
The third inappropriate farm management is **a lack of farm accounting.** This possibly leads to increased loss and decreased profit, for farmers do not know their actual and accurate expense and income.

Question from trainer:

Besides being harmful to health, what are other disadvantages of regularly using chemicals?

Possible answer from participants:

It is costly and pollutes the environment.



Farmers will discover now why the three ways of farm management mentioned earlier are inappropriate and should be changed.

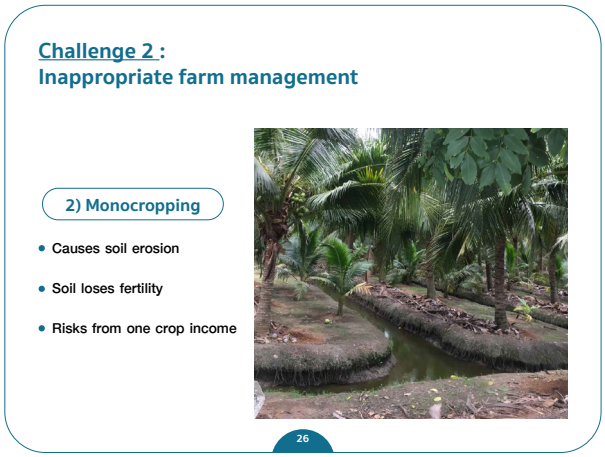
1) Using chemical substances:

A disadvantage of chemicals is the cost. In Module 6 when we talk about the profit and loss, you will see that chemicals are expensive and take a high cost of the farm input, possibly implying a decrease in profit.

Also, chemicals cause environmental problems. Soil, water, and air contaminated by chemicals will be polluted and toxic to people to either drink or breathe. In addition, the chemical substance is harmful to animals, fish, insects and pollinators, bees included, etc. If these ecological elements are destroyed, the sustainable coconut farm cannot be successful.

Possible solution is converting the chemical uses into the organic practices, such as using organic fertilizers, using *Bracon* wasp or *Metarhizium* instead of pesticides.

The topic of pest management will be shown in Module 4.



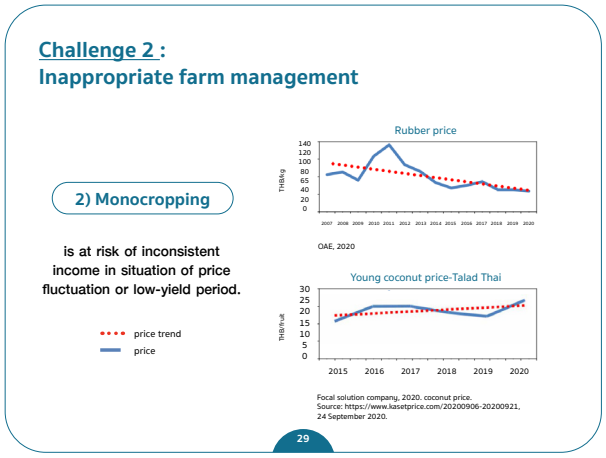
2) Monocropping:

Monocropping, growing only one type of crops in the farm, coconut as an example, easily causes soil erosion. Soil structure and fertility are damaged, moisture content is easily lost, and soil organisms are possibly harmed.

In addition, the monocrop farming could pose a business risk, especially in the situation of price fluctuation or low-yield period.

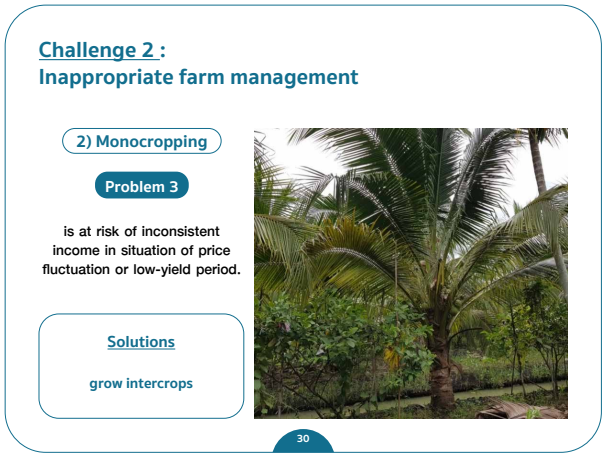
Possible solution is 1. growing cover crops such as roundleaf bindweed, pinto peanut. They are able to decrease soil erosion and keep the soil moisture. Cover crops are also useful for preventing weeds; thus, the necessity of weed removal or herbicides is declined, leading to the cost and time-saving farming. Moreover, some types of cover crops, such as pinto peanut, can increase nitrogen to the soil, hence nourishing the soil fertility.

Possible solution is 2. Applying organic fertilizer, growing cover crops and intercrops. Intercrops able to reduce soil erosion by providing a variety of living root system and depth, and provides additional sources of farm income. The detailed explanation for intercropping is in Module 6, with more details about intercrop species, their merits, and how to choose a proper one for your farm in Module 2. Besides, growing cover crops and applying organic fertilizers also increase soil fertility.



Moreover, intercropping potentially reduces risk of income loss by diversifying sources of farm income from different crops.

Rubber is a good example of monocrop limitation. In the past, the rubber price was above 100 THB/kg but now it continues decreasing to 30-40 THB/kg. This fluctuation could also happen to the aromatic coconut in the future.



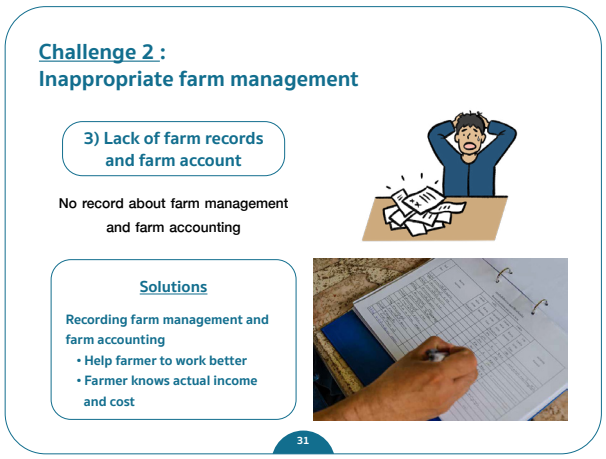
Possible solution is 3. growing intercrops

As shown in the rubber example, instead of monocropping, growing other crops in your coconut farm is recommended. In case that the coconut price drops, you can continue earning income from selling other crops.

There are many intercrops that can grow well along with coconut, guided in Module 2.

Question from trainer:

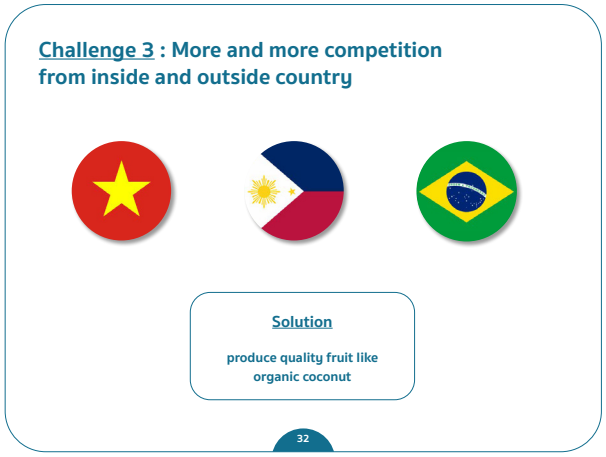
Do any of you do farm accounting?



3) Lack of farm records:

One important thing in farm management is keeping records, especially farm accounting. With farm accounting, farmers know the actual expense and income and can easily plan their farm activities. Moreover, cost and profit calculation is likely accurate as farmers can track the redundant cost and find what cost should be decreased.

We will focus on the topic of farm accounting and the necessary information of farming business in Module 6.

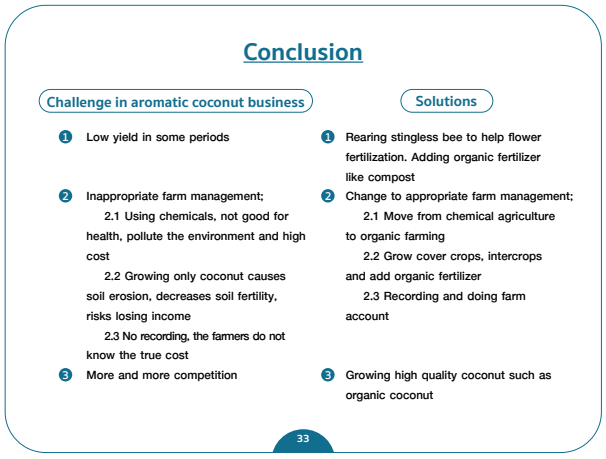


Challenge 3: High competition

Since the global demand for young coconuts is still high, the competition to produce coconuts continues to increase both inside and outside the country.

Domestically, in the past, the main growing areas of aromatic coconut were in the central part of Thailand, while, in the present, the aromatic coconut is widely grown in every part of Thailand. Globally, other countries that can grow coconuts extend their growing areas as well.

Thus, changing from the conventional coconut farm to the organic one is important in the current competitive market to make your farm different with high qualities. In addition, the organic agriculture will improve your farm's capability and increase opportunity to compete with others by giving you access to new market.



1. Concerning the low-yield problem, the solutions are rearing pollinators, namely stingless bee, for better fertilization and applying organic fertilizers for healthier coconut trees.

2.Concerning inappropriate practice in

2.1 using chemicals, the solution is converting the chemical practices into the organic agriculture, mainly using organic materials and any chemical-free farming methods.

2.2. Concerning monocrop culture, resulting in soil erosion, loss of soil fertility, and income fluctuation, the solutions are growing cover crops and intercrops. Not only does the cover crop and intercrop agriculture prevent soil erosion, but it also enriches soil fertility and diversifies farm income from other crops or activities. Applying organic fertilizer also necessary to increase soil fertility.

2.3. Without farm recording or accounting, farmers do not know their actual expense and income and cannot accurately calculate their cost and profit. The solution is to regularly record farm's expense and income.

3. In the current situation that coconut market is very competitive, the organic coconut farming could be a solution to make coconut products different with high quality.

4. About ReCAP project

The ReCAP project started in June 2020 and will last until August 2023. It is financed by Danone Ecosystem Fund, and Harmless Harvest. The project is implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with the support of Harmless Harvest. ReCAP aims to support and train aromatic coconut farmers to establish their coconut farms according to regenerative organic practices, and equip farmers with business skills to increase their productivity.

Regenerative Organic Certification (ROC)

- ROC is the organic system that not only prohibit using chemical in agriculture but also concerns about 3 things which are 1) soil health 2) animal welfare 3) social welfare
- ROC will help the polluted environment caused by inappropriate management to be back in good balance

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As we know, organic agriculture has many standards. There is a standard for regenerative organic agriculture, called “ROC”. The ROC is one of the organic systems that not only prohibits using chemicals in agriculture, but also focuses on; animal welfare, social welfare, and soil health. The details about ROC principles are in Module 1.

Why ROC is important?

- Help the unfertile soil that caused by inappropriate management become fertile again by 1) less or no tillage 2) grow cover plant 3) grow intercrop and 4) using organic fertilizer
- Good soil help the plant grow well. It also trap the carbon which is the component of greenhouse effect that cause the warm climate. Thus, ROC is the way to make a sustainable agriculture

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Agricultural practices required by ROC will revive the unfertile soil caused by inappropriate management to become fertile again by means such as reducing soil disturbance, growing cover crops and intercrops to protect the soil and increase soil moisture that is also good for soil organisms and using organic fertilizer to increase soil fertility. When the soil is healthy, the plant can grow well and produce optimal yield. Good soil also has ability to trap the carbon which is the component of greenhouse effect. That is why ROC will help coconut farm to be sustainable.

What benefit you will get in joining this project?

Your coconut farm will be sustainable after changing to ROC

Farmers have better health after stop using dangerous chemicals. Environment also be unspoiled

More income from other crops or other activities besides coconut sale and expand the market for organic coconut

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The benefits for the farmers if they join this project.

Your coconut farm will be sustainable after changing to ROC practices. With no chemical applied, farmers’ health will improve and environment will not be polluted. Farmers will have more income from other crops or activities.

5. Overview of the training program

The topics in this training are important for regenerative organic practices. They are:

1. Module 1: ROC. This module explains the principles of ROC.

2. Module 2: Soil health. This will show you how to make the soil become fertile and prevent the soil erosion by growing cover crops and intercrops.

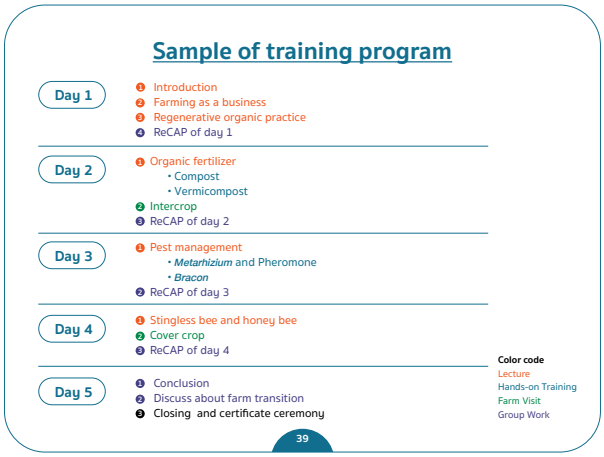
3. Module 3: Organic fertilizer. This module will show you why fertilizer especially organic fertilizer is necessary for coconut palms and how to make compost and vermicompost.

4. Coconut important pests and how to control them without chemicals are in **Module 4**

5. Module 5: Pollinators. Insects that will help pollination in coconut resulting in yield increasing. This training focuses on the stingless bee.

6. Module 6: Coconut farming as a business. This module will give guidance to the participants about how to make the coconut farm as a business. In Module 6, we will have some exercises about farm accounting which will help the participants know the actual cost and income.

7. Module 7: How to transform your present farm to sustainable farm following regenerative practices.



The training takes 5 days, which includes lectures, exercises, practices, and study visits. At the end of each day (D1-D4), there will be a summary of the topics in each day.

The training schedule may look like this:

Day 1: Introduction and the training overview, farming as a business and ROC

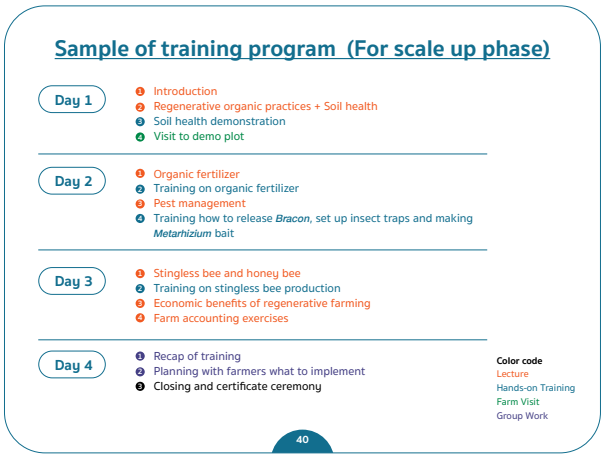
Day 2: Organic fertilizer with lecture, a study visit, and practices (compost, vermicompost, and intercropping). Visit orchard with intercrops.

Day 3: Coconut pest and how to control it in organic way with lecture and practices

Day 4: Soil health and stingless bee with lecture, demonstration, and practice. Visit coconut farms with cover crops (e.g., roundleaf bindweed).

Day 5: Summary of the training, plan of actions with farmers, and certificate ceremony.

Closing training.



The program can be adjusted like in the sample.

Sample Training Program
(Taken from pilot training conducted in October 2020)

Day 1	Day 2	Day 3	Day 4	Day 5
08:30 – 09:00 Registration				
09:00 – 10:30 Welcome & introduction (Module 0)	**09:00 – 10:30** Lecture on organic fertilizer (Module 3) + experience sharing	**09:00 – 10:00** Lecture on pest management (Module 4)	**09:00 – 10:00** Lecture on pollinators (Module 5)	**09:00 – 10:00** Recap of training
BREAK				
10:45 – 12:15 Farming as a business (Module 6)	**10:45 – 12:15** Training on organic fertilizer	**10:15 – 12:15** Training on *Metarhizium* biopesticide	**10:15 – 12:15** Training on stingless bee production	**10:15 – 12:00** Planning with farmers what to implement
LUNCH				
13:00 – 14:45 Farming as a business (cont.) + farm accounting exercises	**13:00 – 14:30** Training on earthworms	**13:00 – 14:30** Training on *Bracon* parasitoid wasp	**13:00 – 14:00** Lecture on soil health (Module 2)	**13:00 – 14:00** Closing and certificate ceremony + evaluation
BREAK				
15:00 – 16:30 Regenerative organic practices (Module 1)	**15:00 – 16:30** Visit to intercrop farm	Training on *Bracon* parasitoid wasp (cont.)	**14:30 – 16:30** Visit to cover crop farm	
16:30 – 17:00 Wrap-up day 1	**16:30 – 17:00** Wrap-up day 2	**16:30 – 17:00** Wrap-up day 3	**16:30 – 17:00** Wrap-up day 4	

Color code
Lecture
Hands-on Training
Farm Visit
Group Work

Sample Training Program
(For scale up phase)

Day 1	Day 2	Day 3	Day 4
08:30 – 09:00 Registration			
09:00 – 10:30 Welcome & introduction (Module 0)	**09:00 – 10:00** Lecture on organic fertilizer (Module 3)	**09:00 – 10:00** Lecture on stingless bee and honeybee (Module 5)	**09:00 – 10:00** Recap of training
BREAK			
10:45 – 11:45 Regenerative organic practices (Module 1) + Soil health (Module 2)	**10:15 – 12:00** Training on organic fertilizer	**10:15 – 11:00** Training on stingless bee production	**10:15 – 11:30** Planning with farmers what to implement
11:45 – 12:15 Soil demonstration		**11:00 – 12:00** Farming as a business (Module 6)	**11:30– 12:00** Closing and certificate ceremony + evaluation
LUNCH			
13:00 – 15:00 Visit to demo plot	**13:00 – 14:00** Lecture on pest management (Module 4)	**13:00 – 14:00** Economic benefits of regenerative farming	
BREAK			
	14:15 – 15:00 Training how to release *bracon*, set up insect traps and making *metarhizium* bait	**14:15 – 15:00** Farm accounting exercises	

Color code
Lecture
Hands-on Training
Farm Visit
Group Work

Even though aromatic coconut is still in high demand, it is facing many challenges, especially from inappropriate farm management.

It includes using more chemicals to increase yield, monocropping, and leaving soil uncovered. These will damage farmer's health and environment, which leads to unsustainable agriculture in near future.

Applying regenerative organic practices will help the farmer to overcome these problems.

Questions:

(The trainer may ask 2-3 questions to the farmers at the end of the session, depending on time)

1. Who in here already has an organic farm?
2. Which topics of the training are you interested in and why?
3. What are your expectations for the training?

Summary and closing

Inappropriate farm management—using chemical, leaving soil uncovered, monocropping, and a lack of basic business management—leads to unsustainable coconut farming in the future. Adopting regenerative organic practices will help coconut farming sustainable. The practices prohibit the use of chemicals to protect farmer's health, as well as to restore and improve the environment. By diversifying their income, farmers also increase their chances earning additional income from other crops besides coconut.

Close this session by thanking the farmers for their interest and participation in the training program.

Module 1

REGENERATIVE ORGANIC PRACTICES

OBJECTIVES

To make farmers understand the importance of organic farming and provide them with knowledge and requirements about Regenerative Organic Certification (ROC)

ACQUIRED KNOWLEDGE

The participants understand:

1. Differences between conventional and regenerative organic farming

2. Requirements and benefits of Regenerative Organic Certification (ROC)

ACQUIRED SKILLS

The participants can:

Adjust the traditional practices/ conventional farm to organic farm/ regenerative organic farm

ACQUIRED ATTITUDES

The participants understand and have good attitude on regenerative organic agriculture for sustainable crop production.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Holistic agriculture concerns about environment, economic and social, emphasizing on reduction of off-farm input and recycle of farm biomass resulting in a balance in the ecosystem and sustainable crop production.

METHODS

1. Lecture with PowerPoint presentation for 90 minutes.

2. Study visit and experience sharing with local lecturer at a model farm with recommendations to adjust their farm to comply with the regenerative organic certification requirements.

TRAINING SUPPLIES, TOOLS AND MATERIALS

1. PowerPoint (PPT) presentation

2. A notebook computer with PPT program

3. An LCD projector and a screen or smart TV

4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and guide questions and issues to be discussed in Module 1

5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 1, and blank pages for taking notes

DURATION

Main topic	period (min)
1. Definition and importance of organic farming	10
2. Greenhouse effect and global warming	15
3. Regenerative organic certification requirements	20
4. Case study	10
5. Regenerative organic practices provide solution for ongoing problems	30
6. Summary and closing	5
Total time of training in Module 1	**90 (1 h 30 min)**

KEY MESSAGES

1. Although regenerative agriculture has no universal definition, the term is often used to describe practices aimed at promoting soil health by restoring soil's organic carbon. The world's soils store several times the amount carbon as the atmosphere, acting as a natural "carbon sink."

2. Agriculture is the major source of greenhouse gas emissions and has been increasing steadily due to the expansion of agricultural activities to feed increasing population. Reducing greenhouse gases from agriculture is the key to resolve global warming problem in the long term.

3. Regenerative Organic Certification (ROC) is a new certification from June 2020, based on 3 pillars: soil health & land management, animal welfare and social fairness.

4. Transition from conventional to regenerative organic agriculture can restore ecosystem balance and sustainable crop production. Industrial agriculture is one of the most unsustainable practices of modern civilization. It has been proved now that monocropping and intensive chemical use are harmful for the environment and people. It is then important to make the agricultural practices evolved to new model in order to assure our ability to provide food to future generation.

LECTURE

1.1 Definition and importance of organic farming

Get the Attention

In this module, we will talk about regenerative organic farming system, following the certification created by the Rodale Institute. The practice will enhance the organic farming to be more sustainable, and not only maintains resources but improves them. Before going into details, let's see why organic agriculture is important and interesting.

→ See Page 24 in the Handbook for Farmers

What is organic agriculture/farming?

One of the bases of regenerative agriculture is organic farming and the regenerative model is using those practices.

Organic farming is the agricultural practice that promotes natural processes and prohibits the use of toxic or synthetic chemicals to avoid chemical contamination in soil, water, and air in order to preserve and restore the ecosystem and environment balance. Genetically modified organisms or GMO are prohibited.

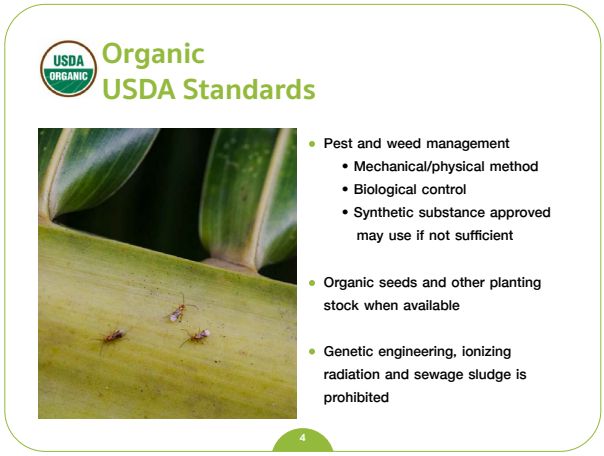
To maintain the integrity of the soil, organic farming uses natural materials such as manure and compost from dung or plants to circulate resources in the farm and minimize the outsource inputs.

Organic USDA Crop Standards

The organic crop production standards require:

- Land must have had no prohibited substances applied to it for at least 3 years before the harvest of an organic crop.

- Soil fertility and crop nutrients will be managed through tillage and cultivation practices, crop rotations, and cover crops, supplemented with animal and crop waste materials and allowed some synthetic materials.



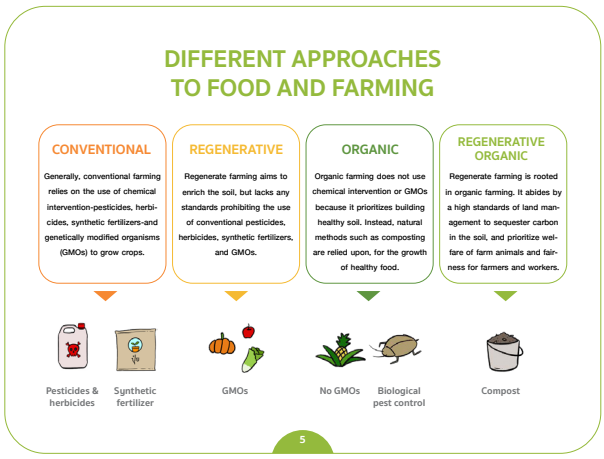
Organic USDA Crop Standards

- Crop pests, weeds, and diseases will be controlled primarily through management practices including physical, mechanical, and biological controls. When these practices are not sufficient, a biological, botanical, or synthetic substance approved for use on the National List may be used.

- Operations must use organic seeds and other planting stock when available.

- The use of genetic engineering, ionizing radiation and sewage sludge is prohibited.

More information can be found at https://www.ams.usda.gov/rules-regulations/organic

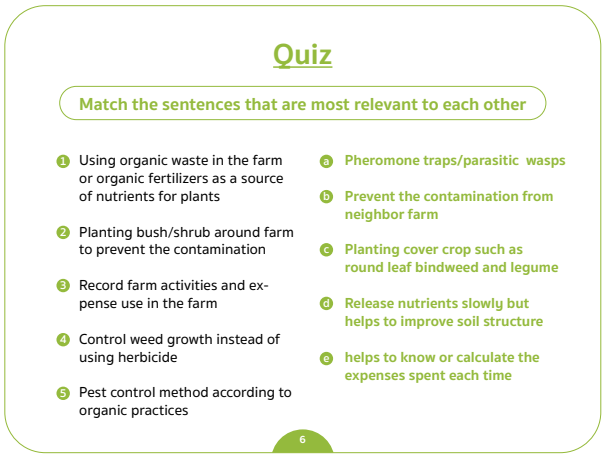


How is regenerative different from organic?

Regenerative Agriculture is defined by the creation of beneficial ecological outcomes.

Organic is usually defined as a way to "not harm" via specific production system that aims to avoid the use of synthetic and harmful pesticides, fertilizers, growth regulators, and livestock feed additives but will not have a direct beneficial.

Conventional farming, also known as **industrial agriculture,** refers to farming systems which include the use of synthetic chemical fertilizers, pesticides, herbicides and other continual inputs, genetically modified organisms, Concentrated Animal Feeding Operations, heavy irrigation, intensive tillage, or concentrated monoculture production. Thus, conventional agriculture is typically highly resource and energy intensive, but also highly productive. Despite its name, **conventional agriculture methods have been widely spread only after World War 2 (green revolution).**



Quiz

Match the sentences that are most relevant to each other

D **Using organic waste in the farm or organic fertilizers as a source of nutrients for plants**

B **Planting bush/shrub around farm to prevent the contamination**

E **Record farm activities and expense use in the farm**

C **Control weed growth instead of using herbicide**

A **Pest control method according to organic practices**

A. Pheromone traps/parasitic wasps

B. Prevent the contamination from neighbor farm

C. Planting cover crop such as round leaf bind weed and legume

D. Release nutrients slowly but helps to improve soil structure

E. helps to know or calculate the expenses spent each time

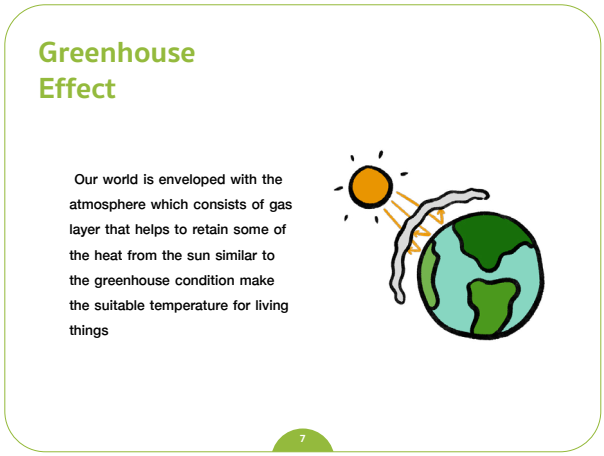
Question from trainer

1. Who in here already practices in USDA organic farming?
2. Which organic practices are you implementing on your farm and what are the advantages?

1.2 Greenhouse effect and global warming

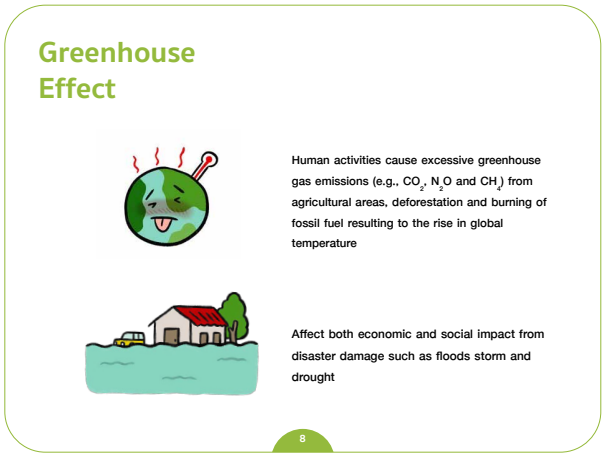
Questions from trainer:

Ask the participants about the greenhouse effect or may use simple word such as “global warming”. What do they think about the meaning of the word and how does the situation affect to the environment and them?



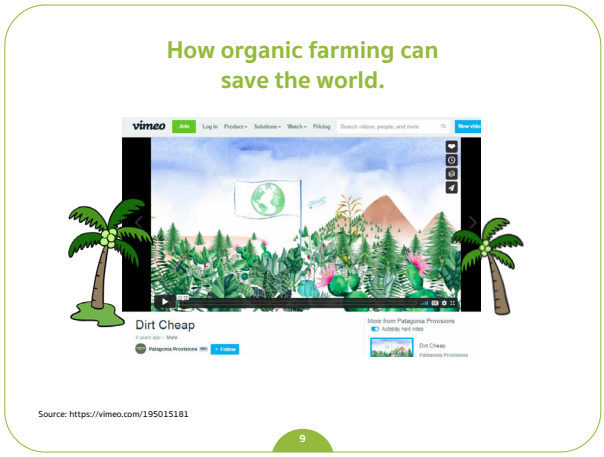
Greenhouse effect and global warming

Our planet is enveloped with the atmosphere consisting of gas layer that helps to maintain the earth’s temperature like the greenhouse condition making the world temperature suitable for life, but excessive greenhouse gas makes the heat from the sun trapped on the surface of the earth causing the global temperature to rise as known as “Global warming,” which affects humans and the environment. Human activities cause excessive greenhouse gas emissions, e.g., carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) from burning of fossil fuel and deforestation, so that most of the heat cannot be reflected causing the rise in global temperature.



Greenhouse effect and global warming

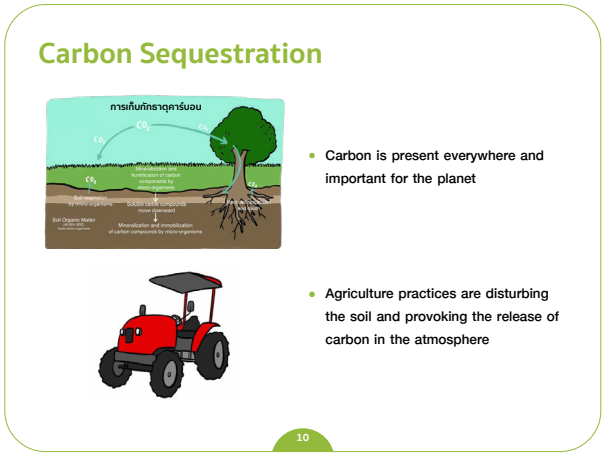
Agricultural areas are a major source of greenhouse gas emissions due to the large areas around the world. Most of the agricultural greenhouse gas emissions are methane, nitrous oxide and carbon dioxide. Carbon dioxide is caused by the degradation of microbial organic matter and the burning of plant residue. Methane is caused by decomposition of organic matter in an anaerobic condition and from manure or plant residue fermentation and from rice fields. In addition, the excessive nitrogen fertilizer applied to plants causing nitrous oxide emission, the leftover nitrogen that hasn’t been absorbed by the plants reacts with the soil to produce the greenhouse gas.



How regenerative farming methods can save the world (video clip)

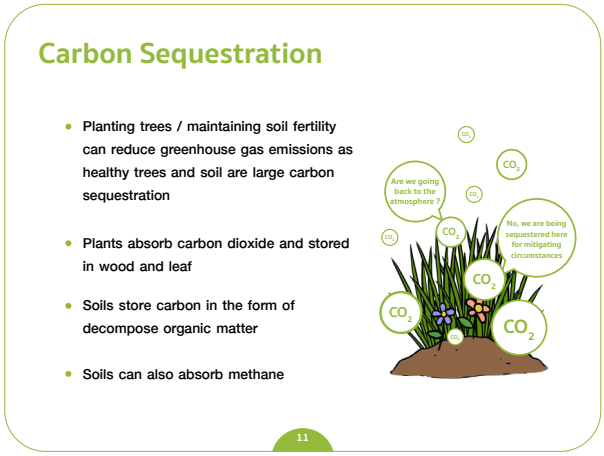
Lecture while watching video about global warming problems and climate change. The human activities generate excess carbon gas (greenhouse gas) to environment causing rise of world temperature. The solution for this problem is already exist, which is the natural processes; plants can store excess carbon in the atmosphere and keep them in the form of plant structure (leaf, branch & trunk), also in soil and microorganisms. This process is disturbed by industrial agriculture and the chemicals use, causing soil structure degradation. We just need to switch from intensive conventional farming and turn to organic farming, reduce soil disturbance with low-tillage practices; and we will be able to restore the soil health and produce high-quality food from the use of organic compost, crop rotation and reduce excess carbon gas. We believe that the regenerative organic agriculture will be the holistic solution of long-term global warming problem. Although now it is no conclusion about its impact to the world, we should move on for sustainable agriculture that helps the world.

Trainer opens the video clip.



Carbon sequestration

Carbon is present everywhere and important for the planet. However, the negative cause is from the excess of carbon released in the atmosphere. The current agriculture practices are not helping as they are disturbing the soil and provoking the release of carbon in the atmosphere.



Carbon sequestration

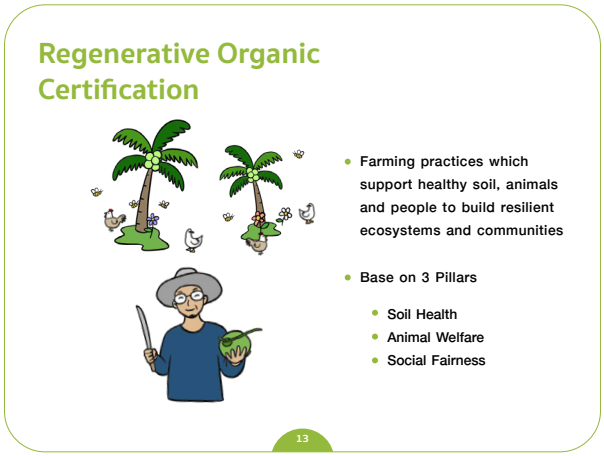
Planting trees / maintaining soil fertility can reduce greenhouse gas emissions because healthy trees and soil are large carbon repositories. The plants can absorb carbon dioxide and store them in the form of wood and leaves, while soil stores carbon in the form of decomposed organic matter and can also absorb methane as well.

USAID and Harmless Harvest study results – Carbon Emissions

- Never put leaves or coconut residues in the canal because anaerobic decomposition generates methane.
- Landfill decomposition (on the bund in dry condition) is better, but still one of the highest sources of carbon emission for organic farms.
- It is ideal to shred waste and reuse waste for compost, mulching, etc. to minimize the carbon emission.

1.3 Regenerative organic certification requirements

In this module, we will talk about the regenerative organic agriculture, which is a holistic approach that provides a way to restore soil and care for the animals and people who work on it. (Trainer can check more details on *www.regenorganic.org*.)



Regenerative organic certification

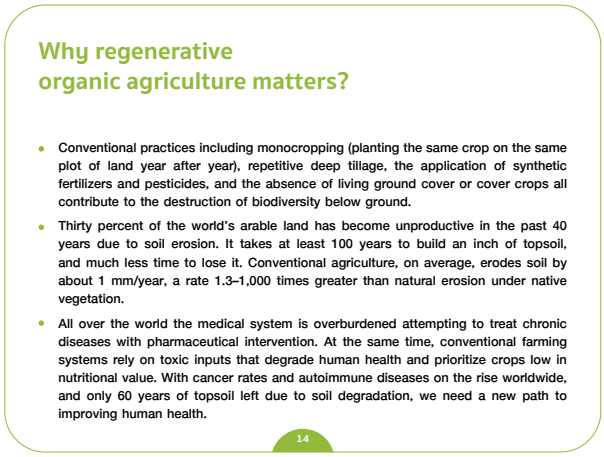
The ROC is built on 3 main principles: soil health, animal welfare, and social fairness. Farmers can decide to apply for this certification like for other certifications (USDA, IFOAM organic …) following the same principles.

The Regenerative Organic Alliance (ROA), a group of experts in farming, ranching, soil health, animal welfare, and fair trade, announced that the Regenerative Organic Certified™ (ROC™) certification standard for food, fiber, and personal care products has completed and is officially open for general certification since summer 2020.

This certification is very new and for now mainly driven by the USA, but people all over the world are more and more interested by those principles.

Several companies already got ROC certified such as:

- Apricot Lane Farms: Avocado Oil from Moorpark, CA
- Dr. Bronner's: Regenerative Organic Coconut Oil from Serendipol Ltd. in Sri Lanka
- Nature's Path: Oats from Legend Organic farm in Saskatchewan, Canada
- Grain Place Foods: Popcorn and Cornmeal from Marquette, NE
- Patagonia Provisions: Regenerative Organic Chile Mango from Sol Simple, Masaya, Nicaragua
- Lotus Foods: Brown and White Basmati Rice from Rohini, India
- Sol Simple: Banana from Masaya, Nicaragua
- Other farms and businesses that received certification with products forthcoming:
  - Tablas Creek Vineyards: Paso Robles CA
  - Herb Pharm: Williams OR
  - Guayaki Yerba Mate: Misiones, Argentina



Why regenerative organic agriculture matters?

Problems of conventional agriculture:

Conventional practices including monocropping (planting the same crop on the same plot of land year after year), repetitive deep tillage, the application of synthetic fertilizers and pesticides, and the absence of living ground cover or cover crops all contribute to the destruction of biodiversity below ground.

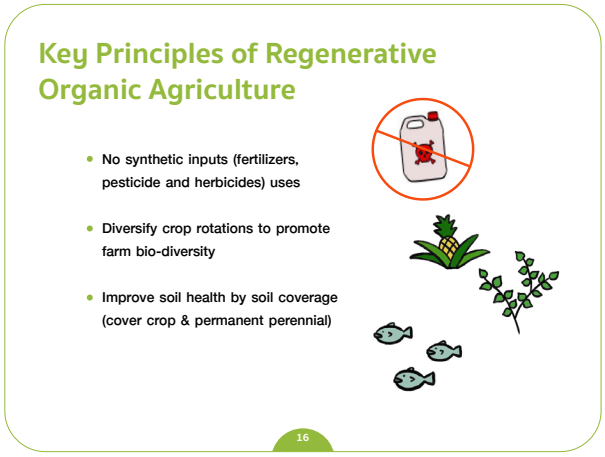
Thirty percent of the world's arable land has become unproductive in the past 40 years due to soil erosion. It takes at least 100 years to build an inch of topsoil, and much less time to lose it. Conventional agriculture, on average, erodes soil by about 1 mm/year, a rate 1.3–1,000 times greater than natural erosion under native vegetation.

All over the world the medical system is overburdened attempting to treat chronic diseases with pharmaceutical intervention. At the same time, conventional farming systems rely on toxic inputs that degrade human health and prioritize crops low in nutritional value. With cancer rates and autoimmune diseases on the rise worldwide, and only 60 years of topsoil left due to soil degradation, we need a new path to improving human health.

Benefits of regenerative organic agriculture

This certification was built to heal a broken system, repair a damaged planet, and empower farmers and consumers to forge a brighter future through better farming.

We could increase the availability of nutrient-dense foods and initiate regeneration of the soil by shifting to a regenerative organic farming system that eliminates toxic inputs and focuses on foods optimal for our health. A shift in our medical system to an integrative system founded on lifestyle medicine—supported by regenerative, whole, nutrient-dense foods—could dramatically alter the trajectory of chronic disease and create a healthier future. It doesn't only matter what we eat, but how our food is produced.

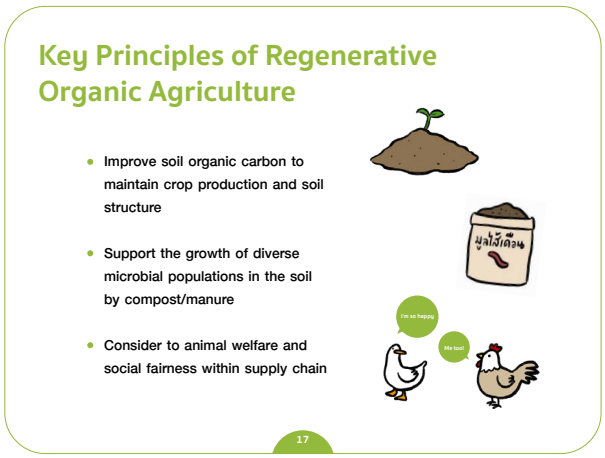


KEY PRINCIPLES

1. Eliminate the use of toxic, synthetic inputs like fertilizers and herbicides, thus eliminating the potential harm caused through exposure via diet, air, water, and occupational exposure.

2. Diversify crop rotations, promote on-farm biological diversity, and institute strategies to manage insect, disease, and weed pressures that reduce or eliminate the need for chemical inputs.

3. Maximize soil coverage and biodiversity through cover cropping, permanent perennial agriculture and integrated livestock systems to maintain and improve soil health.



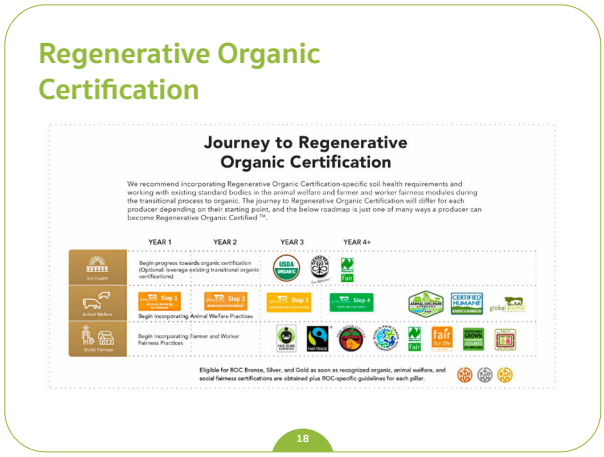
KEY PRINCIPLES

4. Increase soil organic carbon levels, resulting in greater soil structure and water-holding capacity to maintain crop production during periods of climate uncertainty.

5. Support the growth of diverse microbial populations in the soil through natural soil fertility measures such as compost and green manures.

6. Ensure humane practices in the raising and/or handling of animals that intend to be sold.

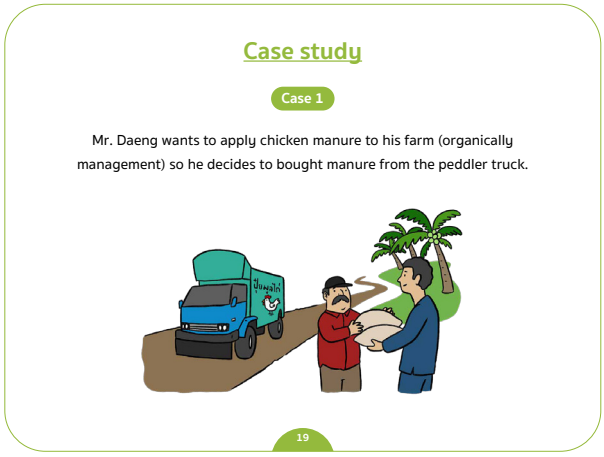
7. Ethical, fair and respectful partnership within and along supply chain.



Journey to regenerative organic certification

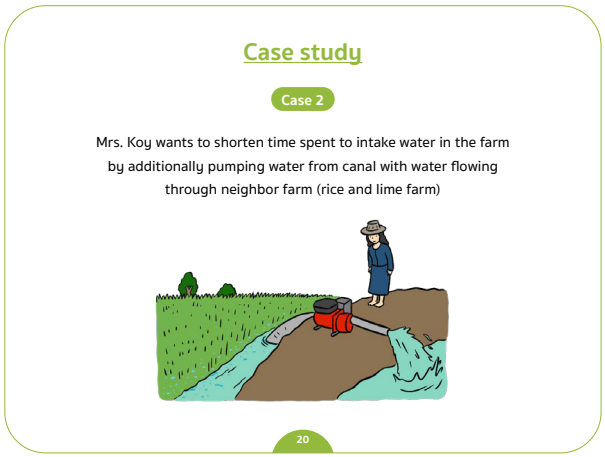
The journey to become Regenerative Organic Certified is unique for each participant. The goal is not to standardize one way of doing regenerative farm, but for each farm to develop what is the right set up based on the type of crops, environment, and soil quality. To achieve the approved ROC, participant (farmer) needs to achieve the baseline certification in each pillar as the prerequisites. For example, in the soil health pillar, it must be certified with the National Organic Program (NOP, USDA) standard or similar international standards before participate in the ROC program, as well as the animal welfare and social fairness, which need to be certified in the related standards, but in case that none of your process are related with raising animals, you may not need to be certified in animal welfare certification. Contact the certification bodies for more information.

1.4 Case study



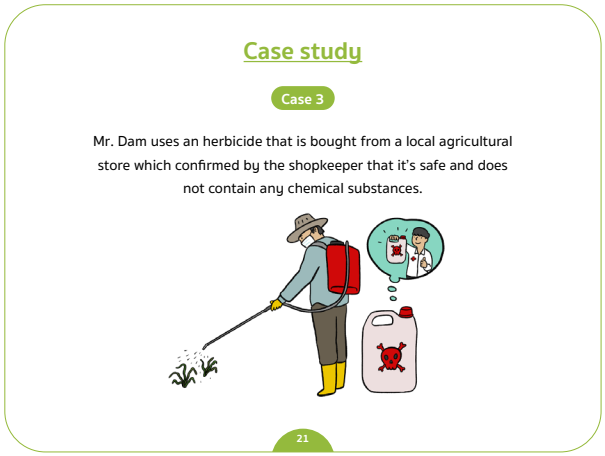
Trainer: Mr. Daeng wants to apply chicken manure to his farm (organically managed), so he decides to buy manure from the peddler truck.

Answer: It's non-compliant because the source of chicken manure is unknown. There is a high risk of contamination from chemical or prohibited substance used in the ingredient such as caustic soda (use as disinfectant in the chicken production) which can severely affect the growth of coconuts.



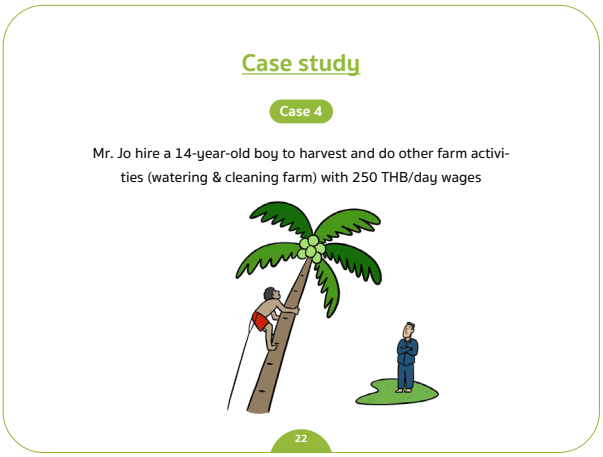
Trainer: Mrs. Koy wants to shorten time spent to intake water in the farm by additionally pumping water from a canal that flows through neighbor farm (rice and lime farm)

Answer: It's non-compliant because the water source is at high risk of being contaminated with chemicals used in neighbor farm such as pesticides or chemical fertilizers.



Trainer: Mr. Dam used an herbicide that was bought from a local agricultural store, of which the shopkeeper confirmed that it's safe and does not contain any chemicals substance.

Answer: It's non-compliant, despite the confirmation from the shopkeeper, we cannot be 100% sure that the product does not contain any chemicals or substances that are not allowed to use, unless it is already approved by certification bodies or specified in the approved list.



Trainer: Mr. Jo hired 14-year-old boys to harvest and do other farm activities (watering & cleaning farm) with 250 THB/day wage.

Answer: It's non-compliant, this case conflict with 2 requirements. First, hiring child labor under the age of 15 for quite hard work that can jeopardize their health and safety. Second, the wage is lower than the minimum wage (more than 310 THB/day/person according to the local law).

1.5 Regenerative organic practices provide solution for ongoing problems

To conclude and make it easy to understand, we summarize the practices you need to implement in your farm in order to be eligible to join ROC program below;

1. Grow intercrop or do crop rotation at least 3–7 types.

2. Create and maintain proper habitats for pollinators such as bees or stingless bees in your farm area

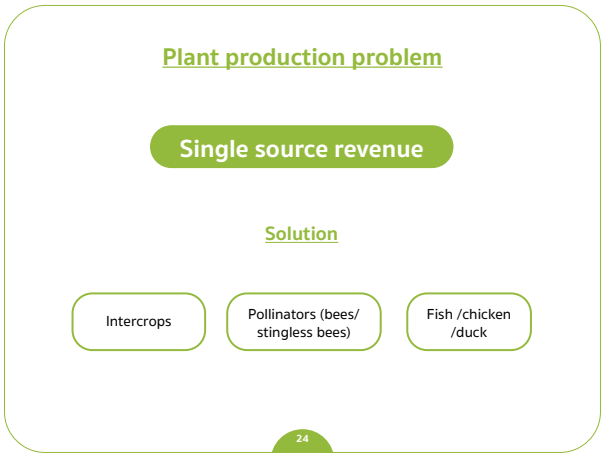
3. You may raise small animals in your farm such as chicken, duck, or fish to increase your extra income from their products.

4. Any practices that demonstrate the recycling of on-farm resources as inputs, such as green manure from old coconuts and leaves or duckweed in the canal, include green manure crop during crop rotation.

5. Soil mulching with crop residues or living vegetative cover like cover crops at least 25–75% of your farm area.

6. Build a windbreak line around your farm borders from herbaceous or perennial plant such as acacias, bamboos, or pines to prevent the contamination risk.

These practices should be documented with photos and records, 3–5 practices should be implemented.

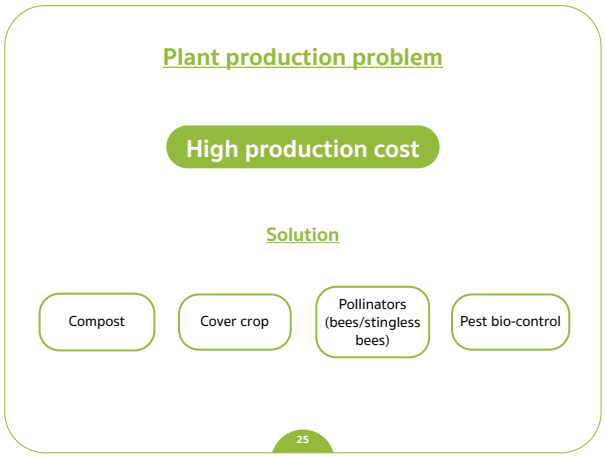


Plant production problems

Problems commonly encountered in plant production systems or obstacles that may be found during transition from conventional / chemistry farm to organic farm are:

1. A single income source: this may be at high risk of product price fluctuation, especially during the period of oversupply. The business may be at risk of profit loss in the long term as the area of coconut plantation has increased steadily.

Finding additional sources of income such as growing various types of crops, raising of productive animals such as chickens and ducks for eggs, fish, or insect pollinators for honey as by-products may help to create income stability as well.



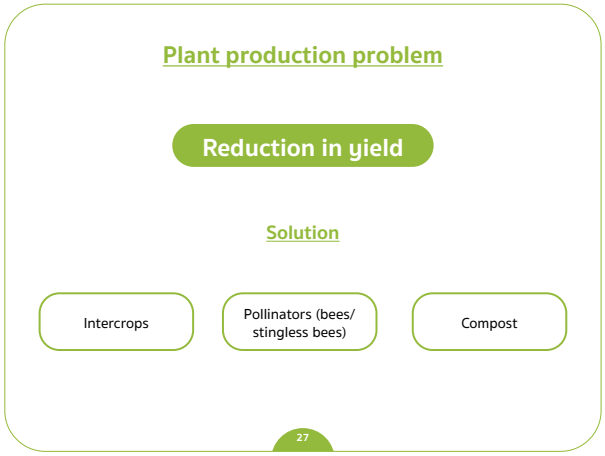
2. The problem of higher production costs, which mainly come from chemical fertilizers, herbicides and pesticides that tend to be used continuously at higher rates.

Use organic compost, which slowly releases nutrients, to reduce risk of nutrient loss. Cover soil surface and control weed growth with mulching materials or vegetative cover plant instead of using herbicide. Improve coconut yield with insect pollinators. Control pest and disease by biological methods such as *Bracon* wasp. All these approaches may help to replace the high-cost method in the long term.

Plant production problems (Cont.)

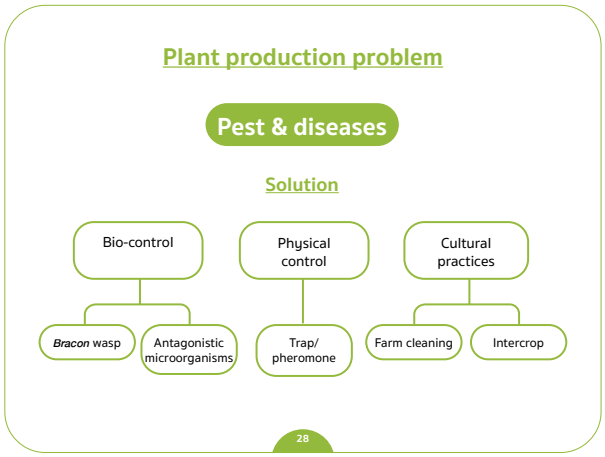
3. Soil degradation problem due to cultivation of the same plants continuously and use of chemicals for a long time. Unhealthy soil directly affects plant growth.

Increase soil fertility by adding organic matter from organic compost and growing a wide variety of plants to increase the diversity of beneficial organisms in the soil and increase the availability of nutrients. Planting cover crops to maintain soil moisture, reduce erosion, and replace the use of chemical herbicides to control weeds.



4. Low productivity may be caused by many factors, but we can control only some factors.

Use insect pollinators (bees/stingless bees) to increase the fruit set rate and use organic fertilizers to improve soil structure and health. Growing intercrops is also good for soil health increasing nutrient availability and maintaining soil moisture.



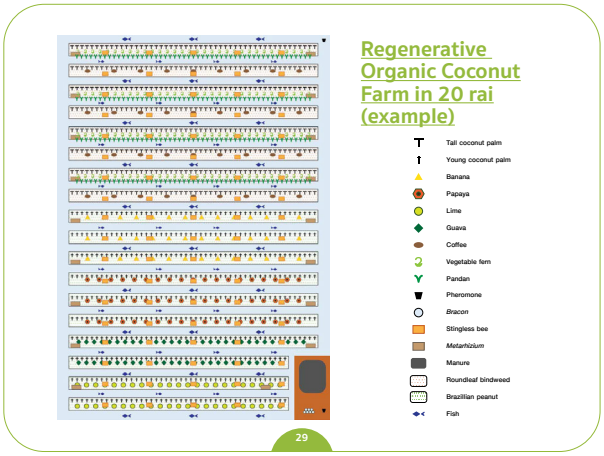
5. Diseases and insects affect both the quantity and quality of the yield. The use of chemicals for pest control also increases production cost while affecting farmers' health and leaving residues in the environment in long term.

Using natural methods is both cost-saving and good for health (control black-headed caterpillar and hispine beetle by insect predators, use pheromone traps and *Metarhizium* fungi to control coconut rhinoceros beetle, use *Trichoderma* fungi to control plant diseases). Cultural management is also helpful, for example, clean coconut leaves regularly to reduce disease risk, monitor spreading of pests, and clean the damaged leaves.

Additional information

Summary of solutions by regenerative organic agriculture for problems in coconut production

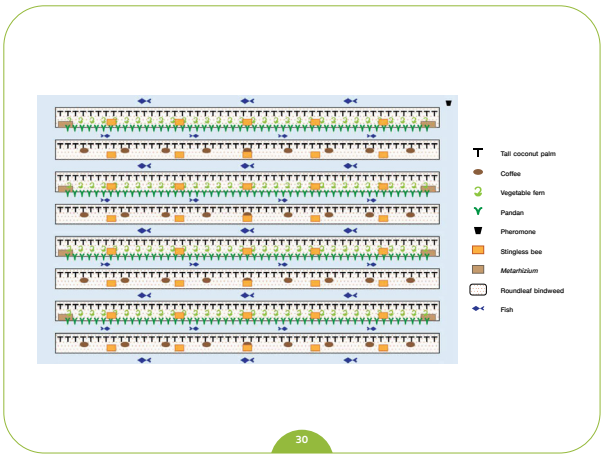
Problem	Consequence	Solution
1. Single source revenue	• Dependent on market price fluctuations • High risk business model (e.g., cut trees because of pest)	✓ Intercrop ✓ Honey ✓ Fish
2. High production cost	• High cost from input such as fertilizer, herbicide, and pesticide	✓ D.I.Y. organic compost ✓ Cover crop to control weed growth ✓ Pollinator to increase yield ✓ Biocontrol such as *Bracon* wasp
3. Poor soil	• Decreasing yields • More input costs • Increase floating risk • Less moisture in soil	✓ Intercrops to increase soil biodiversity ✓ Cover crops (especially nitrogen fixing crop) to keep soil moisture and decrease soil erosion ✓ Compost to increase soil organic matter
4. Reduction in yields	• Less profit • More input costs	✓ Bees for pollination ✓ Intercropping ✓ Organic compost to increase nutrient available in soil and promote soil health
5. Pest and diseases	• Loss yields • Low quality yields • Loss of income • High production cost • Health problem from using chemical substance to control weeds and pest	✓ Biocontrol ✓ Insect trap such as pheromone trap ✓ *Bracon* wasp to control black-headed caterpillar ✓ Cultural practices such as farm cleaning ✓ Monitor pest spreading regularly



Summary of solutions

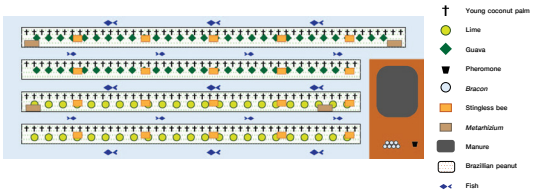
This slide shows ideal regenerative organic coconut farm (ROC) under 20 rai, implemented with intercrops, cover crops, organic compost, integrated pest management and pollinators, such as bees and stingless bees, as mention in the **Handbook for Farmers Pages 34-37.**

For the input cost for 20 rai ROC production, you can see the details in the **Handbook for Farmers Page 40-41.**



This 20-rai example farm is divided into 18 rows, the first 8 rows have tall coconut trees as the main crop. Vegetable fern and pandan are grown in rows 1, 3, 5 and 7 and coffee is grown in rows 2, 4, 6 and 8. Control coconut beetle spreading with *Metarhizium* traps in each row, grow roundleaf bindweed as a cover crop, and stingless bee hives are placed in each row to improve fruit setting.

Small coconut trees are grown in rows 9–11 as the main crop, with banana as an intercrop. In rows 12–14, papaya is used as an intercrop. Roundleaf bindweed or pinto peanut may be grown as a cover crop, with fish farming as an extra income.



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For rows 15–16, there are also small coconut as the main crop with guava as an intercrop during coconut immature and non-productive stage. In rows 17–18, you can grow lime as an intercrop, or you may choose other plants which will be ready for harvest within 1–2 years. The storage area may be used for compost heaps. *Bracon* wasps may be used to control black-headed caterpillar spreading.

The above diagram is only a guideline for regenerative organic cultivation and management within 20 rai area, the number of plants, 3-year income, and expenses in the table on **Pages 38-39 in the Handbook for Farmers** are calculated based on the total area of 20 rai for each plant type and adjustable according to grower's preference.

Three years income & expense on estimate (example)

Input cost	List	Amount unit/THB	Yr 0 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 1 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 2 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 3 (THB) (Nov.19-Oct.20)
Cover crop									
Roundleaf bindweed 10 rai	Plant cost Planting cost Weeding cost	25,600 bags × 6 2 days × 300 12 days × 300	-153,600 -600 -3,600						
Pinto peanut 9 rai	Plant cost Planting cost	23,040 plants × 1 2 days × 300	-23,040 -600						

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There are various activities in the demonstrative coconut farm (growing ground cover and many other intercrops, purchase organic inputs, e.g., compost, *Bracon* wasp, *Metarhizium*, pheromone or stingless bees). That is why the investment in the beginning is high, but with little profit. However, the farmer can choose to begin with some activities that fit them most and start other activities afterward. Some intercrops like vegetable ferns, pandan, banana, and papaya will yield early, while lime and coffee may take time. In conclusion, during these 3 years the income of this farm increase markedly compared to the farm that grow only coconut and use chemicals. (This description applies to slides 33-36.)

Input cost	List	Amount unit/THB	Yr 0 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 1 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 2 (THB) (Nov.19-Oct.20)	Amount unit/THB	Yr 3 (THB) (Nov.19-Oct.20)
Intercrop									
Banana 2 rai	Seedling cost Planting cost	80 trees × 20 1 day × 300	-1,600 -300	2 rai × 49,005	98,010	2 rai × 49,005	98,010	2 rai × 49,005	98,010
Guava 2 rai	Seedling cost Planting cost	80 trees × 15 1 day × 300	-1,200 -300	2 rai × 90,460	180,920	2 rai × 90,460	180,920	2 rai × 90,460	180,920
Papaya 3 rai	Seedling cost Planting cost	120 trees × 12 1 day × 300	-1,440 -300	3 rai × 40,720	122,160	3 rai × 40,720	122,160	3 rai × 40,720	122,160
Lime 2 rai	Seedling cost Planting cost	80 trees × 40 1 day × 300	-3,200 -300				98,010	2 rai x 191,250	382,500

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Notes

- Symbol (-) indicate expense
- Watering cost base on 20 rai
- Cost for *Metarhizium* is only for cow dung, the leavening can be requested from government agency.
- Stingless bee hives are placed only in rows with yielding trees.
- Raising fish for weed control in canal and for family consumption

Three years incomes & expenses on estimate (example)

Input cost	List	Unit × THB	Yr 0 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 1 (THB) (Nov.20-Oct.21)	Unit × THB	Yr 2 (THB) (Nov.21-Oct.22)	Unit × THB	Yr 3 (THB) (Nov.22-Oct.23)
Cover crop									
Roundleaf bindweed 10 rai	Plant cost Planting cost Weeding cost	25,600 bags × 6 2 days × 300 12 days × 300	-153,600 -600 -3,600						
Pinto peanut 9 rai	Plant cost Planting cost	23,040 plants × 1 2 days × 300	-23,040 -600						
Intercrop									
Banana 2 rai	Seedling cost Planting cost	80 trees × 20 1 day × 300	-1,600 -300	2 rai × 49,005	98,010	2 rai × 49,005	98,010	2 rai × 49,005	98,010
Guava 2 rai	Seedling cost Planting cost	80 trees × 15 1 day × 300	-1,200 -300	2 rai × 90,460	180,920	2 rai × 90,460	180,920	2 rai × 90,460	180,920
Papaya 3 rai	Seedling cost Planting cost	120 trees × 12 1 day × 300	-1,440 -300	3 rai × 40,720	122,160	3 rai x 40,720	122,160	3 rai x 40,720	122,160
Lime 2 rai	Seedling cost Planting cost	80 trees × 40 1 day × 300	-3,200 -300					2 rai x 191,250	122,160
Vegetable fern 4 rai	Seedling cost Planting cost	7,680 trees × 2 1 day × 300	-15,360 -300	4 rai × 28,600	114,400	4 ไร่ x 28,600	114,400	4 rai × 28,600	114,400
Pandan 4 rai	Seedling cost Planting cost	1,920 trees × 1.8 1 day × 300	-3,456 -300	4 rai × 21,600	86,400	4 rai × 21,600	86,400	4 rai × 21,600	86,400
Coffee 2 rai	Seedling cost Planting cost	80 trees × 10 1 day × 300	-800 -300						

Three years incomes & expenses on estimate (example)

Input cost	List	Unit × THB	Yr 0 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 1 (THB) (Nov.20-Oct.21)	Unit × THB	Yr 2 (THB) (Nov.21-Oct.22)	Unit × THB	Yr 3 (THB) (Nov.22-Oct.23)
Organic compost		14 tons × 1,700	-23,800	14 tons × 1,700	-23,800	14 tons × 1,700	-23,800	14 tons × 1,700	-23,800
Watering	Labor cost	96 days x 100	-9,600	96 days x 100	-9,600	96 days x 100	-9,600	96 days x 100	-9,600
Pest management									
Bracon wasp		84 boxes × 50	-4,200	84 boxes × 50	-4,200	84 boxes × 50	-4,200	84 boxes × 50	-4,200
Pheromone		6 pieces × 500	-3,000	6 pieces × 500	-3,000	6 pieces × 500	-3,000	6 pieces × 500	-3,000
Metarhizium	Cow dung (for trap)	1,440 kg × 2	-2,880	1,440 kg × 2	-2,880	1,440 kg × 2	-2,880	1,440 kg × 2	-2,880
Other	Fish	500 fish × 3	-1,500	50 fish × 50	2,500	50 fish × 50	2,500	100 fish × 50	5,000
Stingless bee	Hive box	40 boxes × 1,500	-60,000						
Aromatic coconut	Sell coconut	38,400 nuts × 10	384,000	38,400 nuts × 10	384,000	38,400 nuts × 10	384,000	38,400 nuts × 10	384,000
Total			**68,424**		**944,910**		**944,910**		**1,329,910**

Notes

- Minus sign (–) indicates expense
- Watering cost is based on 20 rai
- Cost for *Metarhizium* is only for cow dung, the leavening can be requested from government agency.
- Stingless bee hives are placed only in areas with yielding trees
- Raising fish for weed control in canal and for family consumption

Additional information
Input costs for ideal regenerative organic coconut farm (1 rai and 20 rai)

	Number/1 rai	Number/20 rai	Price/unit	Total price
Coconut palm	35–44 plants	700–880 plants	100 THB	70,000–88,000 THB
Cover crop				
Roundleaf bindweed	2,560 bags	51,200 bags of cuttings	6–8 THB	307,200–409,600 THB
Pinto peanut	~2,560 plants (2 kg of seeds)	51,200 plants (40 kg of seeds)	1 THB/plant (200 THB/kg of seeds)	51,200 THB (8000 THB for seeds)
Intercrop				
Young coconut palm				
Banana	40 plants	800 plants	20-30 THB/plants	16,000-24,000 THB
Guava	40 plants	800 plants	15 THB/plants	12,000 THB
Papaya	40 plants (120 seeds)	800 plants (2,400 seeds)	12 THB/plant (1 THB/seed)	9,600 THB (2,400 THB for seeds)
Lime	40 plants	800 plants	40 THB (rooted cuttings)	32,000 THB
Tall coconut palm				
Vegetable fern	1,920 plants	38,400 plants	2–5 THB	76,800–192,000 THB
Pandan	480 plants	9,600 plants	1.80 THB (price for >3,000 plants/order)	17,280 THB
Coffee	40 plants	800 plants	10–20 THB	8,000–16,000 THB
Compost	700–800 kg (20 kg/plant/year)	14–16 tons	25 THB/15 kg (Chicken manure) (Cow manure's price is about 20–30 THB/15 kg)	23,500–26,700 THB (Chicken manure) (18,700–32,000 THB for cow manure)

	Number/1 rai	Number/20 rai	Price/unit	Total price
Pest management				
Bracon wasp	2 boxes/6 rais/month	7 boxes/month	50 THB/box	350 THB/month
Pheromone	1 set/10 rais /4 months	2 sets	500 THB/set	1000 THB/4 months
Metarhizium trap	72 kg of cow dung/rai	1,440 kg of cow dung	2 THB/kg of cow dung	2880 THB/kg of cow dung
Stingless bee	4–5 boxed hives (recommended by Phupha Farm)	80–100 boxed hives	1,500 THB (Rent at 30 THB/ boxed hive/day)	120,000–150,000 THB

**Metarhizium* = live *Metarhizium* (1 kg/2 L) mix with 12 kg of cow dung (* free of charge)

Summary and closing

1. Regenerative organic farming is holistic agriculture which supports the environment, economy and society.

2. Monoculture or industrial agriculture with the use of chemicals or synthetic substances excessively to increase production can affect environment and degrade soil structure damaging plant health, increasing needs to use more and more chemicals to control pest.

3. Regenerative organic agriculture will help to restore soil fertility and ecosystem balance and promote plant health. Growing variety of crop rotation makes additional income and reduces the risk of fluctuation in the price of main crop, resulting in sustainable crop production.

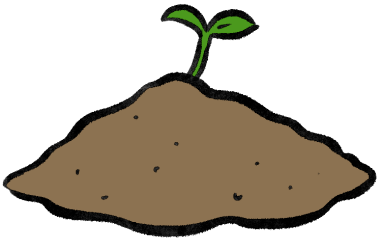
4. Regenerative organic agriculture is an upgrade of organic farming to be completer and more sustainable. The practices below can elevate from general organic system to ROC system:

- Grow cover crops and do mulching to maintain moisture and reduce soil erosion
- Reduce off-farm inputs & recycle on-farm biomass
- Plant intercrops and do crop rotation
- Grow windbreak trees around farm borders as buffer zone
- Raise pollinators such as bees or stingless bees

To close, ask participants for feedback or comments on this topic, the difficulties, and obstacles in their opinion in order to join ROC program. Discuss and debate about problems and case study from their experiences.

Module 2

SOIL HEALTH



OBJECTIVES

To provide the participants the knowledge and understanding of the importance of soil health for aromatic coconut farming as well as the basic principles for maintenance and improvement, supporting regenerative organic farming

ACQUIRED KNOWLEDGE

The participants:

1. Know and understand the meaning and importance of soil health for sustainable coconut farming.

2. Know the basic principles for maintenance and improvement of soil health for regenerative organic coconut farming.

3. Realize the importance of compost, cover cropping and intercropping for soil health. (Compost will be described in the dedicated module 3 on organic fertilizers.)

ACQUIRED SKILLS

The participants can:

1. Differentiate farm activities disturbing soil health and those promoting it.

2. Choose and implement farm activities promoting soil health to apply in their own coconut farm.

ACQUIRED ATTITUDES

The participants realize the importance of soil health, both for their sustainable coconut farming and for the environment, minimize or stop practicing farm activities that disturb or harm the soil health, and keen to apply the acquired knowledge in their farming to maintain and improve the soil health in their farms.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Healthy soil promotes coconut health, increase productivity, and reduce production costs. It will also have a positive impact on the environment by reducing risk of erosion and increasing carbon sequestration.

METHODS

1. Lecture with PowerPoint presentation for approximately 60 minutes.

2. Soil test demonstration comparing healthy soil and common soil taking about 30 minutes to illustrate soil erosion and soil water absorption.

3. Study visits and experience sharing with the farmers.

    1. Cover cropping in aromatic coconut farming, taking about 90 minutes.

    2. Intercropping in aromatic coconut farming, taking about 85 minutes.

TRAINING SUPPLIES, TOOLS, AND MATERIALS

Lecture:

1. PowerPoint (PPT) presentation
2. A notebook computer with PPT program
3. An LCD projector and a screen or smart TV
4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the contents, and guide questions and issues to be discussed
5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 2, and guide questions for the study visit, as well as blank pages for taking notes.

Demonstration/study visit:

In this module, there is a soil test demonstration displaying differences in water absorption and water drainage qualities of healthy soil and common soil (demonstration preparation and explanation are provided in the contents of this Module in this Manual for Trainers).

Study visits to coconut farms where cover cropping, and intercropping are successfully practiced are suggested. For each visit, the owner of the visited farm is invited as a guest trainer to share real-life experiences and exchange ideas with the participants on the subject. The owner should be contacted at least 1 month earlier to arrange the visiting date, time, place, transportation, and brief her/him on the presentation. A compensation for the owner and training materials should be arrange if any. Suggested questions and discussion topics relating the subject of visits should be listed and provided to the participants ahead of the visits. In case the guest trainer is not available, the trainer of the module should be ready to provide key information from the visit and answer questions the participants may have.

DURATION

A. Lecture Topics	Period (min)
1. Definition of soil health	5
2. Soil heath test	30
3. Benefits of soil health	5
4. Soil health principles	5
5. Good practices to improve soil health: cover cropping, intercropping, and organic mulching	45
Total time of lecture and demonstration	**90 (1 h 30 min)**
B. Study Visits	
1. Study visit: cover cropping in coconut farms	90
2. Study visit: intercropping in coconut farms	85
3. Summary and closing	5
Total time of study visit	**180 (3 h)**
Total time of training in Module 2	**270 (4 h 30 min)**

KEY MESSAGES

1. Building soil health is prioritized in regenerative organic agriculture in order to produce high quality, nutrient dense food while simultaneously improving, rather than degrading land, and ultimately leading to productive farms and healthy communities and economies.

2. Soil health helps combat climate change effects (drought, flood, erosion, carbon emission, etc.)

3. Soil is a living ecosystem that sustains plant, animal, and human lives, and helps sustain agricultural productions.

4. Four soil health principles:
   a) Minimize soil disturbance
   b) Maximize soil cover
   c) Maximize biodiversity
   d) Maximize the presence of living roots

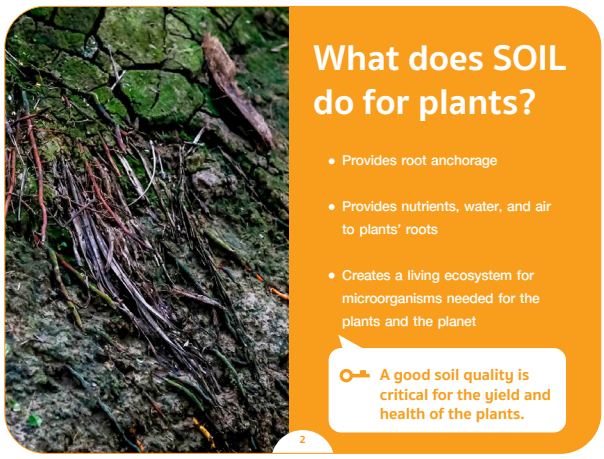
5. Cover cropping and intercropping help improving soil health, keep moisture, reduce cost such as that for irrigation or weeding, increase income and secure business with diversification.

A. LECTURE

Get the Attention

In this module, we will explain the importance and benefits of “soil health”, as well as its maintenance and improvement in coconut regenerative organic farming.

→ See Page 46 in the Handbook for Farmers



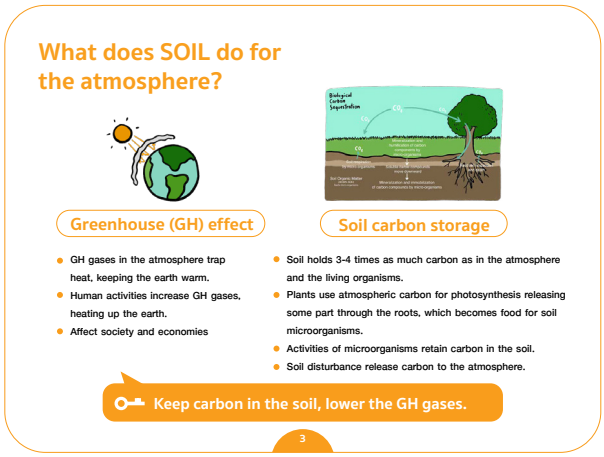
Question from trainer:

Before we get into the topic, I would like to ask, “Can someone explain what soil does for plant?”

Possible answers from participants:

Soil provides root anchorage, water, and nutrients to plants. It also creates a living ecosystem for microorganisms needed for the planet and the plants.

A good soil quality is critical for the yield and health of the plant. A soil is alive and needs to be taken care of or it will be died.



In addition to the benefits for the plants, **soil has an important function to support the earth's atmosphere.**

Gases in the atmosphere, i.e., carbon dioxide (CO_2), have the property of heating to keep the earth warm. This is the natural process called **Greenhouse Effect.** However, increasing concentration of the gases, so-called **Greenhouse Gases,** from human activities has been heating up the earth. The continuously rising temperature widely affects ecosystems, human lives, societies, and economies.

Soil can store carbon, a key component of greenhouse gases, **about 3–4 times more than the atmosphere and the living organism.** Soil holds carbon through plants and soil microorganisms.

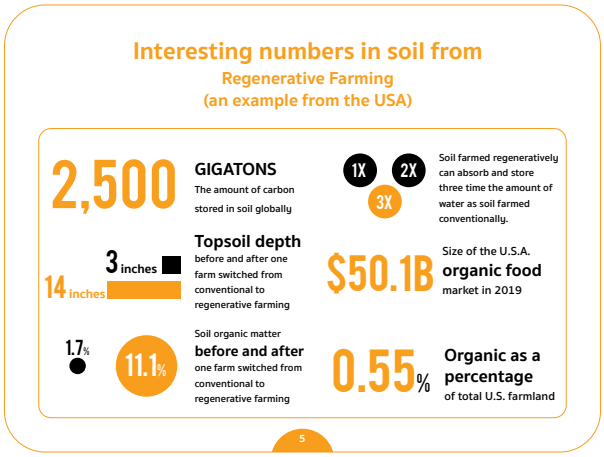
Plants use atmospheric carbon, in the form of CO_2, for photosynthesis converting light energy into chemical energy in the form of sugar, which contains carbon. Plant roots release some of the sugar and other carbon compounds into the soil to feed soil microorganisms.

Soil microorganisms decompose organic materials (plant, animal, and microbial residues) producing humus, which consists of 60% carbon and can remain in the soil for centuries. Soil disturbance exposes the soil to oxygen causing microbial population explosion that consumes soil carbon, which is released as CO_2 to the atmosphere.

Keeping carbon in the soil lowers the greenhouse gases.

Link with the training subject: Soil has important functions for the plants and the atmosphere. Organic aromatic coconut farming that maintains soil health is good for the coconut trees and, concurrently, helps mitigate climate change problems.

Regenerative organic agriculture, thus, prioritizes building soil health.



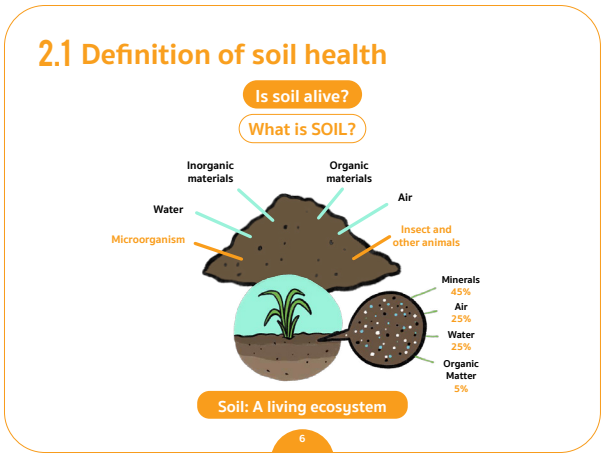
Interesting numbers in soil from Regenerative Farming

The amount of carbon stored in soil globally: 2,500 gigatons. When we destroy the soil, we release the carbon into the atmosphere.

After switching from conventional to regenerative farming, we observed the following in the farm:

- Topsoil increase from 3 to 14 inches.
- Soil organic matter increases from 1.7% to 11.1%.
- Soil can absorb and store 3 times the amount of water as soil farmed conventionally.

2.1 Definition of soil health
What is SOIL?



Before we talk about the importance of soil health, let's get to know what "soil health" is.

Question from trainer: Is soil alive?

Possible answer from participants: Yes

Soil supports lives:

- 100 million–1 billion of various microorganisms in 1 teaspoon of healthy soil
- Home to insects and animals, e.g., mites, nematodes, worms, ants, and mice
- Fundamental resource for crop production

Soil: A living ecosystem
Think of soil as a living thing
Only living things can have health

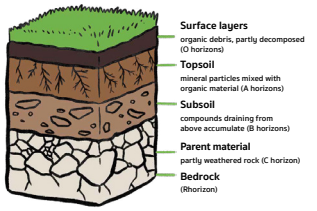
7

Soil is a mixture of minerals, water, air, and organic matter. Soil is not only dirt that acts as the skin of the earth, but it supports life and is vital to lives on earth. A teaspoon of healthy soil could have one hundred million to one billion of various microorganisms such as bacteria, fungi, protozoa, and algae. The soil is also home to insects and animals such as mites, nematodes, worms, ants, and mice.

Soil is a living ecosystem. Think of soil as a living thing. Only living things can have health. (Health = a condition of optimal well-being)

In addition, soil is fundamental resource for crop production. Without soil, food cannot be produced on a large scale, nor would the livestock be fed.

Soil layers



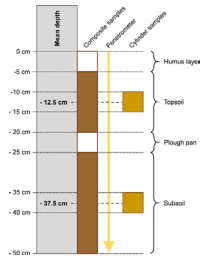
Surface layers
organic debris, partly decomposed (O horizons)

Topsoil
mineral particles mixed with organic material (A horizons)

Subsoil
compounds draining from above accumulate (B horizons)

Parent material
partly weathered rock (C horizon)

Bedrock
(Rhorizon)



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If you dig down deep into any soil, you will see that it has different layers. Each has its own characteristics. The surface of the soil is a thin layer of humus or organic matter such as decomposed leaves. Below the surface layer is topsoil which contains minerals from parent material that the soil developed from. It also incorporates organic matter and is a good layer for plants and other organisms to live.

What is soil health?

Soil in good health

Soil in poor health

Soil health

is the capacity of soil to function as a living ecosystem that sustains plant, animal, and human lives.

involves soil physical, chemical, and biological aspects.

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What is soil health?

Soil health:

- is the capacity of soil to function as a living ecosystem that sustains plants, animals, and human lives.
- involves soil physical, chemical, and biological aspects.

2.2 Soil health test

To see the differences between healthy soil and common soil, we are going to do a soil health test together.

→ **See Page 50 in the Handbook for Farmers**

Demonstration: soil health tests

Trainer: set up the soil testing system in advance (prepare samples and material + do one experiment to validate the results before the training).

- Remind the participants about the importance of soil aggregates in relations to soil health.
- Invite participants to conduct the test.
- Conduct the demonstration more than 1 round if needed.
- For a large group of participants, divide them into smaller groups to better observe the demonstration.

Detailed information for the demonstration
Importance of soil aggregates.

There are two major components we will demonstrate: 1) the link to the soil erosion and 2) the water absorption.

A healthy soil is stable by nature and will not fall apart easily into dirt under the effect of rain or wind. What makes the soil stable is the organic matter, fungal mycelia, and plant roots, playing an important role as cementing agent to hold the mineral soil particles into stable aggregates of different sizes leading to the good soil structure with porosity.

Different pore sizes make soil loosen and allows the water to infiltrate easily, leading to an increase in holding capacity: the excess water drains out during the rainy season and, at the same time, keep a better soil moisture during the dry season.

Low aggregate formation and poor aggregate stability are common in soils with low organic matter content, bare soils without any cover crops or intercrop, or highly disturbed soils by tillage. Once the aggregates fall apart, small soil particles pack together and seal the soil surface and pore spaces. This leads to poor infiltration and poor moisture holding capacity and increases water runoff, soil erosion and losses of topsoil and organic matter.

Soil health tests

1) Soil aggregate stability test; slake test

Objectives:

To compare soil aggregate stability between healthy soil and common soil with low organic matter content.

Materials:

1. A 500-ml clear drinking water bottle; cap and bottle neck are cut off, or a clear plastic cup of similar size to serve as a container. Fill the bottle with water until it is almost full (Fig. 2.1A)

2. Wire mesh: cut into a rectangular piece and fold into a basket that fits to the top of the bottle or plastic cup (Fig. 2.1B). A soil clod sample will be placed in this basket.

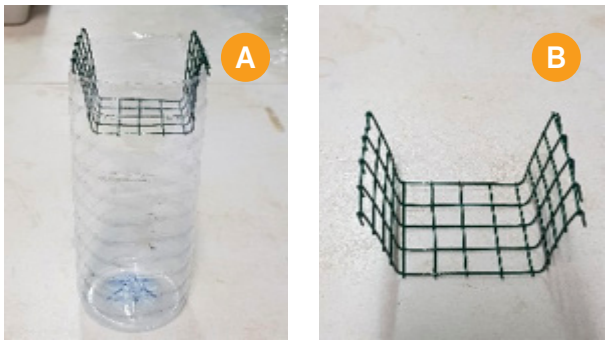


Fig. 2.1 A water container modified from a clear drinking water (A), a basket made of wire mesh serves as a holder for soil clod sample (B).

3. Soil samples for testing:

a. Healthy soils collected from an undisturbed plot with cover crops and continuously supplied with organic fertilizer and organic matter

b. Common soils collected from a bare soil plot (no cover crops or mulching) with low organic matter or compacted soils from a walkway.

Soil samples should be collected at least 1 week before the test, air dried until the soil breaks into small clods. A suitable size of a soil clod for testing is about the size of a lime fruit.

4. Stopwatch

Method:

Prior to the demonstration to begin, ask a volunteer trainee to place at the same time the two soil samples in the water

1. Place a soil clod gently in a wire mesh basket so that the clod is well under the water level in the container (Fig. 2.2A). Time and observe changes happening to the soil clod.

2. Once the soil clod absorbs water, the aggregates inside begin to break apart by water pressure and soil particles fall down to the bottom of the container (Fig. 2.2B).

a) If it takes less than 1 min for the whole clod to break apart, the aggregates stability is poor.

b) If it takes between 1–5 min for the whole clod to break apart, the aggregate stability is good.

c) If it takes more than 5 min, the aggregate stability is excellent.

Fig. 2.2 Place an air-dried soil clod sample in a wire mesh basket (A), after water absorption, aggregates inside the clod are forced by water to break apart and small soil particles sink to the bottom of the container (B).

2) Rainfall simulation test

Objectives:

To compare infiltration of soil samples of different aggregate stability and to demonstrate that the healthy soil with good aggregate stability has good infiltration and better water holding capacity than common soils with low organic matter and poor aggregate stability.

Materials: (Fig. 2.3)

1. A plastic cup with perforated holes at the bottom served as a rainfall simulator. It is placed on top of a clear perforated plastic cup.

2. A clear plastic cup with perforated holes at the bottom for drainage. It serves as a soil sample holder and collects simulated rain coming from the top container.

3. A plastic or metal grid. A clear plastic cup is sat on this grid.

4. A container to collect drained water. It is placed under the grid.

5. Water in a 1.5-L bottle.

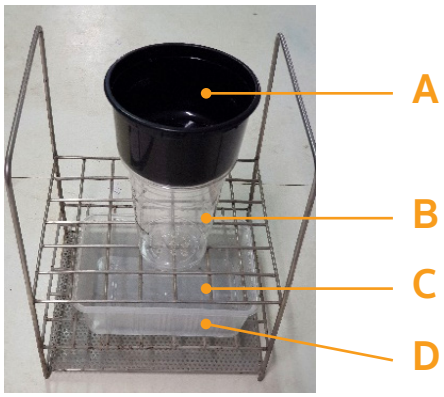


Fig. 2.3 A simple rainfall simulator for testing the stability of soil aggregates and infiltration. A plastic cup with perforated holes at the bottom served as a rainfall simulator (A), a clear plastic cup with perforated holes at the bottom for drainage (B), plastic or metal grid (C), and a container to collect drained water (D).

Method:

1. Preparing soil samples (healthy soil vs. common soil); break a soil clod into smaller pieces and soil particles. Fill about 1/3 of the clear plastic cup with the prepared soil sample (Fig. 2.3B). Gently tap the bottom of the clear plastic cup on the table a few times to settle that sample evenly. Repeat the whole step for the next soil samples.

2. Place the plastic cup with soil sample on the grid (Fig. 2.3C).

3. Place the water-collecting container (Fig. 2.3D) under the grid and the soil sample cup.

4. Place the plastic cup (Fig. 2.3A) on top of the soil sample cup and ask 1 or 2 participants to slowly pour water into the cup to create simulated rainfall. For comparison, this simulated rainfall should be done on the healthy and the common soil samples at the same time.

5. Observe infiltration of the soil samples, evaluate the time for the water (the simulated rainfall) to be 100% in the drained container.

Result interpretation: Importance of soil aggregate

Healthy soil with good aggregate stability and pore space have good infiltration rate. The simulated rainfall can infiltrate the soil in a very short time. The soil sample holds water evenly (= good soil moisture holding capacity) (Fig. 2.4A). Excess water that soil sample can no longer hold will drain out by gravity (Fig. 2.4B).

For a common soil with low organic matter content and poor aggregate stability, the rainfall simulator forces it to break apart. Small soil particles will be packed sealing the surface of the soil; as a result, infiltration is very slow or the water is retained above the soil surface (Fig. 2.4C). Some light debris (organic matter) floating in water may be observed. It will take longer time for infiltration and drainage to occur in this soil sample.

In field conditions, such remaining water will quickly run off to the lower areas before infiltration or generate a floating depending on the area. This will result in erosion and losses of topsoil, including nutrients, organic matter, and death of soil microorganisms.

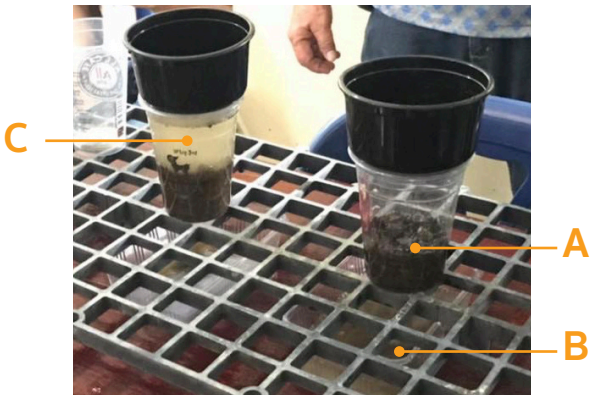


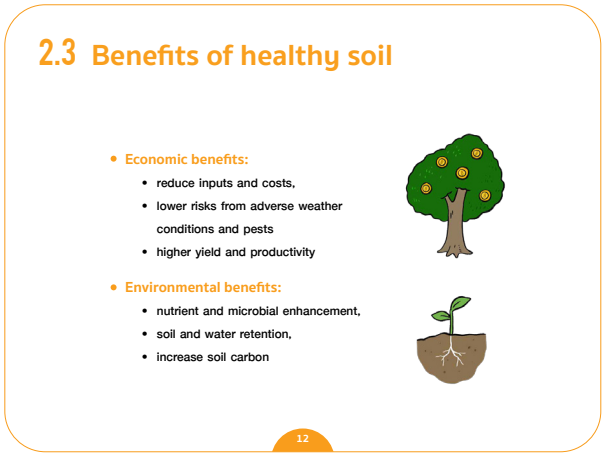
Fig. 2.4 Comparison of infiltration rate between soils of different aggregate stability. Healthy soil sample holds water evenly (A) and drained excess water out into a container (B). Infiltration of common soil is very slow, retaining water above soil surface (C).

Healthy and functioning soil

Healthy and functioning soils are able to:

- Store and cycle nutrients effectively making them available for the plant to grow
- Provide good aeration to promote root growth
- Reduce soil runoff and erosion
- Improve water storage and plant available water
- Be resilient to drought, heavy rainfall, and temperature fluctuation
- Reduce disease and pest problems

2.3 Benefits of soil health



Benefits of healthy soil

Economic benefits:

- Higher yield and productivity
- Lower risks from adverse weather conditions and pests
- Reduce inputs (irrigation, fertilizers …) and maintenance costs (digging, weeding, …)

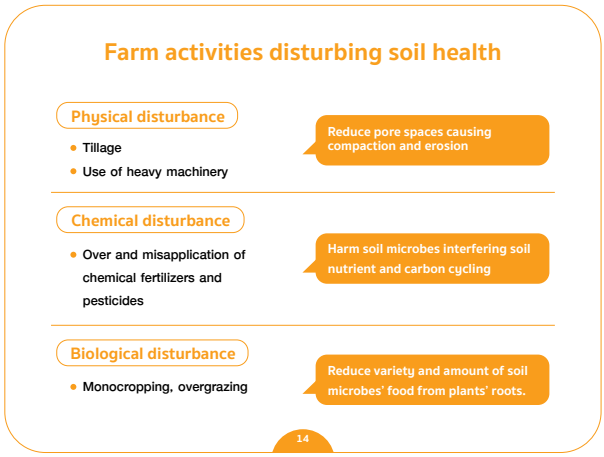
Environmental benefits:

- Nutrient and microbial enhancement
- Soil and water retention
- Increase soil carbon

Ask participants to give examples of their farm activities probably disturbing the soil. Categorize the answers into the three following categories:

Question from trainer: Which activities in your farm could disturb soil health?

Possible answers from participants: tilling, using chemical herbicides or fertilizer regularly.



Below are some examples of farm activities already categorized according to their disturbing effects on soil health

Physical disturbance

- Tillage
- Use of heavy machinery

Over time, these activities reduce and remove pore spaces between soil aggregates, where soil water and air locate, adversely affecting soil structure causing compaction, restricting infiltration, and resulting in soil erosion.

Chemical disturbance

- Over and misapplication of chemical fertilizers and pesticides

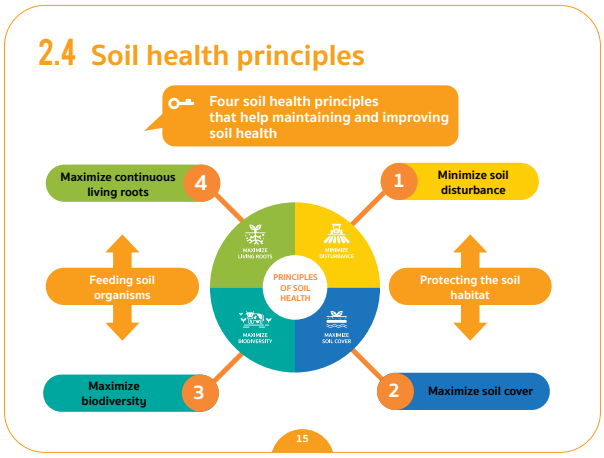
These chemicals harm soil microorganisms, disrupt composition, diversity, and functioning of soil microflora, thus interfering soil nutrient and carbon cycling.

Biological disturbance

- Monocropping limits living root system diversity.
- Overgrazing limits plant ability to harvest CO_2 and sunlight.

Soil microbes get food from various plant root exudates. These activities reduce the variety and amount of the microbes' food.

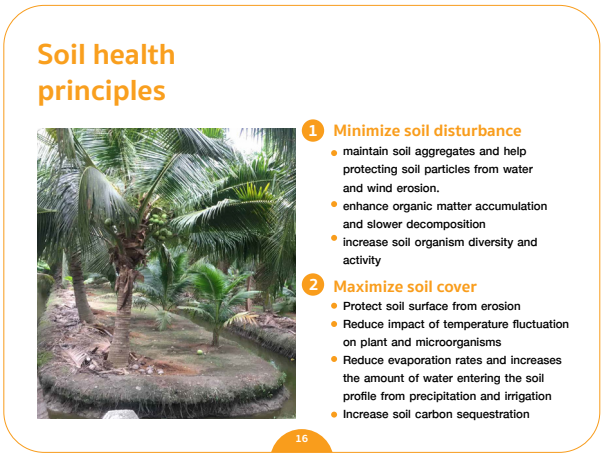
2.4 Soil health principles



There are four soil health principles that help maintain and improve soil health.

1) Minimize soil disturbance
2) Maximize soil cover
3) Maximize biodiversity
4) Maximize the presence of living roots

Details of each principle are as follows.



1) Minimize soil disturbance

- Maintain soil aggregates and help protecting soil particles from water and wind erosion

(Trainer: see additional information below)

- Enhance organic matter accumulation and slower decomposition
- Increase soil organism diversity and activity

2) Maximize soil cover (If you look in nature, there is no bare soil, it was invented by the humans)

- Protect soil surface from erosion
- Reduce impact of temperature fluctuation on plant and microorganisms
- Reduce evaporation rate and increase the amount of water entering the soil profile from precipitation and irrigation.
- Increase soil carbon sequestration

Additional information

Destabilized soil aggregates are easily broken into soil particles when they are hit with raindrops. The soil particles (look like dust) will pack and seal the surface of the soil, blocking water and air movement in the soil. With stable soil aggregates, there are spaces among them that retain moisture and keep water and air exchanges in the soil.

3) Maximize biodiversity

- Maintain the chain of food, energy, and water among different plants and other organisms
- Break disease cycles and provide habitat for pollinators

4) Maximize continuous living roots

- Rhizosphere is an area full of microorganism activities having exchanges of food, nutrients, and water between soil organisms and plants.

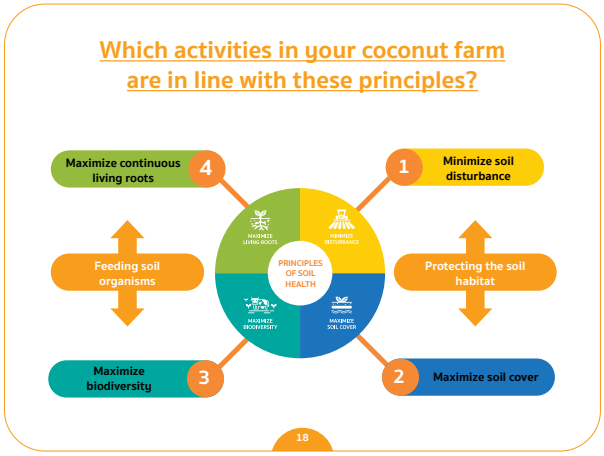
(Trainer: see additional information below)

Additional information

Plants and rhizosphere microorganisms interact. Plants provide root exudates (contain a variety of carbon compounds) and root debris, whereas the microorganisms' activities make nutrients available for plants, protect plants from pathogens, produce growth regulators for plants, etc. This generates food, energy, and water cycles in the soil. Varieties of circles from diverse microorganisms and plants result in healthy soil.

Key purpose of **principles 1 & 2** is to **protect the soil habitat.**

Key purpose of **principles 3 & 4** is to **feed soil organisms.**



Question from trainer: Which activities in your coconut farm are in line with these principles?

Then trainer discusses the answers with the participants how their activities comply with the principles.

Example of some possible answers from participants are shown in the table below

(There may be other answers; however, trainer should try to link the answers to the principles.)

Answers from participants	Principles
No chemical fertilizer, nor pesticide is applied. No burning weed is done. No heavy machine is used for soil preparation.	1. Minimize soil disturbance
Cover the soil with farm wastes, such as fallen leaves, cut grasses, etc. Grow cover crops	2. Maximize soil cover
Grow other crops between coconut trees or along the sides of the soil bunds	2. Maximize soil cover 3. Maximize biodiversity 4. Maximize continuous living roots

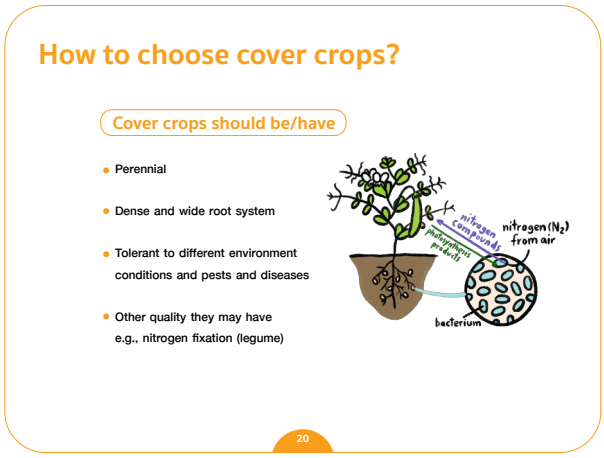
2.5 Good practices to improve soil health

Trainer says: we have talked about some examples of farm activities either disturb or maintain soil health. Now, let's see in more details some activities that can improve soil health in aromatic coconut farm.

2.5.1 Cover cropping

Cover cropping

A *cover crop* is a plant grown to prevent soil erosion, manage soil fertility, weeds, and pests. Depending on the type of cover crop, it can also have additional value like fixing nitrogen into the soil.



How to choose cover crops?

Cover crops should be/have:

- Perennial
- Dense and wide root system
- Tolerant to different environment conditions and pests and diseases
- Additional benefit, e.g., nitrogen fixation (legume)

Questions from trainer:

1. Do you grow any cover crops in your coconut farm?
2. Do you see any differences in the farm from before you grow cover crops?

Possible answers from participants:

Positive

- Less weeds in the field
- Watering frequency is reduced.

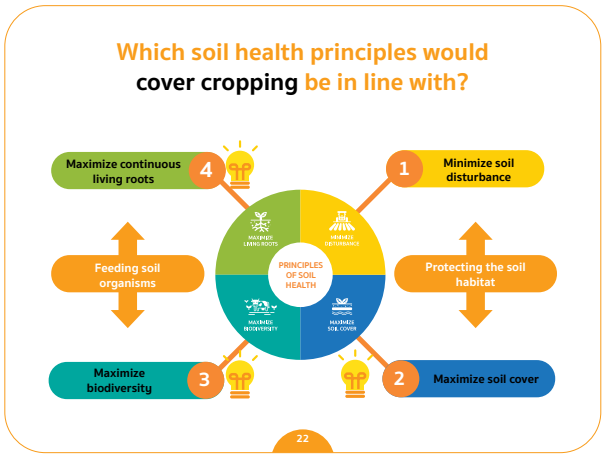
Negative

- Weeds outgrow the cover crop.
- The ground is untidy with overgrown cover crops; difficult to notice poisonous animals.

Trainer listens to the participants' answers, discuss with them, and might use them to ask the next questions.

For negative answers:

trainer should suggest some possible solutions, e.g., take out weeds before planting cover crops, choose suitable cover crop species for the coconut farming, prepare healthy propagules (seeds, seedlings, cuttings) in an adequate amount for the growing area and regularly take proper care.



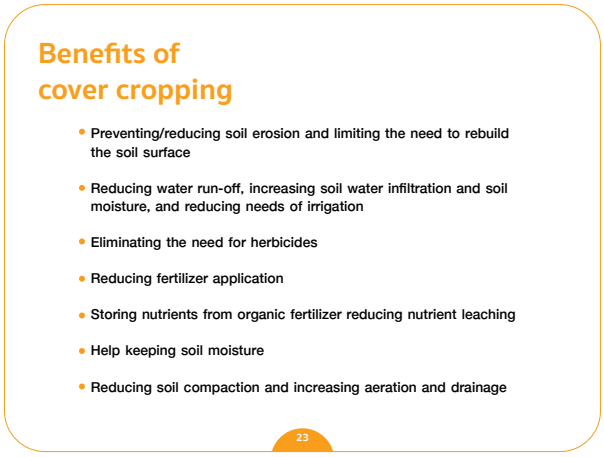
Question from trainer: Which soil health principles would cover cropping be in line with?

Possible answers from participants:

2. Maximize soil cover
3. Maximize biodiversity
4. Maximize continuous living roots

Reminding:

Do not forget to encourage the participants to exchange their ideas to each other and note down any questions to ask the owners of the farm during the study visit.



Benefits of cover cropping

- Preventing/reducing soil erosion and limiting the need to rebuild the soil surface
- Reducing water run-off, increasing soil water infiltration and soil moisture, reducing needs of irrigation
- Eliminating the need for herbicides
- Reducing fertilizer application
- Storing nutrients from organic fertilizer reducing nutrient leaching
- Help keeping soil moisture
- Reducing soil compaction and increasing aeration and drainage

Lessons learned by pilot farmers – Cover crops

• To grow cover crops successfully, it is highly recommended to grow cover crops at the beginning of the rainy season (May–July). This way you will need to water the seedlings less and they will expand by themselves easily. The ReCAP pilot farmers were able to cover their bunds completely within 6–8 months when they started to grow in the rainy season. If you grow them in the dry season, you can expect it to take up to 1 year.

• Before you grow cover crops, think about how fast you want your bunds to be covered with cover crops. The more seedlings you plant, the faster your bunds will likely be covered. This will also depend on how much you are willing to invest in the seedlings and the availability of your labor. Generally, it can be said, that the faster your bund is covered with cover crops, the faster you will reap its benefits (including less soil erosion, better soil quality and saving costs for weed control)

• Moisture is essential for growing cover crops. You can select a place to start growing the cover crops nearby the canals, as the soil is richer in moisture here.

• It is important to loosen the soil with a shovel gently before planting your cover crop seedlings, so that the seedlings can easily attach to the soil. Avoid using heavy machinery so that you are not accidentally harming the roots of the coconut trees.

• Even if you grow cover crops in the rainy season, if there is no rain, you will need to water them regularly: every day in the first week, afterwards 2-3 times a week.

If you want to grow cover crops in the dry season, you should keep the following in mind:

• Cover crops need a lot of water in the beginning. Water the seedlings/cuttings every day in the first week, afterwards 2–3 times per week.

• Protect the seedlings/cuttings from direct sunlight; you can do this by covering them with coconut leaves.

• You may consider creating a nursery first for the cover crop seedlings to improve the percentage rate of survival.

“Growing cover crops has cut my labor costs for weed control significantly and my farm is looking good now and is easy to take care of.”
- Jitisak

Lessons learned by pilot farmers – Cover crops

To show you what a difference cover crops can have on the quality of the soil on your farm, we took soil samples of a coconut farm in Ratchaburi that had areas covered with cover crops (for 3 years) as well as uncovered areas, and tested them for their organic matter content.

Sample 1: Soil with cover crops after 3 years

Soil organic matter: 4.05%

Sample 2: Uncovered/bare soil

Soil organic matter: 2.48%

As you can see, **by growing cover crops, you can expect the soil organic matter content of your soil to increase quite significantly.**

Cover crop examples

(★ A red star is given to cover crop species with nitrogen fixation providing additional benefits to soil health)

(1) Roundleaf bindweed

- Tolerant to drought, trampling. Soft texture.
- Can grow on several soil conditions, especially well-drainage soil.
- Shade-tolerant. Bigger leaves, longer internode than those grown under full sun whose leaves are smaller and denser.
- Cover area quickly, outgrow and suppress weeds.
- No need for trimming, require minimum care and water

Additional information

Roundleaf bindweed (*Evolvulus nummularius*, Family Convolvulaceae—morning glory family)

- Herbaceous, perennial plants; creeping with roots at nodes
- Leaf round shaped, about 1.5 cm long
- Flower cup-shaped, white petals, deeply loped, 7–8 cm in diameter
- Fruit globose, brown, 3–4 mm in diameter

Cultivation of roundleaf bindweed

- Plant roundleaf bindweed between two coconut trees, close to the water on the side of the bund
- Plant roundleaf cuttings or plants at 50×50 cm spacing (the plant is often sold as cuttings in 2" plastic nursery bags. Use 4 bags/sq. m)
- Takes 4 months to cover the bund
- Cost: 6–8 THB/2" bag of ~5 roundleaf cuttings. Around 15,360–20,480 THB/rai (640 sq. m)
- It is recommended to plant in the beginning of rainy season to ensure the maximum survival rate and reduce farmer's work to water the cover crop daily.

Lessons learned by pilot farmers – Roundleaf bindweed

Depending on how fast you want your farm to be covered with roundleaf will determine how many seedlings you will need to plant:

Planting seedlings or cuttings (sold in 2" bags or seedling plug trays)

- If you want 25% of your bund to be covered after 6–8 months, you will need to use 1 bag or 1 plug per sq. m or 640 bags or plugs per rai (640 sq. m growing area).
- If you want 50% of your bund to be covered after 6–8 months, you will need to use 2 bags or 2 plugs per sq. m or 1,280 bags or plugs per rai.
- If you want 75% of your bund to be covered after 6–8 months, you will need to use 3 bags or 3 plugs per sq. m or 1,920 bags or plugs per rai.
- If you want 100% of your bund to be covered after 6–8 months, you will need to use 4 bags or 4 plugs per sq. m or 2,560 bags or plugs per rai.

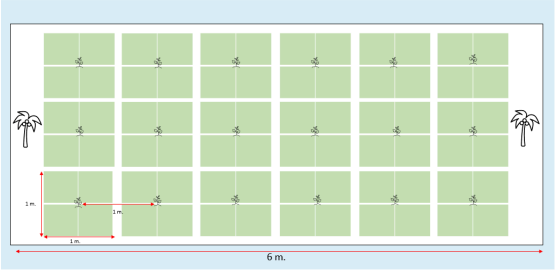
Planting bare-root plants (sold in 10-kg bags of roundleaf patches)

- If you want 25% of your bund to be covered after 6–8 months, you will need to use 1 clump per sq. m or 640 clumps (~10 kg) per rai (640 sq. m growing area).
- If you want 50% of your bund to be covered after 6–8 months, you will need to use 2 clumps per sq. m or 1,280 clumps (~20 kg) per rai.
- If you want 75% of your bund to be covered after 6–8 months, you will need to use 3 clumps per sq. m or 1,920 clumps (~30 kg) per rai.
- If you want 100% of your bund to be covered after 6–8 months, you will need to use 4 clumps per sq. m or 2,560 clumps (~40 kg) per rai.

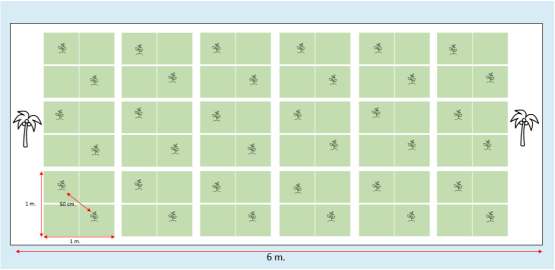
Growing bare-root roundleaf:

- Cut the roundleaf patch into clumps (25–30 cm in diameter) in the morning for planting.
- If you are not transplanting them on the same day, spray the fresh roundleaf clumps with water 1–2 times per day to keep them moist. Keep in mind to transplant the clumps within 3 days.
- Loosen the soil gently and place the roundleaf clumps on the soil 1 meter apart from another.
- Place soil in the middle of the clumps.
- Don't forget to protect the roundleaf from direct sunlight and rain with coconut leaves.

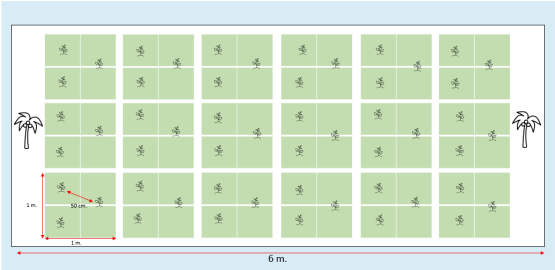
Planting roundleaf for 25% coverage



Planting roundleaf for 50% coverage



Planting roundleaf for 75% coverage



Planting roundleaf for 100% coverage

Cover crop examples

② **Pinto peanut**

- Creeping cover the ground well; about 10 cm tall with yellow flowers
- Roots symbiosis with certain soil bacteria that form root nodules and fix atmospheric nitrogen

30

(2) Pinto peanut

- Creeping cover the ground well; about 10 cm tall with yellow flowers
- Taproot with dense branching lateral roots
- Roots symbiosis with certain soil bacteria that form root nodules and fix atmospheric nitrogen
- Needs sun. Can be implemented in farms with mostly only young coconuts trees or in areas with sufficient sun exposure

Additional information

Pinto peanut, Brazilian peanut (*Arachis pintoi*, family Fabaceae or Leguminosae—pea family)

- Herbaceous, perennial plants; 10–15 cm tall, spreads by rhizomes and creeping stolons, roots at nodes to form a dense mat, roots up to 20 cm long; pinnately compound leaf with 4 oval leaflets, leaves may shed during extended dry periods
- Flower pea-shaped, yellow petals; after pollinated, flower stalks elongate and grow down into the soil up to 7 cm in depth
- Fruiting underground; fruit one-seeded pod, 1–1.5 cm long, 6–8 mm in diameter
- Flowering/fruiting year-round, but more during August–September

Cultivation of pinto peanut

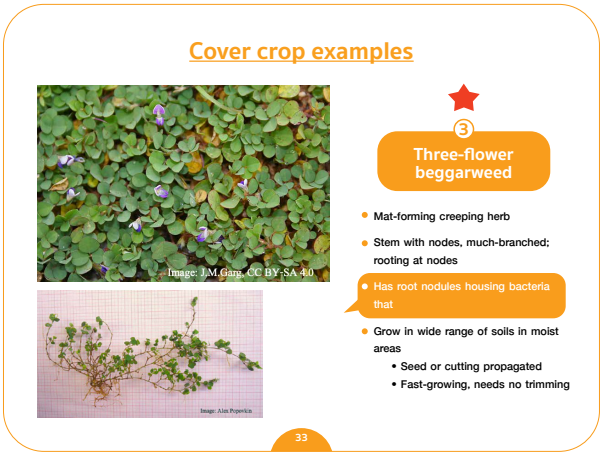
- Weed the bund
- Plant pinto peanut from cuttings or seeds (~70–80% germination rate) at 50×50 cm spacing (4 cuttings/sq. m)
- Water every day during the first 2 weeks, then every other day, and once a month after 2–3 months old
- Weed the bund every week for a month, then every 2 months
- Takes 6 months to cover the bund. Trim 3 times/year with a brush cutter or lawn mower
- Seeds can be collected at ~8 months old
- Cost 1 THB/plant in 2" bag– 2,560 THB/rai
~200 THB/kilogram of seeds

Lessons learned by pilot farmers – Pinto peanut

Depending on how fast you want your farm to be covered with pinto peanut will determine how many seedlings you will need to plant:

Planting seedlings (sold in 2" bags or seedling plug trays)

- If you want 25% of your bund to be covered after 6–8 months, you will need to use 1 bag or 1 plug per sq. m or 640 bags or plugs per rai (640 sq. m growing area).
- If you want 50% of your bund to be covered after 6–8 months, you will need to use 2 bags or 2 plugs per sq. m or 1,280 bags or plugs per rai.
- If you want 75% of your bund to be covered after 6–8 months, you will need to use 3 bags or 3 plugs per sq. m or 1,920 bags or plugs per rai.
- If you want 100% of your bund to be covered after 6-8 months, you will need to use 4 bags or 4 plugs per sq. m or 2,560 bags or plugs per rai.



(3) Three-flower beggarweed

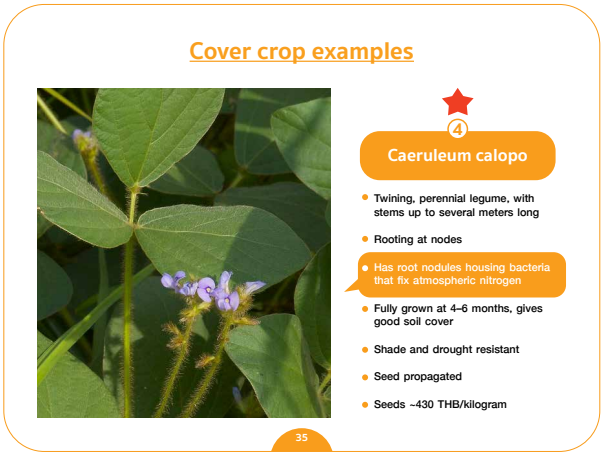
- Mat-forming creeping herb in legume family
- Stem with nodes, much-branched; rooting at nodes
- Has root nodules housing bacteria that fix atmospheric nitrogen
- Grow in wide range of soils in moist areas
- Seed or cutting propagated
- Fast-growing, needs no trimming

Lessons learned by pilot farmers – Three-flower beggarweed

Depending on how fast you want your farm to be covered with three-flower beggarweed will determine how many seedlings you will need to plant:

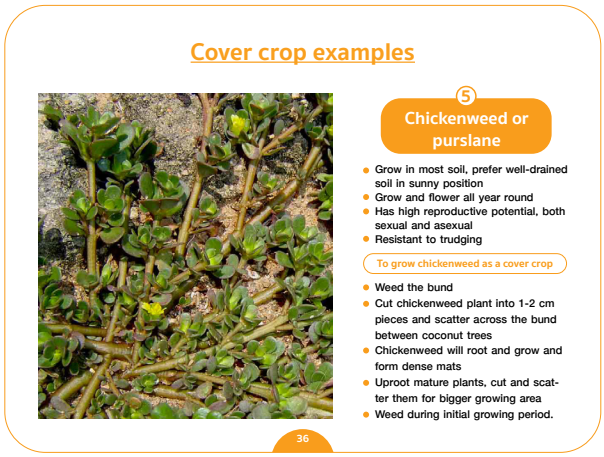
Planting seedlings (sold in 2" bags)

- If you want 25% of your bund to be covered after 6–8 months, you will need to use 4 bags per sq. m or 2,560 bags per rai (640 sqm growing area).
- If you want 50% of your bund to be covered after 6–8 months, you will need to use 8 bags per sq. m or 5,120 bags per rai.
- If you want 75% of your bund to be covered after 6–8 months, you will need to use 12 bags per sq. m or 7,680 bags per rai.
- If you want 100% of your bund to be covered after 6–8 months, you will need to use 16 bags per sq. m or 10,240 bags per rai.



(4) Caeruleum calopo

- Twining, perennial legume, with stems up to several meters long
- Rooting at nodes, dense fibrous roots hold onto soil
- Has root nodules housing bacteria that fix atmospheric nitrogen
- Fully grown at 4–6 months, gives good soil cover
- Shade and drought resistant
- Seed propagated
- Seeds ~430 THB/kilogram

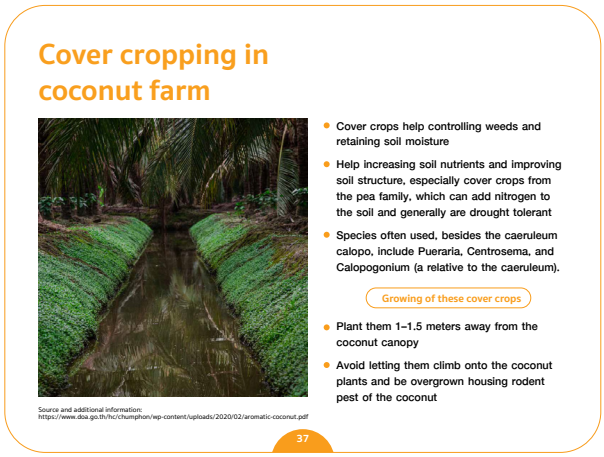


(5) Chickenweed or purslane

- Grow in most soil, prefer well-drained soil in sunny position
- Grow and flower all year round
- Has high reproductive potential, both sexual and asexual
- Resistant to trudging

Cultivation

- Weed the bund
- Cut chickenweed plant into 1–2 cm pieces and scatter across the bund between coconut trees
- Chickenweed will root and grow and form dense mats
- Uproot mature plants, cut and scatter them for bigger growing area
- Weed during initial growing period



Cover cropping in coconut farm

- Cover crops help controlling weeds and retaining soil moisture
- Help increasing soil nutrients and improving soil structure, especially cover crops from the pea family, which can add nitrogen to the soil and generally are drought tolerant
- Species often used, besides the caeruleum calopo, include *Pueraria*, *Centrosema*, and *Calopogonium* (a relative to the caeruleum).

Growing of these cover crops:

- Plant them 1–1.5 meters away from the coconut canopy
- Avoid letting them climb onto the coconut plants and be overgrown housing rodent pest of the coconut

Additional information

1. Academic publication on “weed control in fruit and perennial orchards by using cover crops” by the Department of Agricultural Extension is available at

or *http://www.ptlw.ac.th/schoolnet/agri/job205/topic2.htm*

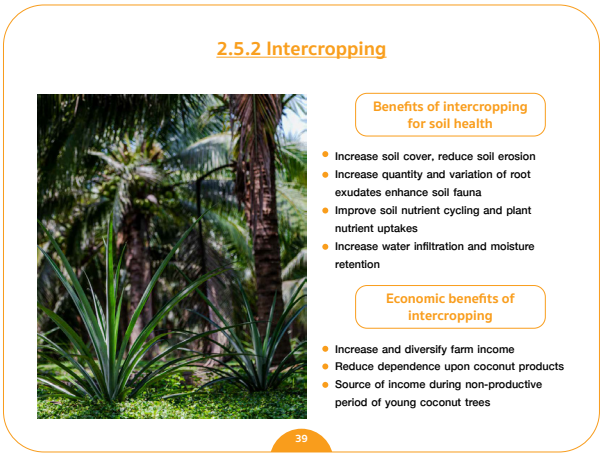
2. Topic “Farm Maintenance” in an academic publication under the title of “Knowledge Management on Coconut Production Technology” (in Thai) by Horticulture Research Institute, Department of Agriculture is available at

or *https://www.doa.go.th/hc/chumphon/wp-content/uploads/2020/02/aromatic-coconut.pdf*

2.5.2 Intercropping

Intercropping

The practice of growing two or more crops together in the same row or in rows in a beneficial manner and for efficient use of light, nutrients, and water.



Benefits of intercropping for soil health

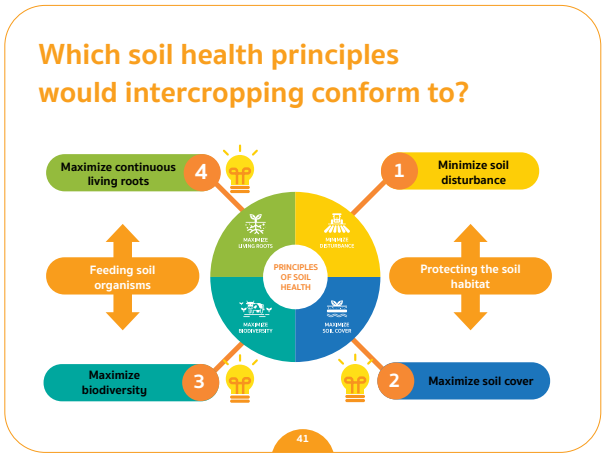
- Increase soil cover, reduce soil erosion
- Increase quantity and variation of root exudates to enhance soil fauna
- Improve soil nutrient cycling and uptake of plant nutrient
- Increase water infiltration and moisture retention

Economic benefits of intercropping

- Increase and diversify farm income
- Reduce dependence upon coconut products
- Source of income during non-productive period of young coconut trees

Trainer shows the picture of the 4 soil health principles and let the participants answer the question.

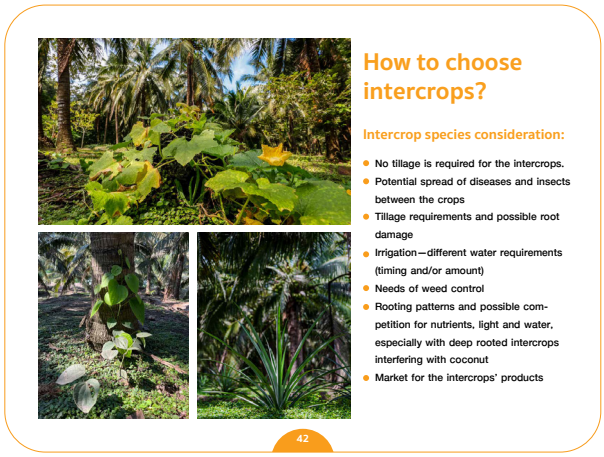
Question from trainer: Which soil health principles would intercropping conform to?



Possible answers from participants:

2. Maximize soil cover
3. Maximize biodiversity
4. Maximize continuous living roots

Trainer discusses with the participants how intercropping serves the principles.



How to choose intercrops?

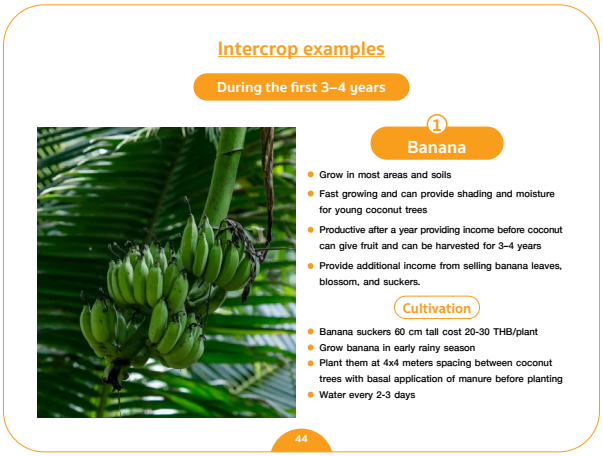
Significant points for consideration:

- No tillage is required for the intercrops as the tillage could damage coconut roots.
- Potential spread of diseases and insects between the crops
- Irrigation—different water requirements (timing and/or amount).
- Needs of weed control
- Rooting patterns and possible competition for nutrients, light, and water, especially with deep rooted intercrops interfering with coconut
- Market for the intercrops' products

Intercropping in coconut farm during immature, non-productive stage of coconut (the first 3–4 years)

- Coconut trees are small. Most of the land between coconut trees is available.

- Short-lived plants or small trees, which prefer full sun, e.g., vegetables, banana, guava, etc.



Intercrop examples: For coconut at immature stage (the first 3–4 years)

(1) Banana

- Banana suckers cost 20–30 THB/plant

- Grow in most areas and soils

- Fast growing and can provide shading and moisture for young coconut trees

- Productive after a year and can be harvested for 3–4 years

- Can provide additional income from selling of banana leaves, blossom, and suckers.

Cultivation

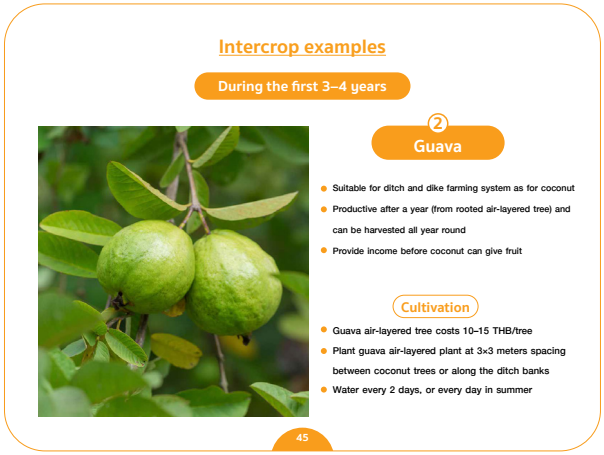
- Grow banana in early rainy season

- Plant them at 4x4 meters spacing between coconut trees with basal application of manure before planting

- Water every 2–3 days

Limitation

- Once become old, the big banana clump may be difficult to remove

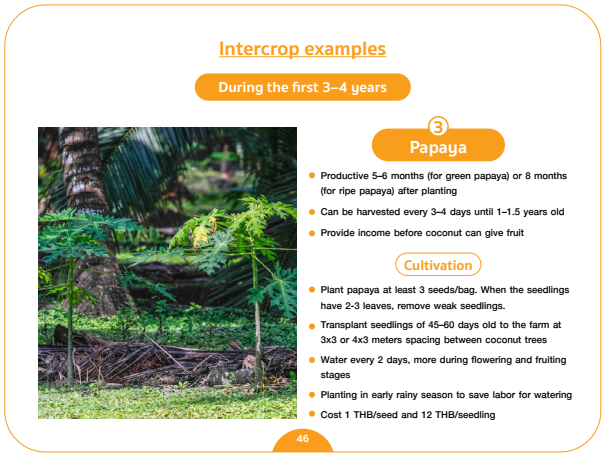


(2) Guava

- Guava air-layered tree costs 10–15 THB/tree
- Suitable for ditch and dike farming system as for coconut
- Productive after a year (from tree propagated by air-layering) and can be harvested all year round
- Provide income before coconut can give fruit

Cultivation

- Plant guava air-layered plant at 3x3 meters spacing between coconut trees or along the ditch banks
- Water every 2 days, or every day in summer

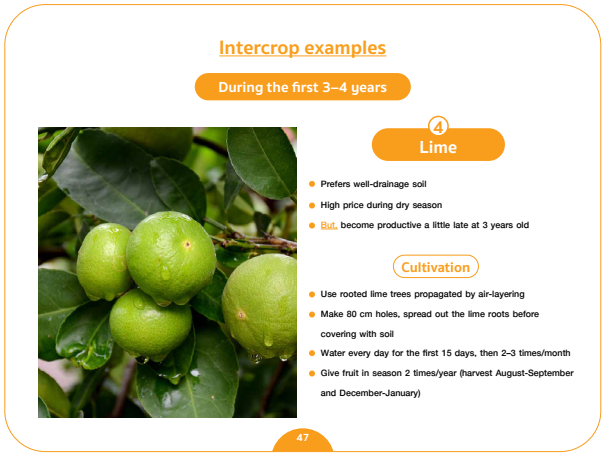


(3) Papaya

- Productive 5–6 months (for green papaya) or 8 months (for ripe papaya) after planting
- Can be harvested every 3–4 days until 1–1.5 years old
- Provide income before coconut can give fruit

Cultivation

- Plant papaya at least 3 seeds/bag. When the seedlings have 2-3 leaves, remove weak seedlings.
- Transplant seedlings of 45–60 days old to the farm at 3×3 or 4×3 meters spacing between coconut trees
- Water every 2 days, more during flowering and fruiting stages
- Planting in early rainy season to save labor for watering
- Cost 1 THB/seed and 12 THB/seedling

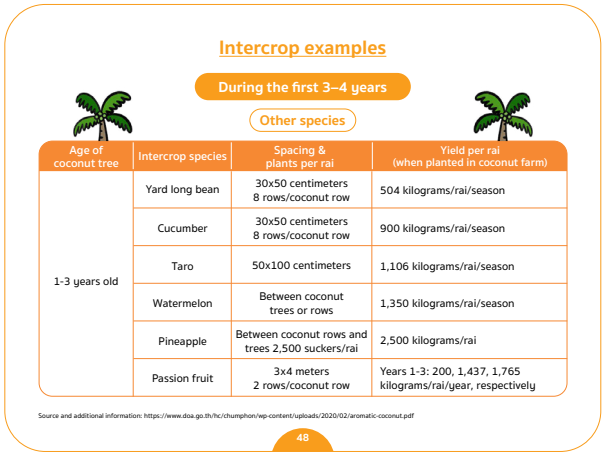


(4) Lime

- Prefers well-drained soil
- High price during dry season
- But, become productive a little late at 3 years old

Cultivation

- Use rooted lime trees propagated by air-layering
- Make 80 cm holes, spread out the lime roots before covering with soil
- Water every day for the first 15 days, then 2–3 times/month
- Give fruit in season 2 times/year (harvest August–September and December–January)



Intercrop examples

During the first 3–4 years

Other species

Age of coconut tree	Intercrop species	Spacing & plants per rai	Yield per rai (when planted in coconut farm)
1-3 years old	Yard long bean	30x50 centimeters 8 rows/coconut row	504 kilograms/rai/season
	Cucumber	30x50 centimeters 8 rows/coconut row	900 kilograms/rai/season
	Taro	50x100 centimeters	1,106 kilograms/rai/season
	Watermelon	Between coconut trees or rows	1,350 kilograms/rai/season
	Pineapple	Between coconut rows and trees 2,500 suckers/rai	2,500 kilograms/rai
	Passion fruit	3x4 meters 2 rows/coconut row	Years 1-3: 200, 1,437, 1,765 kilograms/rai/year, respectively

Source and additional information: https://www.doa.go.th/hc/chumphon/wp-content/uploads/2020/02/aromatic-coconut.pdf

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Other species

Horticulture Research Institute provides information on other intercrop species, plant spacing, plants per rai, and yield per rai, when planted in coconut farm.

Additional information

Academic publication "Knowledge Management on Coconut Production Technology" (in Thai) by Horticulture Research Institute, Department of Agriculture (page 58) is available at

or

https://www.doa.go.th/hc/chumphon/wp-content/uploads/2020/02/aromatic-coconut.pdf

2.5.2 Intercropping

During mature, productive period (4–12 years old)

- Coconut leaves are fully expanded shading the ground. At 4–8 years old, coconut trees are relatively short, not much height under the canopy.
- Short-lived or small plants, which thrive under shade, that would not obstruct coconut harvest, e.g., pandan, wild betel leaf, etc.

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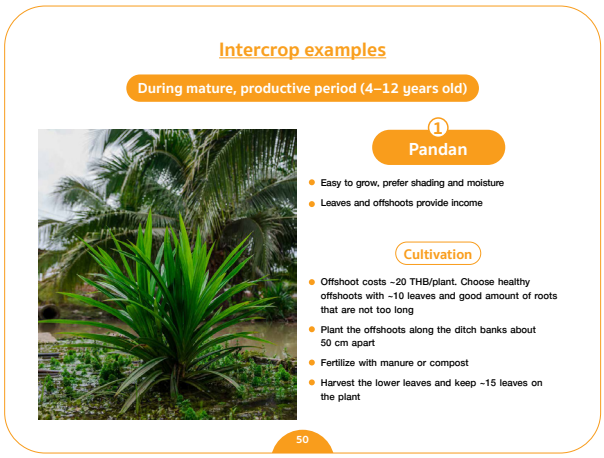
Intercropping in coconut farm during coconut mature, productive period (4–12 years old)

- At this stage, coconut leaves are fully expanded shading most of the ground. At 4-8 years old, coconut trees are relatively short, not much height under the canopy.

- Short-lived or small plants, which thrive under shade that would not obstruct coconut harvest, e.g., pandan, betel, etc.



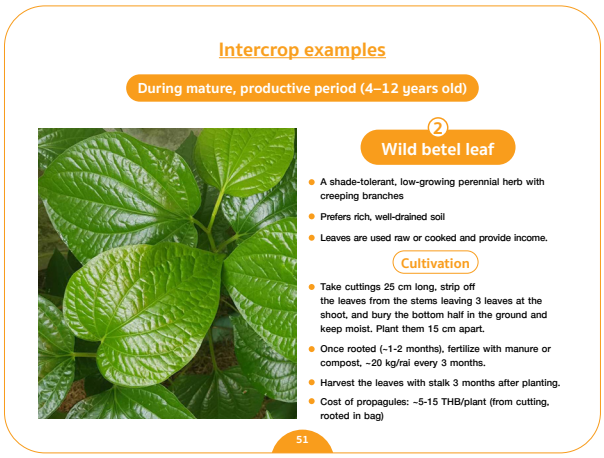
Intercrop examples: For coconut in mature and productive period (4–12 years old)

(1) Pandan

- Easy to grow, prefer shading and moisture
- Leaves and offshoots provide income

Cultivation

- Offshoot costs ~20 THB/plant. Choose healthy offshoots with ~10 leaves and a good number of roots that are not too long
- Plant the offshoots along the ditch banks about 50 cm apart
- Fertilize with manure or compost
- Harvest the lower leaves and keep ~15 leaves on the plant

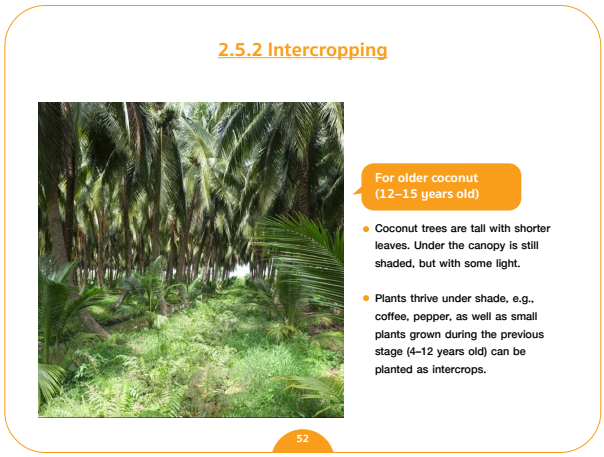


(2) Wild betel leaf

- A shade-tolerant, low-growing perennial herb with creeping branches
- Prefers rich, well-drained soil
- Leaves are used raw or cooked and provide income.

Cultivation

- Take cuttings 25 cm long, strip off the leaves from the stems leaving 3 leaves at the shoot, and bury the bottom half in the ground and keep moist. Plant them 15 cm apart.
- Once rooted (~1–2 months), fertilize with manure or compost, ~20 kg/rai every 3 months.
- Harvest the leaves with stalk 3 months after planting.
- Cost of propagules: ~5–15 THB/plant (from cutting, rooted in bag)



Intercropping in coconut farm for older coconut (12-15 years old)

- Coconut trees are tall with shorter leaves. Under the canopy is still shaded, but with some light.

- Plants thrive under shade, e.g., coffee, pepper, as well as small plants grown during the previous stage (4–12 years old) can be planted as intercrops.

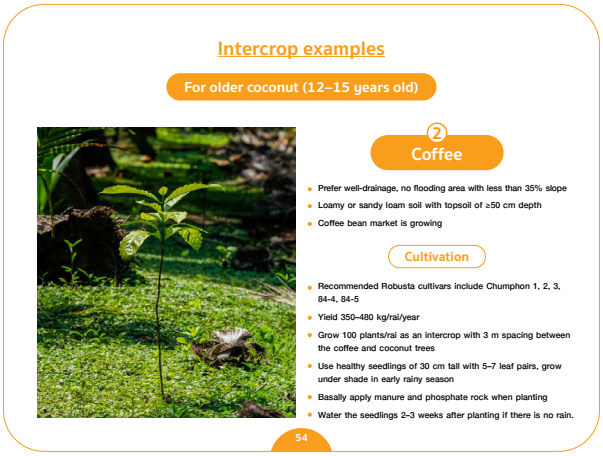
Intercrop examples: For older coconut (12-15 years old)

(1) Vegetable fern

- Known for edible young shoots
- Prefer 60–80% shading, moist soil, high humidity
- Suitable for farm with old and tall coconut trees, where shade and moisture are available
- Become productive 6 months after planting

Cultivation of Vegetable fern

- Shallow plowing the soil in the middle of the bund, mixing with coconut coir as a planting material
- Plant the vegetable fern rhizomes in rows at 30×50 or 50×50 cm for 4 rows
- Water 2 times/day for the first month, then every 2–3 days, and weed the bund
- No fertilizer needed
- Young shoot can be harvested every 2 days 6 months after planting
- Trim old fronds to promote new shoots
- Cost: 2–5 THB/fern rhizome
- Shoots are priced ~25–30 THB/kg



(2) Coffee

- Prefer well-drainage, no flooding area with less than 35% slope
- Loamy or sandy loam soil with topsoil of ≥50 cm depth
- Coffee bean market is growing

Cultivation

- Recommended Robusta cultivars: Chumphon 1, 2, 3, 84-4, 84-5
- As a single crop, yield 350–480 kg/rai/year
- Grow 100 plants/rai as an intercrop with 3 m spacing between the coffee and coconut trees
- Use healthy seedlings of 30 cm tall with 5–7 leaf pairs, grow under shade in early rainy season
- Basally apply manure and phosphate rock when planting
- Water the seedlings 2–3 weeks after planting if there is no rain.

Lessons learned by pilot farmers – Intercrops

• The most important success factors of growing intercrops on your farm are based on the conditions of your farm (age of coconut trees, space between coconut trees, light, soil pH etc.) and on the time availability of your labor force

• It is recommended to test a few plants first before implementing them on the entire farm. You can also check with your neighboring farms what they are growing.

• When deciding on what intercrops to grow, think also about the different harvesting periods of each intercrop. By growing a variety of intercrops, you can have an income from them all year round.

• Prepare the soil well in order to achieve the best results (depending on the intercrops: size of hole to dig, distance between the plants)

• Keep the seedlings in a nursery until they are ready to be transplanted.

• Grow the plants between the coconut trees, either in the middle of the bund or in parallel.

• Add compost directly after planting to nourish the seedlings.

• For most seedlings, you will need to water them every day in the beginning.

• Protect the seedlings from direct sunlight and keep in the shade.

• Especially in the beginning, your need to pay attention to the growth, health, and possible diseases.

• For organic farms, you must use certified seedlings only or those approved by your certification body. This is very important!

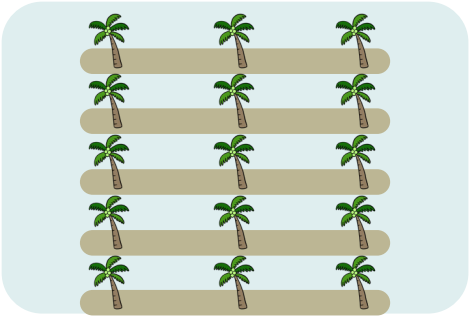
"There is an increasing market for organic products, so by growing other intercrops I can increase my income sources. Besides, I look forward to tasting the new products that my farm can grow!" - Bandit

Lessons learned by pilot farmers – Closing the canals

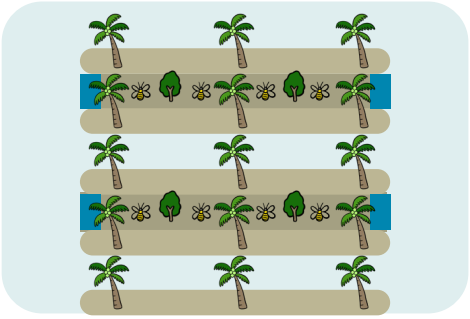
To increase the space on your farm to grow intercrops and other plants, you may think about closing some of your canals.

Benefits of closing canals include:

- Allow more space for the roots of your coconut trees to grow.
- More space to grow intercrops, cover crops and keeping bees.
- Save labor costs from dredging the mud out of canals
- Reduce cost of draining and adding water into the farm, which is done 1–2 times/week in the dry season, as less water is needed.
- Decrease methane emissions due to anaerobic fermentation
- Reduce bad smell and mosquitos



Before



After

General Guidance:

- If you want to close a canal, it is recommended to close the canals during the dry season (March–May).
- If the bunds have different heights, start with the higher ones because then it is easier to control the water level.
- Better results are achieved when closing the canals with a backhoe instead of manual labor, because the soil will be packed becoming difficult for rats, eels and crabs to dig.
- It takes around 8 hours per rai to close the canals completely with a backhoe and costs around 3,600 THB/day.
- After closing the canal, you can deposit your farm waste into the closed canal.
- To avoid waterlogging and thus the release of methane emissions, there should be enough waste (leaves/nuts/trees) to close the canal completely. There should be no water in the canal, only soil and coconut waste.
- It has taken the pilot farmers in total 7–10 years to close a canal completely to grow other plants.

"After closing the canal, I can save the cost for watering at my farm by approximately 30%."
- Chaichana

Additional information

on intercropping is available at:

1. Academic publication "Knowledge Management on Coconut Production Technology" (in Thai) by Horticulture Research Institute, Department of Agriculture is available at

or *https://www.doa.go.th/hc/chumphon/wp-content/uploads/2020/02/aromatic-coconut.pdf*

2. Pamphlet # 5/2560 Intercropping and Activities for Additional Income in Rubber Tree Farm (in Thai). Published by Rubber Tree and Palm Oil Promotion Group, Bureau of Agricultural Commodities Promotion and Management, Department of Agriculture Extension. Available at

or *https://esc.doae.go.th/wp-content/uploads/2018/11/leaflet_05_Page_2.pdf*

2.5.3 Organic mulching

2.5.3 Organic mulching

Cover soil 2 m around the tree with chopped fallen leaves, cut weeds, or other plant residues

- Reduce evaporation, retain soil moisture
- Limit soil erosion
- Maintain proper soil temperature for the growth of plant and soil microorganisms
- Improve soil condition by the decomposition of organic matters
- Limit weed growth
- Make use of plant residues without cost

Summary

In this module we have talked about some important basics on soil health including:

Soil: A living ecosystem, think of soil as a living thing

Soil health: the capacity of soil to function as a living ecosystem that sustains plants, animals, and human lives.

Summary and closing

Like any other crops growing in the ground, aromatic coconut uses soil for root habitation, to support the tree, as source of water and nutrients for the growth and fruit production we look for. Soil health is thus very important. Effects of farm activities on soil health have to be considered. Activities that conform to any of the four soil health principles we discussed would help maintain and improve soil health. Activities that are against the principles should be avoided.

The four soil health principles include:

1) Minimize soil disturbance
2) Maximize soil cover
3) Maximize biodiversity
4) Maximize the presence of living roots

Summary

The two practices we discussed in detail in this module, **cover cropping and intercropping**, conform well to the soil health principles because they help:

- Reduce soil erosion
- Conserve soil moisture
- Improve soil health
- Reduce cost
- Increase income

Open to farmers' questions

Questions

1. Which practice(s) will you adopt to implement in your aromatic coconut farm?
2. How do those practices benefit soil health?

B. STUDY VISITS

Trainer provides a brief introduction of the places to the participants ahead of the visits. Trainer leads the participants in study visits introducing them to the guest trainer, the owner of the places to visit, and let them learn from the actual condition with the guest trainer.

Trainer: encourage the participants to observe and ask the guest trainer

Some interesting questions to be asked during the visits:

For a study visit to coconut farm with cover cropping:

1. Sources and cost of cover crop materials
2. Planting spacing, number of trees/an area and plant care
3. Benefits of cover cropping: yield increase, weed control, watering?
4. Limitations

For a study visit to coconut farm with intercropping:

1. Sources and cost of intercrop materials
2. Planting spacing, number of trees/an area and plant care
3. Cost of cultivation and maintenance of intercrop
4. Selling, marketing, incomes of/from the intercrops
5. Effect of intercropping on coconut yield

Module 3

ORGANIC FERTILIZER

OBJECTIVES

To understand the importance of organic fertilizer, principles, and methods of making your own organic fertilizer, and application methods of organic fertilizer in organic production of aromatic coconut.

ACQUIRED KNOWLEDGE

The participants understand:

1. Basic needs for plant nutrients and different types of organic fertilizer
2. Principles of organic fertilizer production
3. Application of organic fertilizer for aromatic coconut corresponding to the regulation of United States Department of Agriculture (USDA) organic production

ACQUIRED SKILLS

The participants can produce:

1. Their own compost from plant residues and farmyard manure
2. Vermicompost
3. Compost tea

ACQUIRED ATTITUDES

The participants realize the importance of orchard nutrient management for organic production of aromatic coconut, and learn how to upcycle orchard plant residues to make compost.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Appropriate uses of organic fertilizer can improve soil fertility, soil structure and orchard soil productivity, which are the key factors for successful organic production of aromatic coconut. Growers are able to make their own organic fertilizer from orchard plant residues, which can recycle nutrients back to the soil and reduce the amount of organic materials to be brought into the orchard.

METHODS

1. PowerPoint presentation lecture for 60 minutes
2. Study visit, demonstration, hands on practices and discussion for 300 minutes

TRAINING SUPPLIES, TOOLS, AND MATERIALS

Lecture:

1. PowerPoint (PPT) presentation
2. A notebook computer with PPT program
3. An LCD projector and a screen or smart TV
4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and guide questions and issues to be discussed in Module 3
5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 3, a survey form regarding organic fertilizer utilization in the orchard, and guide questions for the study visit and demonstration, as well as blank pages for taking notes.

Practice/demonstration/ study visit:

In this module, demonstration and practices of making your own organic fertilizer such as compost of plant residues and vermicompost are provided. The study visits of a successful orchard producing organic aromatic coconut is included for better understanding of nutrient management (best practices).

Resource persons and potential trainers to provide knowledge and lead the demonstration and practices in each topic should be contacted one month in advance. Also, scheduling for date, time and places, transportation, payment for the invited trainers and cost of materials to be used in demonstration and practices should be determined in advance. In case that the invited trainers or resource person cannot give a lecture, trainers of the project should assist for concluding the key content and asking questions for clarity. Guide questions regarding key points of the study visit should be prepared in advance and included in the Handbook for Farmers.

DURATION

B. Lecture Topics	Period (min)
1. Importance of organic fertilizer	15
2. Principles and methods of making organic fertilizers	30
3. Application of organic fertilizers to aromatic coconut production	15
Total time of lecture	**60**
C. Hands-on Practices	
1. Practice: making compost	90
2. Practice: making vermicompost	90
3. Field trip: producing and applying compost	115
4. Summary and closing	5
Total time of hands-on practices	**300 (5 h)**
Total time of training in Module 3	**360 (6 h)**

KEY MESSAGES

1. Application of organic fertilizer can maintain soil fertility which is a key factor in regenerative production of aromatic coconut.

2. Organic fertilizer is a source of plant nutrients and organic matter. It will improve soil structure and soil biological activities as well as increase soil porosity and moisture holding capacity leading to better soil health.

3. There are varieties of organic fertilizer each of which contains different amount of plant nutrients. Releasing of nutrients from organic fertilizer by microbial decomposition process is relatively slow. Therefore, organic fertilizer is typically applied ahead of the time when crop nutrient requiring is high. Organic fertilizer or the raw materials for making organic fertilizer must be gathered in advance and the supply must be from the sources approved by the authority in charge of USDA organic production regulation.

4. Application of organic fertilizer at the right amount, place and time will provide a good plant growth, productivity, and high-quality products.

5. Organic fertilizer will not only feed the plants but improve soil quality and ecosystem for long term productivity.

A. LECTURE

Get the Attention

Like other plants, an aromatic coconut will grow well with high productivity if it gets enough to eat. Fertilizer is like food for plant.

For organic production, chemical fertilizer is not allowed; only organic fertilizer can be applied. In this topic, we will focus on organic fertilizer and follow the USDA Guide for Organic Crop Producers.

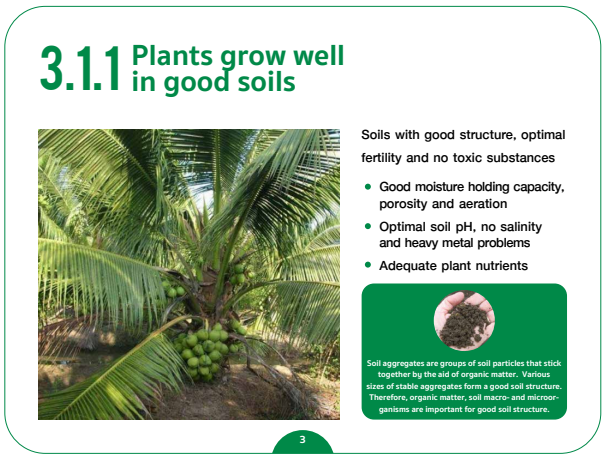
→ See Page 76 in the Handbook for Farmers

3.1 Importance of organic fertilizer

Application of fertilizer to a farm soil is routinely practiced in aromatic coconut production aiming to provide nutrients or plant food and to ensure high yield. Farming at present tend to apply larger amount of fertilizer than that in the past. Poor growth and low yield can be expected when fertilization is neglected.

Question from trainer: What fertilizer do you use in your farm? How much fertilizer do you apply? Are you satisfied with the result?

Possible answers from participants: Plant food is either soil, water, minerals, salts, manure, plant or animal debris, etc. The various answers will reveal the background knowledge of the participants regarding the plant nutrition.



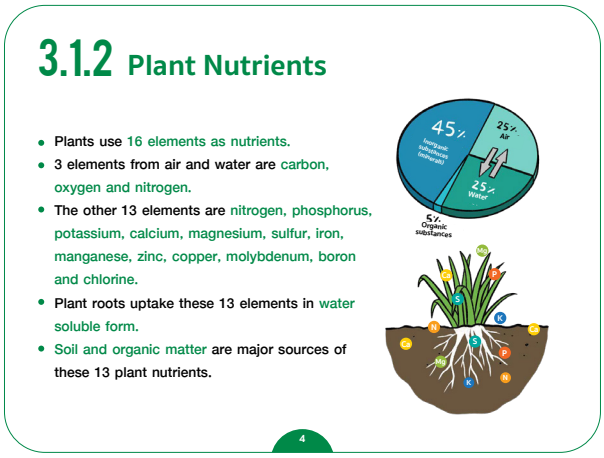
3.1.1 What is a good soil?

As well all know, plants grow well in good soils. Let's start with what a good soil is.

A good soil is a soil with good and stable structure which has optimal porosity to hold enough moisture and allow excess water to drain out. It should have the optimal soil pH, no salinity, and not contain heavy metals or any toxic substances. Additionally, **it should be fertile or can provide enough plant food.**

Additional information

Soil aggregates are groups of soil particles which are bound together by the aid of organic matter as a cementing agent. Aggregates of various sizes provide soil porosity or create soil structure. Soils lacking organic matter tend to be compacted and too wet. Plants cannot grow well in such soils even though they have high fertility. **A good soil must be alive.** It composes of living plant roots and other living creatures such as insects, earthworms and microorganisms all of which involve in decomposition process of plant and animal debris in soil that provides soil organic matter and plant nutrients.



3.1.2 Plant food

Plant food is elements which a plant can take up from the environment. These elements are called **'plant (mineral) nutrients.' There are 16 plant nutrients:**

The first three nutrients are carbon, hydrogen and oxygen, readily available in carbon dioxide gas and water. The other 13 nutrients are nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum and chlorine, available in the farm soils, soil organic matter, chemical fertilizer or organic fertilizer. **A plant root takes these 13 nutrients from the soil in a water-soluble form.**

An aromatic coconut tree grows continuously. It produces a new frond and an inflorescence almost every month. Therefore, it requires continuous supply of plant nutrients.

Additional information

Plant roots take up nutrients in water soluble form. Therefore, we cannot see what plant roots really take up. It is important to note that plant roots cannot directly take up food as small particles of chemical fertilizer, soil, manure or straw in compost.

In the provinces famous for aromatic coconut production located in the delta areas not far from the gulf of Thailand, certain geographical conditions are suitable including alluvial sediment with fine texture and high fertility, all year-round water supply with influence of blackish water in certain period of the year. However, most of plant nutrients in orchard soils are in unavailable forms (or reserve forms) and cannot be used readily. Upon the breakdown of soil and decomposition of soil organic matter, plant nutrients are gradually released. Therefore, available nutrients in water soluble forms present in much less proportion as compared to those in unavailable forms.

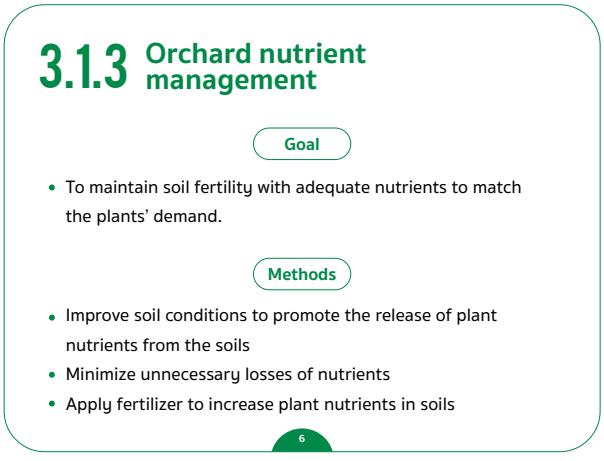
In other regions with different soil characteristics and climatic conditions, orchard soils may not be as fertile as those in aromatic coconut provinces. Low soil fertility is often associated with severe leaching of plant nutrients from the soils, low organic matter and available nutrient content of the soils or tightly bound plant nutrients due to improper soil pH (too acidic or too alkaline). In such regions, proper soil and nutrient management is needed for successful organic production of aromatic coconut.

A coconut tree looks abnormal when it does not get enough nutrients. When soil fertility is low, a plant does not get enough nutrients. Its growth is reduced. Its yield is low and has poor fruit quality. It shows nutrient deficiency symptoms such as leaf yellowing (chlorosis), scorch of leaf margins, leaf wrinkling and sharply bent leaflet tips as well as fruit cracking.

(From left to right) A leaf shows potassium deficiency symptom with leaf scorching. Leaf chlorosis due to nitrogen deficiency. Wrinkling and abnormal leaf expansion of the top leaf due to boron deficiency. Cracking of fruit and shell, abnormal fruit due to boron deficiency.

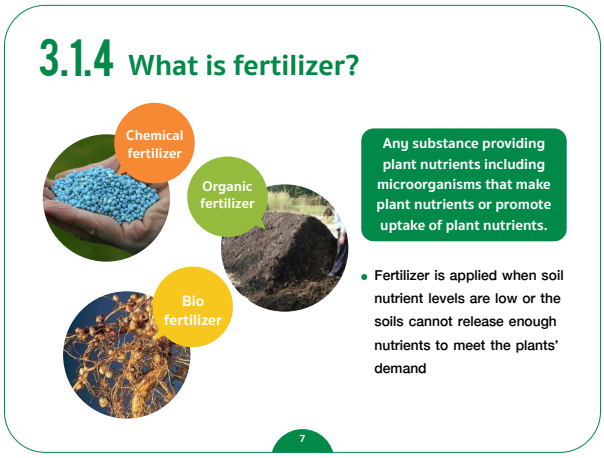
Additional information

For aromatic coconut (perennial tree crop), the tree can use its reserve nutrients stored in different parts of the tree to some degree when it cannot get enough nutrients from soil. In such conditions, the tree compensates itself by reducing plant growth (smaller leaf size). Fruit yield is also decreased due to delay flowering and bearing of an inflorescence with lower number of female flowers to set fruit.



3.1.3 Orchard nutrient management

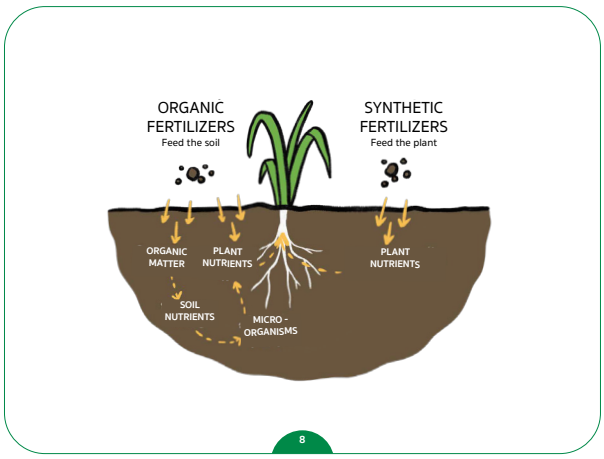
The goal is to maintain soil fertility to supply sufficient plant nutrients matching the plants' demand. Common management includes the improvement of soil conditions to better release nutrients. Optimal soil pH is adjusted to promote nutrient solubility. Excessive nutrient losses via leaching and erosion must be minimized. Organic fertilizer and organic matter are applied to increase plant nutrients.



3.1.4 What is fertilizer?

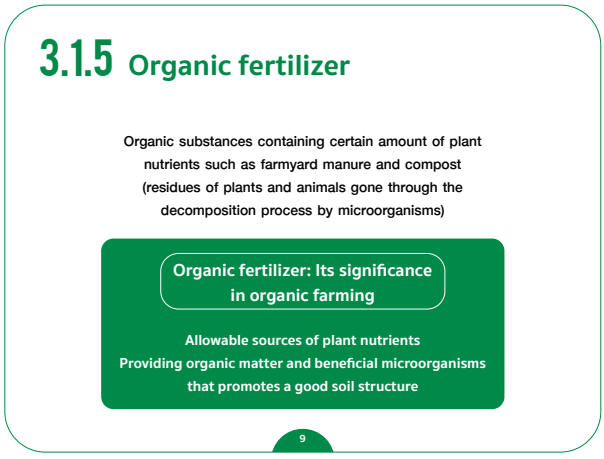
Fertilizer is a substance that provides plant nutrients. This also includes microorganisms that make plant nutrients available or promote better uptake of plant nutrients.

Fertilizer is applied when soil nutrient levels are low or the soils cannot release enough nutrients to meet the plants' demand.



Two groups of fertilizer commonly known are synthetic or chemical fertilizer and organic fertilizer. The synthetic fertilizers provide only plant nutrients to feed the plants. In contrast, the organic fertilizers feed the soil by providing plant nutrients and organic matter, both of which are important components of a good farm soil. It can be said **"chemical fertilizers feed the plants, organic fertilizers feed the soil"**

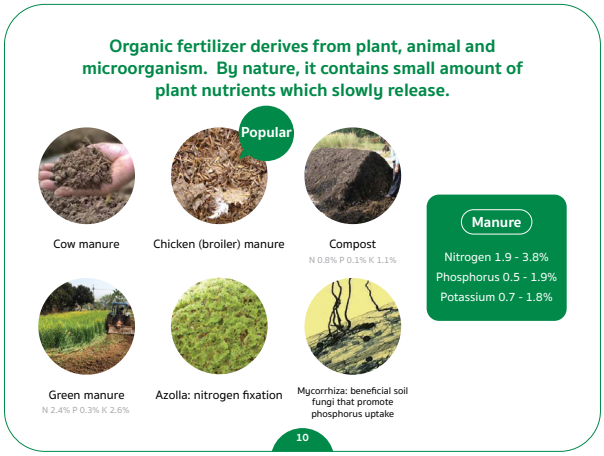
Bio-fertilizer refers to microorganisms, such as rhizobium. These beneficial bacteria associated with root nodules of legume plants are able to convert atmospheric nitrogen gas to the nitrogen forms the plant can use.



3.1.5 Organic fertilizer

In organic production system of aromatic coconut, only organic fertilizer is allowed.

Organic fertilizer: is organic substances (coming from living organisms) containing plant nutrients such as farmyard manure and compost derived from decomposed plant and animal debris. It also provides organic matter and beneficial microorganisms which improve soil health and conditions.



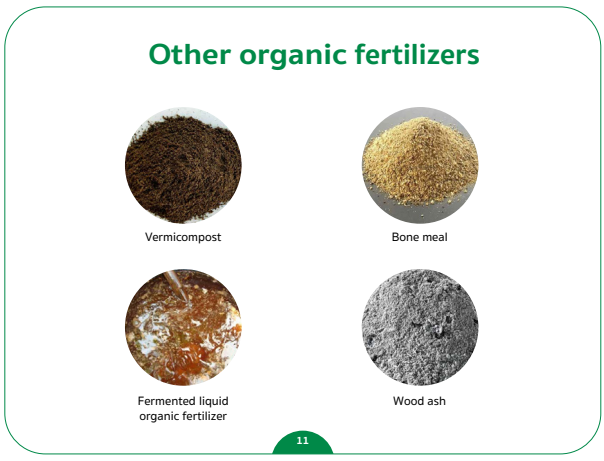
A variety of organic fertilizer is available including manure (cow, chicken, pig, bat,), compost, green manure and bio-fertilizer such as *Azolla*, aquatic ferns with nitrogen fixation capability and mycorrhizal fungi.

Each farm should select what is applicable to their farm based on their soil properties and availability in the area.

Organic fertilizer contains small amount of plant nutrients which are released slowly. For example, farmyard manure has nitrogen, phosphorus and potassium less than 10% by weight in total and slowly releases these nutrients through decomposition process. Applying at the appropriate quantity, it will provide enough nutrients for plants' need with additional advantages including the supply of organic matter and beneficial soil microorganism for improvement of soil condition.

The 16-16-16 chemical fertilizer contains 7 times and 12 times higher primary nutrient concentrations than those in chicken manure and cow manure, respectively and it releases nutrients instantaneously. Therefore, the chemical fertilizer will act like a "quick shot" for the plants without improving soil condition. Over time you will need to use more and more of it as the soil quality will decline. You will have the opposite effect with organic fertilizer.

Releasing too big quantity of nutrients chemically will also increase risk of water pollution as the plants will not be able to absorb them and the nutrients will be carried away by the water.



Other organic fertilizers

These are vermicompost, bone meal, fermented organic material liquid extract or liquid organic fertilizer and wood ash.

Beneficial microorganisms have been cultured in mass and used to speed up decomposition process in making compost and liquid organic fertilizer. For example, LDD composting accelerator developed by the Land Development Department, Ministry of Agriculture and Cooperatives. Available as a ready-to-use, dry powder of beneficial microorganism inoculant in a package, growers can get them for free from the Regional Office of Land and Development.

****** Organic fertilizer and its raw materials to make organic fertilizer must be approved by the organic production standard ******

Manure and agricultural residues from non-organic production farm, therefore are not allowed.

****** The DOA announcement on organic fertilizer criteria B.E. 2557 following the Fertilizer Act is on Page 129 of this manual. ******

Additional information

Different types of organic fertilizer

1. Farmyard manure: excretion (feces and urine) of farm animals such as chicken, cattle, pig, etc.

2. Compost: Mixture of plant residues, organic materials, manure or soil which has been undergone decomposition by microbial activity such as leaf compost, straw compost.

3. Green manure: Plants with fast growing habit, high biomass and high nitrogen content such as various kinds of legume are planted. Once they reach the stage of highest biomass, they are ploughed over. Natural decomposition of these plant residues or so called 'green manure' in the soil provides plant nutrients and organic matter.

4. Bio-fertilizer: Referring to microorganisms which make plant nutrients or increase nutrient uptake efficiency. Examples of bio-fertilizer are rhizobium in nodules of legume and blue green algae which convert atmospheric nitrogen gas to organic nitrogen substances readily to use as plant nutrient (= nitrogen fixation). Certain bacteria known as phosphate dissolving bacteria can make soil bound phosphorus which is not available as nutrients to be more soluble. Mycorrhizal fungi associated with plant roots enhance nutrient uptake efficiency. Effective microorganisms or EM in short, are used to speed up the decomposition process for making compost and liquid organic fertilizer.

5. Vermicompost: Organic materials such as cow manure and kitchen waste (vegetables, fruits) are consumed by earthworms, passed through their digestive system and the excretion so called vermicompost containing plant nutrients and beneficial microorganism are obtained from the process.

6. High grade organic fertilizer: It is a compost made from plant residues, farmyard manure and other organic materials high in plant nutrients such as soybean meal and rice bran. It is similar to a common compost except for having higher concentration of plant nutrients.

7. Compost tea: Farmyard manure or compost is soaked in water to extract readily available plant nutrients in the same manner as steeping tea. The extract is diluted with water before application as foliar spray or soil drench.

8. Fermented organic materials liquid extract or liquid organic fertilizer: Plant residues, fruit and vegetable residues, fishes, manure and other microbial food sources such as molasses and rice bran and effective microorganisms (EM) are mixed and fermented under anaerobic conditions. The liquid extract coming out from the process known as liquid organic fertilizer contains plant nutrients, organic acids, plant hormones and beneficial microorganisms. The extract is diluted with water before application as foliar spray or soil drench.

Farmyard manure contains animal excretion (faces and urine), feed residues and bedding materials such as rice hull and straw. Manure from poultry contains higher nitrogen, phosphorus and potassium than that from ruminant animals. Bat manure contains unusually high phosphorus (Table 1).

Table 1 Nutrient analysis in farmyard manure

Manure	Concentration (% by weight)		
	Nitrogen	Phosphorus	Potassium
Cow	1.9	0.6	1.4
Water buffaloes	1.2	0.6	0.7
Chicken	3.8	1.9	1.8
Sheep	1.9	0.8	0.9
Horses	2.3	0.8	1.3
Pigs	2.8	1.3	1.2
Bats	1.1	14.8	1.8

(Land Development Department, 1992)

Compost made of plant residues, agricultural waste and manure has plant nutrients in low concentrations as compared to farmyard manure. In general, quickly decomposed materials contain high concentrations of plant nutrients than slowly decomposed materials (Table 2)

Table 2 Nutrient concentrations in different types of compost

Compost	Concentration (% by weight)		
	Nitrogen	Phosphorus	Potassium
Quickly decomposed materials: rice straw, water hyacinth, corn cob	1.1	0.5	2.0
Slowly decomposed materials; rice hull, saw dust, bagasse, coir dust	0.7	0.2	0.4

High grade organic fertilizer is a compost made from organic materials with high plant nutrient content such as soybean meal, rice bran, fish meal and Ami (organic substance, by product from a factory producing monosodium glutamate) mixed with farmyard manure of high plant nutrients such as chicken manure, pig manure and bat manure. The fertilizer has nitrogen, phosphorus, and potassium greater than 1%, 2.5% and 1% by weight, respectively. All ingredients must be approved by authority in charge of the organic production standard.

Uses of organic fertilizer in aromatic coconut farms

The following information is based on the interviews of aromatic coconut farmers and general recommendation by the Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand.

Farmyard manure: is commonly used because it is in sufficient supply and its price is reasonable. The orchard survey indicated that most growers use **broiler chicken manure** containing chicken excretion and rice hull used as bedding. **Application rate is 20–40 kg/tree/year** for a bearing tree.

Compost: is not commonly used today in aromatic coconut farms. However, in organic production system, compost is one of the best choices of organic fertilizer to be used in the orchard with less restriction as compared to other organic fertilizers and a high content of organic matter.

Green manure: using green manure in aromatic coconut farms is very limited although it can considerably provide reasonable amount of plant nutrients and organic matter to the orchard soils. It is suitable to plant the green manure crops and incorporate them into the soil before planting coconut trees. Once trees are established, such practice is not possible and can damage the roots.

Bio-fertilizer: using bio-fertilizer in aromatic coconut farms is not common due to its limited supply and high price. Mycorrhizal fungi and phosphate dissolving bacteria are used more in field crops but not in fruit orchards. Alginure is a bio-fertilizer made from nitrogen fixing blue green algae. Application rate is low as compared to manure but it is still expensive. Another nitrogen fixing blue green algae associated with *Azolla* or water fern is of interest. Growers can grow *Azolla* in water ditches of an orchard. They grow fast and produce biomass with high nitrogen content which can be used similarly to green manure.

Vermicompost: is not commonly used in aromatic coconut farms. Although it is a good organic fertilizer and convenient to use, its unit price is higher than other organic fertilizers which limits its uses. If growers can make their own vermicompost, this can be either used in the orchard or served as additional source of income.

Fermented organic materials liquid extract or liquid organic fertilizer: Its usage is raising in aromatic coconut farms as growers can make their own liquid organic fertilizer from agricultural waste in the orchard and from household waste. It is also promoted by Land Development Department (LDD), Ministry of Agriculture and Cooperatives, Thailand, as an alternative source of organic fertilizer. Although liquid organic fertilizer contains low plant nutrients, it contains plant hormones and beneficial microorganisms which make plants grow better and have disease resistance. In organic production, all ingredients to make this fertilizer must be approved by authority in charge of the organic production standard. According to the USDA Guide for Organic Crop Producers, this type of liquid organic fertilizer has not been approved. The example recipe for making liquid organic fertilizer commonly used in Thailand is provided as follows:

A. Formula 1

Ingredients: 3 parts of fishes or golden apple snails, 1 part of molasses, 1 part of fruit, 1 part of water and LDD no. 2 composting accelerator (a package of LLD no. 2 contains 50 g of dry inoculant and it is used to make 100 L of liquid organic fertilizer)

Fermentation method: Add LDD no. 2 (composting accelerator) in 30 L of water and mix well for 5 minutes. In a 200-L plastic drum, add organic materials, molasses and the LDD no. 2 mixture and mix well. Place the drum in shade area, close the lid loosely. Stir the mixture once a week to release carbon dioxide gas.

Observation of the changes: On the first 1 – 3 days of fermentation, yeast and other microorganisms grow quickly and appear as film on top of the mixture. Foam of carbon dioxide gas produced from the fermentation process also appears on top of the mixture. The smell of alcohol increases. The liquid in a drum is clear and turns to brown color.

When it is ready: It takes about 21 days for the fermentation. Microbial growth, carbon dioxide production and alcoholic smell decrease significantly while smell of organic acid increases. The clear liquid is acidic with

the pH of 3 – 4. This liquid organic fertilizer contains lactic acid, acetic acid, humic acid and plant hormones including auxins, cytokinins and gibberellins which promote plant growth.

Application rate: Mix 1 part of liquid organic fertilizer to 500 parts of water. Apply as foliar spray of soil drench every 10 days.

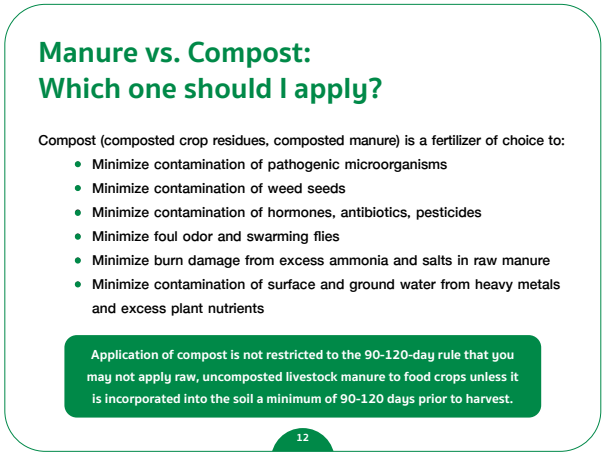
B. Bokashi compost: It is a kind of dry compost originated in Japan. Organic materials are composted with EM (effective microorganisms) in relatively short time and low oxygen conditions. The amount of plant nutrients in Bokashi depends on types of organic materials used. Bokashi also provides beneficial microorganisms to the soils. Bokashi compost is promoted by Land Development Department (LDD), Ministry of Agriculture and Cooperatives, Thailand, as an alternative source of organic fertilizer. Standard for this type of compost has been established by LDD and the compost can be officially certified for commercial purpose in Thailand. Although the benefit of Bokashi compost is well documented and it has been widely used in organic crop production in different regions of the world, this type of compost has not been approved by USDA, yet. A selected recipe to make manure Bokashi is as follows:

Ingredients: 1 bag of cow manure, 1 bag of rice husk, 1 bag of rice bran, 2 table spoons of EM, 2 table spoons of molasses and 10 L of water.

Composting method: Mix dry ingredients well and make a pile of mixture. Mix EM and molasses in 10 L of water in a watering can and gradually drench it over the pile of mixture and mix well until the mixture has about 40 – 50% moisture content. This optimal moisture content can be easily checked by grabbing a handful of the mixture and squeeze it tightly. The mixture should stay intact as a ball without any water coming out. The ball breaks apart upon opening a hand. Put the moist mixture in a sack or breathable woven plastic bag (animal feed bag) loosely, about ¾ of the bag volume, secure the top of the bag and place the bag in shade area. Turn the bag daily. Decomposition begins within 2 days and the temperature rises to 50 – 60 degrees Celsius. Within 4 – 5 days, the temperature of the mixture drops to the ambient temperature and it is ready to use or to store for further use. The mixture is more crumble as compared to the initial condition.

Application rate: For bearing perennial fruit trees, 3 – 5 handfuls/m^2 is suggested. Raw materials to make Bokashi compost, effective microorganisms (EM) and molasses must be approved according to the organic production standard.

Manure vs. Compost: Which one should I apply?



Livestock manure is the organic fertilizer most used for soil improvement and increased soil fertility followed by compost. Although manure is generally higher of plant nutrients than compost, easier to obtain and less expensive, certain cautions must be concerned. Manure contains pathogenic microorganisms harmful to human. It also contains weed seeds, organic substances such as hormones, antibiotics and pesticides. Its foul odor and flies are unpleasant. High ammonia and salts in manure cause plant damage known as salt burn. Moreover, heavy metals and mineral nutrients leached out from manure contaminate surface and ground water.

Composting of raw manure alone or raw manure mixed with plant residues under proper moist and aerated condition is the decomposition process by microorganisms that generates heat. Pathogens, weed seeds, undesirable organic substances and foul odor in manure are eliminated by such high temperature along the process. Composting also reduces the amount of heavy metals, salts, plant nutrients and gases harmful to plants as well as keeping contamination of surface and ground water minimized.

Therefore, compost made from manure or mixture of manure and plant residues, if available, is more desirable to use as soil amendment than raw manure. Compost is a fertilizer of choice to:-

- Minimize contamination of pathogenic microorganisms
- Minimize contamination of weed seeds
- Minimize contamination of hormones, antibiotics, pesticides
- Minimize foul odor and swarming flies
- Minimize burn damage from excess ammonia and salts in raw manure
- Minimize contamination of surface and ground water from heavy metals and excess plant nutrients

Methods of making composted manure, compost from plant residues and information of desirable temperature to be reached and composting duration are provided in detail in this manual.

The advantage of using compost is that its application is not restricted to the 90-120-rule like manure. Raw, uncomposted manure cannot be applied to food crops unless it is incorporated into the soil a minimum of 90-120 days prior to harvest.

Additional Information

According to the National Organic Production Guideline of United States Department of Agriculture (USDA), application of raw, uncomposted livestock manure on food crops for soil improvement and increased soil fertility is restricted to the 90-120-day rule. The rule states that manure must be incorporated into the soil (spreading on the soil surface is not allowed) a minimum of 120 days prior to harvest when the edible portion of the crop has soil contact such as leafy vegetables or incorporated into the soil a minimum of 90 days prior to harvest of all other food crops.

Aromatic coconut is a perennial fruit tree that its fruits may have soil contact when the tree is still young. The fruits can be harvested almost every month all year round from a productive tree. Therefore, routine application of compost made from manure or a mixture of manure and plant residues is the appropriate practice and it is not against the National Organic Production Guideline of USDA.

3.2 Principles and methods of making organic fertilizers

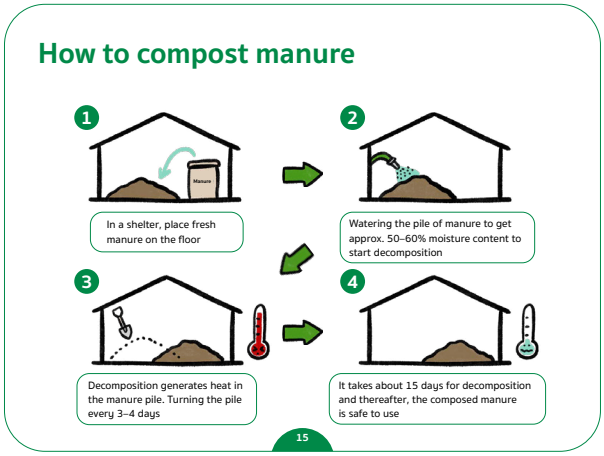
In commercial orchards using both chemical and organic fertilizers, the cost of fertilizer is about 30% of the production cost. It is possible to reduce this cost as most fruit orchards still practice over fertilization which increases nutrient deposition in orchard soils in excess and also increases partial losses of nutrients.

In most orchards, growers still buy fertilizers for convenience. Making your own organic fertilizer and using organic fertilizer more efficiently can reduce production cost in organic production of aromatic coconut which mainly depends on plant nutrients from organic fertilizer.

This topic will cover the principle and methods of making your own organic fertilizer. Composting of fresh farmyard manure before using, making of compost tea, compost of plant residues and vermicompost will be discussed.

There will be a demonstration and practice on making compost and vermicompost after this. You may get more detail information during the demonstration and practice. Please take note of such information in your Handbook for Farmers.

(A red star is given to the techniques or recipes recommended by the ReCAP project)



3.2.1 Composting of farmyard manure

Farmyard manure contains excretion of animals and bedding such as rice hull and straw. Fresh manure has high moisture content and strong smell of ammonia. Although it has high nutrient concentrations but direct application of fresh manure is not recommended. **Manure will undergo natural decomposition process and create heat that is harmful to plants. Microbes involved with decomposition consume nitrogen from surrounding area and plants may suffer from nitrogen deficiency. Moreover, excessive salts and ammonia gas are toxic to plants.**

It is recommended either to allow time for manure to dry out or composting it before using.

Method of composting manure

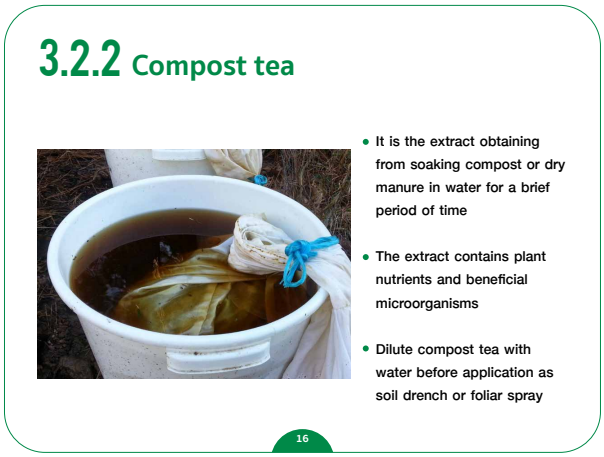
1. Under a shelter (shade and rain protection), place a pile of fresh manure on the floor. Initial moisture content around 70-80%. Let it dry for a while until its moisture content is about 50 – 60% (feels damp but not soggy; like the feel of a wrung-out sponge) which is optimal for microbial activity in composting.

2. If the manure is too dry, sprinkle water on it and mix to increase moisture content.

3. As the existing microbes in manure start to grow and the decomposition process occurs, heat is generated. The temperature of the manure pile rises up to 60 degrees Celsius. Hot air from decomposing manure moves upward and releases out from the top of the manure pile. Cooler air from surrounding area moves in from both sides of the manure pile. Piling of manure to certain height allows better air movement than spreading it flat. If the manure pile does not heat up, it is probably too wet and aeration is not sufficient. Decomposing microbes cannot work in this condition.

4. Turn the manure pile every 3 – 4 days to get ventilation and release of excess heat which will speed up the activity of decomposing microbes. Turn un-decomposed manure from the outer part of the pile into the pile.

5. Composting is done in 15 days. The temperature of composted manure is now similar to an ambient temperature and it is ready to use. According to the international organic production standard and USDA Guide for Organic Crop Producers, composted manure is recommended.



3.2.2 Compost tea

Compost is put in a nylon net bag and submerged in water. Readily available nutrients are extracted the same manner as steeping tea bag. The extract contains plant nutrients and beneficial microorganisms. It is quick and easy to make. The compost tea is diluted with water before application as foliar spray or soil drench. Plant roots can take up nutrients in diluted compost tea right away.

The idea of applying compost tea to quickly provide nutrients came from its application for several annual crops, as well as in organic aromatic coconut farm in Thailand, where the compost tea trials gave good results. According to the USDA organic standard, its application is allowed. Manure tea made from fresh, undecomposed manure is, however, not allowed. Composted farmyard manure or vermicompost can be substituted for compost to make compost tea.

Making compost tea

1. In a shelter (shade and rain protection), put dry compost in a nylon net bag and tie the bag.

2. Submerge the compost bag in water. Leave open space on the top of the bucket for ventilation. Put a brick on top of the bag to prevent floating. The ratio of 1 part of compost and 10 parts of water is suggested. Experiment in a small scale and then expand to the larger volume later.

3. Soak for 24 hours without stirring or aerating. The brown extract looks like tea containing plant nutrients in soluble forms and beneficial microorganisms.

****Soaking for longer time can extract more nutrients but not longer than 3 – 4 days.**

****Dry manure can be soaked directly without bag for suggested time and the extract is filtrated for further uses.**

4. Collect the extract for use. The compost left after extraction can be applied as organic fertilizer later.

Application rate of compost tea

Mix 1 part of the extract with 10 – 20 parts of water before application as foliar spray or soil drench to quickly supply plant nutrients. For soil drench, higher concentraion, mixing 1 part of the extract with 4-10 parts of water, can be applied.

Additional information

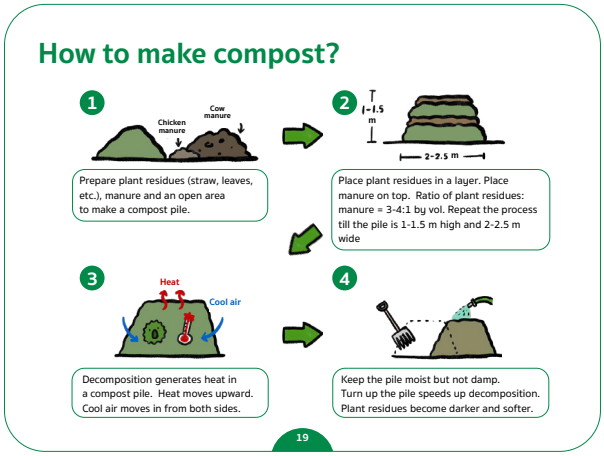
The compost tea is different from liquid organic fertilizer. The liquid organic fertilizer is obtained from fermentation process of plant residues, fishes or organic waste from kitchen in anaerobic condition. Molasses is added as feed source for microorganisms. These microorganisms are different from those active in a compost pile. The liquid organic fertilizer is acidic and contains organic substances which stimulate plant growth similar to plant hormones and inhibit certain plant diseases to occur. Similar to compost, liquid organic fertilizer contains low concentration of plant nutrients.

Precaution: certain microorganisms in manure can be human pathogen and their numbers can increase significantly during the soaking process. Contamination of such microorganisms in manure tea should be considered, particularly, when water is supplement with air bubbles as exponential growth of microorganisms in such condition can be expected. Composted manure is recommended for making manure tea.

3.2.3 Compost of plant residues

Plant residues such as leaves, rice straw, water hyacinth, grass clippings and weeds are composted with farmyard manure. Using plant residues available in orchards to make compost is the effective way to recycle nutrients back to the orchard soils. Manure is a source of microorganisms involved in decomposition of organic materials. With optimal moisture level and ventilation, these plant residues are decomposed by microorganisms to get humus or compost. Mature compost has darker color and more tender texture than the starting materials. It contains plant nutrients and can be used as organic fertilizer.

Decomposition of a compost pile in the early stage generates heat that can destroy eggs of insects, pathogen and weed seeds.



Making compost of plant residues

1. Prepare a location to make a compost pile: It should be outdoor, flat, open area without waterlogging. Ample supply of water is needed as you will need to water the compost pile to maintain optimal moisture content continuously. Prepare ingredients including plant residues and farmyard manure.

2. Making a compost pile: Spread ingredients on the ground in layer. The first layer, about 10 – 15 cm thick is plant residues. If plant residues come in various sizes, the bigger ones are laid at the bottom of a pile. Step on the layer to make it tight only if the pile will be turned later on or leave it loose. Spread manure on top of the plant residue layer. The ratio is 3-4 parts of plant residues to 1 part of manure. Water the whole layer thoroughly but not too wet. Repeat the step for the second layer and so on until the pile reaches the predetermined height (about 15 layers). The width of the upper layers is gradually reduced to get a pile shape of trapezoid.

- Size of a compost pile: the base width = 2.5 m, the pile height = 1.2–1.5 m and the pile length is not fixed depending on the amount of plant residues and manure. The width and height of a compost pile influence its maintenance of moisture level and ventilation which provide better decomposition than that of a flat and wider pile.

3. Decomposition: Under optimal moisture content and ventilation, decomposition of plant residues and manure in a pile by bacteria occurs. The process generates heat and the pile temperature is increased to 50–60 degrees Celsius within 2–4 days after piling. Heat and carbon dioxide from the process move out from the top of the pile while cool air moves into the pile from both sides which increases ventilation and promotes decomposition.

4. Cares of a compost pile: Water the pile regularly to maintain optimal moisture content but not too wet. For a static compost pile (no turning) you will need to use an aeration blower and water the pile once a day and not water on a rainy day. Turning of a compost pile once in a while increases aeration and moves undecomposed materials from the outside into the pile for better decomposition and keeping the pile heat continuously.

According to the USDA Guide for Organic Crop Producers, the compost pile temperature must remain between 131 and 170 degrees Fahrenheit (55–77 degrees Celsius) for 15 days and the compost pile should be turned over at least 5 times during that period to ensure good decomposition.

Additional information

Plant residues can be divided into 2 groups based on their decomposition rate. The first group is easy to decompose such as grass clipping, rice straw and water hyacinth. The second group is slow to decompose such as rice husk, saw dust, twigs and dry palm fronds. Plant residues with high water content can make a compost pile soggy and reduce aeration which is unfavorable condition for decomposing bacteria to work. Moisture reduction of such plant residues is suggested either by sun drying or shade drying. Shredding of plant residues to small pieces can speed up decomposition rate.

5. Curing a compost pile: Once decomposition passes the early stage, the temperature of the compost pile decreases and the pile shrinks down due to decomposition of organic materials and water loss. The decomposition still goes on by fungi, actinomycetes and other soil macro-fauna.

6. Compost is ready to use: It takes at least 2 months to make compost. After decomposition, plant residues become dark, tender and stable with earthy smell. It has the carbon: nitrogen ratio of 20:1. Seeds can normally germinate in this compost.

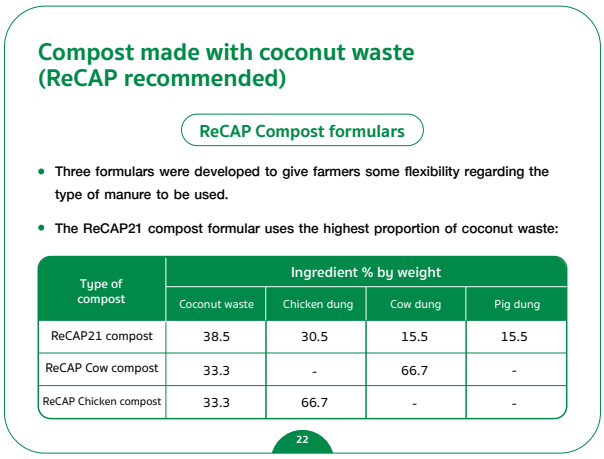
***** In the actual training, explaining all of the compost formulas would take too much time. Thus, the following 23 slides from compost made with coconut waste to DOA compost are considered additional information. Trainer may choose to explain only those that would be demonstrated.**

Compost made with coconut waste (ReCAP recommended)

A lot of waste is produced on coconut farms, including coconut leaves and discarded coconuts. In fact, on average 4 tons of coconut waste is produced annually on a coconut farm per rai. How much waste is produced on your farm?

____ size of your farm (rai) x 4 tons = _____ tons

Most farmers tend to deposit the coconut waste into their canals, which is problematic because the waste in the water will decompose anaerobically and thereby generate methane. Some farmers also burn the waste, but this releases emissions into the atmosphere and is forbidden for some certifications. Either option is not ideal, so **the ReCAP project developed compost formulars to provide an alternative to farmers on how to manage their waste, by making compost with their own coconut waste.**



ReCAP Compost formulars

Three formulars were developed to give farmers some flexibility regarding the type of manure to be used. This can vary due to price, location and availability. So depending on your access to organic inputs, you can select the compost formular that makes the most sense to you. The ReCAP21 compost formular uses the highest proportion of coconut waste:

ReCAP Compost formulars

- For all 3 formulars, the coconut waste (husks, leaves, dry fronds, dry spadix, spathe) needs to be chopped into small pieces and is then mixed with chicken manure, cow manure and/or pig manure in a desirable ratio and piled up.
- Composting takes about 90 days, so it can be made 4 times a year.

23

For all 3 formulars, the coconut waste (husks, leaves, dry fronds, dry spadix, spathe) needs to be chopped into small pieces and is then mixed with chicken manure, cow manure and/or pig manure in a desirable ratio and piled up. Composting takes about 90 days, so it can be made 4 times a year. More detailed instructions will follow.

ReCAP Compost formulars

- The amount of raw materials is higher than the amount of compost produced at the end. This is because there is a yield loss between 23–31%.
- On average a farm will require approximately 0.5 tons of compost per rai.

Type of compost	Raw Material weight (kg)					Yield loss	Compost produced
	Coconut waste	Chicken dung	Pig dung	Cow dung	Total weight		
ReCAP21 compost	560	444	226	226	1,456	31.3%	1 ton
ReCAP Cow compost	434	-	-	868	1,302	23.2%	1 ton
ReCAP Chicken compost	466	934	-	-	1,400	28.6%	1 ton

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The amount of raw materials is higher than the amount of compost produced at the end. This is because there is a yield loss between 23–31%. You can of course make more than 1 ton of compost at the same time, depending on your farms' needs. On average a farm will require approximately 0.5 tons of compost per rai.

ReCAP Compost formulars

Cost

The cost to make each ton of compost varies

Type of compost	Estimated cost of raw materials (THB)					Estimated cost of management (THB)				Total cost / Ton (THB)	Cost / kg (THB)
	Coconut waste (0.4/kg)*	Chicken dung (3/kg)	Pig dung (2/kg)	Cow dung (2/kg)	Total cost	Set the pile (3hrs.)	Turn the pile + watering (2.5hrs)	Collect the compost (4hrs)	Total cost		
ReCAP21 compost	224	1,332	452	452	2,460	123	103	164	390	2,850	2.85
ReCAP Cow compost	174	-	-	1,736	1,910	123	103	164	390	2,300	2.30
ReCAP Chicken compost	186	2,802	-	-	2,988	123	103	164	390	3,378	2.38

* Coconut waste is free if the farmers use it from their own farm.
0.4 THB/kg is the cost to chop the waste: labor cost and fuel for machine.
The cost for the chopping machine is not included here.

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Cost

The cost to make each 1 ton of compost varies, as this table demonstrates.

Remark: Coconut waste is free if the farmers use it from their own farm.

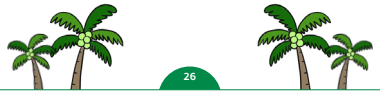
0.4 THB/kg is the cost to chop the waste: labor cost and fuel for machine.

The cost for the chopping machine is not included here.

ReCAP Compost formulars

Cost

- The costs displayed here are of only the raw materials and labor. Cost of equipment and machinery will need to be added, depending on whether you want to buy, rent or already own them.
- The cost to make the ReCAP compost ranges between 2.30–2.85 THB/kg. Most composts that you can find on the market are much more expensive, so by making your own compost, you can make some savings!



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The costs displayed here are only the raw materials and the cost of labor. Cost for equipment and machinery will need to be added, depending on whether you want to buy, rent or already own them.

The cost to make the ReCAP compost ranges between 2.30–2.85 THB/kg. Most composts that you can find on the market are much more expensive, so by making your own compost, you can make some savings!

Other than price, it is also important to have a look at the nutrients in the compost for your soil.

ReCAP Compost formulars

Compost NPK values

Type of organic input	%N (>1)*	%P (>0.5%)*	%K (>0.5%)*	Total N, P, K (>2%)*	C:N ratio Final compost (8:1-14:1)*
★ ReCAP21 compost	1.93	4.94	1.04	7.91 pass	10 : 1
ReCAP Cow compost	1.75	1.41	1.82	4.98 pass	10 : 1
ReCAP Chicken compost	1.84	3.91	1.18	6.93 pass	9 : 1

Remark : * Based on the criteria of the Department of Agriculture (DOA), the numbers in the parentheses are the recommended values for organic compost. The total NPK value is the most important factor to look at.

In summary, we recommend farmers to make the ReCAP21 compost as it has the highest NPK values.
However, if access to all raw materials is difficult, then the ReCAP cow compost and ReCAP chicken compost are also good alternatives.

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Compost NPK values

The percentages of these nutrients are above the recommended values for organic compost, hence passing the DOA criteria. The most important factor to consider is the total NPK value.

In summary, we recommend farmers to make the ReCAP21 compost as it has the highest NPK values. However, if access to all raw materials is difficult, then the ReCAP cow compost and ReCAP chicken compost are also good alternatives.

ReCAP Compost formulars

For all USDA organic certified farmers, you have to keep in mind that fresh manure is not allowed to be used as fertilizer on your farm. The manure you use on your farms must be composted for 90 days.

https://www.ams.usda.gov/sites/default/files/media/Compost_FINAL.pdf

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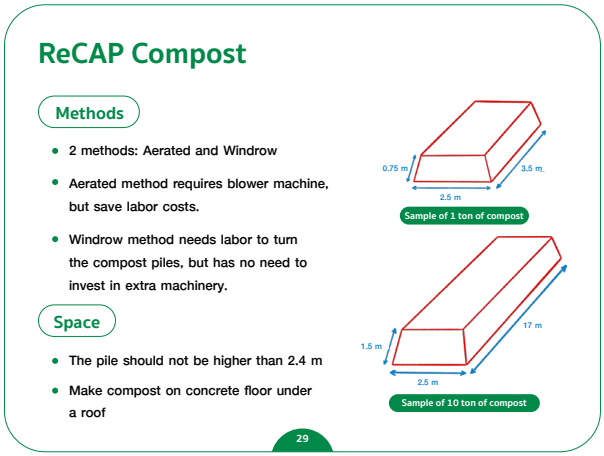


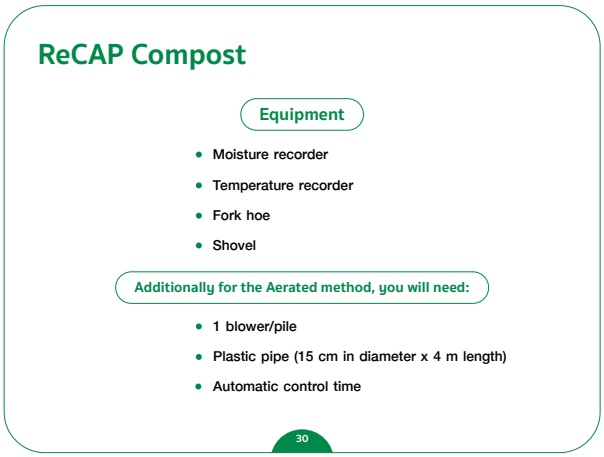
Method

There are two methods of making the composts: Aerated and Windrow method. You can use either method for all compost formulars. The aerated method requires you to invest in a blower machine but will save you labor costs by not having to turn the compost pile. For the windrow method you will need to have labor to turn the compost piles, but no need to invest in extra machinery.

Space

To make your compost you will need to have space on your farm. No matter what amount of compost you make, we recommend you that the pile should not be higher than 2.4 m to make it easier to turn the pile. For example, for 1 ton of compost, the pile could have a width of 2.5m x 3.5m length and a height of 0.75m. For 10 tons of compost, the pile could have a width of 2.5m x 17.5m length and a height of 1.5m.

While you can make the compost on a field, it is helpful to make the compost on concrete floor, to avoid leaching of nutrients and contamination of inert matters. Having a roof over the compost also is recommended to protect the compost from direct sunlight and rainfall.



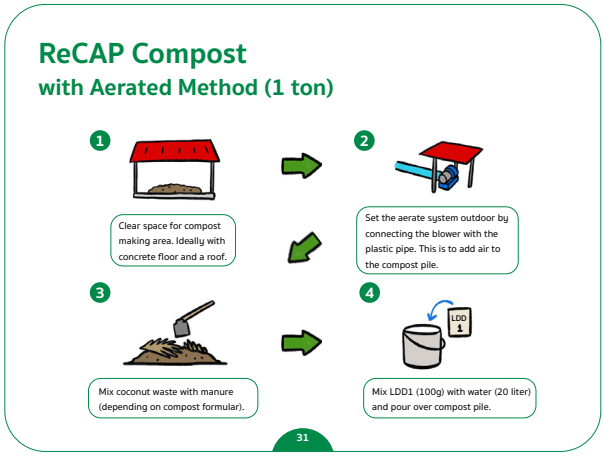
Equipment

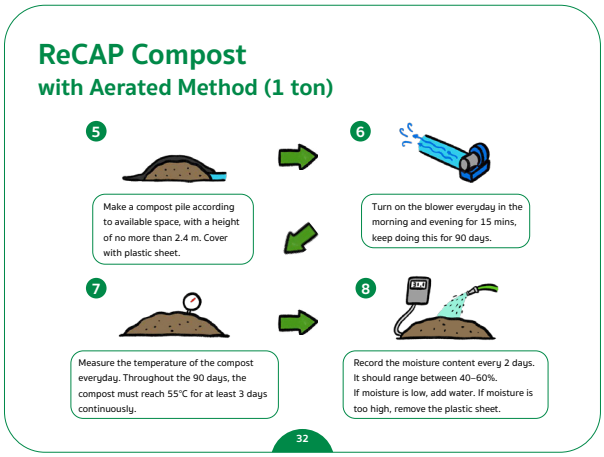
You will need:

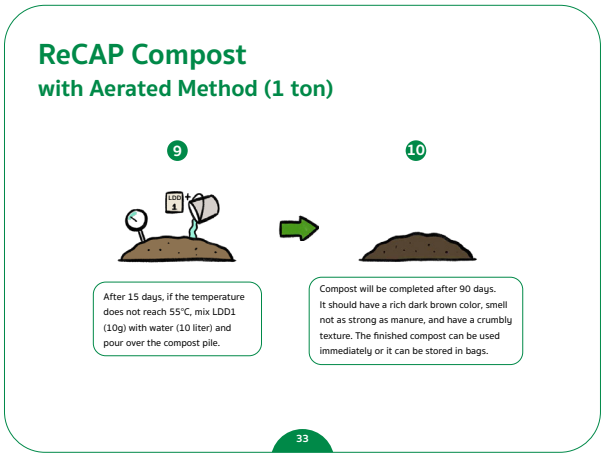
- Moisture recorder
- Temperature recorder
- Fork hoe
- Shovel

Additionally, for the Aerated method you will need:

- 1 blower / pile
- Plastic pipe (15 cm in diameter x 4 m in length)
- Automatic control timer







ReCAP Compost with Aerated Method (1 ton)

1. Clear space for compost making area, ideally with concrete floor and a roof.

2. Set the aerate system outdoor by connecting the blower with the plastic pipe. This is to add air to the compost pile.

3. Mix coconut waste with manure (depending on compost formular).

4. Mix LDD1 (100g) with water (20 liter) and pour over compost pile.

5. Make a compost pile according to available space, with a height of no more than 2.4 m. Cover with plastic sheet.

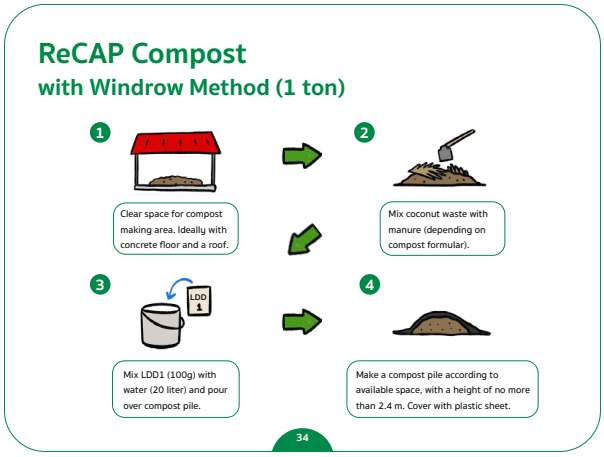
6. Turn on the blower every day in the morning and evening for 15 mins, keep doing this for 90 days.

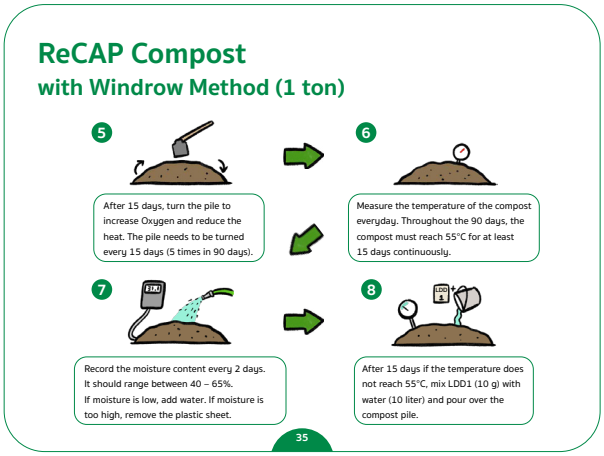
7. Measure the temperature of the compost every day. Throughout the 90 days, the compost must reach 55°C for at least 3 days continuously.

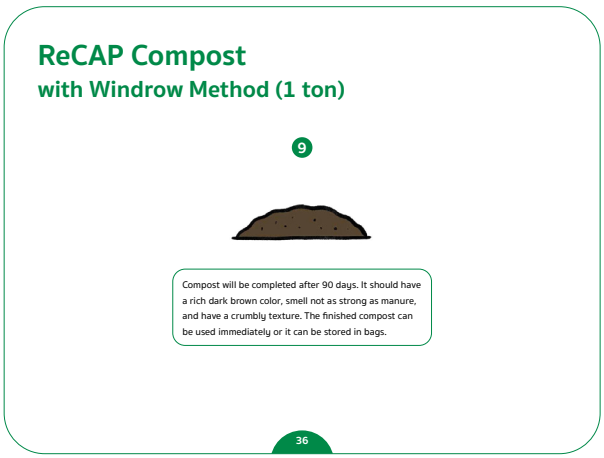
8. Record the moisture content every second day. It should range between 40 – 60%. If moisture is low, add water. If moisture is too high, remove the plastic sheet.

9. After 15 days, if the temperature does not reach 55°C, mix LDD1 (10g) with water (10 liter) and pour over the compost pile.

10. Compost will be completed after 90 days. It should have a rich dark brown color, smell not as strong as manure, and have a crumbly texture. The finished compost can be used immediately or it can be stored in bags.







ReCAP Compost with Windrow Method (1 ton)

1. Clear space for compost making area, ideally with concrete floor and a roof.

2. Mix coconut waste with manure (depending on compost formular).

3. Mix LDD1 (100g) with water (20 liter) and pour over compost pile.

4. Make a compost pile according to available space, with a height of no more than 2.4 m. Cover with plastic sheet.

5. After 15 days, turn the pile to increase oxygen and reduce the heat. The pile needs to be turned every 15 days (5 times in 90 days).

6. Measure the temperature of the compost every day. Throughout the 90 days, the compost must reach 55°C for at least 15 days continuously.

7. Record the moisture content every second day. It should range between 40 – 65%. If moisture is low, add water. If moisture is too high, remove the plastic sheet.

8. After 15 days if the temperature does not reach 55°C, mix LDD1 (10g) with water (10 liter) and pour over the compost pile.

9. Compost will be completed after 90 days. It should have a rich dark brown color, smell not as strong as manure, and have a crumbly texture. The finished compost can be used immediately, or it can be stored in bags.

Lessons learned by pilot farmers – ReCAP21 Compost

We recommend the farmers to cover the compost pile with a plastic sheet because this will make the compost process more efficient, by increasing the compost temperature and trapping moisture. Especially in the rainy season, we recommend you to cover the compost pile to protect the compost from the rain. This is important because otherwise the rain will wash essential nutrients away and reduce your overall nutrients amount of compost.

Bio-fertilizer
(Hua Ao center's formula)

	Ingredient	Amount	Ratio (%)
1.	Pig manure	400 kg	30
2.	Cow manure	400 kg	30
3.	Sediments scraped off from salt farm*	100 kg	8
4.	Rice bran	40 kg	3
5.	Dolomite	40 kg	3
6.	Bat manure	10 kg	1
7.	Fermented fish liquid extract	30 L	3
8.	Molasses	30 L	3
9.	Water	200 L	19

* Sediments containing plant nutrients are mainly dry algae and microorganisms left on the surface of the salt field.

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Hua Ao Compost

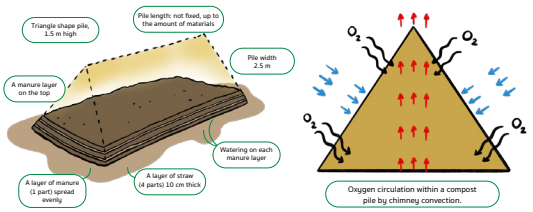
This Bokashi type compost is made by putting raw materials in a fertilizer sack or feed sack (breathable woven poly sack) instead of making a compost pile. The making process takes shorter time than common compost. This compost is developed and commercialized by the Community Learning Center, Ban Hua Ao, Bang Chang Sub-district, Sam Phran District, Nakhon Pathom. Hua Ao compost has been certified by the Land Development Department (LDD), Ministry of Agriculture and Cooperatives, Thailand for commercial purpose.

Considering fermentation process, time used, and doubts about types and sources of ingredients used in this formula, this Hua Ao compost does not meet the USDA organic criteria.

Method: The solid dry ingredients are different kinds of manure, sediments (dry algae and microorganisms containing plant nutrients) scraped off from the surface of salt field, rice bran and dolomite. The liquid ingredients are molasses and microorganism extract (fishes fermented with LDD compost accelerator). Mix all ingredients well and add water to the mixture in desirable ratio. Put the well mixed ingredients about ¾ of a sack, tie up a sack and keep it in shade area with good ventilation. The fermentation takes place in the first week of the process and it generates heat. Temperature of the mixture gradually decreases with time. It takes about 1 month to complete the process and the mixture is not hot anymore. The Bokashi then is ready to use as compost. This Bokashi may not as tender as common compost as it is made from different process.

Maejo Engineering 1 Compost

	Ingredient	Amount (kg)
1.	Straw or corn husks and cobs	4
2.	Animal manure	1



Source: https://ka.mahidol.ac.th/ClinicTechnology/file/techBook/คู่มือการผลิตปุ๋ยหมักแบบไม่พลิกกอง%202558.pdf

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Mae Jo Engineering 1 compost

The main ingredients of this compost are plant residues such as rice straw, dry leaves, dry husk and cob of corn (for animal feed) and manure.

Method: A compost pile is made in layers, a plant residue layer alternated by a manure layer, to form a triangle-shape pile with 2.5 m wide base and 1.5 m high. The pile length is not fixed depending on the amount of ingredients available. The shape of compost pile promotes chimney convection allowing heat to move upward and cool air to move into the compost pile from both sides which increases oxygen ventilation and promotes decomposition of raw materials. Therefore, it is no need to turn over the compost pile. It takes at least 2 months or longer for the process to get compost.

The recommended ratio of ingredients is 4 parts of plant residues: 1 part of manure.

Songkhla Thepa DOAE90 Compost

	Ingredient	Amount
1.	Rice husk	200 kg or 10 sacks
2.	Animal manure	160 kg or 8 sacks
3.	Rice bran	2 kg
4.	Rice husk charcoal	3 kg
5.	Bat manure	5 kg
6.	Molasses	12.8 kg or 10 L
7.	LDD 1*	0.1 kg or 1 pack

Covered with canvas fabric

* Compost accelerator containing selected microorganisms developed by Land Development Department, Ministry of Agriculture and Cooperatives.

Source and additional info: http://www.thaismartfarmer.net/index.php/userservice/p_know_detail/show/6657

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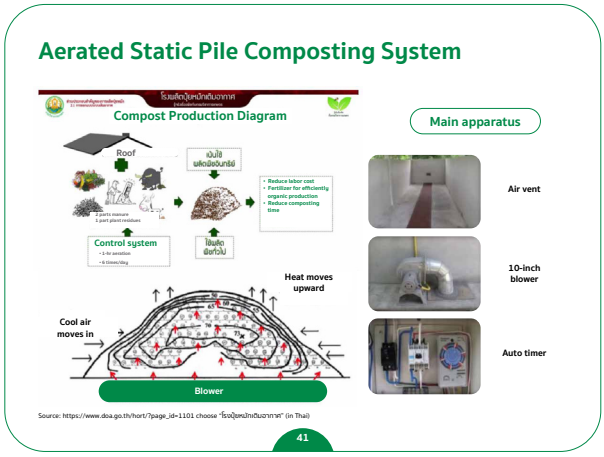
Songkhla Thepa DOAE90 compost

This compost has rice husk, rice husk charcoal, rice bran, manure and bat manure as main ingredients. LDD 1 compost accelerator is added to increase microorganisms which decompose such agricultural materials and molasses is also added as feed for microorganisms.

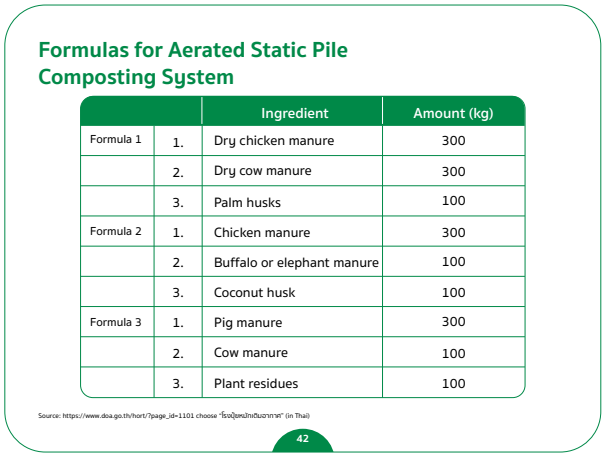
Method: All ingredients are mixed well and water is added to increase moisture content. A compost pile is made and it is turned over every 7 days. For an outdoor compost pile, covering the pile with plastic fabric to maintain its moisture content is suggested. It takes about 1 month to get this compost ready to use.



Aerated static pile compost

In this system, air is forced into a no-turn-over compost pile by blower to improve ventilation and speed up decomposition process. The main ingredients of this compost are manure and plant residues. A roof is required for rain protection.

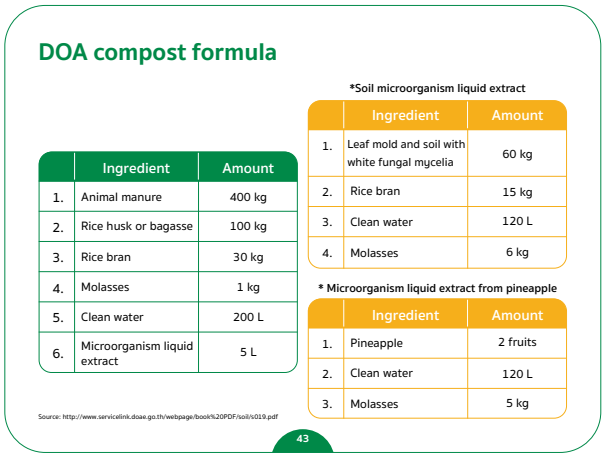
Method: All ingredients are put into a permanent concrete block of 2.5 m high (deep), 1.5 m wide and 8.0 m long with air vent on the floor. This block serves as a compost bin. A pile is watered every 7 days to maintain 60% moisture content. The blower is turned on to force air from underneath the pile every 3 hours for 1 hour long by automatic timer control. It takes about 1 month for this process. After that, the mixture is moved out of the block and spread out on a floor to form a pile of 1.5 m wide and 50 cm high. The pile length depends on the amount of materials. Let the compost pile cure for 30 – 45 days and the compost is ready to use.



		Ingredient	Amount (kg)
Formula 1	1.	Dry chicken manure	300
	2.	Dry cow manure	300
	3.	Palm husks	100
Formula 2	1.	Chicken manure	300
	2.	Buffalo or elephant manure	100
	3.	Coconut husk	100
Formula 3	1.	Pig manure	300
	2.	Cow manure	100
	3.	Plant residues	100

Aerated static pile compost; Recipes

Three recipes are presented. Each recipe contains manure and plant residues as major ingredients.



DOA compost formula

	Ingredient	Amount
1.	Animal manure	400 kg
2.	Rice husk or bagasse	100 kg
3.	Rice bran	30 kg
4.	Molasses	1 kg
5.	Clean water	200 L
6.	Microorganism liquid extract	5 L

*Soil microorganism liquid extract

	Ingredient	Amount
1.	Leaf mold and soil with white fungal mycelia	60 kg
2.	Rice bran	15 kg
3.	Clean water	120 L
4.	Molasses	6 kg

* Microorganism liquid extract from pineapple

	Ingredient	Amount
1.	Pineapple	2 fruits
2.	Clean water	120 L
3.	Molasses	5 kg

Source: http://www.servicelink.doae.go.th/webpage/book%20PDF/soil/s019.pdf

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DOA compost

Department of Agriculture (DOA) has compiled different compost recipes some of which are those successfully practiced by farmers. The example here is Bokashi type compost having manure, plant residues, rice husk charcoal, rice bran, molasses and microorganism liquid extract as main ingredients.

Method: The dry materials are mixed well. Molasses and microorganism liquid extract are mixed with water and added to the dry mixture to get about 40% moisture content. Spread out the mixture on a floor to form a pile of 30 cm high. Cover the pile with wet hemp sacks. Water the pile every day to maintain its moisture content. The compost pile is heated up in the first 2 -3 days indicating that the fermentation process has taken place. The temperature of the pile will gradually decrease until it remains stable and the compost has mushroom-like odor, tender texture and darker color. The process takes about 7 days to complete.

Microorganism liquid extract contains natural EM either from leaf mold and soils or from fruits. Such EM are simply cultured by fermentation with addition of rice bran, molasses and clean water.

Windrow Composting

Ingredients

1. Compost materials (rice husk or plant materials)
2. Animal manure (chicken, cow, or pig)
3. Water
4. Microbial Activator Super LDD 1 (1 pack/ton)

Ratio

Compost materials: Manure = 3:2 by weight

Method of Making Compost Pile

In general, one-ton compost pile is 2 m in width, 3 m in length, and 1.5–2.4 m in height. There are two methods of making a compost pile depending on the type of materials. For the small materials, they should be mixed together and piled up into a rectangle shape. For the large materials, they could be put on one another in a vertical layer. The height of each layer should be approximately 30–40 cm and there should be 5–6 layers. The method of constructing compost pile from the large materials is as follows.

Bring compost materials together and pile them up as a first layer having 2 m in width, 3 m in length, and 30–40 cm in height. Water the pile and sprinkle manure over the surface of the compost materials. Proceed the same method with the next 4–5 layers. At the top layer, it should be covered by the remaining materials to prevent moisture loss.

How to Maintain Compost Pile

1. Watering: regularly water the compost pile to maintain percentage of its moisture content at approximately 40–65 %. The moisture content could be measured by Moisture Meters or manually tested by grabbing an amount of materials from the compost pile. If the compost has an extremely low moisture content, the degradation will happen slowly. Still, the intense moisture content obstructs the effective ventilation and eventually causes the delay in degradation process.

2. Turning a Compost Pile: turning compost could help aerate the compost pile, increase oxygen content, improve mixture of materials, and reduce heat inside the pile.

Remark

According to the USDA standard, initial Carbon to Nitrogen ratio (C: N) of compost materials is between 25:1 and 40:1. During the Windrow Composting, the temperature must be maintained at the range of 55°C–77°C for consecutive 15 days. In one composting process (90 days), the compost pile needs to be turned a minimum of five times, and its height should be approximately 1.5–2.4 m

Sources

Compost Process by using Microbial Activator Super LDD 1, Land Development Department

Tipsheet: Compost (USDA), ATTRA Sustainable Agriculture

Compost Activity Record

Date	Temperature (°C)					Moisture Content (%)					C:N Ratio	Remark
	1st time	2nd time	3rd time	4th time	Average	1st time	2nd time	3rd time	4th time	Average		

Remark : 1. Measure temperature every day at the same time for a minimum of 90 days
2. Measure moisture content every 3–4 days at the same time
3. Please put ✓on the Remark column when the compost pile is turned
*In case that there is an additional information, the record format could be adjusted accordingly.

Sources: Compost Process by using Microbial Activator Super LDD 1, Land Development Department
Tipsheet: Compost (USDA), ATTRA Sustainable Agriculture

Aerated Static Composting

Ingredients and Tools

1. Compost materials (rice husk or plant materials)
2. Animal manure (chicken, cow, or pig)
3. Water
4. Microbial Activator Super LDD 1 (1 pack/ton)
5. A 4-inch-PVC pipe with holes
6. A 3-HP fan motor

Method of Making Compost Pile

1. Material Preparation

Mix decaying leaves and animal manure together at a 3:1 ratio by volume. Also, moisten the mixture with water.

2. Making Compost Pile

Lay sticks overlapping each other on the 4-inch PVC pipe with holes connected to the 3 HP fan motor. These sticks will help aerate inside the compost pile. Mix and slightly water the prepared materials. Then pile them up in the shape of a triangular prism along the length of the pipe. Size of the compost pile is 2.5 m in width, 1.5–2.4 m in height, and 3.5 m in length. The pile could be located outdoor without roof.

3. Aeration

Turn on blower two times a day, every morning and evening, 15 minutes at a time, for 30 days or more. The process will produce the light, black, loose and no-smell compost.

4. Maintaining Compost pile

Keep measuring moisture content every 4–5 days by putting your hand or the Moisture Meters inside the compost pile. The compost should not be too dry or too wet that your hand feels some leaking water. If it is too dry, water can be added by pushing a stick into the center of the compost pile and letting water in. Turning or covering compost is unnecessary for this method.

5. Curing and Bagging

After the composting process has completed, the compost will be moved in the shade and leaved for 20–30 days to make it more stable and to cool down microbial activity. Then the compost could be bagged up. One compost pile approximately equals to 50 bags, one bag containing 30 kg of compost.

Remark

According to the USDA standard, initial Carbon to Nitrogen ratio (C: N) of compost materials is between 25:1 and 40:1. During the Aerated Static Composting, the temperature must be higher than 55°C for consecutive 3 days. The height of the compost pile should be between 1.5 and 2.4 meters. Also, the moisture content should be maintained at 40–60% throughout the composting process.

Sources

http://www.compost.mju.ac.th/aerated/prod/default.htm (Research project on knowledge transfer to the community about the technology of the aerated static composting for the industrial production by Teerapong Sawangpanyangkura, from the Department of Agricultural and Food Engineering, at the Faculty of Engineering and Agro-Industry, Maejo University, Chiang Mai)

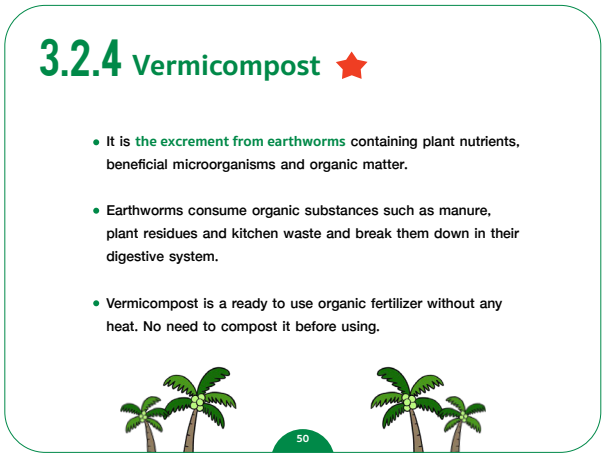
Tipsheet: Compost (USDA), ATTRA Sustainable Agriculture

Compost Activity Record

Date	Temperature (°C)					Moisture Content (%)					C:N Ratio	Remark
	1st time	2nd time	3rd time	4th time	Average	1st time	2nd time	3rd time	4th time	Average		

Remark : 1. Measure temperature every day at the same time for a minimum of 90 days
2. Measure moisture content every 3–4 days at the same time
3. Please put ✓on the Remark column when the compost pile is turned
*In case that there is an additional information, the record format could be adjusted accordingly.

Sources: Compost Process by using Microbial Activator Super LDD 1, Land Development Department
Tipsheet: Compost (USDA), ATTRA Sustainable Agriculture



3.2.4 Vermicompost

It is the excrement from earthworms which feed on organic materials, kitchen waste and manure. Vermicompost is fluffy and contains plant nutrients and beneficial microorganisms. Differing from manure which required pre-composting, vermicompost is ready to use as organic fertilizer (no heat being produced).

Making vermicompost

We will talk about how to simply make vermicompost in a plastic tub. These are materials you will need.

1. A bag of dry dairy cow manure (about 15 kg) served a bedding (food and house for earthworms)

2. A large bucket for soaking manure

3. A black plastic tub (no. 55), drilling drainage holes at the bottom (used as earthworm house), 4 tubs

4. African night crawler earthworms (AF). This type of earthworm has a large body. It is a good eater and produces large amount of vermicompost. You can buy AF from a commercial earthworm farm.

5. Wire screen for mouse protection

6. Stand or table for placing earthworm houses. Earthworms may escape from a plastic tub that is placed on the ground.

7. Clean water for soaking manure and for watering the bedding

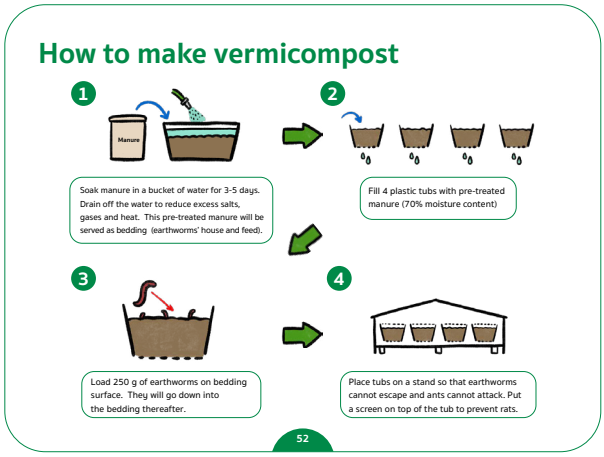
8. Shelter providing shade and rain protection with good ventilation to keep the culture.

For the initial set, you will need 1 bag of dairy cow manure, 4 plastic tubs and 1 kg of AF earthworms

Additional information

Materials used for bedding can be different types of farmyard manure, soils, plant residues, vegetables, fruit peel, paper, etc. For a beginner, dairy cow manure is recommended to use for bedding as it is uniform and easy to buy. Earthworms can consume and convert most of the dairy cow manure to vermicompost.

Local earthworms commonly found in soils are the small body type. They grow slowly and produce less amount of vermicompost as compared to commercially produced AF or other exotic earthworms.



Making vermicompost

1. Preparation of bedding: Soak 1 bag of dry dairy cow manure in a large bucket of water for 3–5 days until decomposition stops and no heat produces. This step means to reduce heat from natural decomposition of manure and remove excess gases and salts which can be harmful to earthworms.

2. Fill the bedding in a tub: After removing excess water, this pre-soaked manure or bedding has moisture content about 70% (moist but not too wet) which is optimal for earthworm culture. Put bedding in 4 plastic tubs equally, about ¾ of the volume for each tub.

3. Fill the bedding with AF earthworms: Fill about 250 g of AF on the bedding surface of each tub. If the bedding is well prepared with optimal moisture content, earthworms will craw into it. Water the bedding again to maintain moisture content.

4. Place a tub on shelf or stand: This means to protect the culture from ants and the escape of earthworms.

Additional information

Bedding, which serves as a house and feed for earthworm to get going, is the key element in production of vermicompost. Bedding preparation may differ from farm to farm such as soaking duration of manure, ratio of manure to water, how often the soaking water being changed, etc. The preparation method of bedding presented here is a common one. Modification of the method to speed up the process may be risky.

Although starting with excess number of earthworms can get vermicompost faster, earthworms tend to compete to each other for feed. The drawbacks which tend to occur are poor growth and lower number of eggs and new worms being produced.

5. Watering and vermicompost being produced: Watering once a day in the morning just to keep bedding moist but not too wet. Earthworms live and feed on bedding and excrete fluffy and crumbly feces or vermicompost on the surface of the bedding. It accumulates gradually on top of the bedding.

When the culture is 20 days old, stop watering to allow gradual decrease of bedding moisture content to ease harvesting of vermicompost.

Besides feeding and excretion, earthworms grow, breed, lay eggs, hatch and increase small babies in bedding.

6. Harvesting of vermicompost: When the culture is 30 days old, the bedding has been fed almost completely and turned to fluffy and crumbly vermicompost. Vermicompost can be harvested by sieving to separate small particles of vermicompost from earthworms and bedding residues.

7. Separation of vermicompost by sieving: Vermicompost passes through the sieve while earthworms, eggs, babies and bedding residues are kept on the sieve.

8. Moisture reduction: Place vermicompost under shade with good ventilation to reduce moisture content before further using or storing.

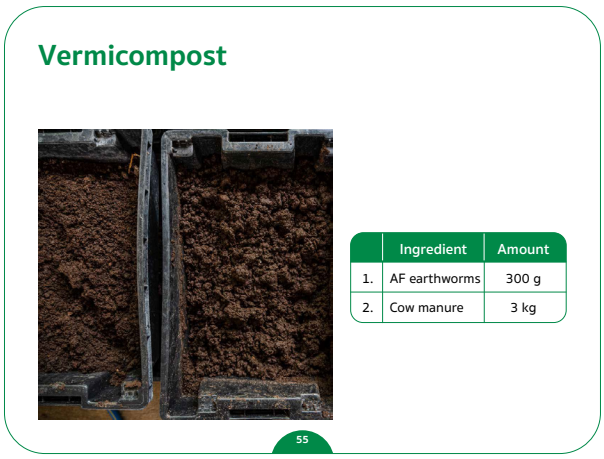
9. Management of earthworms and bedding residues: Earthworms and bedding residues left on the sieve can be used for the next round of vermicompost production.

Starting from 1 bag of dry dairy cow manure, 20 kg of vermicompost is produced.

10. Baby earthworms in vermicompost: They are very small and can pass through the sieve along with vermicompost. Without bedding, they will die soon. If such vermicompost is used immediately as a component in growing media of low organic matter in particular, they may feed on plant roots and cause damage.

11. Separation of baby earthworms from vermicompost: Prepare a plastic tub filled with moist bedding. Lay a blue nylon net on the bedding surface. Pour vermicompost with baby earthworms on the blue nylon net. Babies naturally moves towards moist and dark place. They will eventually craw down through the net into bedding.

12. Vermicompost free of baby earthworms: Collect vermicompost on the net which is free from baby earthworms and it is ready to use or store.



Vermicompost

In general, **3 kg of cow manure** and **300 g of AF earthworms** is recommended for a common recipe of vermicompost.

	Ingredient	Amount
1.	AF earthworms	300 g
2.	Cow manure	3 kg

Additional information

Vermicompost is clean, no strong odor and ready to use (no heat produced). Nowadays, it becomes more popular and expensive. Growers can produce vermicompost for farm use or produce it for commercial purpose to have additional incomes.

*** For vermicompost to be approved by the USDA, bedding materials must meet USDA organic regulations requirements.**

Lessons learned by pilot farmers – Vermicompost

• Recheck the bedding before filling it with earthworms and extend the fermentation time if necessary because earthworms will die if the fermentation process of the bedding is incomplete.

• Pay attention to the quality of the raw materials for the bedding as insufficient quality will kill the earthworms (use raw materials from certified sources).

• Check the bedding weekly to control temperature and moisture because the surface of the bedding should not be dry, if needed add water and cover with wet newspaper.

• In case you find mites in the trays, spray water around the trays and cover them with soaked paper to keep moisture, the mites will move from the vermicompost bed.

• If you find larvae of rhinoceros beetles, remove them from the tray and you can use them for *metarhizium* culture.

• Build a cage to protect the vermicompost against rats, house gecko, birds and rhinoceros beetles.

• As an additional benefit, you can mix the vermicompost with coconut coir and used it as substrate/ media for the seedlings.

"I found a lot of benefits from making vermicompost. I apply it to my coconut trees, intercrops and seedlings." - Prayad

3.3 Application of organic fertilizers to aromatic coconut production

3.3

How to apply organic fertilizer in a coconut orchard

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3.3 How to apply organic fertilizer to a coconut farm?

In the past, common practices such as dredging a water ditch to return muddy soil and nutrients back to the surface of a planting bed, mulching with dry fronds and application of manure once a year may provide adequate plant nutrients. But nowadays, fertilization is routinely practiced by growers. How can fertilizer be efficiently applied to get the maximum benefit?

DOA announcement on organic fertilizer criteria B.E. 2557 following the Fertilizer Act

It focuses on nutrient concentrations, moisture content and carbon to nitrogen ratio.

Organic fertilizer in a dry form contains total nitrogen > 1%, total phosphorus as P_2O_5 > 0.5% and total potassium as K_2O > 0.5% by weight or the total concentrations of primary nutrients > 2.0%. The carbon: nitrogen ratio < 20:1. Moisture content < 30% by weight. Other criteria are as follows:

Organic matter > 30% by weight

pH 5.5 – 8.5

Electrical conductivity < 6 dS/m

not contain plastic, glass, sharp particles and other metal parts

Rocks and gravels < 2% by weight

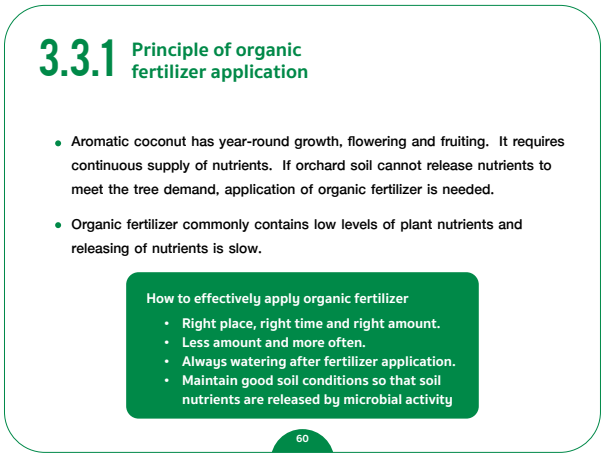
Fertilizer particles < 12.5 x 12.5 mm

Complete decomposition > 80% seed germination index

Additional information

Levels of heavy metals and toxic elements allowed in organic fertilizer

Cadmium	< 5 mg/kg
Arsenic	< 50 mg/kg
Chromium	< 300 mg/kg
Copper	< 500 mg/kg
Lead	< 500 mg/kg
Mercury	< 2 mg/kg



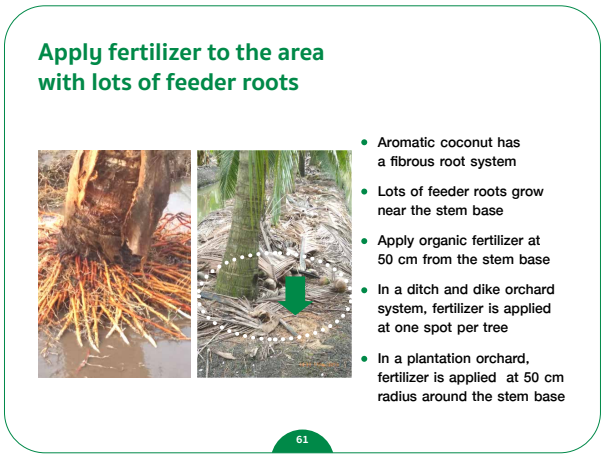
3.3.1 Principles of organic fertilizer application

It must be understood that aromatic coconut is a perennial tree. It has a year-round growth, flowering and fruiting. Therefore, it requires continuous supply of nutrients from soil. An orchard soil may have considerable amount of plant nutrients but they are not available to plants or the soil cannot release nutrients to meet the trees' demand. In such conditions, application of fertilizer is needed and only organic fertilizer is allowed to use in the organic production system.

How can we apply fertilizer more efficiently to meet the trees' demand?

The common principles of practices are:

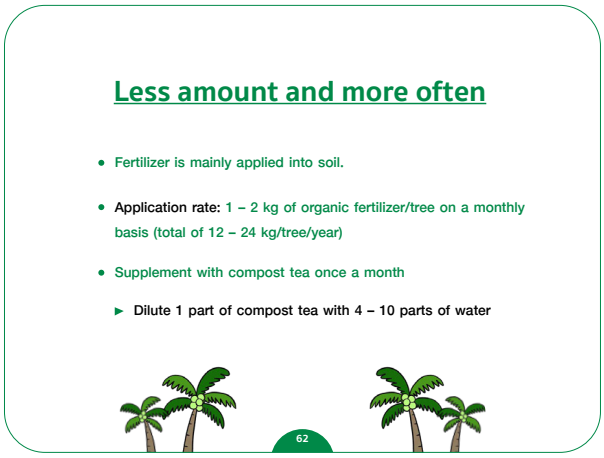
1. Apply fertilizer at the right place, right time and right amount.
2. Apply fertilizer in less amount and more often.
3. Always watering after fertilizer application.
4. Maintain good soil conditions suitable for releasing of nutrients by microbial activity.



Apply fertilizer where feeder roots are densely located

A coconut tree has a fibrous root system. Most of active feeder roots are located near a tree trunk differing from other fruit trees such as mango, wax apple and guava which their feeder roots are densely found around the drip line of the canopy.

Organic fertilizer is applied at a single spot about 50 cm away from a tree trunk for trees grown in a lowland orchard system with a ditch of water to minimize leaching loss of fertilizer into the ditch. In a plantation system or highland orchards, organic fertilizer is applied in cycle about 50 – 100 cm radius around a tree trunk, the area with dense feeder roots. A shallow ditch should be made and fertilizer is applied into the ditch and covered with soil. This practice can better reduce nutrient losses as compared to application of organic fertilizer on bare soil without cover crops or mulch.



Apply fertilizer in less amount and more often

A recommendation for application of organic fertilizer alone in the production of organic aromatic coconut is limited. According to the practices in a successful organic production of aromatic coconut, the following fertilization is proposed as a guideline.

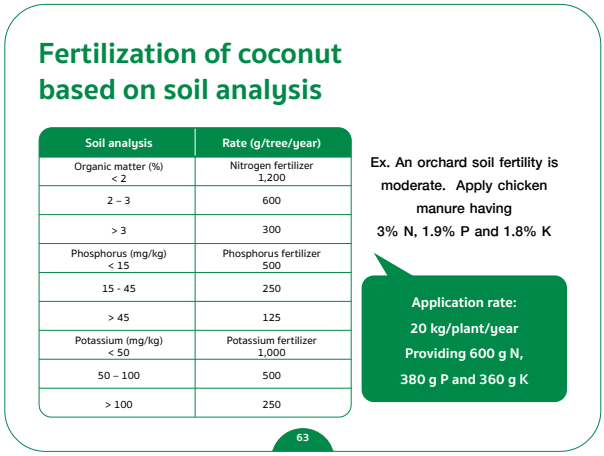
1) Fertilizer is mainly applied into soil.

Application rate: **1–2 kg of organic fertilizer/tree on a monthly basis (total of 12–24 kg/tree/year).**

2) Compost tea is applied as supplement once a month

Dilute 1 part of compost tea with 4 – 10 parts of water and apply as soil drench

According to USDA Guide for Organic Crop Producers, a regular compost can be used without restriction. Use of fresh or aged farmyard manure for food crops must followed the 90- and 120-day rule (manure being applied into the soil a minimum of 120 days prior to harvest when the edible portion of the crop has soil contact or a minimum of 90 days prior to harvest of all other food crops). Therefore, application of fresh or aged manure on a monthly basis as proposed above is against the rule. Although composting of manure is not widely practiced in Thailand, it is recommended in this training program for safety and to meet the requirements of USDA organic crop production standard.



Fertilization of coconut based on soil analysis

An orchard soil can be simply analyzed using a test kit and the results indicate whether the soil has low, moderate or high fertility. The amount of fertilizer to be applied varies with soil fertility. In low fertility soils with low levels of available nutrients, more fertilizer is required than that of moderate and high fertility soils.

For example, an orchard soil has moderate fertility (2-3% organic matter, 15-45 mg/kg phosphorus and >100 mg/kg potassium). Chicken manure is a choice to be applied. Chicken manure has 3% N, 1.9% P and 1.8% K. Look at the nitrogen requirement first. The orchard soil has 2-3% organic matter and from the table, nitrogen fertilizer of 600 g/tree/year is needed. To meet that requirement, 20 kg of chicken manure/tree/year is applied to supply 600 g of nitrogen. In addition, 380 g of phosphorus and 360 g of potassium come along with that chicken manure application.

Additional information

From this guideline, plant nitrogen requirement is used as a criterion to determine the amount of organic fertilizer to be applied. Actually, more than 20 kg of chicken manure must be applied to compensate for some losses of nutrients and ineffective nutrient uptake of plant roots (plant roots cannot take up 100% of nutrients applied).

For Regenerative Organic Certification (ROC), application rate of organic fertilizer brought from outside the farm is restricted. ROC aims for self-sufficiency in its manure and fertilizer. Manure and organic fertilizer may only be used as demand dictates and must be approved under USDA standard. The regulation states that the orchard is allowed to import not more than 36 lbs of nitrogen and 31 lbs of phosphorus in the form of organic fertilizer from outside the farm to apply in each acre annually (= 6.5 kg nitrogen/rai/year and 5.6 kg phosphorus/rai/year, respectively). At spacing of 6 x 6 m, there are 45 aromatic coconut trees in 1 rai. If chicken manure is applied at the rate of 20 kg/tree/year, it will be 900 kg/rai/year of manure being applied. As chicken manure contains 3% of N and 1.9% of P, therefore, 27 kg of N and 17.1 kg of P/rai/year are imported from outside the farm which is over the limit allowed by ROC! The operation that targets for ROC, must use integrate approach for nutrient management rather than relying on nutrients from organic fertilizer alone.

Application of different organic fertilizers

Soil analysis values	Rate (g/tree/year), 5 m canopy dia	Chicken manure	Cow manure	Pig manure	Bat manure
Organic matter (%)	Nitrogen fertilizer	3-1.9-1.8	1.9-0.6-1.4	2.8-1.3-1.2	1.1-14.8-1.8
< 2	1,200				
2 – 3	600	20 (kg/tree/year)	32 (kg/tree/year)	22 (kg/tree/year)	55 (kg/tree/year)
> 3	300				
Phosphorus (mg/kg)	Phosphorus fertilizer				
< 15	500				
15 - 45	250	Phosphorus fertilizer gained			
> 45	125	380*	192*	286*	8,104***
Potassium (mg/kg)	Potassium fertilizer				
< 50	1,000				
50 – 100	500	Potassium fertilizer gained			
> 100	250	360*	448*	264*	999***
Price (THB/tree/year)		**33**	**53**	**51**	**1,650**

Soil has moderate organic matter and high levels of phosphorus and potassium. The amount of organic fertilizer to be applied is based on nitrogen fertilizer a tree needs because nitrogen is required in larger amount than other nutrients.
*Such amount of organic fertilizer tends to have phosphorus and potassium fertilizer in excess.

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Application of different organic fertilizers

Organic fertilizers generally have low nutrient content. The amount of nutrients and unit price vary among different organic fertilizers. Using the concept in the example mentioned above to determine the amount of organic fertilizer of choice to be applied. The following examples show the amount of nutrients to be obtained from different types of organic fertilizer. In contrast to the synthetic or chemical fertilizer which provides only major plant nutrients such as NPK, please keep in mind that organic fertilizer provides essential nutrients as well as organic matter and beneficial microorganisms to the orchard soil to improve soil fertility and soil health in the long run.

Example:

The orchard soil has moderate level of organic matter and high phosphorus and potassium.

According to the table, a coconut tree needs 600 g nitrogen, 125 g phosphorus and 250 g/tree/year, respectively.

Chicken manure which contains more nutrients than other farmyard manures is chosen. Application rate is 20 kg/tree/year to provide 600 g of nitrogen corresponding to the tree's requirement but the coming along phosphorus and potassium are in excess, particularly phosphorus. This will create the 'soil nutrient imbalance' conditions which adversely affect both the amount of available nutrients in the orchard soil and plant nutrient uptake.

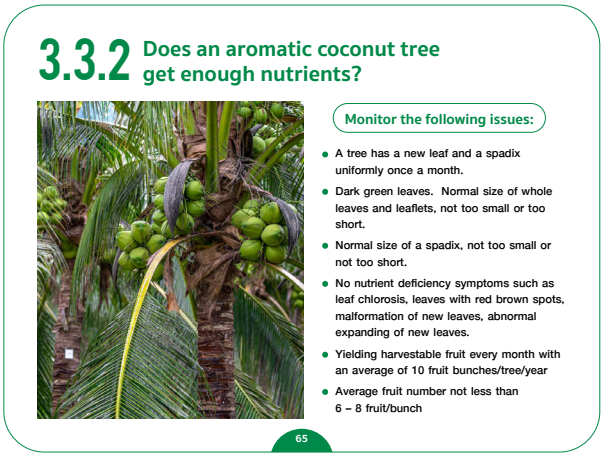
If cow manure, pig manure or aged bat manure which contain less nitrogen than chicken manure are chosen to be applied, they must be applied in larger amount to provide 600 g of nitrogen as needed. The coming along phosphorus and potassium are again in excess and the cost of these organic fertilizers/tree are higher as compared to chicken manure.

Compost made of plant residues contains even lower nitrogen, phosphorus and potassium (total of 1-1.5% of NPK) as compared to farmyard manure. To meet the nutrient requirement of a tree, large amount of compost must be applied and it is costly. Furthermore, commercially available compost that is certified to use in organic production is very limited. Therefore, making your own compost is a choice of interest.

Integrated approach of nutrient management is recommended. For example, a supply of nutrients can be from application of organic fertilizer, periodical supplement of compost tea, dredging a water ditch annually to return muddy soil and nutrients back to the surface of a planting bed and planting legumes or green manure crops which enhance soil nitrogen.

Additional information

Depending on nutrients from organic fertilizer alone may be too costly and not economical. An integrated approach such mulching with shredded dry fronds, dry inflorescences, dropped fruit and coconut husk and planting cover crops is suggested. This approach increases soil organic matter, soil microbial activity and soil health which promotes decomposition of organic matter and continuous release of plant nutrients from the soil. This suggested approach in combination with the efficient application of organic fertilizer will ensure adequate nutrient supply in organic production of aromatic coconut.



3.3.2 Does an aromatic coconut tree get enough nutrients?

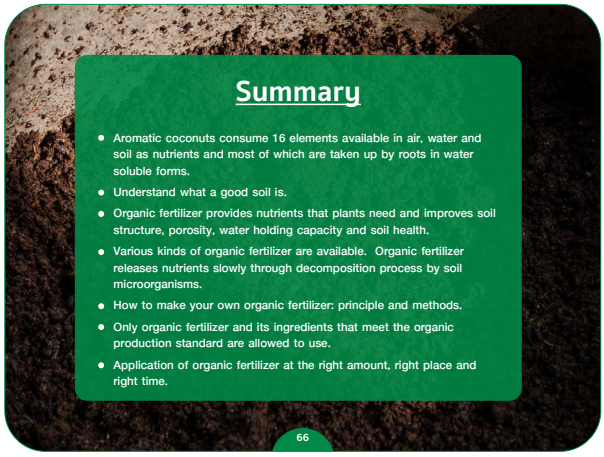
When an aromatic coconut tree shows nutrient deficiency symptoms, it means a tree is in serious problem because it has not got enough nutrients for some time. This is undesirable!

An aromatic coconut tree that gets enough nutrients has a new leaf and a spadix uniformly once a month. A whole leaf and leaflets have normal size, not too small or not too short, and leaf color is dark green. A spadix has normal size, not too small or not too short. Leaves do not show nutrient deficiency symptoms such as leaf chlorosis, leaves with red brown spots, malformation of new leaves and abnormal expanding of new leaves. A tree yields harvestable fruit every month with an average of 10 fruit bunches/tree/year and average fruit number not less than 6–8 fruit/bunch.

Additional information

Fruit yield varies seasonally. It is often associated with delayed flowering, fruit drop, or low fruit set mainly caused by unfavorable weather conditions and rain. Proper management to ensure that a tree gets continuous supply of nutrients and water can reduce this problem.

Summary and closing



Summary

In this module you have learned different things about organic fertilizer. It can be concluded as follows:

- Aromatic coconuts consume 16 elements available in air, water and soil as nutrients and most of which are taken up by roots in water soluble forms.

- Organic fertilizer provides nutrients that plants need and improves soil structure, porosity, water holding capacity and soil health.

- Various kinds of organic fertilizer are available and they release nutrients slowly through decomposition process by soil microorganisms.

- How to make your own organic fertilizer: principle and methods.

- Only organic fertilizer and its ingredients that meet the organic production standard are allowed.

- Application of organic fertilizer at the right amount, right place and right time will ensure better plant growth, reasonable yield and high fruit quality.

Before ending the lecture, please fill information in **the survey form: utilization of organic fertilizer in your farm on Page 109 in the Handbook for Farmers.** We will go through the information question by question together. Feel free to skip the questions you cannot give the answers and do them later.

Survey form: Utilization of organic fertilizer in farms

Farm area ..... rai (bearing trees, non-bearing trees, various tree ages, monoculture or mixed-crops)

1) Utilization of organic fertilizer

a. Fertilizer is not applied at all **b.** Use only chemical fertilize **c.** Use both chemical and organic fertilizers

d. Use only organic fertilizer **e.** Use granulated organo-chemical fertilizer (organic fertilizer supplemented with chemical fertilizer)

2) If organic fertilizers are used in the farm, please indicate what type(s) of them.

Choose as many choices as you are really using.

a. Cow manure **b.** Poultry manure (chicken, duck, quail) **c.** Pig manure

d. Bat manure **e.** Plant based compost **f.** Fermented fishes/golden apple snails liquid extract

g. Fermented fruits/vegetables extract **h.** Others (indicate) .....

3) Sources of organic fertilizer and raw materials to make organic fertilizer

a. Get organic fertilizer or raw materials for free, pay only transportation cost

b. Buy ready to use organic fertilizer, pay transportation cost

c. Buy some raw material, use some raw materials in the orchard and make my own organic fertilizer

d. Make my own organic fertilizer from raw materials in the orchard

e. Others (indicate) .....

4) How often do you apply chemical fertilizer?

a. Once a year (When) ..... **b.** Twice a year (every 6 months)

c. Three-time a year (every 4 months) **d.** Four-time a year (every 3 months)

e. Six-time a year (every 2 month) **f.** Once a month

g. Uncertain, depending on convenience (indicate) .....

5) How often do you apply organic fertilizer in your orchard?

a. Once a year (When) ..... **b.** Twice a year (every 6 months)

c. Three-time a year (every 4 months) **d.** Four-time a year (every 3 months)

e. Six-time a year (every 2 month) **f.** Once a month

g. Uncertain, depending on convenience (indicate).....

Labor cost for fertilizer application each time ..... THB

Total labor cost for fertilizer application for the whole year..... THB **(a)**

6) How often do you buy organic fertilizer or raw materials to make organic fertilizer?

a. Once a year

b. Occasionally due to the limitation of budget / storage area

7) Volume of organic fertilizer or raw materials to make organic fertilizer bought/year

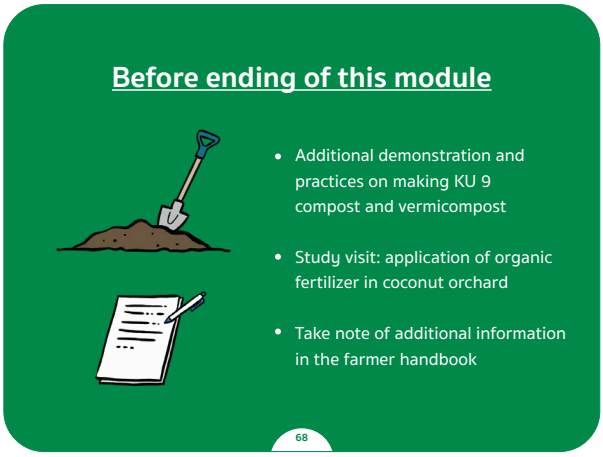
(indicate the unit such as bag, Ton, a 6-wheel truck, a 10-wheel truck, or other units)

.....

Prize of organic fertilizer or raw materials to make organic fertilizer plus transportation cost.

The total cost = ... THB **(b)**

8) Organic fertilizer application cost **(a)** + **(b)** ..... THB



Closing

To end this lecture, the trainer: Thank you for your attention. The next session will be demonstration and practices on making coconut waste compost and vermicompost. After that we will visit the aromatic coconut farms to observe the best practice under organic production system and how to use organic fertilizer properly.

Why coconut waste compost is chosen? Because the recipe has coconut residues, which are normally discarded as waste, to make this compost. In the original recipe, a compost pile is made and turned periodically using empty fruits which are chopped into small pieces and manure as raw materials. LDD compost accelerator is added and it takes at least 2 months or more for composting. In this demonstration, raw materials and composting method are modified. Coir dust is used in place of empty fruits. Manure is used at the same proportion as indicated in the original recipe. Other ingredients are added and the compost is made in a sack as Bokashi compost which takes shorter time to make. This demonstration is based on the protocol developed by the Community Learning Center of Ban Hua Ao, Sam Phran District, Nakhon Pathom.

For vermicompost, although it is not a good choice to use as the main organic fertilizer in an aromatic coconut farm because it is costly, it can be considered as an alternative and it can generate additional income to the orchard.

Please note additional information during the study visit in the Handbook for Farmers.

Questions

1. What knowledge topics in the module 3 will you implement in the near future?

2. What are the most significant limitations or obstacles in using organic fertilizer in organic production of aromatic coconut?

B. HANDS-ON PRACTICES

Some questions are suggested to be asked during the demonstration and study visits:

For the demonstration of making compost from plant residues:

1. Suggested recipe, advantages and disadvantages
2. Component materials and their ratio
3. Techniques / tips for successes
4. Production cost

For the demonstration of making vermicompost:

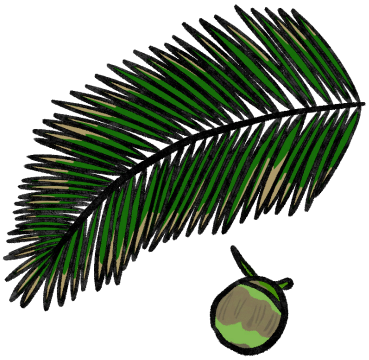
1. Suggested recipe, advantages and disadvantages
2. Component materials and their ratio
3. Techniques / tips for successes
4. Production cost

For the study visit of producing and applying compost:

1. Types of organic fertilizer used
2. Sources of organic fertilizer or raw materials used for making organic fertilizer
3. Application of organic fertilizer, rate and time
4. Satisfactory of the organic fertilizer uses
5. Cost of organic fertilizer and relevant cost

Module 4

INTEGRATED PEST MANAGEMENT



Objectives

To understand what pests and diseases are common at coconut farms and how to manage them using regenerative organic practices.

ACQUIRED KNOWLEDGE

The participants have deepened knowledge on:

1. Natural enemies of coconut insect pests, including their life cycle, damage characteristics, and methods of pest control
2. Strategies of Integrated Pest Management (IPM)
3. Practices of rearing *Bracon hebetor* and *Metarhizium*
4. Using pest monitoring form

ACQUIRED SKILL

The participants can:

1. Identify pest and beneficial insects
2. Monitor pests of coconut
3. Use biological methods to control major insect pests of coconut
4. Rear parasitoid *Bracon hebetor* and *Metarhizium*
5. Transfer knowledge and experience about IPM of coconut to others

ACQUIRED ATTITUDES

The participants perceive the importance of IPM as a strategy to improve farm profitability, environmental quality, and farmer health.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

The knowledge on IPM will enhance farm's compliance with ROC standard. In addition, farmer's familiarity with non-chemical methods of pest control will help minimize potential losses produced by pests, reduce pesticide cost, and protect farmer heath from chemical residue.

METHODS

1. Lecture with PowerPoint presentation for approximately 60 minutes.
2. Study visit, exchange of experience, practices, training and discussion for approximately 1 day

TRAINING SUPPLIES, TOOLS, AND MATERIALS

Lecture:

1. PowerPoint (PPT) presentation
2. A notebook computer with PPT program
3. An LCD projector and a screen or smart TV
4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and guide questions and issues to be discussed in Module 4
5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 4, and guide questions for the study visit and demonstration, as well as blank pages for taking notes

Field trip/practice:

In this module, the participants will visit a successful farm and have hands-on practice in rearing of parasitoid *Bracon hebetor* and entomopathogens *Metarhizium* to let the participants learn biological method of coconut pest control and gain best practice of how to use IPM for coconut pests.

For each practice, the expert should be contacted at least one month earlier. Also, training topic, training activities, the expert fee, training material fee, training date, training duration, transportation to farm should be determined. The trainer of this module has to prepare all subjects related to IPM, in case that the expert becomes unavailable. Questions and discussion topics related to the practice should be prepared in advance and may distribute to trainees on the training date.

DURATION

A. Lecture Topics	Period (min)
1. Major pest insects in coconut farms (incl. life cycle, damage characteristics, natural enemies and control methods)	15
2. Major diseases of coconut (incl. causes, symptoms, the favorable condition, and control methods)	10
3. Integrated Pest Management (incl. pest monitoring and pest population controls)	35
Total time of lecture	**60**
B. Hands-on Practices	
1. Rearing of *Bracon hebetor*	120
2. Rearing of *Metarhizium*	175
3. Summary and closing	5
Total time of hands-on practices	**300 (5 h)**
Total time of training in Module 4	**360 (6 h)**

KEY MESSAGES

1. Major pests of coconuts are black-headed caterpillar, coconut rhinoceros beetle, red palm weevil, and coconut eriophyid mite.

2. Major diseases regularly happened with the young coconut trees are leaf spot and bud rot, whereas bud rot or nut fall, basal stem rot, stem bleeding and gray leaf spot are often found in the old coconut trees.

3. Potential methods of pest control are pheromone trap, rearing of *Metarhizium* and rearing of *Bracon hebetor*, etc.

4. Prevention is key to avoid infection, by managing properly the waste in your farm you can reduce the risk.

5. Integrated Pest Management for coconut farming includes maintaining healthy happy plants, increasing natural and beneficial insects, reducing insect pests, and regularly monitoring farming.

A. LECTURE

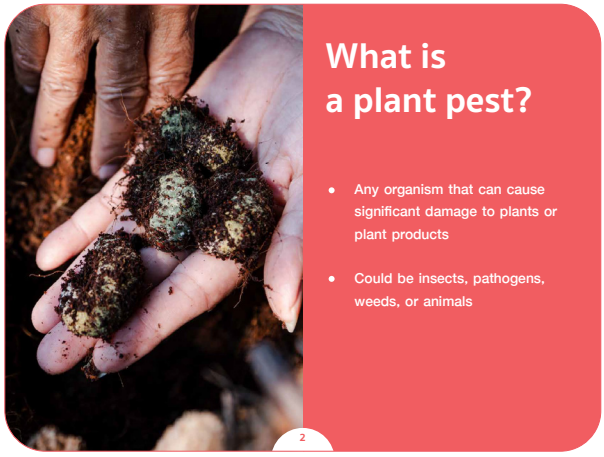
Link with the previous topic

In the previous session, we discussed that plant diversity in the farm is likely to lower incidences of coconut pests. The use of pesticides reduces the biodiversity of the agroecological system in general, including both insect pests and the biodiversity of their natural enemies. Organic farming and intercropping system therefore, serve as potential approach to promote sustainable pest management, healthy environment, and healthy farmer as well as potentially increase farm income.

Start the lecture

→ See Page 116 in the Handbook for Farmers

Start the session with the definition of plant pest.



Plant pest is any organism that can cause significant damage to plants or plant products. Plant pest could be insects, pathogens, weeds or animals.

Pest is one of the most important problems for plant production. More than 30% of yield reduction is caused by pest. This situation drives farmer to come up with different methods to control pest.

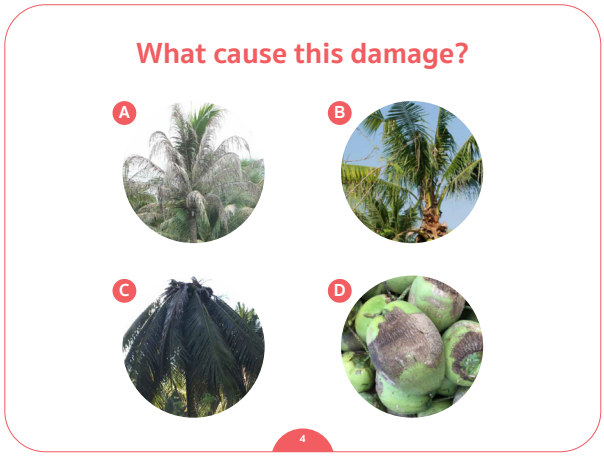
Thus, pest management and control method are crucial to maximize the genetic yield potential.

In this module, we will learn about major pests in coconut farm, characteristic of damage, favorable condition for pest distribution, methods of pest control without pesticide use, principles of IPM, the need to monitor pest, and biological insect pest controls in practice.

Question from trainer: Which ones are considered as coconut insect pests?

Possible answer from participants: Black-headed caterpillar, coconut rhinoceros beetle, red palm weevil and coconut eriophyid mite

(If participants could answer all correctly, it indicates that the participants may have good background of this topic.)

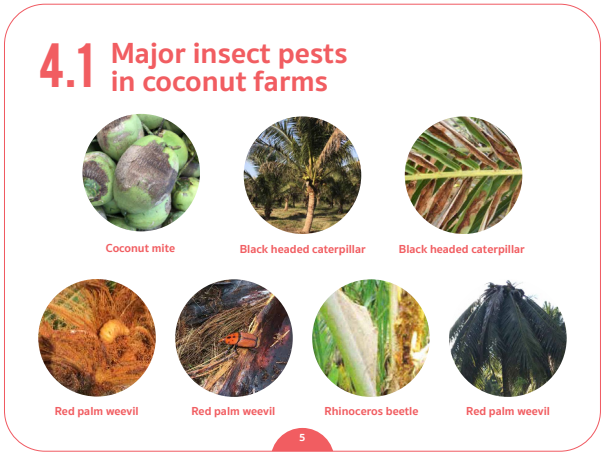


Obviously, there are major coconut pests damaging trees and fruits. Let participants try to identify which pests cause the damage characteristics to coconuts as shown in each image.

Question from trainer: Can you recognize species of insect pests from the damage characteristics? Which pests are able to cause these damages? Which is the pest affecting the most your farm?

Possible answer from participants: by black-headed caterpillar (A), coconut rhinoceros beetle (B), red palm weevil (C) and coconut eriophyid mite (D)

4.1 Major pest insects in coconut farms

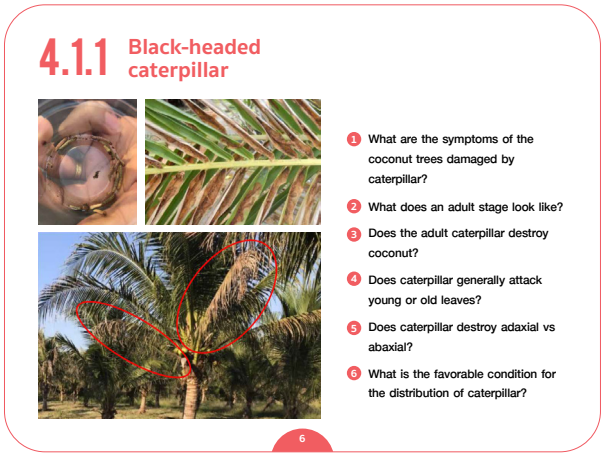


The major insect pests found in coconut farm are listed below:

1. Black-headed caterpillar
2. Coconut rhinoceros beetle
3. Red palm weevil
4. Coconut eriophyid mite

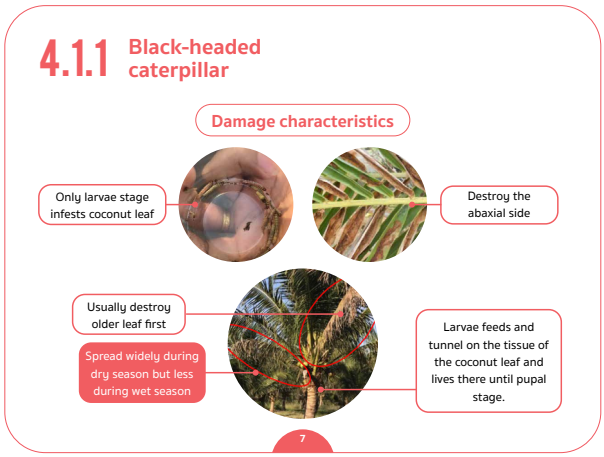
The effective methods to control pests without pesticide are as follows:

1. Take preventives measures to protect your farm, and if farm is infected
2. Identify pests by the damage characteristics appeared on coconut trees.
3. Understand life cycle of pests, favorable condition for their distribution, their natural enemies and pest control methods.



The first one of the major coconut pests are going to be discussed is black-headed caterpillar; however, before getting to the details, we will have a quick survey on your background and familiarity with this pest species. **Questions from trainer:** How much you know about black- headed caterpillar?

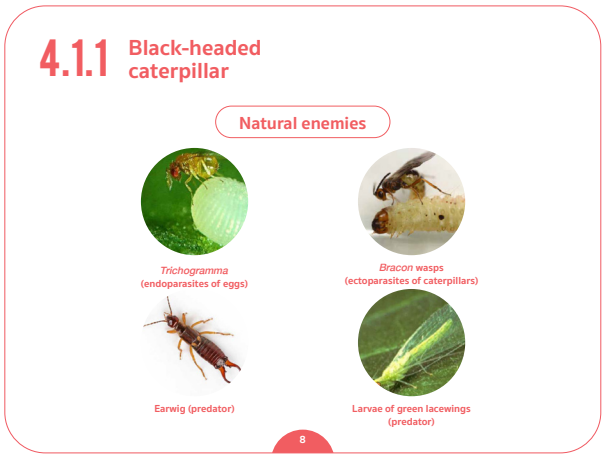
1. What are the symptoms of the coconut trees damaged by the caterpillar?
2. What does an adult stage look like?
3. Does the adult caterpillar destroy coconut?
4. Does caterpillar generally attack young or old leaves?
5. Does caterpillar destroy adaxial vs abaxial?
6. What is the favorable condition for the outbreak of caterpillar?



Possible answers from participants:

1. Larvae feed on and tunnel through the tissue of the coconut leaf and live there until pupal stage.
2. Moth in gray color
3. No, primarily larvae stage infests coconut leaf
4. Usually attacks older leaf first
5. Abaxial leaf
6. Widely outbreak during the dry season (mating season) but less during the wet season (unfavorable for mating).

4.1.1 Black headed caterpillar



Black-headed caterpillar

Natural enemies

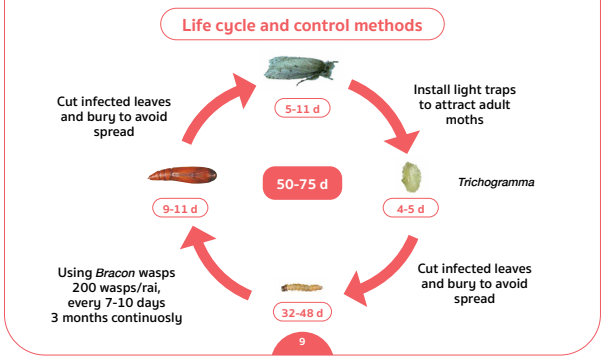
- *Trichogramma* parasitic wasps are parasites that attack the eggs (endoparasites of eggs)
- *Bracon hebetor*, *Goniozus nephantidis* are larval parasitoid (ectoparasitoid) of *Lepidopterous* insect pests. *Brachymeria* sp. is pupa parasitoid of *Lepidopterous* insect pest.
- Earwigs is a predator to control young larva of *Brontispa*.

Additional information

Predators are animals especially insects attacking and killing other species for food.

Parasitoids are animals especially insects living on or in other host animals or insects and eventually killing the host.

4.1.1 Black-headed caterpillar



Life cycle of black-headed caterpillar.

One life cycle of black-headed caterpillar takes approximately 50-75 days (1.5-2.5 months) where the larvae stage (the dangerous stage for coconut) lasts 1.0-1.5 months.

Methods to control black-headed caterpillar

1. Install light traps and use ultraviolet lights in infested areas to attract adult moths.

2. Remove the infested fronds of the coconut palms and bury to avoid spread of larvae and pupae.

3. Use parasitoid wasps:

3.1 Use Trichogramma parasitoid wasps, parasitize egg, leading to the eventual shriveling and death of the organism. The recommendation rate is 20,000 wasps/rai and apply every 15 days.

3.2 Use *Bracon hebetor* parasitoid wasps to parasitize larvae, leading to the eventual shriveling and death of the organism. The recommendation rate is *Bracon hebetor* 200 wasps/rai, and apply every 7–10 days.

3.3 Use *Goniozus nephantidis* to parasitize larvae. The recommendation rate is 50-100 wasps/rai and apply every month.

4. Monitor pest regularly by recording pests, diseases, and their damages in the farms and surroundings, together with keep learning life cycle of insect pests for more effective pest control.

5. All coconut farmers in the community have to collaborate to control black-headed caterpillar.

6. It takes approximately 5-6 months for coconut palm to recover from black-headed caterpillar infestation. During this period, soil health is a key factor to improve the nutrient balance of coconut tree.

Additional information

The adult of black-headed caterpillar (*Opisina arenosella*) is a gray-white moth. The coconut black-headed caterpillar has greenish brown with dark brown head and prothorax, and a reddish mesothorax. There are often brown stripes on the body of the larva.

Life cycle of black-headed caterpillar

1. The adult is a moth with gray color and lasts 5-11 days. It lays eggs in small groups under the surface of coconut leaflets near to feeding larvae.

2. Eggs hatch in 4-5 days on average, and then move into the larval stage where the larvae undergo a series of instars.

3. Larvae of *O. arenosella* generally go through five instars, but could be up to eight instars in the laboratory condition. Larvae last 32-48 days.

4. Pupae last approximately 9-11 days before turning into adult moths.

4.1.2 Coconut rhinoceros beetle

Coconut rhinoceros beetle

Questions from trainer: How much do you know about coconut rhinoceros beetle?

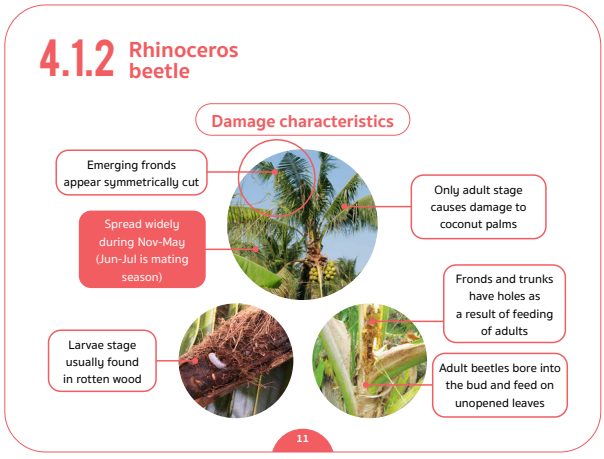
1. What are the symptoms of coconut trees damaged by coconut rhinoceros beetle?

2. Which stage of beetle does usually attack coconut?

3. Which is the part of coconut destroyed by coconut rhinoceros beetle?

4. Does a grub (larva) destroy coconut?

5. What is the favorable condition for the outbreak of coconut rhinoceros beetle?



Possible answers from participants:

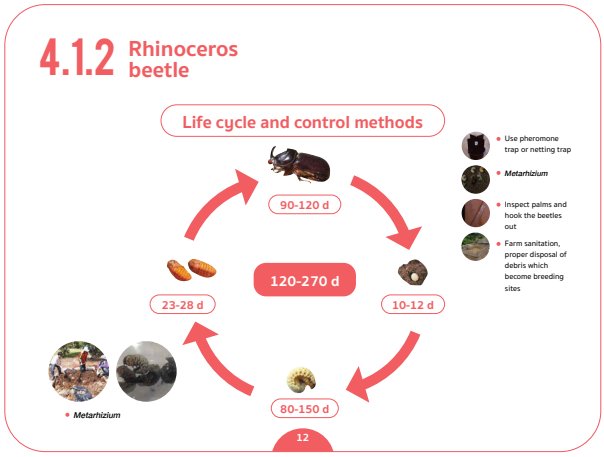
1. Symmetrical cuts on leaves, as well as fronds and trunk having holes are damage characteristics of coconut rhinoceros beetle infestation.

2. Only the adult stage causes damage to coconut palms.

3. The adult coconut rhinoceros beetles eat leaf or shoot of the coconut palms, which enables the red palm weevil to thrive.

4. While eating coconut shoot, the adult beetles lay eggs into decaying wood where the larvae (grub) develop.

5. Coconut rhinoceros beetles are outbreak around the country and the entire year depending on the breeding site. In Thailand, coconut rhinoceros beetles are usually spread widely during November-May while June-July is mating season.



Life cycle of coconut rhinoceros beetle

One life cycle of coconut rhinoceros beetle takes approximately 120-270 days (6-9 months) where the adult stage (the dangerous stage for coconut) lasts 3-4 months. The adult can fly up to 2-3 hours for 2-4 kilometers far. It usually starts its activities after the sundown and continues until sunrise.

Methods to control coconut rhinoceros beetle

Detection of rhinoceros beetles might be difficult due to their nocturnal behavior and habitat inside trees. However, some visual signs, such as holes at the base of leaves and V-shaped feeding damage, helpfully hint where the beetles are living in the farms. Also, farmers should follow and adopt the methods listed below to more effectively control the beetles:

1. Remove or destroy any condition potential to be their breeding site, such as decaying logs and stumps, dead palms, piles of manure, leaves and grass. Piles of these dead leaves or grass can be composted, but need to spread on the ground in a thin layer (less than 15 cm in height).

2. Compost piles should be maintained properly. Regularly turning compost piles or making compost in tighten bag if the compost process takes longer than 2 months.

3. Maintain farm sanitation and a proper disposal of debris

4. Inspect palms and hook the beetles out.

5. Set traps in the farm by using pheromone containing 4-methyloctanoate produced by the male beetle. In breeding sites, the fungus *Metarhizium* could be applied for controlling larval, pupae and adult stages of beetles.

Additional information

Coconut rhinoceros beetle (*Oryctes rhinoceros*) is one of the most damaging insects to palms in Asia and the Pacific Islands.

Life cycle of coconut rhinoceros beetle

1. Adult beetles range from 1.2 to 2.5 inches in length (3.0 to 6.3 cm) with dark brown or black in color and live up to 90–120 days. The horn length is longer on average for males. The female beetle lays eggs several times over their lifetime. Each time, it could lay 10–30 tiny, oval shaped white or yellow eggs, usually in rotten wood.

2. Eggs hatch in 10–12 days on average, then they go into the larvae stage.

3. Larvae (grub) are milky white with red heads, generally go through 3–5 stages and 80–150 days.

4. Pupae lasts approximately 23–28 days before turning into adult beetle. This beetle will then feed itself, mate, and particularly for the female beetle, she will lay eggs for the beginning of another generation.

The fungus *Metarhizium* is used to act as entomopathogens for larval, pupae and adult stages of coconut rhinoceros beetle. For more detail about rearing of parasitoid *Metarhizium* to control coconut rhinoceros beetle,

→ **See Page 123 in the Handbook for Farmers**

Additional information

The *Metarhizium* is a fungus naturally found in soil throughout the world. It kills various insects by acting as an entomopathogens. The disease caused by *Metarhizium* is sometimes called green muscardine disease because of the green color of its spores. When these green spores of the *Metarhizium* contact with the body of an insect host, they begin to germinate and the emerging hyphae penetrate into the insect body. The fungus then develops inside the body, eventually killing the insect after a few days.

Metarhizium is specifically found in the insect hosts whose life cycle is partly in the soil, including coconut rhinoceros beetle.

4.1.3 Red palm weevil

Red palm weevil

Questions from trainer: How much do you know about red palm weevil?

1. What are the symptoms of the coconut trees damaged by red palm weevil?

2. Which is the part of coconut destroyed by red palm weevil?

3. Do larvae destroy coconut?

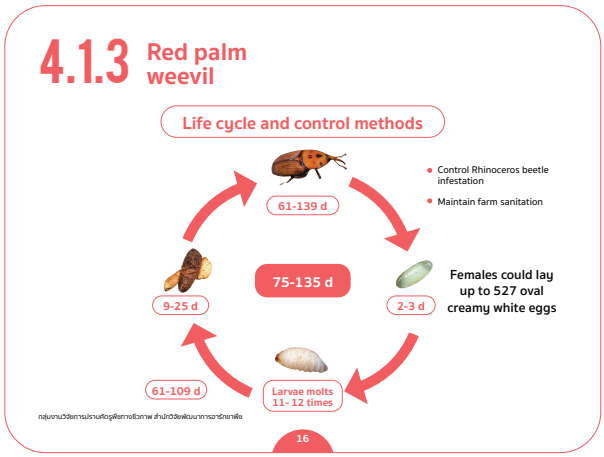
4. What is the favorable condition for the outbreak of red palm weevil?

Possible answers from participants:

1. The damage characteristic from red palm weevil is drooping leaves and palm death. Usually, the weevil enters the holes the coconut rhinoceros beetle has created.

2. The adult and larva stages of the weevil feed on and tunnel through the tissue of the coconut trunk towards the top.

3. Red palm weevil widely outbreaks the entire year. The level of distribution depends on the farm sanitation.



Life cycle of red palm weevil

One life cycle of red palm weevil takes approximately 75-135 days (2.5-4.5 months) where the larvae stage (the dangerous stage for coconut) lives up to 61-109 days (2-2.5 months). The adult weevil can fly up to 900 m and eats during day time.

Methods to control red palm weevil

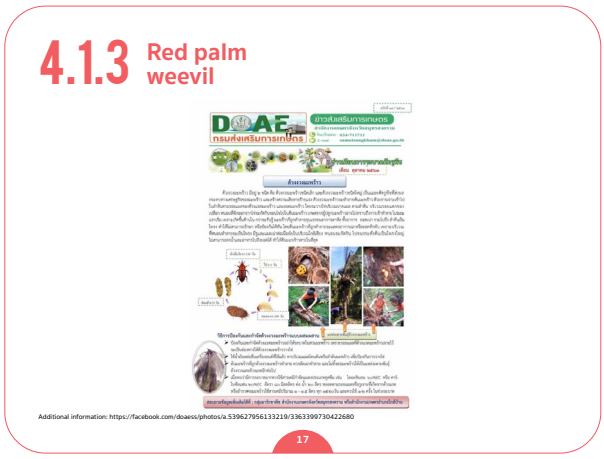
1. Control an infestation of coconut rhinoceros beetle as red palm weevil often enters the palms through holes created by the coconut rhinoceros beetle.

2. Apply the same pest management technique as used with coconut rhinoceros beetle

3. Cut down the infested palm and destroy the red palm weevil inside the palm.

4. Avoid mechanical damage to plants as the weevil prefers to lay its eggs in softer tissues.

5. Maintain farm sanitation.



Additional information about red palm weevil could be found from DOA website such as https://facebook.com/doaess/photos/a.539627956133219/3363399730422680

Life cycle of red palm weevil

1. The adult beetles are relatively large, ranging from 2 to 4 cm in length, and usually rusty red. In general, they live up to 61–139 days. The adult females lay approximately 30 eggs a day and up to 527 eggs in a lifetime.

2. Eggs hatch in 2–3 days on average, then they go into the larvae stage.

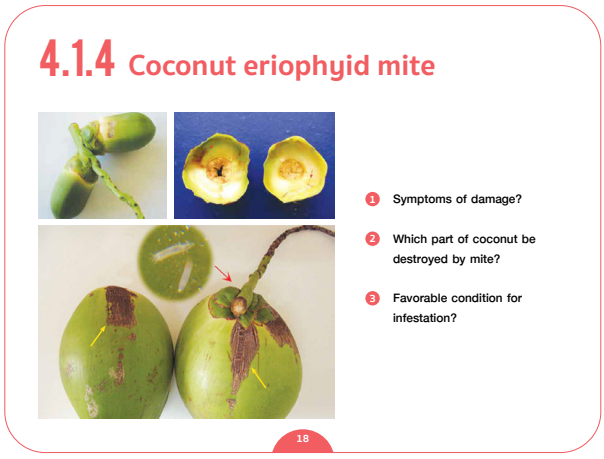
3. Larvae are yellow-white, segmented, legless with dark brown heads, generally, go through 11–12 stages and last 61–109 days. Larvae can excavate holes in the trunks of palm trees up to one meter long, thereby weakening and eventually killing the host plants.

4. At pupation, the larva will leave the tree and form a cocoon built of dry palm fibers in leaf litter at the base of the tree. It takes 9–25 days before turning to the adult stage.

Additional information about red palm weevil could be found from DOA website such as

or http://www.samutsongkham.doae.go.th/wp-content/uploads/2021/12/%E0%B8%94%E0%B9%89%E0%B8%A7%E0%B8%87%E0%B8%87%E0%B8%A7%E0%B8%87%E0%B8%A1%E0%B8%B0%E0%B8%9E%E0%B8%A3%E0%B9%89%E0%B8%B2%E0%B8%A7_page-0001.jpg

4.1.4 Coconut eriophyid mite



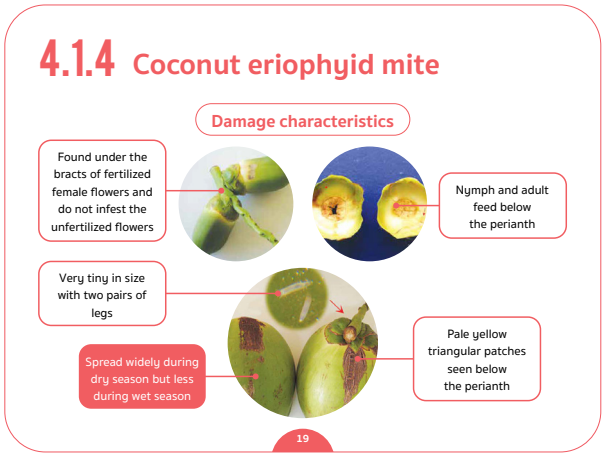
Coconut eriophyid mite

Questions from trainer: How much do you know about eriophyid mite?

1. What are the symptoms of the coconut trees damaged by coconut eriophyid mite?

2. Which is the part of coconut destroyed by coconut eriophyid mite?

3. What is the favorable condition for the outbreak of coconut eriophyid mite?

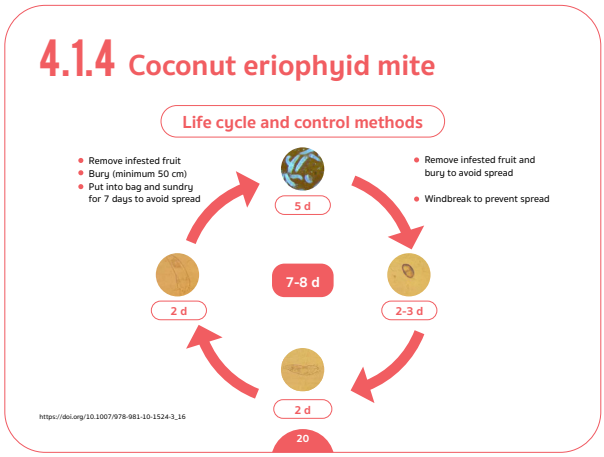


Possible answers from participants:

1. Damage is found from the initial infestation under the perianth. The damage becomes apparent in the developing fruit whose corky turns brown and surface appears some fissured patches. The fruit is probably distorted if the damage occurs only one side.

2. Damage is found under the bracts of fertilized female flowers (mites do not infest the unfertilized flowers). Coconut eriophyid mite contains two pairs of legs and is too tiny to see with the naked eyes. Nymph and adult stage of mites feeds on below the perianth.

3. Mites widely outbreak during the dry season and low during the wet season.



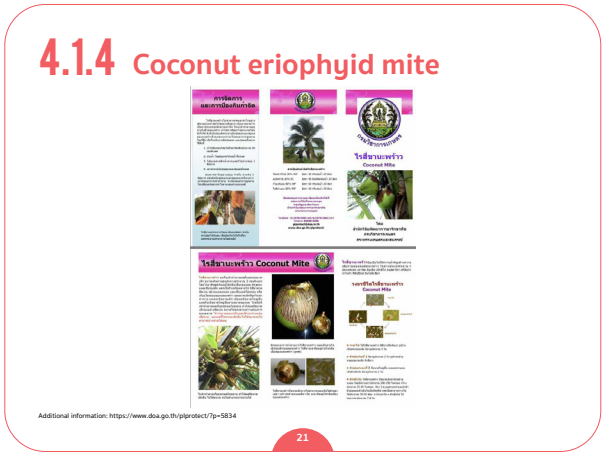
Life cycle of coconut eriophyid mite

One life cycle of coconut eriophyid mite takes approximately 7–8 days where the nymph and adult stage can damage coconut fruit.

Methods to control coconut eriophyid mite

1. Collect and destroy all fallen buttons of affected palms by burying them at the depth of 50 cm, or putting them in the plastic bag and drying in the sun for 7 days to avoid their spread.

2. Since mites are largely dispersed by wind, windbreak is a potential method to prevent the spread.



Additional information about coconut eriophyid mite could be found from DOA website such as https://www.doa.go.th/plprotect/?p=5834

Additional information

The coconut eriophyid mite, *Aceria guerreronis*, is about 220 micrometers in length and 36–52 micrometer in width. The adult females lay eggs on the developing coconut fruit approximately a month after the pollination. The developing larvae thrust their mouthparts into the developing fruit and suck out the juices. The whole developmental cycle takes 7–8 days, thereby mites can rapidly increase their numbers. The mites are probably largely dispersed by wind.

Life cycle of coconut eriophyid mite

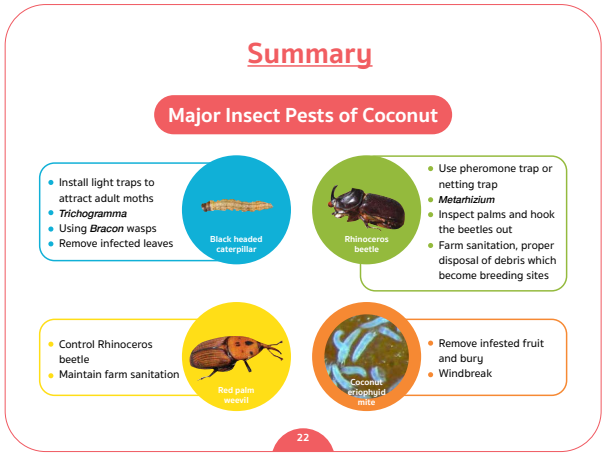
1. The adult mite is white and translucent, long and worm-like slender body with two pairs of legs and lives up to 5 days. The female mite lays up to 20–100 eggs into colonies.

2. Eggs are round shape, glossy and white. It hatches within 2–3 days.

3. Nymphs look similar to the adult stage with the same pale color and features, but smaller. Two nymph stages will be developed. Each nymph stage lasts around 2 days.

More information is available at

or https://www.doa.go.th/plprotect/?p=5834



Summary of major insect pests in coconut farm

1. Major pests of coconuts are black headed caterpillar, rhinoceros beetle, red palm weevil and coconut eriophyid mite.

2. For all a good waste management of the farm will prevent risk of infection. Once infected, potential methods for controlling each pest species are summarized as follows:

- Black-headed caterpillar: use light traps to attract adult moths, use *Trichogramma*, *Bracon hebetor*, remove infected leaves.

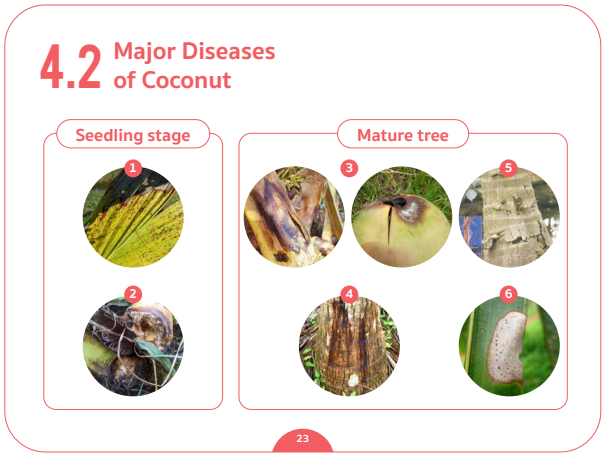
- Coconut rhinoceros beetle: use pheromone trap or netting trap, apply *Metarhizium*, keep inspecting palm trees and hook the beetles out if found, and maintain farm sanitation with a proper disposal of debris.

- Red palm weevil: avoid damage from coconut rhinoceros beetle and maintain farm sanitation.

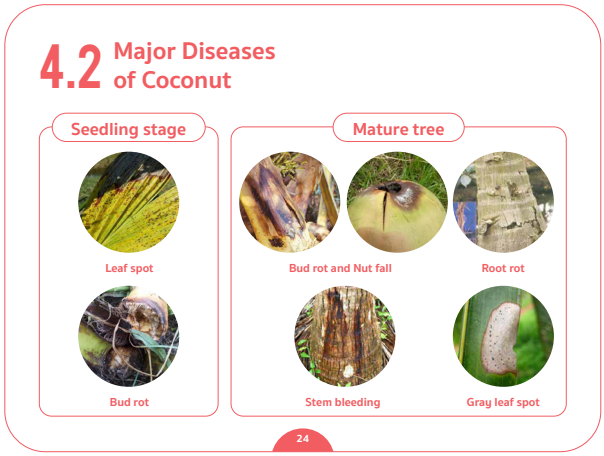
- Coconut eriophyid mite: get rid of infested fruit and use windbreak.

4.2 Major diseases of coconut

Diseases of coconut have been reported to cause economic loss in many countries; however, in Thailand, the coconut diseases are less problematic compared with insect pest problem. Anyhow, a few diseases are found in coconut plantation.



Question from trainer: What diseases occur in your farm? Or do you know any of these diseases?



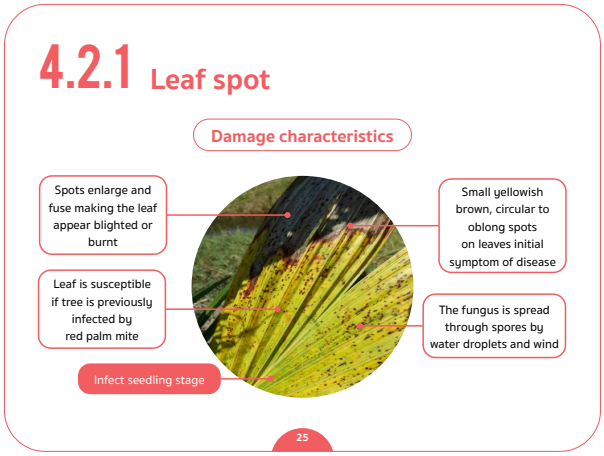
Possible answers from participants:

Major diseases of coconut are leaf spot, bud rot, bud rot and nut fall, basal stem rot, stem bleeding and gray leaf spot.

These diseases can be divided into two categories following the susceptibility of the palm ages:

1. The seedling stage is susceptible to two diseases, namely leaf spot and bud rot.

2. The mature stage is often affected by bud rot and nut fall, basal stem rot, stem bleeding and gray leaf spot.



Diseases of the seedling stage

4.2.1 Leaf spot disease (caused by *Helminthosporium* spp.*)*

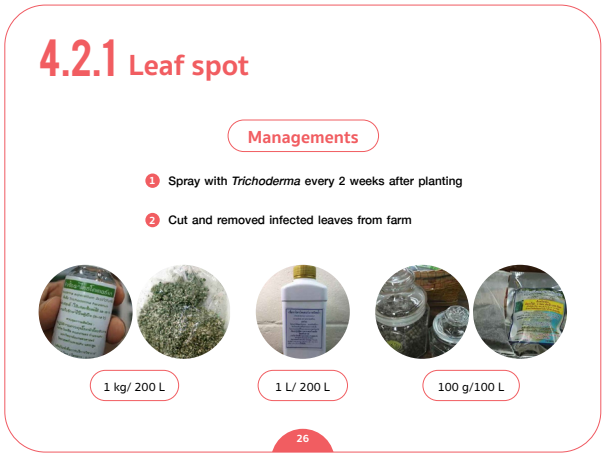
The disease is only of importance at the seedling stage especially in the nursery. After transfer to the field, it is rarely important. Infection causes leaves to dry up and die early, and the defoliation slows growth.

Symptom

First symptom is shown by small, oval and brown spots on leaf; later, they rapidly expand becoming light gray in the center. Often the spots join together causing a leaf blight.

Spread

Spores of the fungus found on the underside of the leaf spots during wet weather, are spread by wind and rain. The fungus needs high levels of humidity for sporulation, and the spores need dew or rain for infection. Note that leaf become more susceptible to leaf spot disease if coconut tree is previously infected by red palm mite.

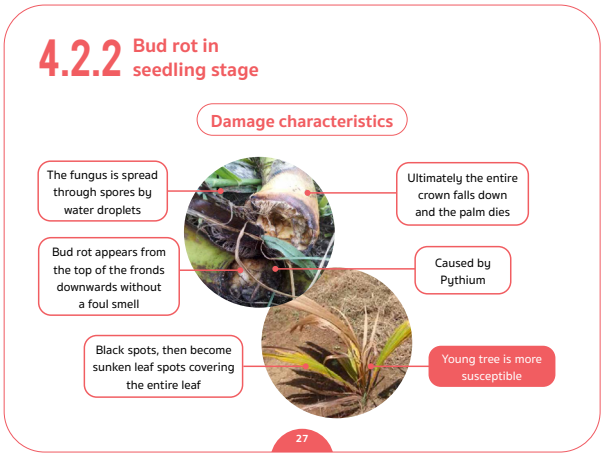


Prevention and control

1. Spray the seedling with *Trichoderma* every 2 weeks after planting. Recommended dose of *Trichoderma* is

- For fresh culture, using 1 kg/200 L
- For liquid form, using 1 L of Trichoderam/200L
- For granular form, using 100 g/200L

2. Cut and remove infected leaves from farm to avoid disease spreading.



4.2.2 Bud rot (caused by *Pythium*)

Every age of palms is liable to get infected to the disease, but normally young palms are more susceptible, particularly during the wet season when the temperature and humidity is high.

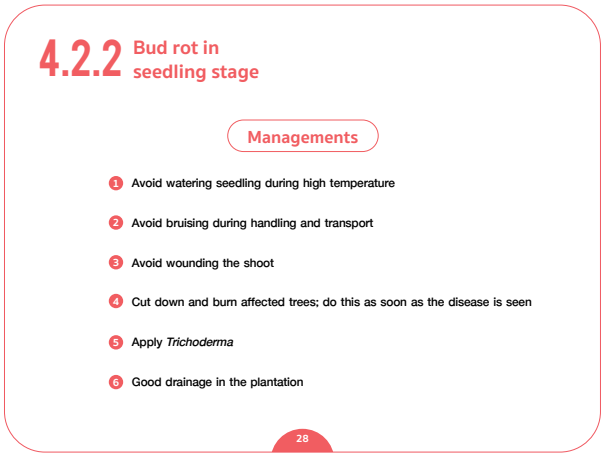
Symptom

The earlier symptom is the yellowing of one or two younger leaves. Black spots appear on leaf, then quickly become sunken covering the entire leaf.

In the later stages the spindle withers and drops down. The spear leaf turns pale and comes off with a gentle pull. **The decayed leaves do not emit foul smell.**

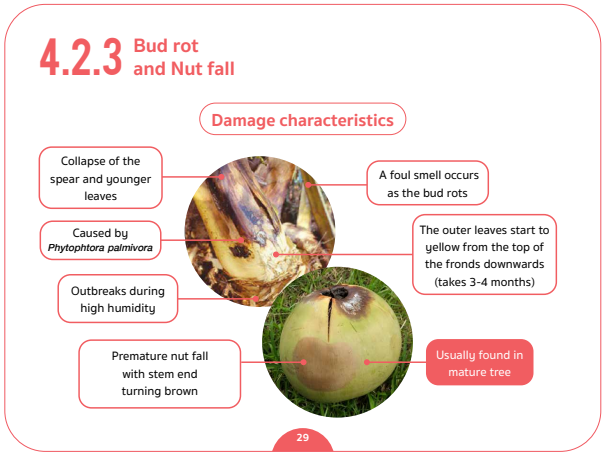
Spread

Pythium spp. can survive in the water, moisten soil and plant debris. It is spread under wet or poorly drained soils condition.



Prevention and control

1. Avoid watering seedling during high temperature
2. Avoid bruising during handling and transportation
3. Avoid wounding the shoot
4. Cut down and burn the affected trees; do this as soon as the disease is detected.
5. Apply *Trichoderma*.
6. Have good drainage condition in the coconut plantation. Avoid growing coconut palm in low land where flooding or poorly drained soil is a problem.



Diseases of the mature stage

4.2.3 Bud rot and nut fall (caused by *Phytophtora palmivora*)

By the time the symptoms appear detectable, the disease is in the advanced stage with the rot of bud and inner leaves.

Symptom

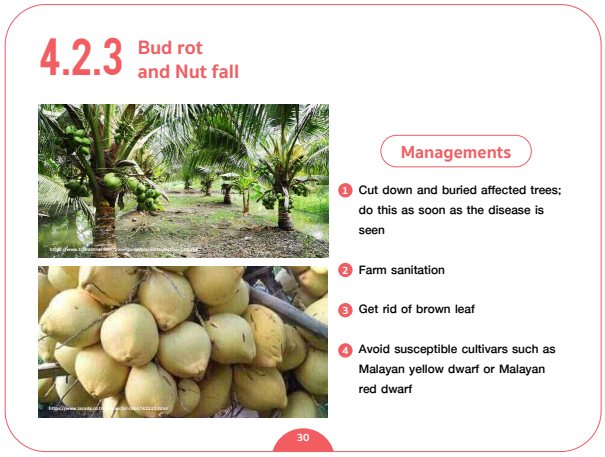
The first sign is a wilt or a bending of the spear leaf. The outer leaves then start to yellow from the top of the fronds downwards, and then turn brown, and sunken patches occur on the leaf stalks.

As the disease progresses, the central leaves fall out as they become completely rotten at the base of the leaf stalks, leaving only a few outer leaves, which remain green. This process takes 3-4 months before leaves dry out and fall.

A foul smell occurs as the bud rots. Nuts are also attacked and may lead to premature nut fall.

Spread

The disease outbreaks are favored by high humidity with poorly drained plantations with dense stands, and in areas of high rainfall especially when rainfall occurs more than 7 days in a row.



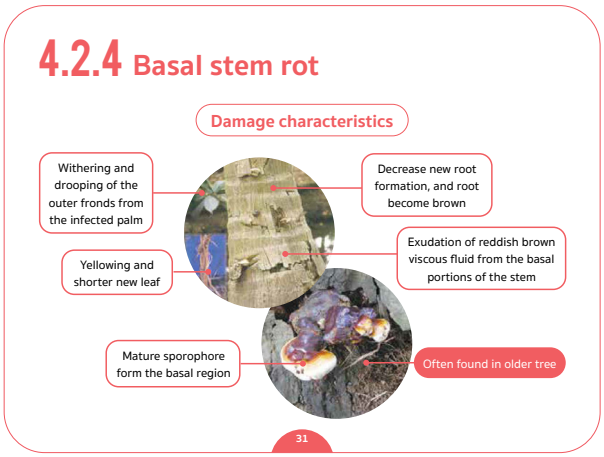
Prevention and control

1. Cut down and buried the affected trees; do this as soon as the disease is found.
2. Maintain farm sanitation
3. Get rid of brown leaf to lower the leaf wetness, which is needed for spore germination.
4. Avoid susceptible cultivars such as Golden Malayan Dwarf or Red Malayan Dwarf

Additional information

In severe case, chemical compound may be allowed in organic farm. However, the farm needs to have a document certified by the related organization stating the urgent and important to use chemical compound to control pests. Otherwise, it will cause disaster.

More information, please consult 'EU (Council Regulation (EC) No 834/2007)' or 'USDA (§205.206 Crop pest, weed, and disease management practice standard' or '§205.271 Facility pest management practice standard'. The example of chemical compound allowed in the severe case needs to contain Copper within the limits of 6 kg/ha/year and avoid directly contacting with the edible part of coconut.



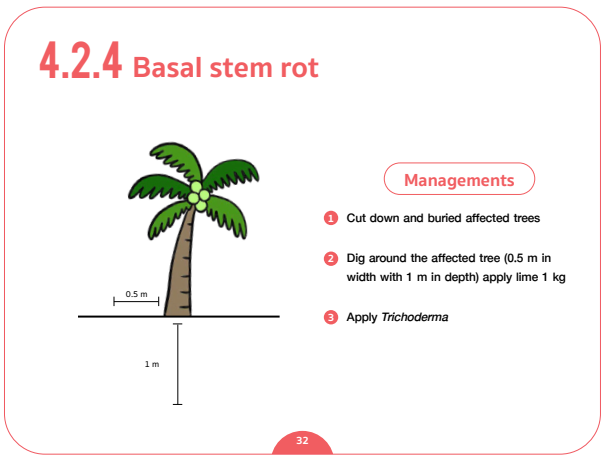
4.2.4 Basal stem rot (caused by *Ganoderma lucidum* (Curtis) P.Karst.)

Symptom

The infection begins from the roots resulting in a decrease of new root formation, and the infected roots become brown. The newly unfolded leaves are shorter and chlorotic. The tips are sometimes necrotized, but lasting for a while. Withering and drooping of the outer fronds are also observed. The growth of new bunches is adversely affected. Mature sporophore and exudation of reddish-brown viscous fluid is often found at the basal portions of the stem.

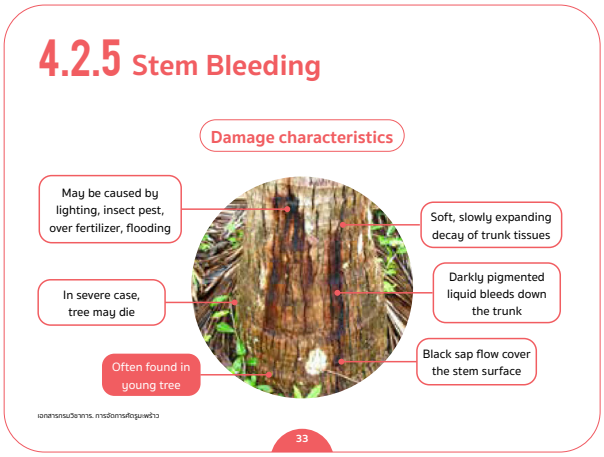
Spread

Basically, the Ganoderma is a soil-borne pathogen and survives well in the soil for a long time. The disease is spread by direct contact with the spore on decaying or affected plant.



Prevention and control

1. Cut down and burn the affected trees.
2. Dig around the affected tree (0.5 meter in width with 1 meter in depth) then apply lime 1 kilogram
3. Apply *Trichoderma*.



4.2.5 Stem bleeding (caused by *Ceratostomella paradoxa* or *Thielaviopsis paradoxa*)

The disease may be caused by lighting, pest insect, over fertilizer, flooding.

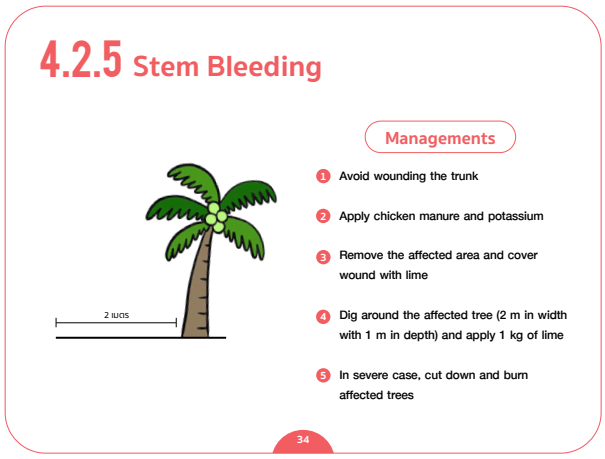
Symptom

Stem bleeding is characterized by the exudation of a dark reddish-brown liquid from the longitudinal cracks in the bark and wounds on the stem. The lesions spread upwards as the disease progresses. The liquid oozing out dries up and turns black. The tissues below the lesions become rotten and turn yellow first then black.

In the advanced stage of the disease, the interior of the affected trunks is hollow due to the decay. The outer whorl of the leaves turns yellow, dry, and shed prematurely. The growth of new bunches is adversely affected. Nut fall is also noticed. The trunk gradually tapers to the apex and the shoot size becomes smaller in the chronic cases. Normally, the decease is often found in young tree.

Spread

Fungi spread their spores by wind and rain.



Prevention and control

1. Avoid wounding the palm trunk.
2. Apply manure and potassium.
3. Remove the affected area and cover wound with lime.
4. Dig around the affected tree (approximately 2 meters in width with 1 meter in depth) and apply 1 kilogram of lime.
5. In severe case, cut down and burn the affected trees.

4.2.6 Gray leaf spot disease (caused by *Pestalotiopsis palmarum* (Cooke) Steyaert)

Symptom

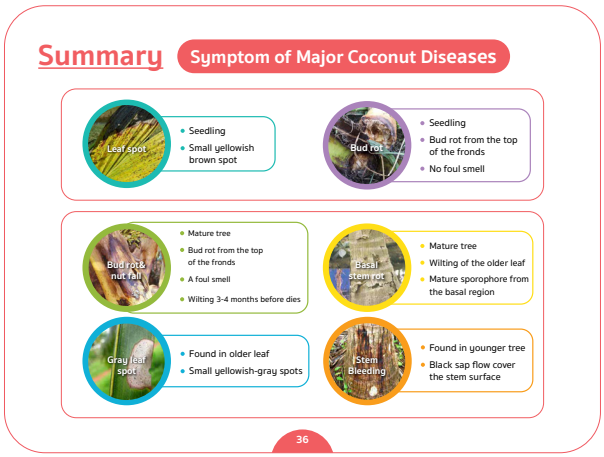
The first sign is lesions surrounded by small yellow spot on the leaflets and becomes dry and gray with sunken necrosis. Some dark gray color often appears in the middle of the lesion. Then, the infected leaves turn gray, leading to defoliation. The disease is often found in older leaf.

Spread

Fungi spread their spores by wind and rain.

Prevention and control

1. Cut down and burn the affected trees.
2. Apply *Trichoderma*.



Summary of the coconut diseases

In Thailand, the coconut diseases are less problematic compared to the outbreaks of insect pests. However, there are six diseases frequently and widely found in coconut plantation.

Diseases are often problematic for the seedling stage

1. Leaf spot is characterized by small yellowish and brown spot on laminar.

2. Bud rot is characterized by bud rot from the top of the fronds without a foul smell.

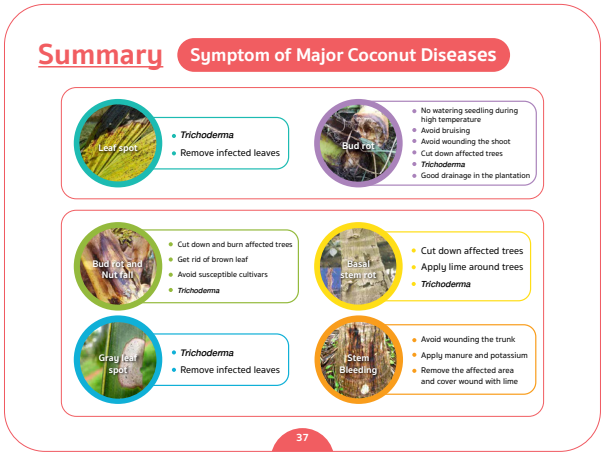
Diseases are often problematic for the mature stage

3. Bud rot & nut fall is characterized by bud rot from the top of the fronds with a foul smell. Outer leaves wilt 3-4 months before the palm dies.

4. Basal stem rot is characterized by wilting of the older leaf and mature sporophore from the basal region of trunk.

5. Stem bleeding is characterized by black sap flow covering the stem surface, often found in the younger tree.

6. Gray leaf spot is characterized by small yellowish-gray spots, often found in the older leaf.



Summary of prevention and control for each disease

1. Leaf spot can be controlled by using *Trichoderma* and removing the infected leaves.

2. Bud rot can be managed by avoiding watering seedling during high temperature, avoid bruising, and wounding the frond, cutting down the affected trees, using *Trichoderma*, and maintaining good drainage in the plantation.

3. Bud rot and nut fall can be managed by cutting down and burning the affected trees, avoiding susceptible cultivars, and using *Trichoderma*.

4. Basal stem rot can be managed by cutting down the affected trees, applying lime around trees, and using *Trichoderma*.

5. Stem bleeding can be managed by avoiding wounding the trunk, applying manure and potassium, removing the affected area and covering it with lime, and cutting down the affected trees.

6. Gray leaf spot can be managed by using *Trichoderma* and cutting the infected leaves.

4.3 Integrated pest management (IPM)

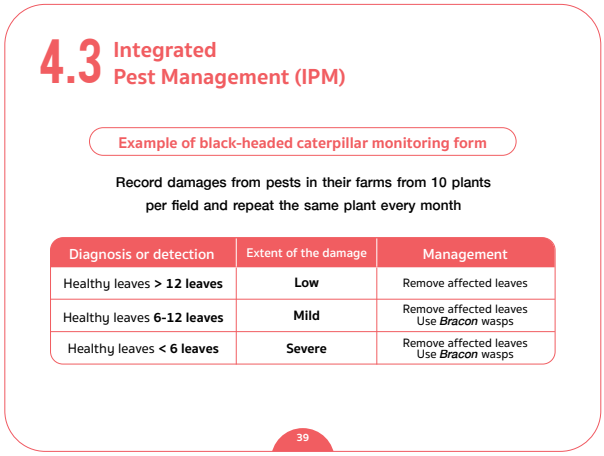
Integrated Pest Management (IPM) is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations and keep pesticides to levels that are economically justified and minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

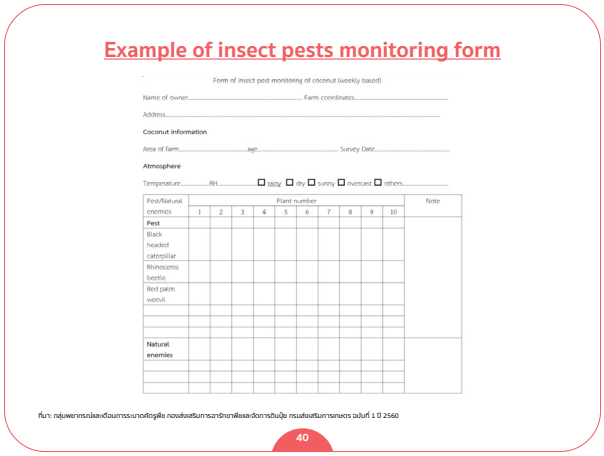
Principles of IPM include

1. The growth of a healthy plant.

2. Maintaining ecological balance in the coconut farm by suppressing pest population to the acceptable level, increasing natural enemies, and diversifying the agro-ecosystem.

3. Pest monitoring with the regular observation, at least once a month.





Pest monitoring

Explain the importance of conducting pest monitoring. The participants have to learn how to record number of pests in the example form and estimate level of damage produced by pests in the example form. If possible, the participants are encouraged to conduct monitoring of their own farm.

Use black-head caterpillar monitoring form as a practicing example (taken from Proceedings of the Dissemination Workshop on the CFC/DFID/APCC/FAO Project on Coconut Integrated Pest Management Held in Colombo Sri Lanka, 12–20 October 2006).

Monitor of black-headed caterpillar keeps recording 10 plants per farm and observing the same 10 plants every month. There are several walking-route patterns to ensure thorough monitoring, for example, crossing the field diagonally, or inverted W pattern. It is important to note that, in this form, the healthy leaves (not the affected leaves) will be recorded.

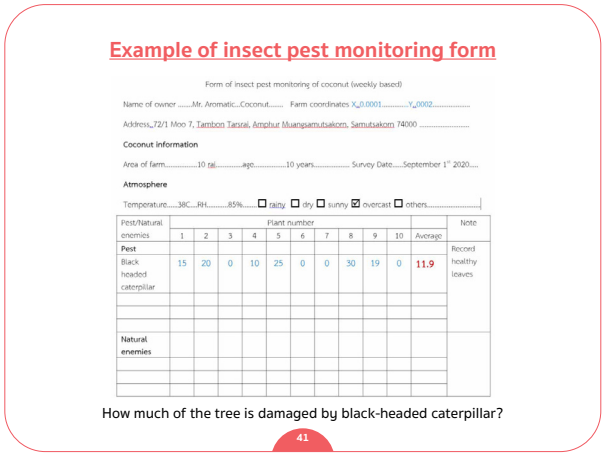
After the record is completed, calculate the average score of the healthy leaves to estimate the level of damage and adopt the appropriate solution:

- No damage is observed—no sign of infestation

- If the average score of the healthy leaves is **more than 13**, it means that the pest population in the farm is low. The recommended management would be cutting the affected leaves, dispose them properly and using *Bracon hebetor* at 150 wasp per rai every 2 weeks.

- If the average score of the healthy leaves is **6–12**, it indicates the pest population is moderate. The recommended management would be cutting the affected leaves and using *Bracon hebetor* at 500 wasp per rai every 2 weeks.

- If the average score of the healthy leaves is **less than 6**, it indicates that farm is facing a serious pest problem. The recommended management would be cutting the affected leaves and using *Bracon hebetor* at 500 wasp per rai every 2 weeks.



Show the form and explain how to enter the information.

Example

In September 1st 2020, Mr. Aromatic observed pests in his 10 rai of coconut farm. He randomly marked 10 palm trees that would individually be monitored and recorded the number of pests every month. For the monitor of Black-headed caterpillars, he recorded the amount of only remaining healthy leaves on each tree. The results are shown as follows:

Tree 1: caterpillars are found and 15 healthy leaves are remained.

Tree 2: caterpillars are found and 20 healthy leaves are remained.

Tree 3: free of caterpillars

Tree 4: caterpillars are found and 10 healthy leaves are remained.

Tree 5: caterpillars are found and 24 healthy leaves are remained.

Tree 6: free of caterpillars

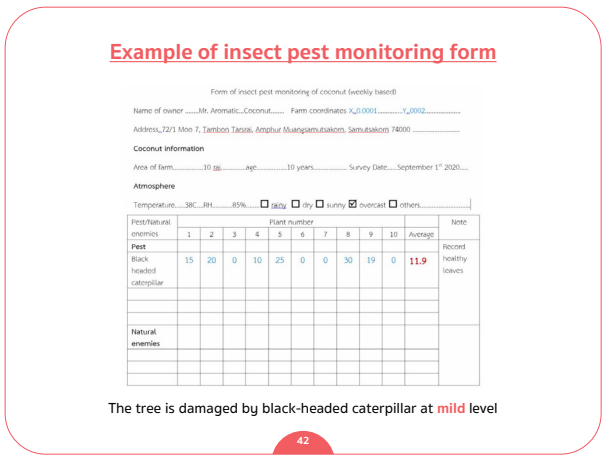
Tree 7: free of caterpillars

Tree 8: caterpillars are found and 30 healthy leaves are remained.

Tree 9: caterpillars are found and 19 healthy leaves are remained.

Tree10: free of caterpillars

After calculating the level of damage, the average number of healthy leaves of 10 trees is **11.9**.



Question from trainer: What is the level of damage from Black-headed caterpillar in this example?

Possible answer from participants: Moderate level

IPM methods to suppress pest population

To suppress pest population to an acceptable level, several methods can be carried out. However, this module will introduce three methods: biological, physical and cultural controls.

4.3.1 Biological control is a method of controlling pests by using other organisms. The successful biological control should be implemented at the early stage of pest detection.

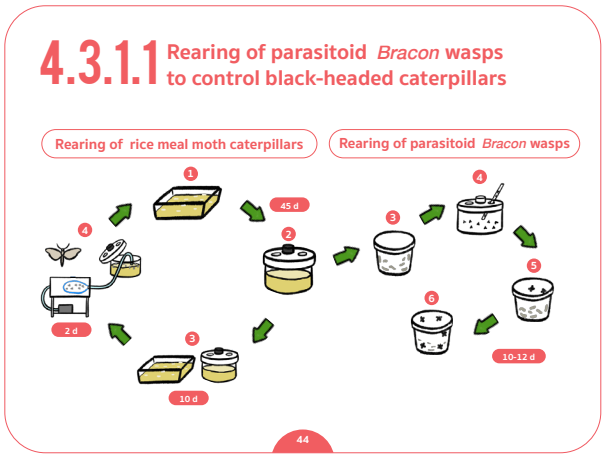
Biological control relies on

1. Predation such as using earwigs to control young larva of Brontispa.

2. Parasitism such as using *Bracon hebetor* to control black-headed caterpillars.

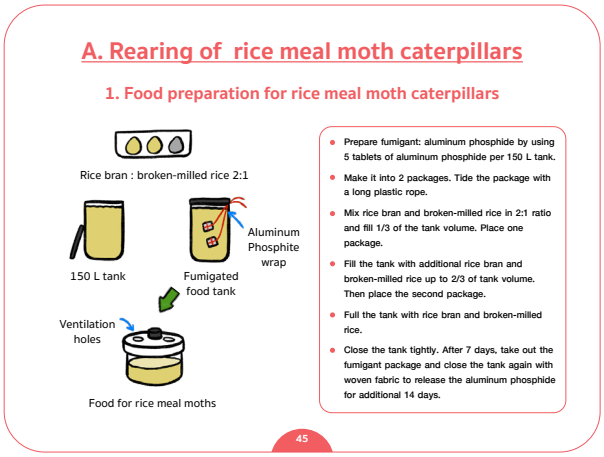
3. Entomopathogens such as using *Metarhizium* to get rid of coconut rhinoceros beetle.

In addition, rearing of parasitoid *Bracon hebetor* and rearing *Metarhizium* to get rid of Rhinoceros beetle are practical for non-experienced farmers.



4.3.1.1 Rearing of parasitoid *Bracon hebetor* to control black-headed caterpillars

Two steps are involved, which are (A) Rearing of rice meal moth caterpillar and (B) Rearing of parasitoid *Bracon hebetor*



A. Rearing of rice meal moth caterpillar

1. Food preparation for rice meal moth caterpillars

- Food for rearing of rice meal moth caterpillar is rice bran and broken-milled rice. This food needs fumigation to kill snout beetle.

- Preparation for fumigation: (FUME TOXIN 56) by taking 5 tablets of aluminum phosphide per 150 L tank. Divide into aluminum phosphide 2 packs, one contains 2 tablets and another contains 3 tablets. Tie the package with a long plastic rope to facilitate package removing after finishing the fumigation.

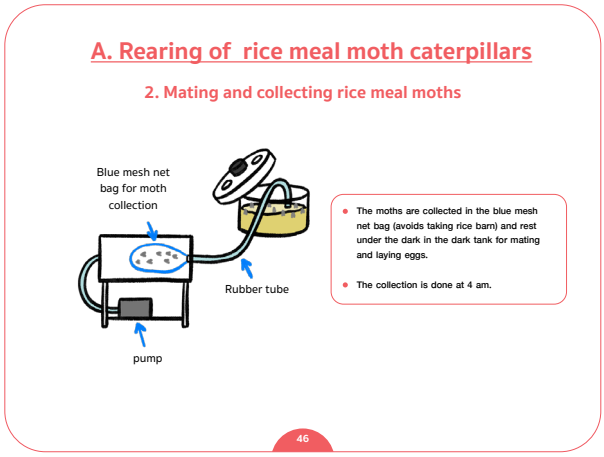
- Mix rice bran and broken-milled rice in the 2:1 ratio and fill 1/3 of the tank volume. Place 3-tablets package.

- Fill the tank with additional rice bran and broken-milled rice up to 2/3 of tank volume. Then place a 2-tablets package.

- Full the tank with rice bran and broken-milled rice.

- Close the tank tightly. After 7 days, take out the fumigant package and close the tank with woven fabric to release the aluminum phosphide for additional 14 days.

Note: For safety concern, gloves and mask should be worn at all time during this step.

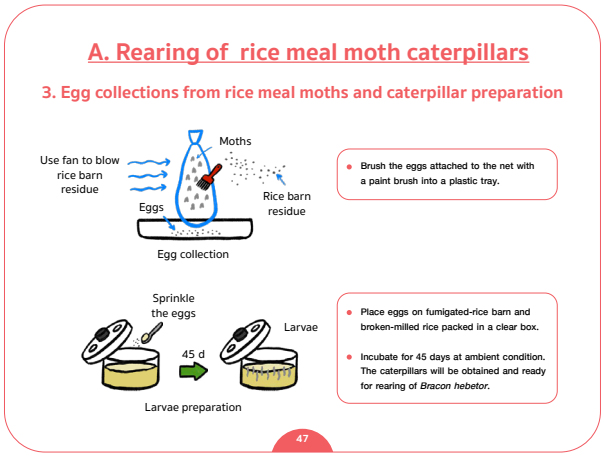


2. Mating and collecting rice meal moths

- The rice meal moths are collected in the blue mesh net bag (avoids taking rice bran).

- Rest the moths inside the mesh bag under the dark condition for mating and laying eggs.

- This step should be completed at 4 am or before sunrise to get as much eggs as possible in the desired container.



3. Egg collections from rice meal moth and caterpillar preparation

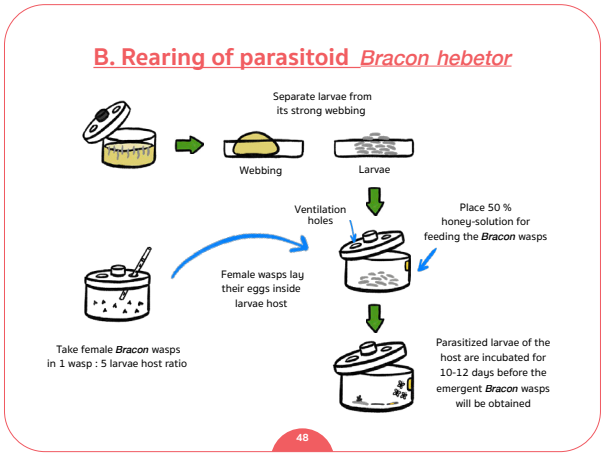
- From previous step, rice meal moths should lay their eggs on the mesh net bag surface.

- Take the nest bag, use a fan to blow out the contaminated rice bran residue (lighter in weight).

- Then, using a paint brush collects eggs which attach to the net. All collected eggs are combined in a plastic tray.

- Place eggs on fumigated-rice bran and broken-milled rice packed in a clear box.

- Incubate for 45 days at ambient condition. The caterpillars will be obtained and ready for rearing of *Bracon hebetor*



B. Rearing of parasitoid *Bracon hebetor*

- Separate larvae from their strong webbing.

- Take female *Bracon hebetor* in 1 wasp: 5 larvae host ratio and put them into a clear box with ventilation holes on the lid.

- Place 50 % honey-solution for feeding the *Bracon hebetor*.

- Female *Bracon hebetor* wasps lay their eggs inside larvae host.

- Parasitized larvae of the host are incubated for 10–12 days before the emergent *Bracon hebetor* wasps will be obtained.

- Five to ten adults (females and males) will emerge from one parasitized larva.

- Adult *Bracon hebetor* wasps are released at 50–80 wasps/rai at 15 days interval.

Lessons learned by pilot farmers – *Bracon*

• Release the *bracon* on the day you receive them for good results. The effectiveness of *bracon* decreases if they are kept for a few days.

• Release the *bracon* at several locations across your farm. The *bracon* won't move far away.

• Our pilot farmers have shown that using *bracon* was a successful method to control coconut black-head caterpillars.

• *Bracon* are easy to handle compared to other methods. However, as the supply of *bracon* is limited you need to order it in advance (delivery time is usually 15 days), otherwise you could use *Trichogramma* spp., *Bacillus thuringiensis* and/or *Beauveria bassiana* as alternatives.

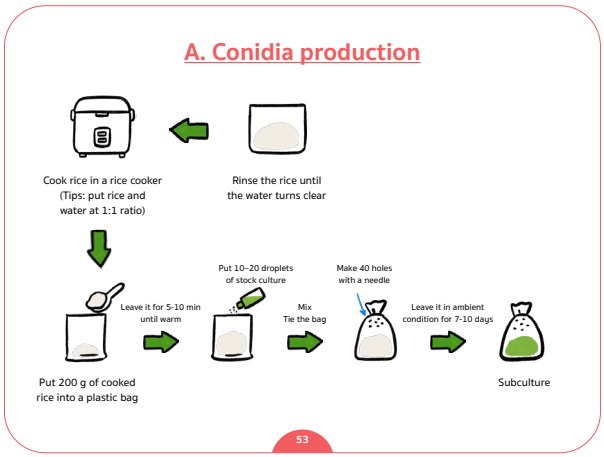
More information about rearing of *Bracon* and *Trichogramma* is available at

1. or https://esc.doae.go.th/แตนเบียนบราคอน

2. or https://www.doa.go.th/plprotect/wp-content/uploads/Publieissue/5.Trichogramma.pdf

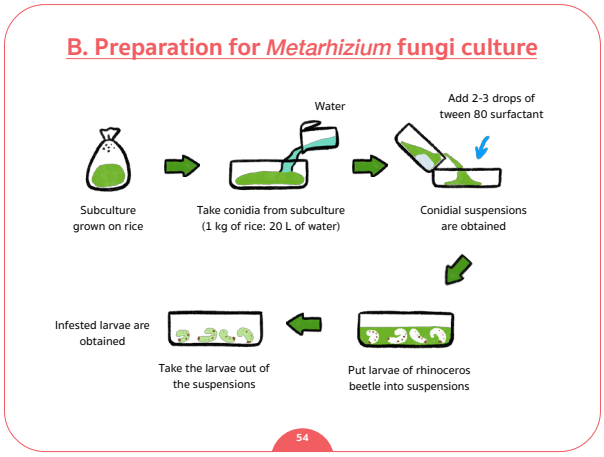
4.3.1.2 Rearing of *Metarhizium anisopliae* fungi to control coconut rhinoceros beetle

Three steps are involved: (A) conidia production, (B) preparation for *Metarhizium anisopliae* fungi culture and (C) preparation of compost baits as the breeding site



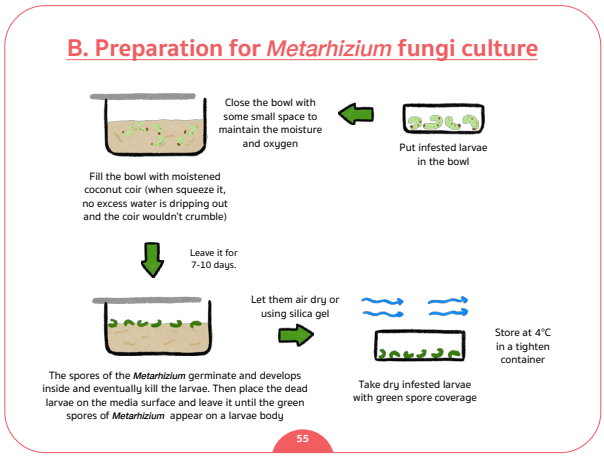
(A) Conidia production

- Clean the rice under tap water to remove any starch and dust until the rinsed water turns clear.
- Steam rice in a rice cooker by using rice and water at 1:1 ratio.
- When cooked, separate the rice into small plastic bags (200 g per bag). These bags are kept until warm.
- Put 10–20 droplets of stock Matarhizium culture on the warm rice and mix them well.
- Use rubber band to tie these plastic bags. Make 40 holes with a needle.
- Leave it in ambient condition for 7–10 days.
- The subculture with conidia on rice will be obtained.



(B) Preparation for *Metarhizium anisopliae* fungi culture

- Take conidia from subculture by rinsing 1 kilogram of rice with 20 L of water.
- Conidial suspensions are obtained. Then 2–3 droplets of tween 80 as a surfactant are added.
- Put larvae of coconut rhinoceros beetle into the suspensions to allow the *Metarhizium* infects the larvae of coconut rhinoceros beetle
- Take the larvae out of the suspensions. Infested larvae are obtained.

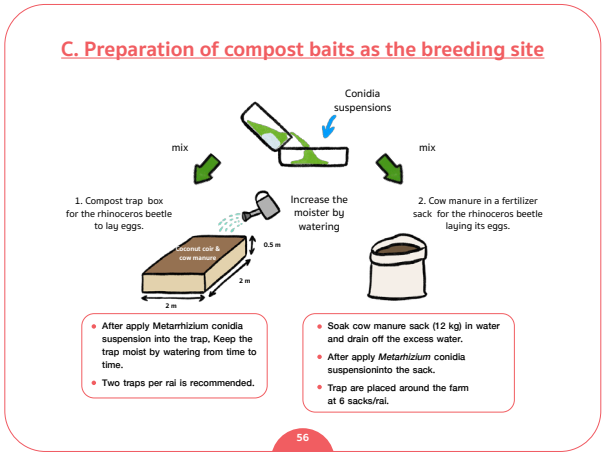


- Fill a bowl with moistened coconut coir (when squeeze the coir, it is neither too crumbly nor soaked that excess water drips down).

- Put the infested larvae on the coconut coir and close the bowl with the lid. Please leave some small spaces to maintain the level of moisture and oxygen.

- Incubate for 7–10 days. The spores of the *Metarhizium* germinate and develop inside and eventually kill the larvae. When the larvae die, take the dead body and leave it on the top of the media to allow *Metarhizium* continues to propagate as the *Metarhizium* grow better with oxygen. Incubate until the green spores of *Metarhizium* appear on dead larvae bodies.

- To re-subculture the fungi, take the infested larvae with green spore coverage and let them air dry before storage at 4∞C in a tightened container. This stock culture will last more than a year.



(C) Preparation of compost baits as the breeding site.

Two options are recommended.

1. Compost trap box for the coconut rhinoceros beetle to lay its eggs. This option requires setting up the compost pile from coconut coir and cow manure in the coconut farm. The pile dimension is 2x2x0.5 m. Keep the trap moist by watering from time to time. Two traps per rai is recommended.

2. Cow manure in a fertilizer sack for the coconut rhinoceros beetle to lay its eggs. This option is easier with less preparation. First, soak cow manure sack (12 kg) in water and drain off the excess water. Traps are placed around the farm at 6 sacks/rai.

The application of *Metarhizium anisopliae* is done by rinsing 1 kilogram of subculture with 2 liters of water. Then the conidia suspension can be applied directly into the trap. *Metarhizium* lasts 6-12 months in the soil; however, additional conidia suspension should be applied in the trap every 4 months.

Lessons learned by pilot farmers – *Metarhizium*

- Compost baits are excellent breeding sites for *Metarhizium*.
- Each farm should use a minimum of 2 baits to kill the larvae of rhinoceros beetles.
- Control the moisture in the compost baits to get active *Metarhizium*.
- Production of *Metarhizium* cultured on rhinoceros larvae is more effective than that from culture medium.
- Wear gloves and a mask when handling *Metarhizium* to protect yourself.
- Pilot farmers have shown that using *Metarhizium* was successful in order to get rid of adult rhinoceros beetles.

Additional information

More information about *Metarhizium* is available at

1. or https://www.doa.go.th/plprotect/wp-content/uploads/Publieissue/14.metarhizium.pdf

2. or https://www.facebook.com/doaessphotos/a.539627956133219/3363399823756004/?type=3&theater

Additional information about *Bacillus thuringiensis* could be also found at

or https://www.doa.go.th/plprotect/wp-content/uploads/Publieissue/3.BT_.pdf

4.3.2 Physical control

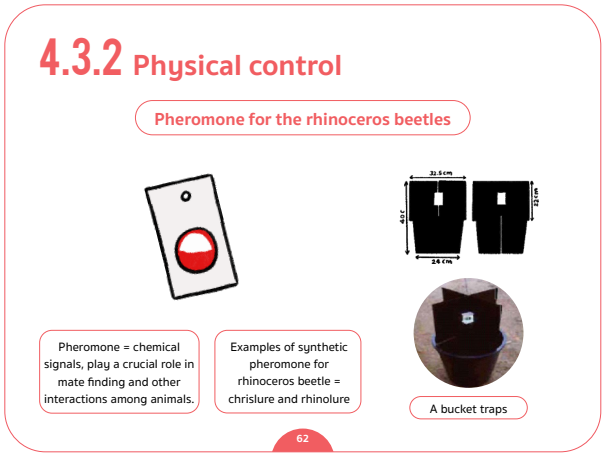
Physical control is the modification of physical factors in the environment to minimize or prevent pest problem

There are many physical controls for insect pests in coconut farm. For examples,

- Use light trap to attract moth and coconut rhinoceros beetle at night. For coconut rhinoceros beetle, set up light traps following the first rains in summer and monsoon period to attract and kill the adult beetles.

- Use sand as a repellent. In case of coconut rhinoceros beetle, a handful of sand is put near leaf base.

- Use pheromone traps for trapping the coconut rhinoceros beetle adults.

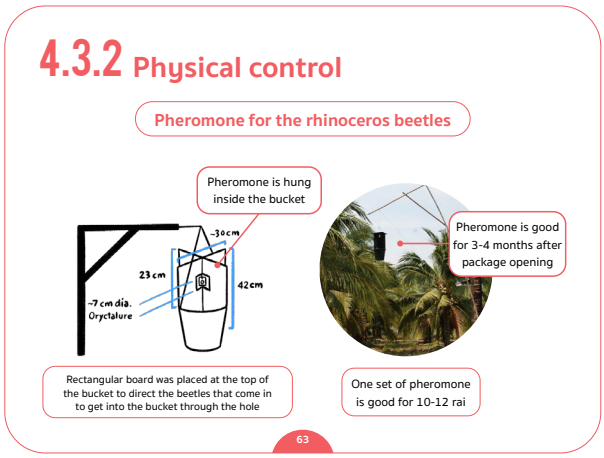


Pheromone for trapping the coconut rhinoceros beetle adults

- Pheromone is chemical signals that play a crucial role in mate finding and other interactions among animals.

- Examples of synthetic pheromone for coconut rhinoceros beetle are christure and rhinolure.

- Pheromones are hung inside the bucket. At the bottom of the bucket, there are holes for water drainage in case of rain. Rectangular plastic board is placed at the top of the bucket to direct the beetles that come in to get into the bucket. Pheromones is efficiently used for approximately 3–4 months.



To set up pheromones trap

The pheromones trap bucket is hung at approximately the height of 2-3 meters. It is placed windward side, close to the coconut plants. Trap is placed at one trap per 10–12 rai and should be placed at the border of the farm to avoid attracting beetle inside the farm. For a better efficient action, it needs to coordinate with other farms in the area at the time.

Lessons learned by pilot farmers – Pheromone

- Set up the pheromone trap in the direction of the wind at the edge of the farm.
- It is recommended to use a wire rope hoist to hang the pheromone trap because then you can check it and change the trap easily. The trap should be placed 3 meters high.
- Remove all dead trees from the farm to avoid the spread of red palm weevil.
- If only one adult rhinoceros beetle is trapped, it can prevent the reproduction cycle of rhinoceros beetle at a ratio of 1 to 150.
- Pilot farmers have shown that using pheromone traps was successful in order to catch red palm weevil and rhinoceros beetles.

"By applying pheromone traps at my farm, I was able to catch a lot of red palm weevil and rhinoceros beetles. The traps helped to reduce plant damage from insects and prevented the coconut trees from dying, which saved costs for replanting coconut trees." - Jitisak

4.3.3 Cultural control

Cultural pest control is the manipulation of the crop production system or cultural practices to reduce or eliminate pest populations.

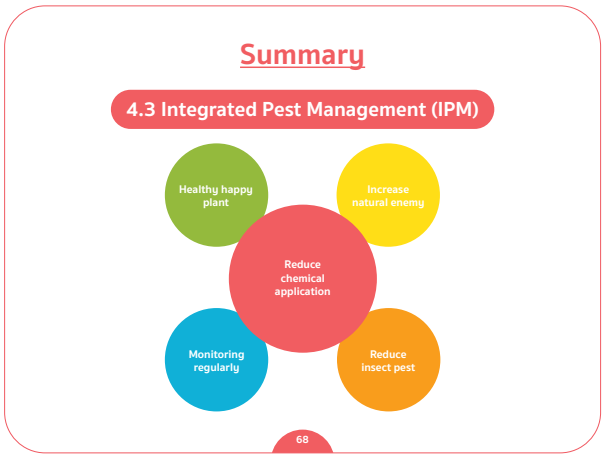
There are many cultural controls for insect pests in coconut farm. For examples,

- Remove debris, such as palm logs and tree stumps.
- Avoid bringing coconut seedling from the affected areas.
- Cut off the affected leaf to avoid the pest spread.
- Adopt intercropping to maintain farm diversification.

Please see module 2 for more detail.

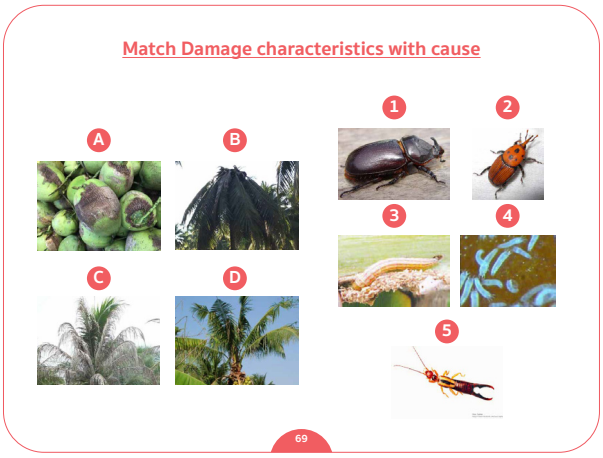
Important Information – Pest Control

- Observe and monitor your farms regularly to check what kind of pests are present in your farm.
- Tackle the pest at the earliest stage possible to prevent major losses.
- Each type of pest requires a different method to control them.



Summary of Integrated Pest Management (IPM)

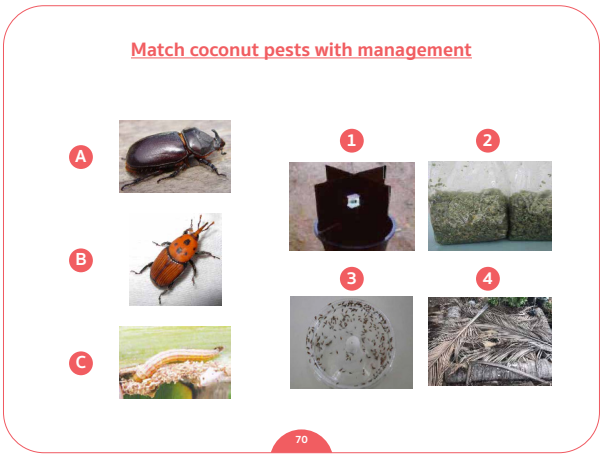
IPM aims to suppress pest populations and keep pesticides to levels that are economically justified and minimize risks to human health and environment. To reach the aim, four activities are involved, which are to maintain healthy plant, increase natural enemies, reduce insect pest, and regularly monitor pest.



Before ending the lecture, asks the participants to complete this exercise.

- Please match the damage characteristics to the pest species producing the damage.

Answer: A-4, B-2, C-3, D-1



Please match the management method to the pest species.

Answer: A-1, 4,2, B-1, C-3

Questions

1. What do participants learn from this module?
2. What will they do to manage pests in their farm?

Summary and closing

1. Major pests of coconuts are black headed caterpillar, coconut rhinoceros beetle, red palm weevil and coconut eriophyid mite.

2. Potential control methods for pests are:

- Black-headed caterpillar: use light traps to attract adult moths, use Trichogramma, *Bracon hebetor*, remove infected leaves.

- Coconut rhinoceros beetle: use pheromone trap or netting trap, apply *Metarhizium*, inspect palms and hook the beetles out, and maintain farm sanitation with proper disposal of debris which become breeding sites.

- Red palm weevil: avoid damage from coconut rhinoceros beetle and maintain farm sanitation.

- Coconut eriophyid mite: remove infested fruit and destroy it and use windbreak.

3. The coconut diseases are less problematic compared with insect pest problem in Thailand. However, six diseases are found in coconut plantation. Leaf spot and bud rot are mostly be problematic at seedling stages while bud rot and nut fall, basal stem rot, stem bleeding and gray leaf spot are problematic at mature coconut stage.

4. Potential control coconut diseases are: using *Trichoderma*, removing of infected leaves, maintaining good drainage in the plantation, cut down affected trees, avoiding susceptible cultivars

B. HANDS-ON PRACTICES

After the lecture, invite an expert to demonstrate how to practice the rearing of *Metarhizium* and *Bracon* wasp step by step.

Materials for rearing *Metarhizium*, you will need to prepare include:

- Stock culture of *Metarhizium*
- Larvae of coconut rhinoceros beetle
- Plastic box/blow
- Coconut coir dust
- Rice
- Rice cooker
- Plastic bag
- Tween 80 surfactant
- Cow manure

During the demonstration, you may ask the expert the following questions:

When practicing *Metarhizium* preparation (For the trainer):

- Source of stock *Metarhizium*?
- How does spore (codinia) look like when *Metarhizium* get contaminated from other fungi?
- Is *Metarhizium* harmful to other pests such as chicken or dogs?
- How much does pheromone trap and *Metarhizium* cost (per rai)?

Possible answers:

- The stock *Metarhizium* can request from National Biological Control Research Center and Suphon Buri Agricultural Technology Promotion Center (Plant Protection)
- The color of spore (codinia) is not green or dark green
- *Metarhizium* is specifically harmful to coconut rhinoceros beetle but is not harmful to other pests.
- Pheromone trap and *Metarizium* cost 300 THB per rai per year

Materials for rearing *Bracon* wasp, you will need to prepare include:

- Rice meal moth caterpillar
- *Bracon* wasps
- Aluminum phosphide or potassium permanganate
- 150 L tank with lid
- A long plastic rope
- Paper
- Rice bran and broken-milled rice
- Woven fabric
- Blue mesh net bag
- Fan
- Plastic tray
- A paint brush
- Spoon
- Honey solution
- Plastic tube/straw

When practicing rearing *Bracon* wasp (For the trainer):

- What is the best time of the day for releasing *Bracon* wasp in the farm for controlling black-headed caterpillar?

- What is the application rate of *Bracon hebetor* in the farm for controlling black-headed caterpillar?

- How much it costs for buying *Bracon* wasp to control black-headed caterpillar in one rai?

Possible answers:

- Brancon prefer cool temperuatre with light condition therefore the test time of the day for releasing *Bracon* in the farm for controlling black-headed caterpillar is 9–10 a.m.

- Recommendated rate of *Bracon hebetor* in the farm for controlling black-headed caterpillar is 500 wasps per rai in severe case or 150 wasps per for non infested case.

- *Bracon* to control Black-headed caterpillar in one rai costs 50 THB per month

Module 5

POLLINATORS

OBJECTIVES

To know about insect pollinators, their usefulness for coconut farming, how to practice beekeeping and commercialize them.

ACQUIRED KNOWLEDGE

The participants:

1. Know and understand the habits of stingless bee and Asian honeybee and how to use them as pollinators.

2. Know beekeeping tasks for the two pollinators and use them commercially.

ACQUIRED SKILLS

The participants can:

1. Use stingless bee or Asian honeybee to pollinate coconut flowers

2. Keep stingless bee or Asian honeybee in their coconut farm.

ACQUIRED ATTITUDES

The participants realize the usefulness of stingless bee and Asian honeybee in coconut pollination and notice a possibility of added income from cultivation of the two pollinators.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Insect pollination is natural. Use of natural phenomenon to increase coconut pollination rate fits well with the organic coconut farming and increase yield productivity of the trees.

METHODS

1. Lecture with PowerPoint presentation for approximately 45 minutes.

2. Study visit, demonstration, hands on practices and discussion for 120 minutes

TRAINING SUPPLIES, TOOLS, AND MATERIALS

Lecture:

1. PowerPoint (PPT) presentation

2. A notebook computer with PPT program

3. An LCD projector and a screen or smart TV

4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and guide questions and issues to be discussed in Module 5

5. The Handbook for Farmers containing the lecture content, summary of knowledge in Module 5, and guide questions for the study visit and demonstration, as well as blank pages for taking notes

Demonstration/study visit:

In this module, a study visit to a stingless bee farm is suggested. During the visit, the owner of the visited farm is invited as a guest trainer to provide her/his knowledge and experience on the cultivation and use of insect pollinators. A demonstration of how to separate the insect hive should be included in the visit.

The owner should be contacted at least 1 month earlier to arrange the visiting date, time, place, transportation, and brief her/him on the presentation. A compensation for the owner and demonstration materials should be arranged, if any. Suggested questions and discussion topics relating the subject of visits should be listed and provided to the participants ahead of the visits. In case the guest trainer is not available, the trainer of the module should be ready to provide key information from the visit and answer questions the participants may have.

DURATION

A. Lecture Topics	Period (min)
1. Stingless bee	25
2. Asian honeybee	20
Total time of lecture	**45**
B. Study Visit/Demonstration	
1. Stingless bee cultivation and colony division	115
2. Summary and closing	5
Total time of study visit	**120 (2 h)**
Total time of training in Module 5	**165 (2 h 45 min)**

KEY MESSAGES

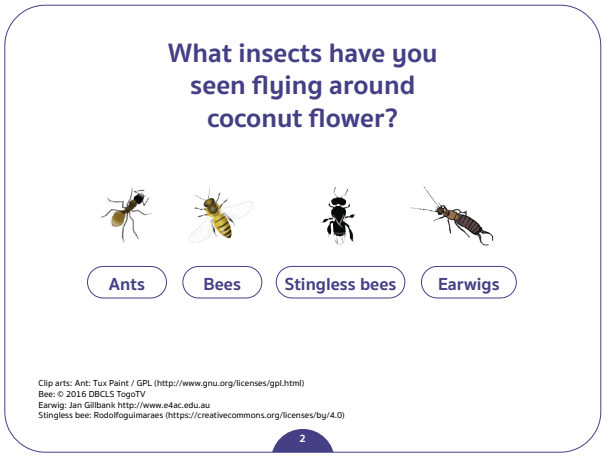
1. Stingless bee and Asian honeybee are effective coconut flower pollinators.
2. Stingless bee and Asian honeybee are sensitive to chemicals, so they are proper for use in organic farming.
3. Stingless bee and Asian honeybee have different behaviors; farmers may choose one suitable for their farm management.

A. LECTURE

Refer to previous module:

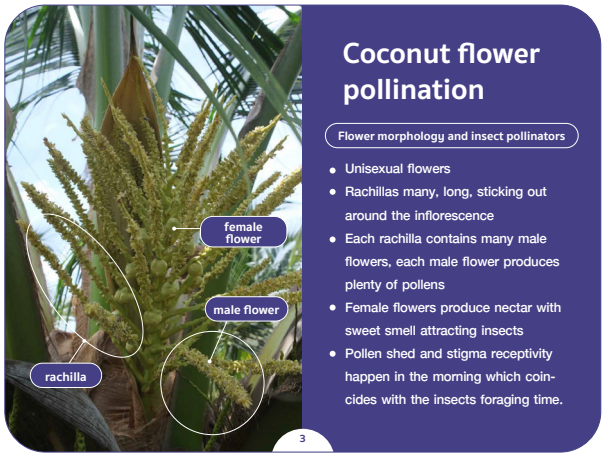
Even though there are some harmful insect pests for coconut, as you have learnt in Module 4 (Integrated pest management), there are also insects, which have mutualistic relationship with plants, including coconut, in the nature.

→ **See Page 150 in the Handbook for Farmers**



Question from trainer: What insects have you seen flying around coconut flower?

Possible answers from participants: ants, bees, stingless bees, earwigs



Coconut flower pollination

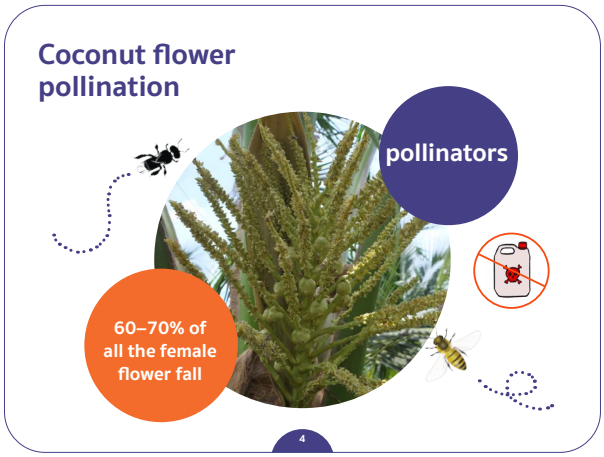
Trainer: explains coconut flower morphology is evolved for wind and insect pollination.

- Unisexual flowers

- Rachillas: many, long, sticking out around the inflorescence

- Each rachilla contains many male flowers, each male flower produces plenty of pollens. Female flowers produce a nectar with a sweet smell to attract insects.

- Pollen shed and stigma receptivity happen in the morning which coincides with insects foraging time.



- Generally, about **60–70% of female flowers** are not fertilized and fall.

- Hand pollination by collecting pollens to hand-pollinated female flowers on the trees is a multi-step, complicated process, and it is not applicable to old, tall coconut trees.

- Foraging behaviors of some insects help pollinate flowers. This natural behavior increases pollination and fruiting rates. Application of insect pollinators in coconut farm supports sustainable farming with a possibility of additional incomes (bees, honey) and increased yield.

5.1 Stingless bees

5.1.1 Get to know stingless bees

- Stingless bees are a group of insects closely related to honeybees and bumblebees, but 2-3 times smaller and without sting.

- They collect flower nectar (honey) and pollens for food.

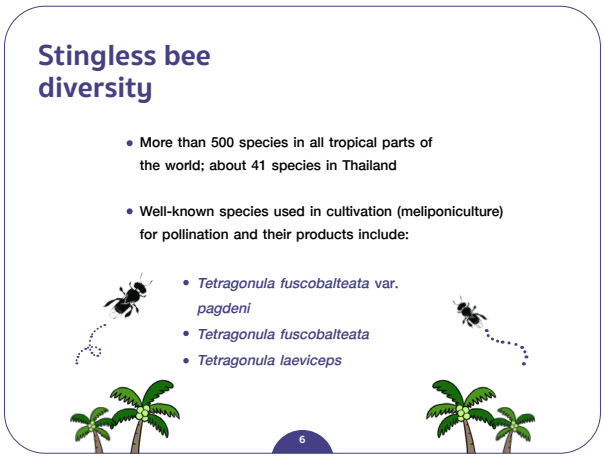
- They usually nest in hollow trunk, rock crevices, in wall cavities, etc.

- There are 3 castes:

1. queen—lays egg and control the whole hive; lives on ~10 years

2. workers—female; built, clean, fix the hives, and rearing the brood, older workers collect honey and pollens, and protect the hive; live on ~6 months

3. Drones (male)—mate with the queen

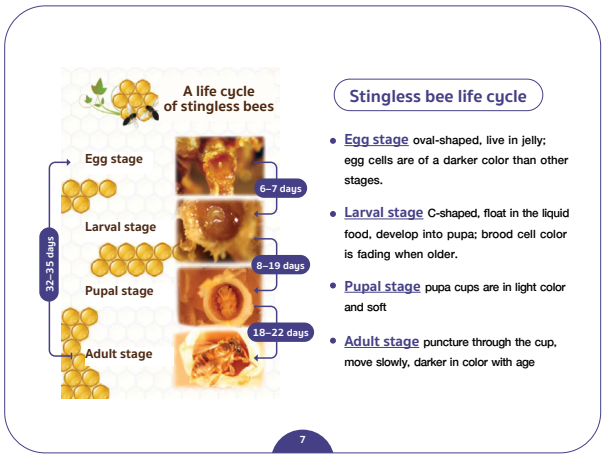


Stingless bee diversity

- More than 500 species in all tropical parts of the world; around 41 species in Thailand

- Well-known species used in cultivation (meliponiculture) for pollination and their products include:

1. *Tetragonula fuscobalteata* var. *pagdeni*
2. *Tetragonula fuscobalteata*
3. *Tetragonula laeviceps*



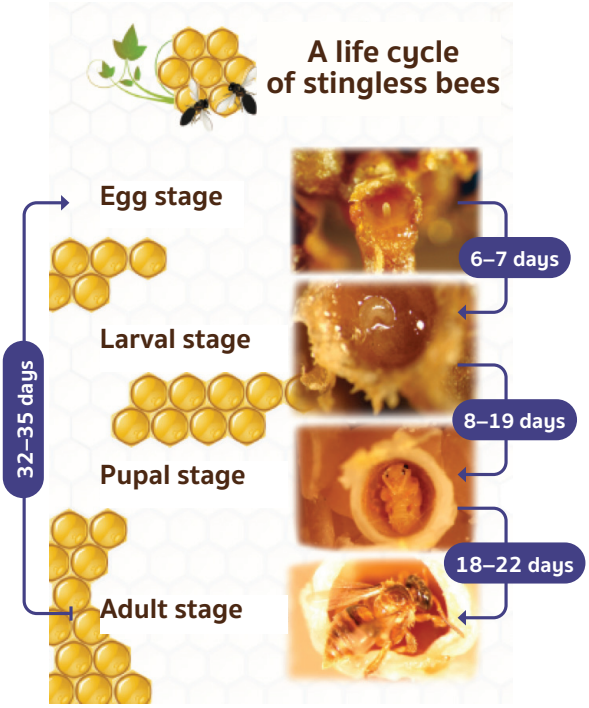
Life cycle of stingless bee

1. Egg stage: oval-shaped, live in jelly; egg cups are in darker color than other stages

2. Larval stage: C-shaped, float in the liquid food, develop into pupa; brood cell color is fading when older.

3. Pupal stage: pupa cups are in light color and soft

4. Adult stage: puncture through the cup, move slowly, darker in color with age



Additional information

Life cycle of Stingless bee

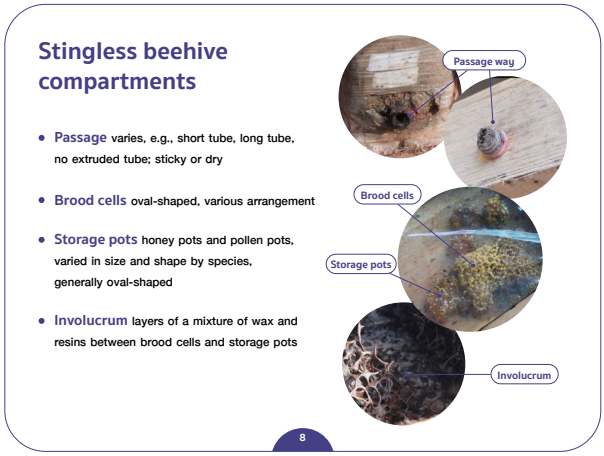
There are 4 stages in a life cycle of stingless bee, and each stage varies by the species of stingless bee:

1. Egg stage: it is oval-shaped, lives in jelly; egg cups are in darker color than other stages. This stage lasts about 6–7 days.

2. Larval stage: A larva is C-shaped, floats in the liquid food, develops into pupa; brood cell color is fading when older. The bee is in larval stage for about 8–19 days.

3. Pupal stage: pupa cups are in light color and soft. Pupa develops into an adult within 18–22 days.

4. Adult stage: an adult puncture through the cup with help from young workers from outside the cup. Young adults are in light color, move slowly, and are darker in color with age. They have age-dependent responsibility. Young workers staying in the hive are responsible for cleaning, building brood cups, storing foods in storage cups. Older workers are responsible for flying out to get foods.



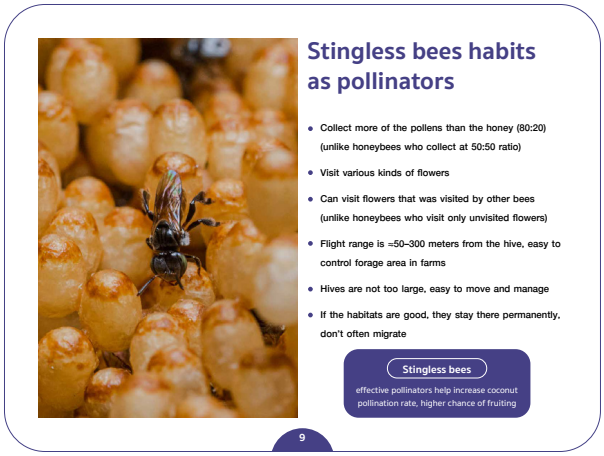
Stingless bee hive compartments

- Passage: varie, e.g., short tube, long tube, no extruded tube; sticky or dry

- Brood cells: oval-shaped, various arrangement

- Storage pots: honey pots and pollen pots, varied in size and shape by species, generally oval-shaped

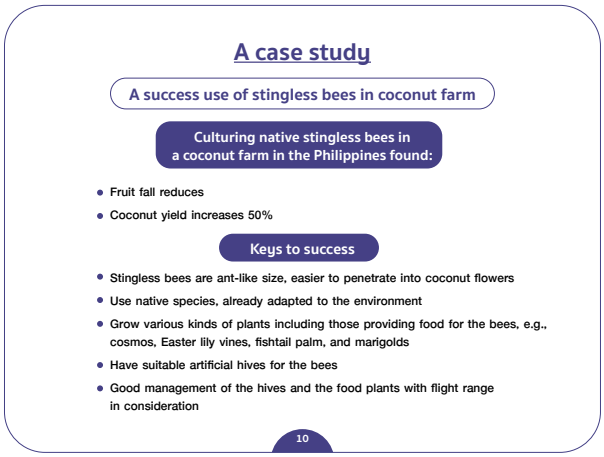
- Involucrum: layers of a mixture of wax and resins between brood cells and storage pots



Stingless bees' habits as pollinators

- Collect more of the pollens than the honey (80:20) (unlike honeybees who collect at 50:50 ratio)
- Visit various kinds of flowers
- Can visit flowers that was visited by other bees (unlike honeybees who visit only unvisited flowers)
- Flight range is ≈50–300 m from the hive, easy to control forage area in farms
- Hives are not too large, easy to move and manage
- If the habitats are good, they stay there permanently, don't often migrate

Trainer emphasizes that stingless bees are effective pollinators, use of stingless bee in coconut farm can help increase coconut pollination and fruiting rates from those without.



A case study: the successful use of stingless bees in coconut farm

Culturing native stingless bees (*Tetragonula biroi*, known locally as kiwot) in a coconut farm in the Philippines found a reduction in fruit fall, while the coconut yield increased by 50%.

Keys to success:

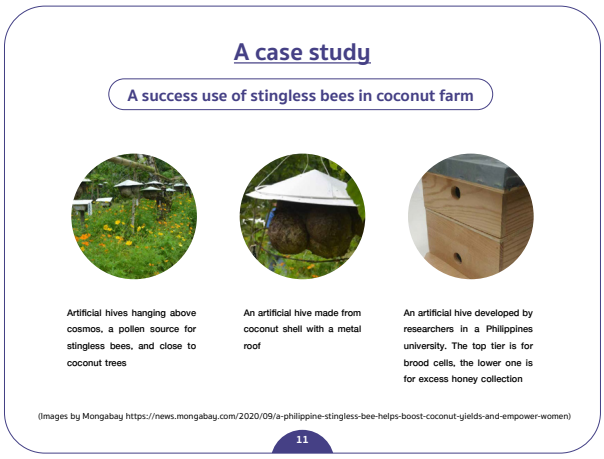
- Stingless bees are ant-like size, easier to penetrate into coconut flowers

- Use native species, already adapted to the environment

- Grow various kinds of plants including those providing food for the bees, e.g., cosmos, Easter lily vines, fishtail palm, and marigolds

- Have suitable artificial hives for the bees

- Good management of the hives and the food plants with flight range in consideration



- An artificial hive is made from coconut shell with a metal roof. They are hung above cosmos, a pollen source for stingless bees, and close to coconut trees

- An artificial hive developed by researchers in a Philippines university. The top tier is for brood cells, the lower one is for excess honey collection

Additional information

The owner of the coconut farm makes lots of effort seeking advices and supports from experts. She received advice on using a native species, making low-cost, but effective artificial hives, and upgrades to common hive mimicking natural hives. The upgraded hive has 2 tiers; the upper level contains the brood while the lower one is for harvest-ready surplus honey.

Another key is various plants grown in the farm providing foods when flowering to the stingless bees. They are planted around the farm within the flight range of the bees and well cared.

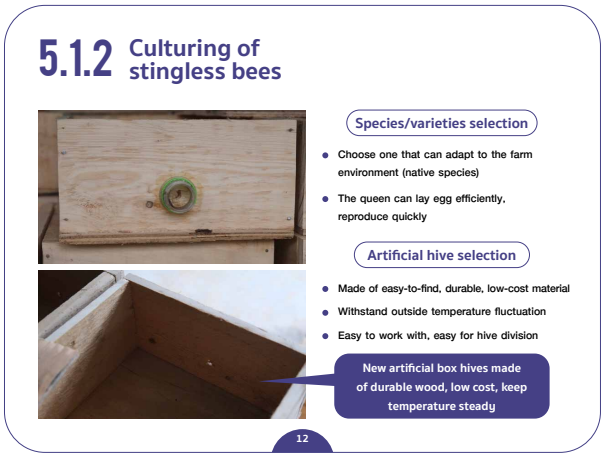
The coconut farm with food plants for stingless bees will get the benefit of the bee pollinating the coconut flowers. The country often encounters disasters, yet the farm survives and have improved yield. The care to food plants of the farmers helps them to have secured incomes.

In addition, the farm also gets additional incomes from several products produced with honey and wax from the stingless bees.

Source: https://news.mongabay.com/2020/09/a-philippine-stingless-bee-helps-boost-coconut-yields-and-empower-women

Trainer emphasizes key points from the case study.

- Good selection of stingless bee species/varieties
- Constantly plant and take care of food plants for stingless bee (e.g., intercrops and flowers)
- Use proper artificial hives and place them in the area where the bees can get food and pollinate coconut
- Additional incomes may come from stingless bee hive products



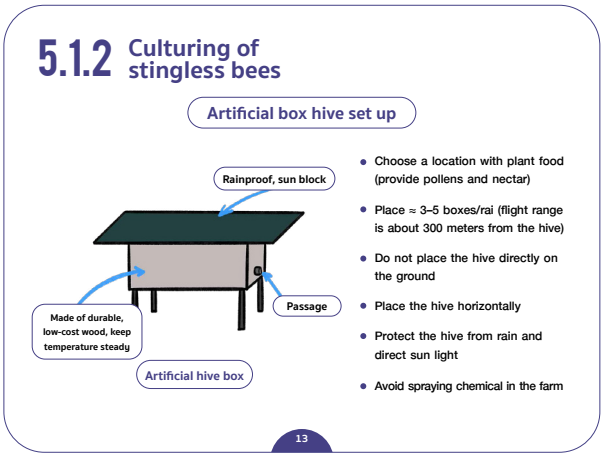
5.1.2 Culturing of stingless bees

Species/varieties selection

- Choose one that can adapt to the farm environment (native species)
- The queen can lay egg efficiently, reproduce quickly

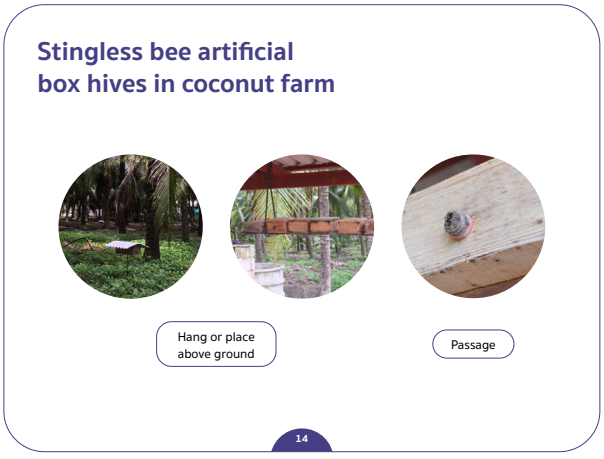
Artificial hive selection

- Made of easy-to-find, durable, low-cost material
- Withstand outside temperature fluctuation
- Easy to work with, easy for hive division



Artificial box hive set up

- Choose a location with plant food (provide pollens and nectar)
- Place ≈ 3–5 boxes/rai (flight range is about 300 meters from the hive)



- Do not place the hive directly on the ground
- Place the hive horizontally
- Protect the hive from rain and direct sun light
- Do NOT spray chemical in the farm

Lessons learned by pilot farmers – Stingless Bees

• In addition to the many benefits already mentioned, the ReCAP pilot farmers observed a reduction in fruit fall.

• Although you can have many beehives on your farm, we recommend you to start with 5 beehives if you are new to rearing bees. This will give you some time to get used to the bees and learn how to take care of them step by step.

• Place the beehives in the center of the farm to ensure the best pollination benefits and to avoid chemicals from neighboring farms. Keep in mind that their flight range is about 50-300 m.

• When the coconuts are harvested, the coconuts can fall onto the beehives. To avoid this, make sure to place them so that they are not in the way of the coconut harvest.

• Don't place the beehives in bright sunlight, because bees don't like high temperatures.

• If the stingless bee house is made out of wood, you may face some problems with termites. In order to prevent this problem, add ashes in the base of the bee house. If termites are present, remove them and change the location of the bee house or soak a cotton with organic coconut oil and put it around the base of the bee house.

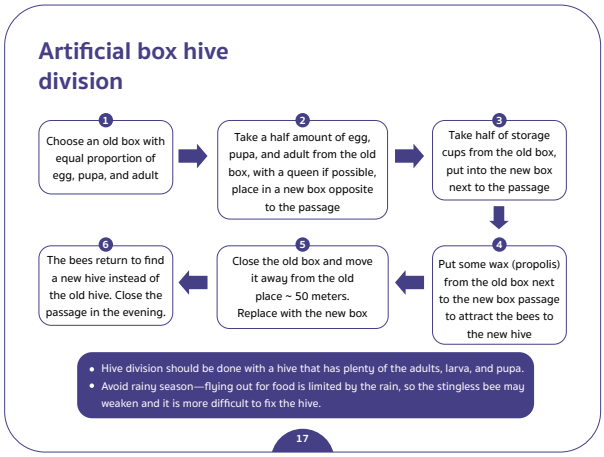
• Check the beehives weekly to observe the conditions of the stingless bees.

• Knock gently on the bee house once a week, this way the bees will become more familiar with you and be less aggressive.

• To increase honey production, grow more flowers and/or intercrops with flowers nearby the beehives. By growing these, others natural pollinators may be attracted.

• When raising bees, you cannot use synthetic chemicals on your farm, as these are toxic to bees.

• To reduce your workload, you can place the beehives not too far from each other. This way you can save time when checking and managing the beehives. For example, if you have 20 bunds and you want to place 10 beehives, you can put 5 beehives on 2 bunds.



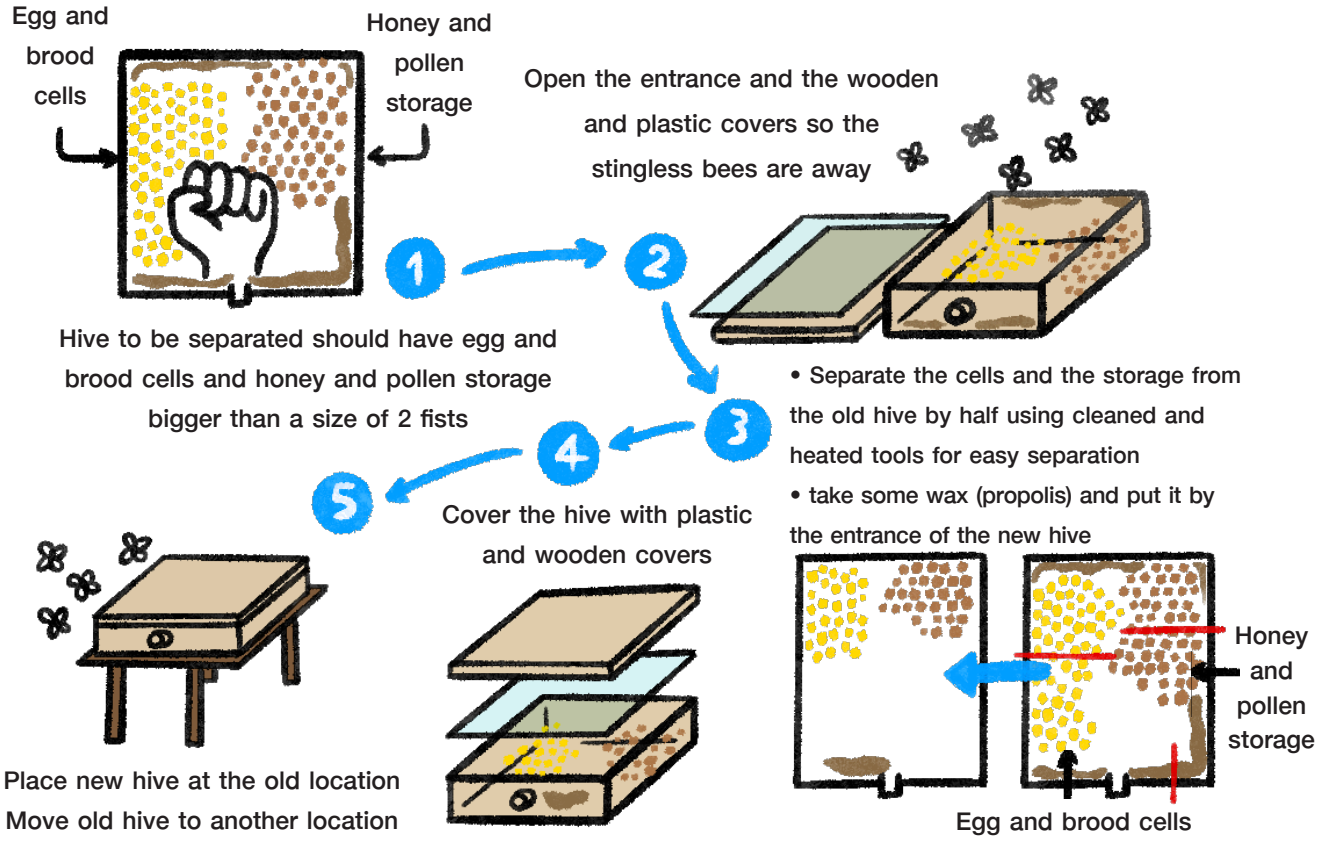
Artificial box hive division

Hive division should be done with a hive that has plenty of the adults, larvae, and pupas. Avoid rainy season—flying out for food is limited by the rain, so the stingless bee may be weakened and it is more difficult to fix the hive.

1. Choose an old box with equal proportion of eggs, pupas, and adults
2. Take a half amount of eggs, pupas, and adults from the old box, with a queen if possible, place in a new box opposite to the passage
3. Take half of storage cups from the old box, put into the new box next to the passage
4. Put some wax (propolis) from the old box next to the new box passage to attract the bees to the new hive
5. Close the old box and move it away from the old place ~ 50 m. Replace with the new box
6. The bees return to find a new hive instead of the old hive. Close the passage in the evening.

Additional information

A separation of a stingless bee colony



Lessons learned by pilot farmers – Stingless Bees

Splitting beehives:

• Depending on the size and the density of the beehives you buy, you can split them after 6-12 months. This way you can increase the number of beehives in your farm steadily. For example, if you buy 5 beehives in year 1, you can split them in year 2 and have in total 10 beehives. In year 3, you can expand to 20 beehives.

• When splitting the beehives, make sure to sterilize the equipment.

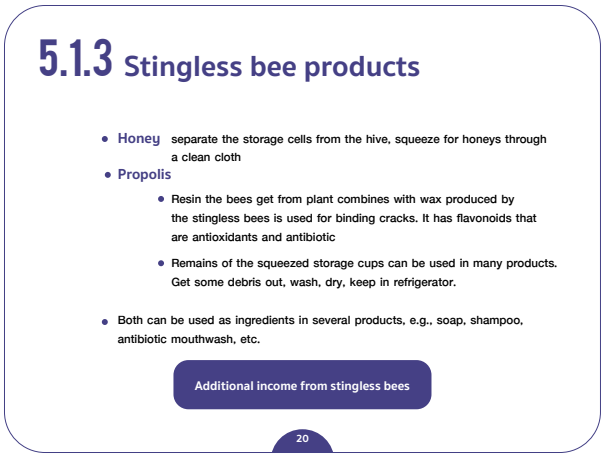
Protect stingless bees from pest:

- Especially the first 2-3 days after division because the passage may have no wax cover.
- Ants are most dangerous, get into the hive for honey and pupa
- Other animals, e.g., fly maggots eating storage cups, lizards eat adults

Commercial stingless bee's hives:

- Rental services ~30 THB/hive/day
- For sale 1,500 THB/hive

Buying is a better option as coconut needs pollination all year round as new flowers are created monthly.



3. Stingless bee products

a. Honey separate the storage cells from the hive, squeeze for honeys through a clean cloth

b. Propolis

- Resin the bees get from plant combines with wax produced by the stingless bees is used for binding cracks. It has flavonoids that are antioxidants and antibiotic
- Remains of the squeezed storage cups can be used in many products. Get some debris out, wash, dry, keep in refrigerator.

Both can be used as ingredient in several products, e.g., soap, shampoo, antibiotic mouthwash, etc.

Culturing of stingless bee may provide additional income for coconut farm.

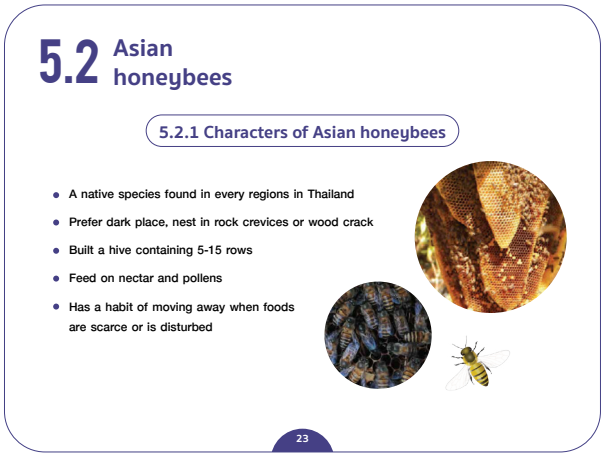
Additional information

"Stingless bee—a great pollinator" (in Thai) is available at

or

https://esc.doae.go.th/ชันโรง/

5.2 Asian honeybees



1. Characters of Asian honeybees

- A native species found in every region in Thailand
- Prefer dark place, nest in rock crevices or wood crack
- Built a hive containing 5–15 rows
- Feed on nectar and pollens
- Have a habit of moving away when foods are scarce or when they are disturbed.

Asian honeybee castes:

Queen—only 1/hive, after flying to mate with a male bee, the queen lays egg and control the hive

Workers—female bees who can't be mated and lay egg. Their jobs are tending to the brood (eggs, larvae, and pupae), cleaning, foraging, and producing honey., protect the hive, and going out for food

Drones—male bees, produced during the reproductive season only to mate with the virgin queen from another colony

Asian honeybees are valuable to human and nature, excellent pollinator of many crops, e.g., longan, lychee, citrus, and coconut

5.2.2 Beekeeping with Asian honeybees

Methods

1. Buying beehive: less practiced, Asian honeybees do not like being disturbed by being moved by humans, or by other animals, e.g., weaver ants.

- If the new environment is not proper, they would move away.

- Place the new beehive away from any old hives already in the area, so they would not get into other hives.

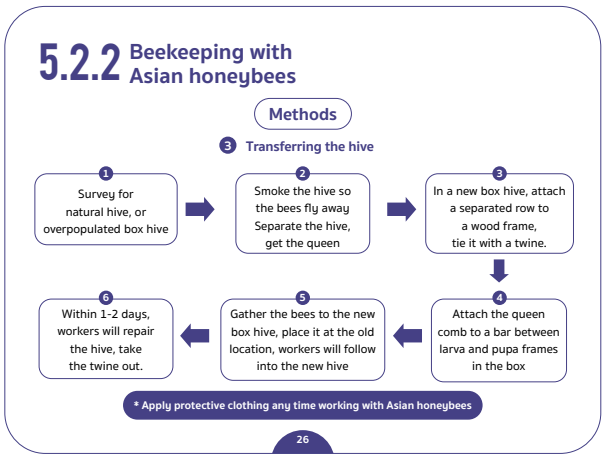
2. Baiting: Asian honeybees have a migratory behavior.

- Built an artificial hive, place it where the bees around in late rainy season when plants are flowering

- The hive can be made from wood or other materials, coat with bee wax to give out odor, have a passage at the front

- The hive should be about 0.5–1 m above ground to avoid bee-eater animals

- Check the hive every 7–10 days for bees



3. Transferring the hive:

1. Survey for natural hive, or overpopulated box hive

2. Smoke the hive so the bees fly away, Separate the hive, get the queen

3. In a new box hive, attach a separated row to a wood frame, tie it with a twine.

4. Attach the queen comb to a bar between larva and pupa frames in the box

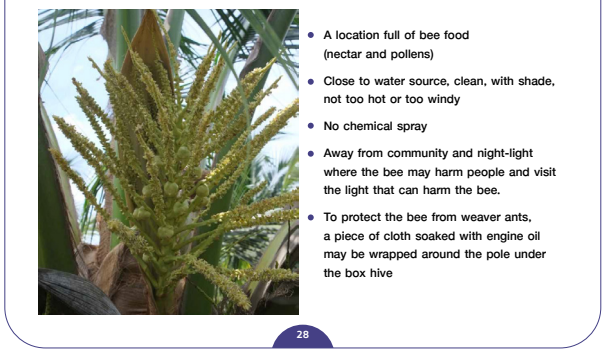
5. Gather the bees to the new box hive, place it at the old location, workers will follow into the new hive

6. Within 1-2 days, workers will repair the hive, take the twine out.

*** Apply protective clothing any time working with Asian honeybees**

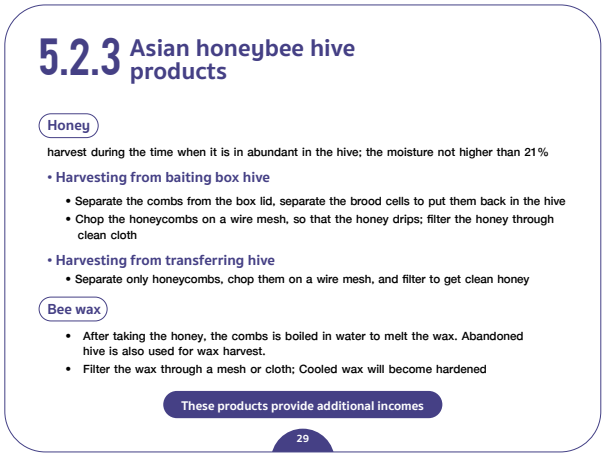
Lessons learned by pilot farmers – Asian honeybees

• For Asian bees, you can expand the beehives naturally by placing an empty beehouse with pheromone next to a full beehouse.



Proper location for beehive

- A location full of bee food (nectar and pollens)
- Close to water source, clean, with shade, not too hot or too windy
- No chemical spray
- Away from community and night-light where the bee may harm people and visit the light that can harm the bee.
- To protect the bee from weaver ants, a piece of cloth soaked with engine oil may be wrapped around the pole under the box hive.



5.2.3 Asian honeybee hive products

Honey: harvest during the time when it is in abundant in the hive, the moisture is not higher than 21%.

1. Harvesting from baiting box hive

- Separate the combs from the box lid, separate the brood cells to put them back in the hive
- Chop the honey combs on a wire mesh, so that the honey drips; filter the honey through clean cloth

2. Harvesting from transferring hive

- Separate only honey combs, chop them on a wire mesh, and filter to get clean honey

Bee wax

- After the taking the honey, the combs are boiled in water to melt the wax. Abandoned hive is also used for wax harvest.
- Filter the wax through a mish or cloth. Cooled wax will become harden.

These products can provide additional incomes.

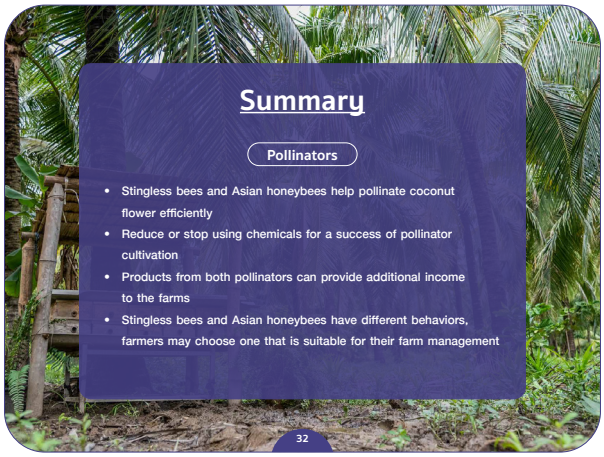
Additional information

Information on Asian honeybee (also Indian honeybee), how to cultivate, and its products is available at

or

https://esc.doae.go.th/ผึ้งโพรงไทย

Summary and closing



Summary

In this module, you have learnt that some insects are natural effective pollinators for coconut. You are introduced to two pollinators: stingless bee and Asian honeybee. They have different behaviors. The beekeeping with them is different. You can choose one that suits your farm management.

To utilize pollinators successfully, chemical application, particularly spraying is prohibited. This is perfectly adapted to organic farming.

Besides, products from the hives of both pollinators can provide additional incomes to the farm and farmers can easily expand by himself the number of bee hives covering his farm as long as he provides enough pollen for the bees.

Questions

1. Would you cultivate insect pollinators in your coconut farm?
2. If yes, which pollinator would you choose?
3. Have participants learnt how to cultivate the stingless bees?
4. Do you think you can do it yourself in your farm?

B. STUDY VISIT

For a study visit to a commercial stingless bee farm, the trainer provides a brief introduction of the places to the participants ahead of the visits. Trainer leads the participants in study visits introducing them to the guest trainer, the owner of the places to visit, and let them learn from the actual condition with the guest trainer.

Activities during the visit:

- Guest trainer gives detailed information on how to cultivate stingless bee
- Demonstration and/or practice on the separation of stingless bee colony

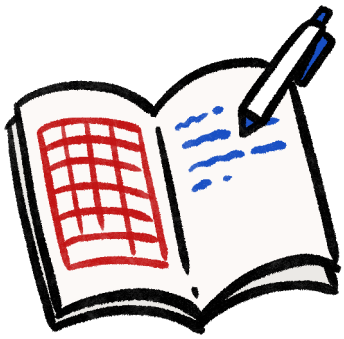
Trainer: encourage the participants to observe and ask the guest trainer

Some questions are suggested to be asked during the visit:

- Which species/varieties of stingless bee are effective in coconut pollination?
- Which one is easy to cultivate?
- What are limitations or cautions in utilization of stingless bee?
- How long the artificial box hives last?
- When does a hive need separation? How to tell?
- Would other crops or plants grown in the coconut farm reduce the visit of the stingless bee to coconut flower?
- What does it need to start a commercial cultivation of stingless bee?

Module 6

COCONUT FARMING AS A BUSINESS



OBJECTIVES

To equip farmers with basic business skills including profit and loss statements, income diversification and understanding of market risks.

ACQUIRED KNOWLEDGE

The participants:

1. Understand basic business management for their coconut farms.
2. Know how income diversification can help farms against market risks.

ACQUIRED SKILLS

The participants can:

1. Identify their farms' strengths and weaknesses.
2. Set up better management for their farms.
3. Understand how to calculate profits and losses.
4. Learn how to diversify their income and thereby potentially increase profits.

ACQUIRED ATTITUDES

The participants realize the importance of doing coconut farm as a business and following the regenerative organic practices.

RELEVANCE TO SUSTAINABLE COCONUT FARMING

Doing farm management as a business together with following the regenerative organic practices will make coconut farm sustainable.

METHODS

1. Lecture with PowerPoint presentation for approximately 105 minutes
2. Exercises for approximately 55 minutes

TRAINING SUPPLIES, TOOLS, AND MATERIALS

1. PowerPoint (PPT) presentation
2. A notebook computer with PPT program
3. An LCD projector and a screen or smart TV
4. This Manual for Trainers containing content of the PPT presentation to be lectured, additional information related to the content, and exercise guidelines and worksheets for Module 6
5. The Handbook for Farmers containing the PPT presentation, exercise worksheets, and summary of knowledge in Module 6, as well as blank pages for taking notes.
6. Flipchart
7. Markers

DURATION

Main topics	Time (min)
1. Lecture on business components	15
2. Lecture on business cycle	5
3. Diagnosis and finding opportunity	40
4. Planning, implementation and evaluation	45
5. Exercises	55
6. Summary and closing	5
Total time of training in Module 6	**165 (2 h 45 min)**

KEY MESSAGES

To make aromatic coconut farm successful and sustainable, farmers should treat their farms as a business and also follow the regenerative organic practice.

A. LECTURE

Get the Attention

Start the module by asking a question: "Do you think that you are now doing your coconut farm as a business? If yes, please share with us how you have done?"

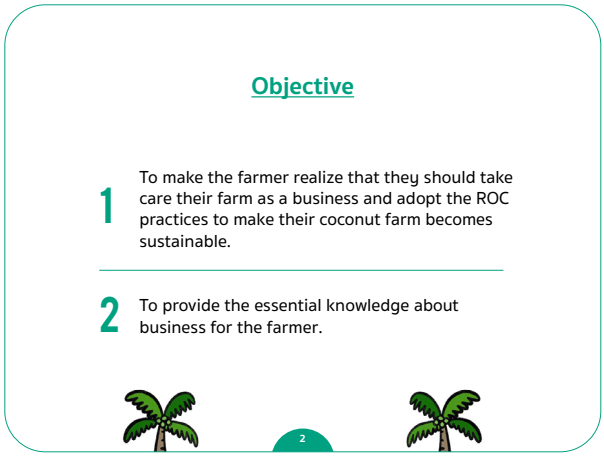
Expected Outcome

The trainer gets an idea about how many participants understand about the business.

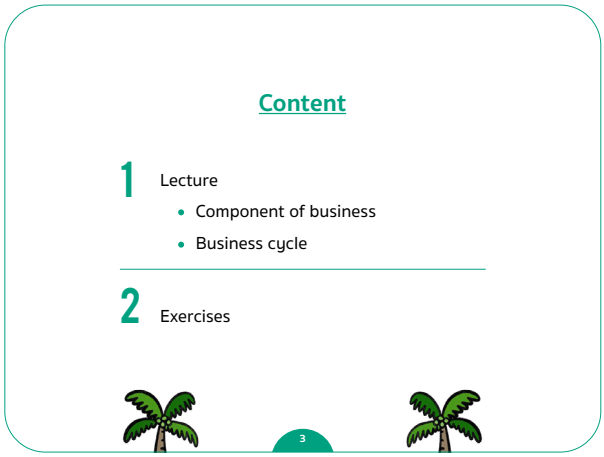
Start the lecture

In this module we will learn about the basic business and how income diversification can help the coconut farm against market risks.

→ See Page 168 in the Handbook for Farmers

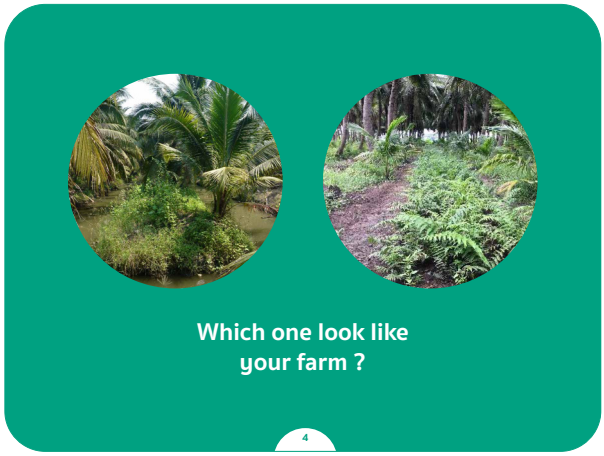


From Module 0 we know the purpose of this training to help coconut farm be sustainable by following the ROC. In addition to the sustainability, the participants need some basic knowledge about the business.



We will begin by learning about the components of business and continue with the topic of business cycle.

Then we will do some exercises to help you get some ideas about how to manage your farm more efficiently and earning more income i.e., changing from traditional farm practices to regenerate organic ones.

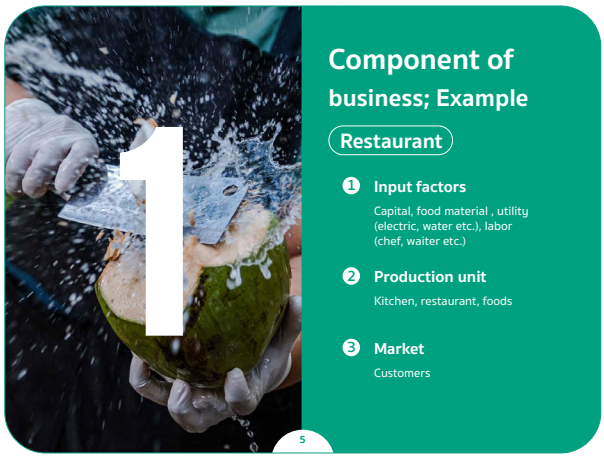


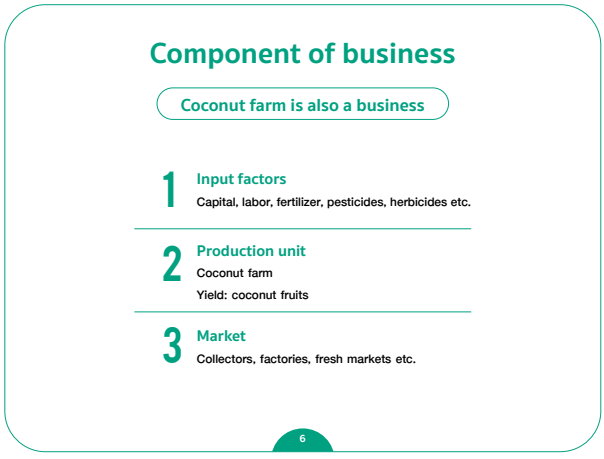
The left picture seems to have an inappropriate farm management. The farm has many yellow coconut leaves suggesting unhealthy coconut trees. As shown in the picture, some fallen coconut fruits are floating in the water, and this will make the water dirty.

On the other hands, the right picture seems to be a coconut farm that has a better farm management. It looks green and clean. Also, some intercrops are grown between the coconut trees, reflecting the efficient use of land. This farm is a coconut farm that should do as a business.

Trainer asks participants: at the present which one look like your farm? Whatever results are, after this training, I hope that all participants' farm will look like the right one.

6.1 Business components





Any types of business are composed of 3 main parts, given here the restaurant business as an example:

1) Input factors: factors that are combined to produce output of goods, such as capital, food materials, utilities (water, electricity), labor (chef, waiters, etc.)

2) Production unit: places like kitchen, restaurant, or what we use to cook food, which is the resulting product

3) Market: customers who buy our product.

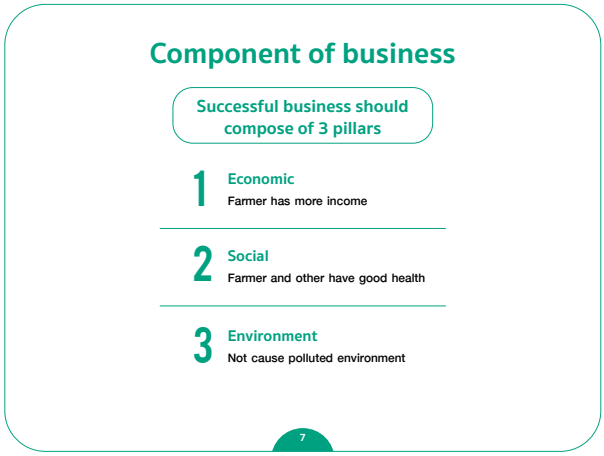
Applying the three elements of business to the coconut farm:

1) Input factors can be capital, labor, fertilizer, pesticides, herbicides, etc.

2) Production unit are coconut farm from which coconut fruits or other products, e.g., pandan, banana, fish, etc. are produced.

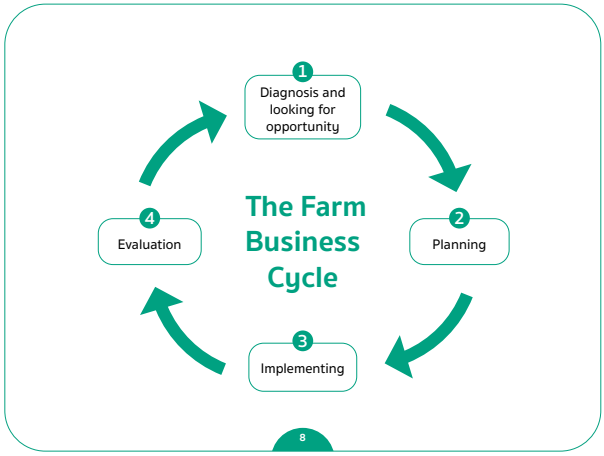
3) Market can be collectors, factories or fresh markets, etc.

Thus, you can see that coconut farm is indeed a business.



Successful and sustainable farming businesses should consider not only economic benefits but also social and environment dimensions.

6.2 Business cycle



Farm business cycle is comprised of these four steps:

1) diagnosis and looking for opportunity
2) planning
3) implementation
4) evaluation

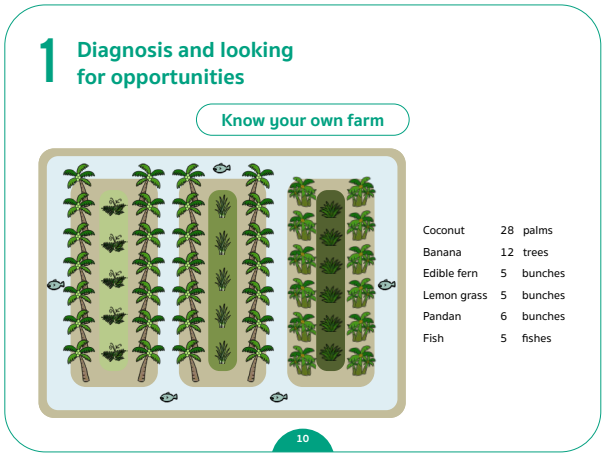
6.2.1 Diagnosis and finding opportunity

The first step of business cycle is diagnosis and looking for opportunity.

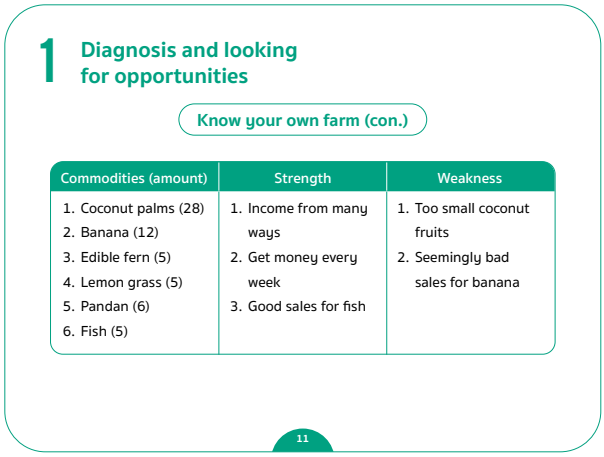
A. Know your own farm:

You should know what what you have or lack in your farm and identify which one is your farm's strength or weakness.

If you have examined your farm condition or regularly keep farm activity and accounting records, you can use those information sources to help identify your farm's strength and weakness as shown in the example below:



Supposing that this picture is your farm, the farm diagnosis will help you clearly see that not only 28 coconut palms are grown in your current farm, but you also have other intercrops and activities, like banana trees, vegetable fern, as well as fish.



According to the information you have, you can identify your farm's strengths and weaknesses as shown in this table.

E.g., the strength is that you can create income every week from selling other crops and implement fish culture in addition to coconut; meanwhile, other farms will earn money once a month from selling only coconuts. However, the weakness is that your coconut fruits are small, so you should find the appropriate method to increase the fruit size, such as watering the coconut palm more often. In addition, you may raise more fish and stop growing banana or change to other crops.

Lessons learned by pilot farmers – Fish

Having fish in your canals is a great way to control duckweed and azolla. By doing this, you will not need to remove aquatic weeds as often and thereby save on labor costs. Furthermore, fish increase oxygen in your canals and improve water ventilation.

- We specifically recommended Thai carp fish as they will feed on both duckweed and azolla in the canals, and you do not need to spend money on fish food. Moreover, they won´t damage the sides of the canals like other fish (such as tilapia), which would cause erosion.
- We recommend you start with releasing 100 fish per rai and they will duplicate by themselves every 8 months. The Department of Fisheries recommends to have a maximum of 480 fish per rai.
- The size of the carp fish should be at least 3 inches before releasing the fish into the canals, so that they can escape from the Asian water monitor.
- It is recommended to start breeding fish directly at the very beginning of starting your coconut farm, because it is the best way to control the weed in the canals naturally. The fish will eat the duckweed while growing in the canal.
- Without fish in the canal, you will need to remove the duckweed and azolla manually. Our pilot farmers have observed that through keeping fish, they were able to cut their labor costs to remove aquatic weeds from their canals on average by 17%.
- Fish in the canals is a good indicator regarding the water conditions. If the fish are dying, the water quality is not good and contaminated with chemicals.

“Fish help to control weeds in the canals, which is the most important way to save costs to remove weed from the canals.” - Prayad

1 Diagnosis and looking for opportunities

Recording

Recording helps you to learn your farm condition as well as track and plan your farm activities.

Doing farm accounting will help you to know your true cost and income.

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B. Recording:

Recording is a very important and helpful method for your coconut business. Not only does the method help you to learn your farm condition (strength and weakness), but you can also track and plan your farm activities (what you did and what is anticipated to do) from this record keeping.

Moreover, if doing farm accounting, you will be able to know how much income your farm business can make and what costs you need to pay for. This will help you to decrease your unnecessary cost and gain more profit and also to identify trends in your farm like decreasing yield or increase cost of inputs. Identifying then the root cause will help you to put in place the right solutions.

1 Diagnosis and looking for opportunities

Recording farm management

Sep. 2020	Irrigation	Fertilizer	Pest management	Harvest	Others
1	/				
2			Pheromone for rhino beetle		
3					
4	/	Manure 20 kg/ palm			
5				/	
6			Weeding		
30				/	

15

There are two things that should be recorded.

1. Farm management: record what you did in your farm with any necessary details of the activities. Like the sample in this table (September 2020), you can see that in which date you need to water your coconut, put the pheromone for trapping rhinoceros beetle, do weeding and harvest.

1 Diagnosis and looking for opportunities

recording income and cost Farm accounting

Date 2020	Items	Quantity	Price/unit (THB)	Income (THB)	Cost (THB	Remark
Sep 1	Sold coconut	2,000 nuts	10	20,000	-	Sell to collector
Sep 9	Sold edible fern	15 bunches	20	300	-	Flea market
Sep 12	Sold coconut	50 nuts	10	500	-	Give to neighbor
Sep 12	Purchase 16-16-16 fertilizer	20 sacks	770	-	15,400	Chemical shop
Sep 12	Purchase herbicide	8 litre	280	-	2,240	Chemical shop
Sep 14	Weeding	3 person	300	-	900	family
Sep 16	Sold edible fern	15 bunches	20	300	-	Flea market
Sep 18	Labor for applying fertilizer	4 persons	300	-	1,200	Mr. Num& team
Sep 23	Sold edible fern	15 bunches	20	300	-	Flea market
Sep 23	Sold coconut	100 nuts	10	1,000	-	Flea market
Sep 30	Sold edible fern	15 bunches	20	300	-	Flea market
Sep 30	Rent fee	10 rai	100	-	1,000	Mr. Li
Total				**22,700**	**20,740**	**1,960**

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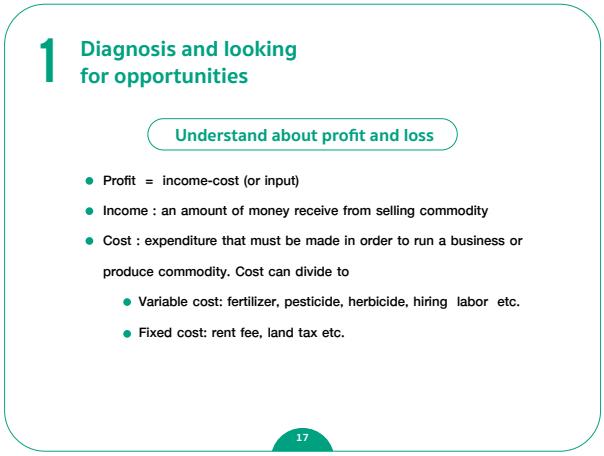
2. Cost and income: record and count every money that a coconut farm has received and spent. According to the table, the total income of the farm, both from the coconuts and other crops, amounts to 22,700 THB. Meanwhile, the total expense of the farm mainly from the input factors as chemicals, is 20,740 THB. In conclusion, this sample farm makes a profit of 1,960 THB.

It will also make sense to look at the cost and income on a long period (like a year) to balance the one-time effect or the impact of low season or dry season.

Additional information

Date 2020	Items	Quantity	Price/unit (THB)	Income (THB)	Cost (THB)	Remark
Sept. 1	Sold coconut	2,000 nuts	10	20,000	-	Sell to collector
Sept. 9	Sold vegetable fern	15 bunches	20	300	-	Flea market
Sept. 12	Sold coconut	50 nuts	10	500	-	Give to neighbor
Sept. 12	Purchase 16-16-16 fertilizer	20 sacks	770	-	15,400	Chemical shop
Sept. 12	Purchase herbicide	8 liters	280	-	2,240	Chemical shop
Sept. 14	Weeding	3 people	300	-	900	Family
Sept. 16	Sold vegetable fern	15 bunches	20	300	-	Flea market
Sept. 18	Labor for applying fertilizer	4 persons	300	-	1,200	Mr. Num & team
Sept. 23	Sold vegetable fern	15 bunches	20	300	-	Flea market
Sept. 23	Sold coconut	100 nuts	10	1,000	-	Flea market
Sept. 30	Sold vegetable fern	15 bunches	20	300	-	Flea market
Sept. 30	Rental fee	10 rai	100	-	1,000	Mr. Li
Total				**22,700**	**20,740**	**1,960**



C. Understand about profit and loss:

From the table of cost and income record, you will find three significant words:

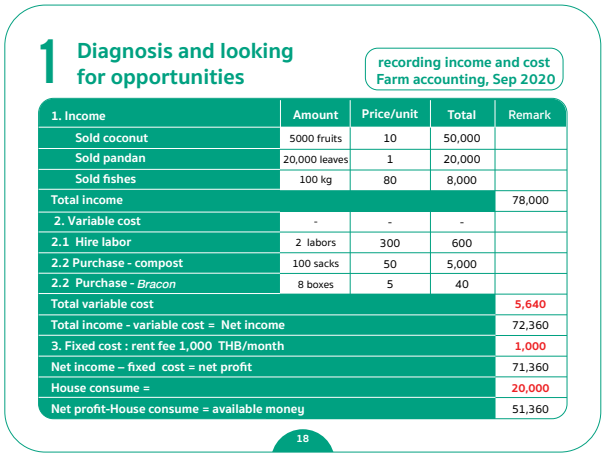
Profit equals income minus cost or input. These two words are interchangeable and from now we will use the word 'cost'. If income is higher than cost, the farm will get profit. On the other hand, if income is less than cost, it is called 'loss'.

Income is an amount of money you receive from selling your products or crop yields.

Cost is the necessary expenditures that must be made in order to run a business or produce commodity. Cost can be divided to

- Variable cost which can be varied or changed in the time period under consideration; fertilizer, pesticides, or inputs whose quantity usually affects yields or products.

- Fixed cost whose quantity is constant or unlikely to change in some period of time; rental fee or land tax.



1. Income	Amount	Price/unit	Total	Remark
Sold coconut	5000 fruits	10	50,000	
Sold pandan	20,000 leaves	1	20,000	
Sold fishes	100 kg	80	8,000	
Total income				78,000
2. Variable cost	-	-	-	
2.1 Hire labor	2 labors	300	600	
2.2 Purchase - compost	100 sacks	50	5,000	
2.2 Purchase - *Bracon*	8 boxes	5	40	
Total variable cost				5,640
Total income - variable cost = Net income				72,360
3. Fixed cost : rent fee 1,000 THB/month				1,000
Net income – fixed cost = net profit				71,360
House consume =				20,000
Net profit-House consume = available money				51,360

This table shows you the example of variable costs and fixed costs:

1) Variable cost depends on the amount of production. In this table, the total variable cost is 5,640 THB.

2) Fixed cost usually is the same in one period.

In this table, fixed cost is 1,000 THB/month for rental fee.

Profit is income (78,000) – variable cost (5,640) – fixed cost (1,000) = 71,360 THB.

Simply put, this farm gets the profit of 71,360 THB.

However, if deducting 20,000 THB for house consumption, the available money of this farm is 51,360 THB.

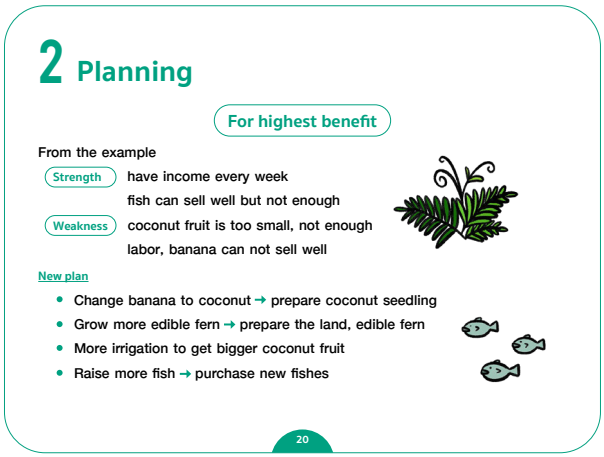
Additional information

	Items	Amount	Price/unit (THB)	Total	Remark
1. Income	Sold coconut	5,000	10	50,000	
	Sold pandan	20,000	1	20,000	
	Sold fishes	100 kilogram	80	8,000	
Total Income					**78,000**
2. Variable cost	Hire labor	2 people/ 1 day	300	600	Apply fertilizer
	Purchase manure	100 sacks	50	5,000	
	Purchase *Bracon* wasp	8 boxes	5	40	
Total Variable Cost					**5,640**
Total Income - Variable Cost = Net Income				72,360	
3. Fixed cost: rental fee 1,000 THB/month				1,000	
Net Income – Fixed Cost = Net Profit					**71,360**
House consume =				20,000	
Net Profit – House Consume = Available Money					**51,360**

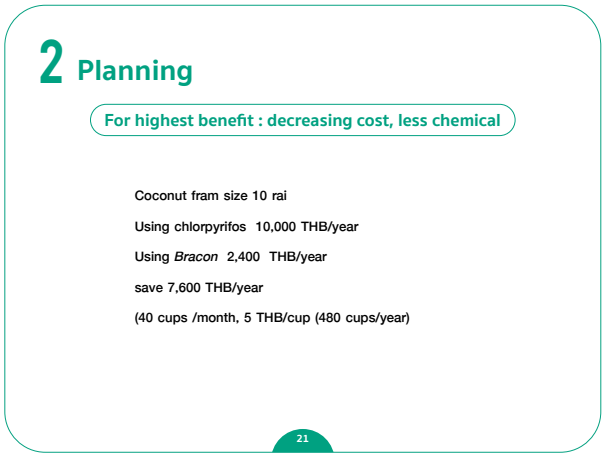
Benefits regarding P&L

"After recording my P&L, I can check the price and demand for coconuts over the year. After analysis, I can make better financial planning for my farm." - Kittisak

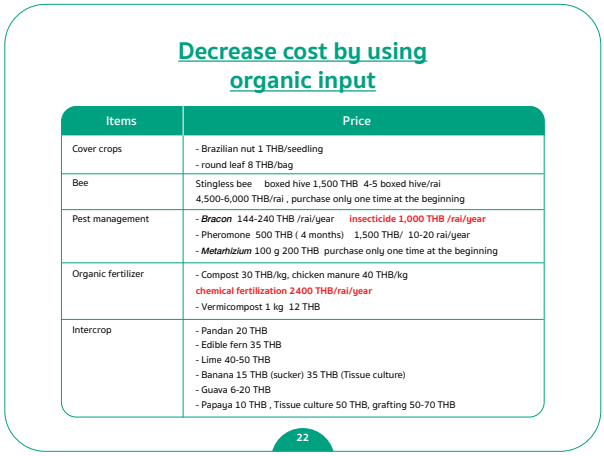
6.2.2 Planning



After the diagnosis of farm condition and opportunity, the second step of business cycle is planning. We could use the information about farm's strengths and weaknesses previously discussed for making a new improved plan to achieve the highest benefits.



a) Cost reduction: To maximize farm benefits, it should start by cost reduction. One method of reducing costs in the farm is to follow the regenerative organic practices and replace any chemical inputs with organic ones.



As shown in this slide, the variable cost can be decreased if we shift from using chemical inputs to organic ones.

Roc farm has lower cost than conventional farm

Conventional farm					ROC				
	Items	Amount	Price/unit (THB)	Total (THB)		Items	Amount	Price/unit (THB)	Total (THB)
Income					Income				
1	coconut	6,000	10	60,000	1	coconut	6,000	10	60,000
					2	honey	10	120	1,200
					3	vegetable fern	15	30	450
					4	pandan	100	20	2,000
					5	vermicompost	25	20	500
Total income				60,000	Total income				64,150
Cost					Cost				
1	chemical fertilizer	18	400	7,200	1	manure	100	20	2,000
2	herbicide	1	300	300	2	cover crop	50	8	400
3	hide labor to spray herbicide	1	300	300	3	compost	7	100	700
4	pesticide	12	250	3,000	4	*Bracon* wasp	200	5	1,000
Total cost				10,800	Total cost				4,100
Net profit				49,200	Net profit				60,050

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As you can see from this table comparing the normal farming practices and the regenerative agricultural practices, the latter farm following regenerative organic agriculture gets higher income, pays lower cost, and consequently gains higher profit.

2 Planning

For highest benefit : grow other crops together with coconut, other activities

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b) Intercropping: In addition to coconut trees, it is suggested to grow other crops in the coconut farm, such as vegetables, vegetable fern, pandan, etc., and implement other activities, namely fish culture or product processing in order to diversify income and probably increase farm benefits.

Intercrops

Plants	Cost/rai (THB)	Price/rai (THB)	Profit/rai (THB)	Advantage	Disadvantage
Banana[1]	10,407	12,840	2,433	- High demand	- Need supporting
Lemon grass[2]	2,600	10,000	7,400	- Short life - Easy to propagate	- Use a lot of labor at harvest time
Pandan[3]	15,000	21,600	6,600	- Can harvest all year	
Edible fern[4]	19,200	28,600	9,400	- Can harvest all year	- Need high humidity
Guava[5]	56,100	135,100	79,000	- High demand	- High investments - Need supporting, bagging

1 BEDO, 2017
2,4 Department of Agricultural Extension, 2017
3 DOA, 2018
5 Department of Agricultural Extension, 2015

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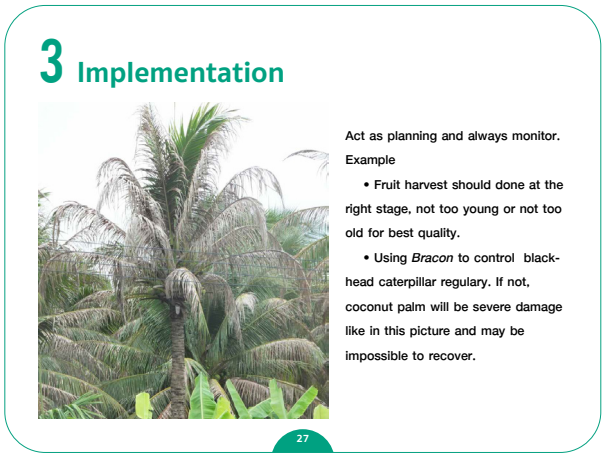
Intercrops, which are other crops grown well with coconut trees, vary by farm condition, skills, market, etc. Each farmer should choose what is adapted to his farm based on different criteria (workforce, soil quality, market …)

More details about intercropping, e.g., considering what kinds of intercrops suit to grow in your farm, are explained in Module 2: Soil health.

c) Better management including increasing irrigation channels, applying organic fertilizers, growing intercrops and cover crops, especially the one that can fix nitrogen to the soil, will help enhance health and yields of coconut palm.

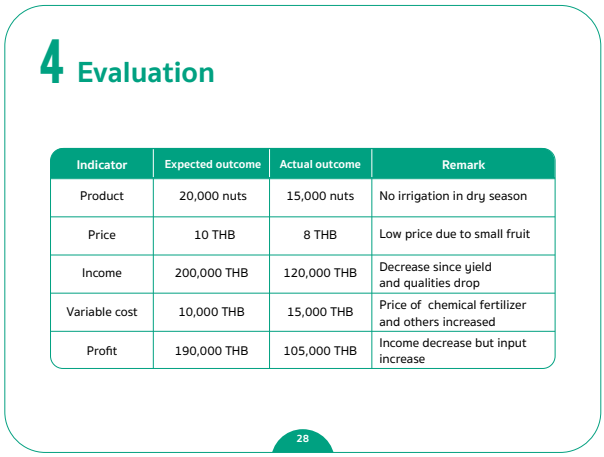
6.2.3 Implementation



The third step of business cycle is implementation; that is to act as planning and always monitor. 'Timing' of taking action is an important factor that should be considered in order to get the best result.

For example, picking up coconut fruits at the right stage to achieve the best quality; using *Bracon* wasp to control caterpillar, which needs to be regularly implemented or immediately react when the invasion occurs. If the action is delayed, the *Bracon* wasp will not effectively function and the coconut palms will be too damaged to recover as shown in the picture on the slide.

6.2.4 Evaluation



Indicator	Expected outcome	Actual outcome	Remark
Product	20,000 nuts	15,000 nuts	No irrigation in dry season
Price	10 THB	8 THB	Low price due to small fruit
Income	200,000 THB	120,000 THB	Decrease since yield and qualities drop
Variable cost	10,000 THB	15,000 THB	Price of chemical fertilizer and others increased
Profit	190,000 THB	105,000 THB	Income decrease but input increase

The fourth step of business cycle is evaluation, where the final results of what we have planned and implemented will be evaluated and concluded.

According to the same example, the evaluation shows that the real income is lower than estimated since the size of coconut yields are small. Thus, the next-year plan of this farm has to focus on solving the smaller size of coconut fruits, probably by more watering or applying more fertilizer.

P&L Experiences from ReCAP's Pilot Farmers

In addition to the many environmental benefits, you can also expect financial rewards when practicing regenerative organic agriculture. Many of the recommended practices will either help to increase your income or save you costs, depending on what you decide to implement.

The ReCAP project tested the various regenerative practices mentioned in this training with 13 pilot farmers from November 2020 – January 2021. Based on their experiences, we were able to collect some financial data on the following activities:

a) Cover Crops
b) Stingless bees
c) Compost
d) Intercrops
e) Fish
f) Pest management

We will show you how you can save or make money by implementing each practice one by one. Please keep in mind of course that the data we have based our recommendations on comes from the experience of just 13 Nam Hom coconut farmers, so they can provide you an indication, but not direct proof.

Before we begin, here are the assumptions we made:

- Average coconuts/rai/year: 8,000 coconuts
- Average price per coconut: 10.36 THB
- Labor cost: 331 THB per day or 41.375 THB per hour

Please also note:

- All calculations are based on a 20-rai farm (average farm size)
- All figures are calculated annually

Let's begin with our findings!

A) Cover Crops

By implementing cover crops, our pilot farmers observed two main cost saving benefits:

- Reduce costs for grass cutting and weeding

By planting cover crops instead of keeping the soil bare, you will have much less grass cutting and weeding to do. On average, farmers without cover crops spend 24 days on cutting grass and weeding. Farmers who had covered their farms 100% by cover crops, only need to spend 12 days (or less) on cutting grass and weeding.

- Reduce expenditures on digging mud out of the canals

By growing cover crops, you can reduce soil erosion from the bunds. The cover crops will hold the soil together when it rains and prevent the soil from eroding into the canal. This means that you will need to spend less on digging out mud from the canals. On average, farmers without cover crops need to hire a big machine (3,600 THB/day) for 20 days every year. Pilot farmers who have cover crops only need to dig out mud from their canals every second year with a small machine (2,880 THB/day) for 16 days.

As shown in the calculations below, this can make quite a big difference!

Example 1: 20-rai farm with bare bunds

Cover crops	Year 1 (0%)	Year 2 (0%)	Year 3 (0%)	Total
Cover crops (materials)	-	-	-	-
Labor (planting cover crops)	-	-	-	-
Labor (watering)	-	-	-	-
Labor (cutting grass)	7,944 (24 days)	7,944 (24 days)	7,944 (24 days)	23,832
Digging mud	72,000	72,000	72,000	216,000
Total	79,944	79,944	79,944	239,832

Example 2: 20-rai farm with 25% cover crops in year 1

Method 1 Planting seedling 2" bag

Cover crops	Year 1 (25%)	Year 2 (50%)	Year 3 (75%)	Total
Cover crops (640 bags, 7 THB/bags)	89,600	-	-	89,600
Labor (planting cover crops)	828 (2.5 days)	-	-	828
Labor (watering cover crops)	828 (2.5 days)	-	-	828
Labor (cutting grass)	7,944 (24 days)	5,958 (18 days)	3,972 (12 days)	17,874
Digging mud	72,000	-	46,080	118,080
Total	171,200	5,958	50,052	227,210

Method 2 Planting seedling from tray

Cover crops	Year 1 (25%)	Year 2 (50%)	Year 3 (75%)	Total
Cover crops (Cover crop from plug tray 640 cells, 1.5 THB/cell)	19,200	-	-	19,200
Labor (planting cover crops)	828 (2.5 days)	-	-	828
Labor (watering cover crops)	828 (2.5 days)	-	-	828
Labor (cutting grass)	7,944 (24 days)	5,958 (18 days)	3,972 (12 days)	17,874
Digging mud	72,000	-	46,080	118,080
Total	100,800	5,958	50,052	156,810

Notice here that your labor costs for cutting grass reduces the more cover crops you have over the years.

Method 3 Planting bare root

Cover crops	Year 1 (25%)	Year 2 (50%)	Year 3 (75%)	Total
Cover crops (20 bags, 200 THB/bag)	4,000	-	-	4,000
Labor (planting cover crops)	828 (2.5 days)	-	-	828
Labor (watering cover crops)	828 (2.5 days)	-	-	828
Labor (cutting grass)	7,944 (24 days)	5,958 (18 days)	3,972 (12 days)	17,874
Digging mud	72,000	-	46,080	118,080
Total	85,600	5,958	50,052	141,610

(In this example, the cover crops expand naturally in year 2 and year 3)

Example 3: 20-rai farm with 100% cover crops in year 1

Method 1 Planting seedling 2" bag

Cover crops	Year 1 (100%)	Year 2 (100%)	Year 3 (100%)	Total
Cover crops (2,560 bags, 7 THB/bags)	358,400	-	-	358,400
Labor (planting cover crops)	3,310 (10 days)	-	-	3,310
Labor (watering cover crops)	3,310 (10 days)	-	-	3,310
Labor (cutting grass)	5,958 (18 days)	3,972 (12 days)	3,972 (12 days)	13,902
Digging mud	46,080	-	46,080	92,160
Total	417,058	3,972	50,052	471,082

Method 2

Planting seedling from tray

The investment to cover your entire farm with cover crops is higher than compared to example 2, but you can already make savings by needing a smaller machine for digging mud out of the canals in year 1.

Cover crops	Year 1 (100%)	Year 2 (100%)	Year 3 (100%)	Total
Cover crops (from tray 2,560 hole, 1.5 THB/hole)	76,800	-	-	76,800
Labor (planting cover crops)	3,310 (10 days)	-	-	3,310
Labor (watering cover crops)	3,310 (10 days)	-	-	3,310
Labor (cutting grass)	5,958 (18 days)	3,972 (12 days)	3,972 (12 days)	13,902
Digging mud	46,080	-	46,080	92,160
Total	135,458	3,972	50,052	189,482

Method 3 Planting bare root

Cover crops	Year 1 (100%)	Year 2 (100%)	Year 3 (100%)	Total
Cover crops (80 bags, 200 THB/bag)	16,000	-	-	16,000
Labor (planting cover crops)	3,310 (10 days)	-	-	3,310
Labor (watering cover crops)	3,310 (10 days)	-	-	3,310
Labor (cutting grass)	5,958 (18 days)	3,972 (12 days)	3,972 (12 days)	13,902
Digging mud	46,080	-	46,080	92,160
Total	74,658	3,972	50,052	128,682

You can decide how fast you want to cover your farm with cover crops. The experience of the ReCAP pilot farmers has shown that it takes approximately 8 - 12 months for the cover crops to duplicate. As shown in example 2, this means if you cover 25% of your bunds with cover crops in year 1, they will cover 50% of the bunds in year 2 and approximately 75-100% by year 3. (Planting bare root)

You can also decide to cover your bunds by 100% with cover crops in the first year. If you do this, you will need to spend more on seedlings in year 1. However, as the data shows, the faster your farm is covered by cover crops 100%, the more savings you will have.

Cost savings (%)	Year 1	Year 2	Year 3	Total
Cover crops (25% in Y1)	-7%	93%	37%	41%
Cover crops (100% in Y1)	7%	95%	37%	46%

Regardless of how much cover crops you decide to grow, savings are significant:

- Farmers can reduce their overall costs by 98,223 THB (41%) over 3 years if they cover their farm by 25% in year 1
- Farmers can reduce their overall costs by 111,150 THB (46%) over 3 years if they cover their farm by 100% in year 1

There are different varieties of cover crops available that you can choose from, based on what is best fitted for your farm and needs.

Very important! Whatever you decide to grow, keep in mind that when you purchase cover crop seedlings, they need to be approved by your certification body. Don't risk the certification of your farm by choosing to buy the cheapest seedlings.

B) Stingless bees

Many studies have shown that by having pollinators, farmers increase their yield quantity and quality significantly. Most of the ReCAP pilot farmers decided to implement stingless bees, Asian bees or already had natural bees at their farms. We compared their average yield to the farms who had no stingless bees. Although the farms on average only had 5 beehives on their farms, we observed that the annual yield of farmers who had stingless bees was 3.84% higher than the farms without stingless bees. Our assumption is that their yields will continue to increase by 3.84% per year until the maximum recommended number of beehives is reached (5 beehives/rai).

If you decide to implement stingless bees, we recommend you to start with 5 beehives. This will give you a chance to get familiar with taking care of stingless bees and how to farm alongside them. The good news is, depending on the size and health of your beehives, you can split them after 6 – 12 months. This means, if you have 5 beehives in year 1, you can have 10 beehives in year 2, and 20 beehives in year 3. By expanding the beehives yourself, you only need to purchase a wooden box, instead of a new expensive beehive.

If you decide to purchase 5 beehives and split them over time, these are the estimated costs you will have over 3 years:

Stingless bees	Year 1 (5 beehives)	Year 2 (10 beehives)	Year 3 (20 beehives)	Total
Material cost (beehives)	5,000	-	-	5,000
Material cost (box for splitting)	-	750	1,500	2,250
Labor (taking care)	828 (2.5 days)	1,655 (5 days)	3,310 (10 days)	5,793
Labor (splitting)	-	104 (2.5 hours)	207 (5 hours)	311
Total cost	5,828	2,508	5,017	13,354

If you compare the costs with the increase in yields of having stingless bees, you will see the benefits:

Example 1: 20-rai without stingless bees

No stingless bees	Year 1	Year 2	Year 3	Total
Income from coconuts (yields x price)	1,657,600	1,657,600	1,657,600	4,972,800
Cost of coconut farm	153,908	153,908	153,908	461,724
Profit	1,503,692	1,503,692	1,503,692	4,511,076

Example 2: 20-rai farm with stingless bees

Stingless bees	Year 1 (5 beehives)	Year 2 (10 beehives)	Year 3 (20 beehives)	Total
Total income	1,721,252	1,787,348	1,855,982	5,364,582
Income from coconuts (yields x price)	1,657,600	1,721,252	1,787,348	5,166,200
Additional income from coconuts via bee pollination	63,652	66,096	68,634	198,382
Total costs	159,736	156,416	158,925	475,077
Cost of coconut farm	153,908	153,908	153,908	461,724
Cost of stingless bees	5,828	2,508	5,017	13,353
Profit	1,561,516	1,630,932	1,697,057	4,889,505

When you compare the sample farm with stingless bees and the sample farm without stingless bees you can see that farms with stingless bees have a higher yield and a higher profit:

- Profit increase in year 1: 57,824 (3.84%)
- Profit increase in year 2: 127,240 (8.44%)
- Profit increase in year 3: 193,365 (13%)
- Profit increase in 3 years total: 378,429 (8.39%)

Other studies conducted that examined the effect of pollinators on crop yield even suggest much higher numbers ranging between 20 – 70%! What is clear is that by having stingless bees on your farms brings a ton of benefits: from increasing biodiversity to boosting your coconut yields. Just make sure you plant enough flowers and flowering intercrops to make sure that they are well fed.

C) Organic Fertilizer

The data collected from the ReCAP pilot farmer revealed that farmers use a varying amount of fertilizers: from no fertilizer at all to double the amount of what their farms actually needed. We recommend you to conduct a soil test and use the appropriate amount of fertilizer according to the Organic Matter (OM) of your soil (<2 = 18 kg, 2-3 = 15 kg, >3 – 7.5 kg/tree/year).

The soils of all ReCAP pilot farms were analyzed, and we found that the average recommended use of fertilizer was 13.5 kg per tree/year. The average actual use among the farmers was 13.88 kg per tree. This means if farmers were using the appropriate amount, they could save on average 0.38 kg of compost per tree. Let's have a look at how this would impact spending on fertilizer:

Number of trees on 20-rai farm x fertilizer amount (kg) x price of fertilizer (THB) = total price (THB)

867 trees x 13.88 kg x 2.44 THB = 29,363 THB

867 trees x 13.5 kg x 2.44 THB = 28,559 THB

*In both calculations we have used the average number of trees and average price for fertilizer based on the data of ReCAP's pilot farmers.

If the farmers used the appropriate amount of fertilizer, they could save on average 804 THB (29,363 – 28,559) per year. This may not sound like much, but if you are someone who is using a lot more fertilizer than your farm actually needs, you can make some significant savings here. Furthermore, by using the right amount of fertilizer will help to keep your soil healthy and provide the right nutrients for your trees to stay healthy and produce a high yield. Unfortunately, during the pilot phase of the project we were not able yet to measure the impact of compost on the coconut yield.

D) Intercrops

Growing intercrops is one of the best ways to diversify your income sources. However, your additional revenue from this activity will depend on what you decide to grow. There are crops that can be sold for a high price, but may require a higher investment in the beginning and then they are crops that you can sell for low prices, which also require lower investments in the beginning. When deciding on what to grow, you also of course need to consider what is suitable to grow on your farm depending on the:

i. Conditions of your farm (the age of your coconut trees, the space between your coconut trees, time availability of you and your farm workers, etc.); and

ii. Price, demand and current supply at the market.

Let's have a look at 3 scenarios:

Reference: Revenue of 20-rai coconut farm with no intercrops

No intercrops	Year 1	Year 2	Year 3	Total
Income from coconuts (yield x prices)	1,657,600	1,657,600	1,657,600	4,972,800
Cost of coconut farm	153,908	153,908	153,908	461,724
Profit	1,503,692	1,503,692	1,503,692	4,511,076

Example 1: 20-rai coconut farm with banana

Watering can continue as usual after Y1, so no additional costs calculated for Y2 and Y3.

Banana (25% of farm)	Year 1	Year 2	Year 3	Total
Total income from banana (yield x price)	22,000 (550 kg x 40 THB)	22,000 (550 kg x 40 THB)	22,000 (550 kg x 40 THB)	66,000
Total cost of banana	9,462	3,972	3,972	17,406
Seedlings	4,000 (200 x 20 THB)	-	-	4,000
Labor (planting banana)	662 (16 hours)	-	-	662
Labor (watering banana)	828 (20 hours)	-	-	828
Labor (harvesting banana)	3,972 (96 hours)	3,972 (96 hours)	3,972 (96 hours)	11,916
Profit	12,538	18,028	18,028	48,594

Bananas are a fast-growing crop and with relatively low investment costs, so you can expect some revenue already in year 1. In this example the farmer chose to cover 25% of the available space on their farm with banana, it is of course up to you how much of the available farm you wish to utilize for growing intercrops. If you double the number of the banana grown, you can double the income, costs, and the profits.

Investment in seedlings in the beginning can be high, but your costs can be recovered via your sales in Y2.

Example 2: 20-rai coconut farm with fern

Fern (50% of farm)	Year 1	Year 2	Year 3	Total
Total income from fern (yield x price)	221,538 (3,692 kg x 60THB)	221,538 (3,692 kg x 60THB)	221,538 (3,692 kg x 60THB)	664,614
Total cost of fern	239,168	43,030	43,030	325,228
Seedlings	192,000 (19,200 x 10 THB)	-	-	192,000
Labor (planting fern)	3,310 (80 hours)	-	-	3,310
Labor (watering fern)	828 (20 hours)	-	-	828
Labor (harvesting fern)	43,030 (1,040 hours)	43,030 (1,040 hours)	43,030 (1,040 hours)	129,090
Profit	-17,630	178,508	178,508	339,386

In this example, the farmer chose to cover 50% of their available space on their coconut farm with fern. Because of the high investment costs in year 1, profits are at a minus in year 1. However, good profits are then observed in year 2 and year 3. This will require some patience from you as a farmer and the willingness to invest in year 1.

Growing 2 crops can reduce your risks, in case one crop doesn't grow as well you might have planned.

Example 3: 20-rai coconut farm with banana and fern

Banana (25%) and Fern (50%)	Year 1	Year 2	Year 3	Total
Total profit from banana	12,538	18,028	18,028	48,594
Total profit from fern	-17,630	178,508	178,508	339,387
Total profit from banana and fern	-5,092	196,536	196,536	387,981

In this farm example, the farmer chose to cover 25% of their available coconut farm space with banana and 50% of their available coconut farm space with fern. This way, the farmer can offset some of the investment costs of the fern in year 1 with the quick revenue from the banana, so they face lower losses. By growing 2 crops, this farmer is able to gain a higher revenue than compared to growing just 1 intercrop over the 3 years.

Comparison of 3 scenarios

Profit increase (%)	Year 1	Year 2	Year 3	Total
Banana (25%)	0.83%	1.2%	1.2%	1.08%
Fern (50%)	-1.17%	12%	12%	7.5%
Banana (25%) and Fern (50%)	-0.34%	13%	13%	8.6%

In this table it becomes clear that the winner of all 3 scenarios is the last scenario with 2 intercrops. Generally speaking, we encourage you to grow a combination of 2 – 3 kinds of intercrops on your farm so that you can get an income from several sources. This will make you more resilient when market prices fluctuate.

This table can give you an indication of what to expect when selecting your intercrops:

Intercrop	Year 1	Year 2	Year 3	Harvest duration
Pandan leaves	High profit	High profit	High profit	7 months – 1 year (harvest 1 time/month)
Piper sarmentosum	High profit	High profit	High profit	4 – 6 months (harvest 1 time/month)
Pepper	High losses	Very high profit	Very high profit	2 – 3 years (harvest 2 times/year)
Coffee	Medium losses	Low losses	Very high profit	3 – 4 years (harvest 1 time/year)
Kaffir lime	Medium losses	Low losses	Very high profit	2 – 3 years (harvest 6 times/year)

Intercrop	Year 1	Year 2	Year 3	Harvest duration
Long pepper	High profit	Very high profit	Very high profit	1 year (harvest 3 times/year)
Vanilla	Very high losses	High losses	Very high profit	3 – 4 years (harvest 1 time/year)
Chrysan-themum	Low profit	Low profit	Low profit	3 – 4 months (harvest 1 time/year)
Banana	Low profit	Low profit	Low profit	1 year (1 time/year)
Chamomile	Low profit	Low profit	Low profit	3 – 4 months (harvest 1 time/year)
Fern	Low losses	High profit	High profit	7 months – 1 year (harvest 1 time/week)

There are of course many more intercrops beyond this list. Please consult your advisors on regenerative agriculture on what combination of intercrops are suitable for you to grow at your farm. Every farm is unique, so planning should be done according to the conditions of your farm. You also need to check whether the intercrop(s) you plan to grow is in demand by markets and consumers, otherwise you risk growing something that you cannot sell.

Very important! Whatever you decide to grow, keep in mind that when you purchase intercrop seedlings, they need to be approved by your certification body. Don't risk the certification of your farm by choosing to buy the cheapest seedlings.

E) Fish

Fish feed on aquatic weeds. If you have fish in your canals, you can reduce the costs of weed control in your canals. Let's compare a farm with and without fish:

Example 1: 20-rai coconut without fish

No fish	Year 1	Year 2	Year 3	Total
Material cost (fish)	-	-	-	-
Labor (buy fish and release)	-	-	-	-
Labor (remove aquatic weeds)	15,880 (48days)	15,880 (48 days)	15,880 (48 days)	47,640
Total	15,880	15,880	15,880	47,640

The fish will expand by themselves over the years. The more fish you have the less time you need to spend on removing the weeds.

Example 2: 20-rai coconut with fish

Fish	Year 1	Year 2	Year 3	Total
Material cost (fish)	6,000	-	-	6,000
Labor (buy fish and release)	83 (2 hours)	-	-	83
Labor (remove aquatic weeds)	15,880 (48 days)	11,916 (36 days)	11,916 (36 days)	39,712
Total	21,963	11,916	11,916	45,795

By having fish, the farmer can reduce their cost for weed control in the canals by 1,845 THB (4%) over 3 years. Whilst this activity will not save you a lot of money, it will save you a lot of time if you are removing the weeds by yourself. It is also relatively easy to do, as you only have to release the fish once. The fish will feed on the aquatic weeds and expand by themselves naturally, no need to purchase fish food. Furthermore, having fish in your farms are good because they are a great indicator of the quality of the water in your farm.

F) Pest Management

Similar to fertilizer usage, the importance is to use the correct amount. Based on the data of ReCAP's pilot farmers, most farmers were spending more on pest management than they needed to:

Average use of pest management on 20-rai coconut farm

Average pest management use	Year 1	Year 2	Year 3	Total
Materials	7,790	7,790	7,790	23,370
Labor	580 (14 hours)	580 (14 hours)	580 (14 hours)	1,740
Total cost	8,370	8,370	8,370	25,110

Recommended use of pest management on 20-rai coconut farm

Recommended pest management use	Year 1	Year 2	Year 3	Total
Bracon (materials)	2,000 (40 boxes)	1,200 (24 boxes)	600 (12 boxes)	3,800
Bracon (labor)	166 (4 hours)	100 (2.5 hours)	50 (1 hour)	316
Pheromone (materials)	3,200 (8 pieces)	3,200 (8 pieces)	3,200 (8 pieces)	9,600
Pheromone (labor)	83 (2 hours)	83 (2 hours)	83 (2 hours)	249
Metarhizium bait (materials)	320 (16 bags)	320 (16 bags)	320 (16 bags)	960
Metarhizium bait (labor)	331 (8 hours)	331 (8 hours)	331 (8 hours)	993
Total cost	6,100	5,234	4,584	15,918

As you can see, by implementing the correct amount of pest management, farmers could have made the following savings:

- Potential savings in year 1: 2,471 (29%)
- Potential savings in year 2: 3,337 (39%)
- Potential savings in year 3: 3,987 THB (47%)
- Potential savings in 3 years total: 9,794 THB (38%)

Now that you have seen how each activity can help in terms of saving costs or increasing your income, we will now combine them all into one example calculation for a 20-rai farm and see what a difference it will make, when implementing all recommended regenerative activities.

The costs calculated in the below examples exclude utilities (water, electricity), fixed costs (land rental and taxes) and other (heavy machinery, renovations, etc.).

Example 1: Monoculture 20-rai coconut farm

	Item	Quantity	Price (THB)	Year 1	Year 2	Year 3	3 Years (Total)
TOTAL INCOME				1,657,600.00	1,657,600.00	1,657,600.00	4,972,800.00
Income	Coconuts	1600,000.00	10.36	1,657,600.00	1,657,600.00	1,657,600.00	4,972,800.00
TOTAL COST				153,908.22	153,908.22	153,908.22	461,724.67
Costs	Fertilizer (kg)	12,036.04	2.44	29,367.94	29,367.94	29,367.94	88,103.83
	Labor (putting compost)	12,036.04	0.25	3,009.01	3,009.01	3,009.01	9,027.03
	Pest management	Various methods	Various methods	7,990.77	7,990.77	7,990.77	23,972.31
	Labor (cutting grass & weed mngt.) days	24.00	331.00	7,944.00	7,944.00	7,944.00	23,832.00
	Labor (watering) days	37.50	331.00	12,412.50	12,412.50	12,412.50	37,237.50
	Labor (duckweed removal) days	48	331.00	15,888.00	15,888.00	15,888.00	47,664.00
	Labor (waste mngt.) days	16.00	331.00	5,296.00	5,296.00	5,296.00	15,888.00
	Digging mud out of canal (days)	20.00	3,600.00	72,000.00	72,000.00	72,000.00	216,000.00
PROFIT				1,503,692	1,503,692	1,503,692	4,511.075

Example 2: Regenerative organic 20-rai coconut farm

		Year 1			Year 2			Year 3			3 Years (Total)
	Item	Quantity	Price (THB)	Total Y1	Quantity	Price (THB)	Total Y2	Quantity	Price (THB)	Total Y3	
TOTAL INCOME				1,964,789.84			2,030,885.91			2,099,520.07	6,095,195.82
Income	Coconuts (nuts)	160,000.00	10.36	1,721,251.84	166,144.00	10.36	1,787,347.91	1,72,523.93	10.36	1,855,982.07	5,364,581.82
	Coconuts (nut) from bees	6,144.00			6,379.93			6,624.92			
	Fern (kg)	3,692.30	60.00	221,538.00	3,692.30	60.00	221,538.00	3,692.30	60.00	221,538.00	664,614
	Banana (kg)	550.00	40.00	22,000.00	550.00	40.00	22,000.00	550.00	40.00	22,000.00	66,000.00
TOTAL COST				417,324.55			121,815.71			167,767.67	706,907.94
Costs	Compost (kg)	11,706.53	2.44	28,563.92	11,706.53	2.44	28,563.92	11,706.53	2.44	28,563.92	85,691.76
	Putting compost (kg)	11,706.53	0.25	2,926.63	11,706.53	0.25	2,926.63	11,706.53	0.25	2,926.63	8,779.89
	Pest management	*Bracon* *Metarhizium* Pheremone	2,000.00 320.00 3,200.00	5,520.00	*Bracon* *Metarhizium* Pheremone	1,200.00 320.00 3,200.00	4,720.00	*Bracon* *Metarhizium* Pheremone	600.00 320.00 3,200.00	4,120.00	14,360.00
	Fern seedlings (50%)	19,200.00	10.00	192,000.00	-	-	-				192,000.00
	Banana seedlings (25%)	200.00	20.00	4,000.00	-	-	-				4,000.00
	Cover crops (25%)	20.00	200.00	4,000.00	-	-	-				4,000.00
	Beehives	5.00	1,000.00	5,000.00	-	-	-				5,000.00

		Year 1			Year 2			Year 3			3 Years (Total)
	Item	Quantity	Price (THB)	Total Y1	Quantity	Price (THB)	Total Y2	Quantity	Price (THB)	Total Y3	
	Boxes for bee splitting				5.00	150.00	750.00	10.00	150.00	1,500.00	2,250.00
	Fish	2,000.00	3.00	6,000.00	-	-					6,000.00
	Total Labor	294.00	331.00	97,314.00	256.36	331.00	84,855.16	255.52	331.00	84,577.12	266,746.28
	Digging mud out of canal	20.00	3,600.00	72,000.00		-	-	16.00	2,880.00	46,080.00	118,080.00
PROFIT				1,547,465			1,909,070			1,931,752	5,388,287

To understand how we calculated the labor for all the activities, you can have a closer look at the table below:

Labor in detail

			Year 1			Year 2			Year 3			3 Years (Total)
	Item		Quantity	Price (THB)	Total Y1	Quantity	Price (THB)	Total Y2	Quantity	Price (THB)	Total Y3	
Labor	Topic		294.00	5,958.00	97,314.00	256.36	5,958.00	84,855.16	255.52	5,958.00	84,577.12	266,746.28
	Overall	Grass cutting and weed mngt.	24.00	331.00	7,944.00	18.00	331.00	5,958.00	12.00	331.00	3,972.00	17,874.00
		Watering coconuts	37.50	331.00	12,412.50	37.50	331.00	12,412.50	37.50	331.00	12,412.50	37,237.50
		Duckweed removal	48.00	331.00	15,888.00	36.00	331.00	11,916.00	36.00	331.00	11,916.00	39,720.00
		Waste management	16.00	331.00	5,296.00	16.00	331.00	5,296.00	16.00	331.00	5,296.00	15,888.00
	Pest Manage-ment	*Bracon*	0.50	331.00	165.50	0.30	331.00	99.30	0.15	331.00	49.65	314.45
		Metarhizium	0.25	331.00	82.75	0.25	331.00	82.75	0.25	331.00	82.75	248.25
		Pheremone	1.00	331.00	331.00	1.00	331.00	331.00	1.00	331.00	331.00	993.00
	Cover crops	Planting	2.50	331.00	827.50	-						827.50
		Watering	2.50	331.00	827.50	-						827.50
	Banana	Planting	2.00	331.00	662.00	-						662.00
		Watering	2.50	331.00	827.50	-						827.50
		Harvesting	12.00	331.00	3,972.00	12.00	331.00	3,972.00	12.00	331.00	3,972.00	11,916.00

			Year 1			Year 2			Year 3			3 Years (Total)
	Item		Quantity	Price (THB)	Total Y1	Quantity	Price (THB)	Total Y2	Quantity	Price (THB)	Total Y3	
	Fern	Planting	10.00	331.00	3,310.00	-						3,310.00
		Watering	2.50	331.00	827.50	-						827.50
		Harvesting	130.00	331.00	43,030.00	130.00	331.00	43,030.00	130.00	331.00	43,030.00	129,090.00
	Bees	Taking care	2.50	331.00	827.50	5.00	331.00	1,655.00	10.00	331.00	3,310.00	5,792.50
		Splitting	-	-	-	0.31	331.00	102.61	0.62	331.00	205.22	307.83
	Fish	Releasing	0.25	331.00	82.75	-	-	-				82.75
Total labor (Days)			294 Days			256 Days			255 Days			805.88 Days

If you compare the two examples (monoculture farm vs regenerative coconut farm), you will notice that the income, costs and profits are all higher in the regenerative farm scenario:

Income	Year 1	Year 2	Year 3	Total 3 years
Monoculture farm	1,657,600	1,657,600	1,657,600	4,972,800
Regenerative farm	1,964,790	2,030,886	2,099,520	6,095,196
% Difference	307,190 (19%)	373,286 (23%)	441,920 (27%)	1,122,396 (23%)

Costs	Year 1	Year 2	Year 3	Total 3 years
Monoculture farm	153,908	153,908	153,908	461,725
Regenerative farm	417,325	193,816	167,768	706,908
% Difference	263,417 (171%)	39,908 (26%)	13,860 (9%)	245,183 (53%)

Profit	Year 1	Year 2	Year 3	Total 3 years
Monoculture farm	1,503,692	1,503,692	1,503,692	4,511,075
Regenerative farm	1,547,465	1,837,070	1,931,752	5,388,288
% Difference	43,774 (3%)	405,378 (27%)	428,061 (28%)	877,213 (19%)

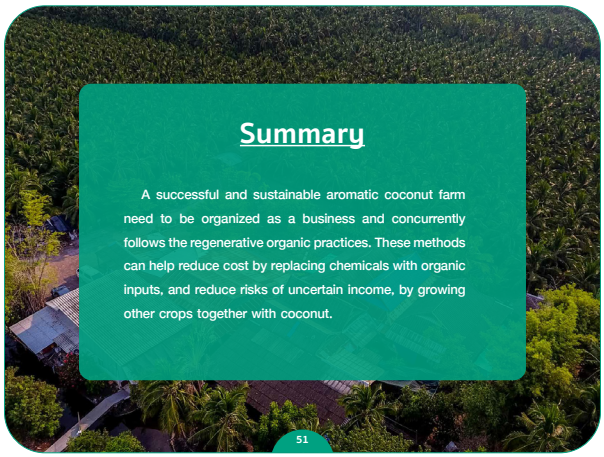
Overall, an increase in profits can be expected from applying the different regenerative organic practices together. The slowest increase in income is in year 1 as most investments (seedlings, bees, fish) are made in the first year. Farmers will be able to experience more significant income increases starting in year 2 (27%).

Although practicing the various regenerative activities can lead to this income increase, the activities that will likely bring the most economic benefits are:

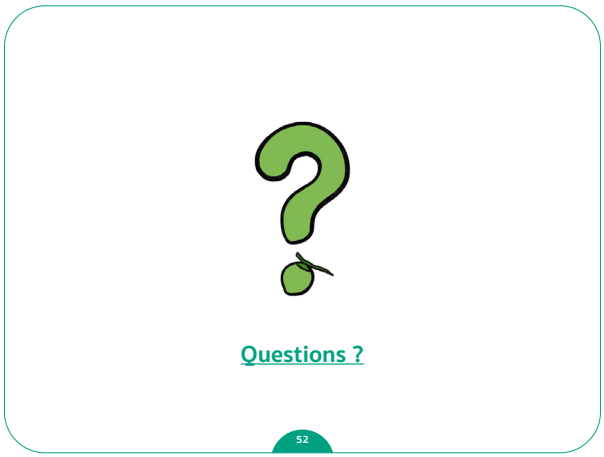
- Rearing stingless bees
- Growing high value intercrops
- Covering bunds with cover crops

This may give you some guidance on what regenerative activities you want to implement. We of course would like to encourage you to implement as many regenerative activities as possible, but each activity also has to be aligned with what you want from your farm and makes sense for your farm. The good news is that many regenerative activities are not only good for the environment, but also for your income!

Summary



A successful and sustainable aromatic coconut farm needs to be managed as a business and concurrently follows the regenerative organic practices. These methods can help reduce cost, by replacing chemicals with organic inputs, and reduce risks of uncertain income, by growing other crops together with coconut.



Any questions?

Questions

1. Do you agree to treat your farm as a business? Why?
2. Which practice from the regenerative organic agriculture that you want to adopt in your farm? Why?
3. Which point/topic will help you get the highest benefit?

B. EXERCISE

DO THIS

Exercise 1: Find your farm's strength and weakness

Write down what you have in your farm on this table as shown in below example.

Example of the farm's strength and weakness identification.

Commodities (number)	Strength	Weakness
1. Coconut palm (28)	1. Income from many ways	1. Too small coconut fruits
2. Banana (12)	2. Get money every week	2. Seemingly bad sales for banana
3. Vegetable fern (5)	3. Good sales for fish	
4. Lemon grass (5)		
5. Pandan (6)		
6. Fish (5)		

Then identify your lists whether they are strength or weakness of your farm and write down on the columns accordingly.

Commodities (number)	Strength	Weakness

DO THIS

Exercise 2: Record your regular work in the farm

Date	Irrigation	Fertilization	Pest management	Others

DO THIS

Exercise 3: Farm accounting; profit and loss

3.1 Identify income and cost

Given an aromatic coconut farming business from one orchard as an example, its income and cost in one month (September 2020) can be identified as follows:

- **Income;**

From selling coconut 2,000 fruits (10 THB/fruit), vegetable fern 15 bunches (30 THB/bunch), pandan 100 bunches (25 THB/bunch), honey 10 small bottles (120 THB/bottle) and coconut seedling 100 seedlings (80 THB/seedling)

- **Cost;**

Hire labor for weeding 3 persons (300 THB/person/day), harvest 2,000 fruit (3THB/fruit), apply fertilizer 3 person (300 THB/person/day), remove dry leaves 1 person (300 THB/person/day), repairing the bund 3 person (300 THB/person/day), fixing boat 500 THB, telephone 299 THB, purchase *Bracon* wasp 200 cups (5 THB/cup), roundleaf bindweed 100 plants (8 THB/plant), compost 100 sacks (20 THB/sacks), gasoline for boat 10 liter (30 THB/liter), water fee 20 m3 (5 THB/m3), electric fee 50 unit (6 THB/unit). Also pay farm rental fee 10 rai (100 THB/rai) and land tax 100 THB/year.

Put all of the income and cost items in the appropriate row:

Item	Amount	Price/unit (THB)	Total (THB)
Total Income			
1. Sold coconut			
2. Other crops			
2.1			
2.2			
2.3			
3.			
4.			
Variable Cost			
1. Labor			
1.1			
1.2			
1.3			
1.4			

Item	Amount	Price/unit (THB)	Total (THB)
1.5			
2. Management/maintenance			
2.1			
2.2			
3. Materials/input			
3.1			
3.2			
3.3			
4. Utility			
4.1			
4.2			
4.3			
Fixed Cost			
5.1			
5.2			
5.3			
Profit			

Example is shown below:

Item	Amount	Price/unit (THB)	Total (THB)
Total Income			
1. Sold coconut	5,000	10	
2. Other crops			
2.1 Vegetable fern	15	30	
2.2 Pandan	100	25	
3. Honey	10	120	
4. Coconut seedlings	100	80	
Variable Cost			
1. Labor			
1.1 Weeding	3	300	
1.2 Harvest	2,000	3	
1.3 Apply fertilizer	3	300	
1.4 Repairing the bund (1 day)	3	300	
1.5 Remove dry leaves	1	300	
2. Management/maintenance			
2.1 Boat fixing	500	0	
2.2 Gas for boat	10	30	

Item	Amount	Price/unit (THB)	Total (THB)
3. Materials/input			
3.1 Purchase *Bracon* wasp	200	5	
3.2 Purchase roundleaf bindweed	100	8	
3.3 Purchase compost	100	20	
4. Utilities			
4.1 Electric fee	50	6	
4.2 Water fee	20	5	
4.3 Telephone	1	299	
Fixed Cost			
5.1 Farm rent	10	100	
5.2 Land tax 100 THB/year	100		
5.3 Others			
Profit = Income - Cost			

3.2 Calculate profit and loss

After identifying income and cost, sum up the total amount of each to calculate whether the farm gets profit or loss and how much in September 2020.

Item	Amount	Price/unit (THB)	Total (THB)
Total Income			**62,150**
1. Sold coconut	5,000	10	**50,000**
2. Other crops			
2.1 Vegetable fern	15	30	**450**
2.2 Pandan	100	25	**2,500**
3. Others			
3.1 Honey	10	120	**1,200**
3.2 Coconut seedlings	100	80	**8,000**
Variable Cost			**14,299**
1. Labor			**9,000**
1.1 Weeding	3	300	**900**
1.2 Harvest	2,000	3	**6,000**
1.3 Apply fertilizer	3	300	**900**
1.4 Repairing the bund	3	300	**900**
1.5 Remove dry leaves	1	300	**300**
2. Management/maintenance			**800**
2.1 Boat fixing	500	0	**500**
2.2 Gas for boat	10	30	**300**

Item	Amount	Price/unit (THB)	Total (THB)
3. Materials/input			**3,800**
3.1 Purchase *Bracon* wasp	200	5	**1,000**
3.2 Purchase roundleaf bindweed	100	8	**800**
3.3 Purchase compost	100	20	**2,000**
4. Utilities			**699**
4.1 Electric fee	50	6	**300**
4.2 Water fee	20	5	**100**
4.3 Telephone	1	299	**299**
Fixed Cost			**1,100**
5.1 Farm rent	10	100	**1,000**
5.2 Land tax 100 THB/year	100		**100**
5.3 Others			
Profit = Income (62,150)-Cost (14,299+1100=15,399) =46,751 THB			

So, in September 2020, the total income of this farm is **62,150** THB and the total cost is **15,399** THB. Then, this farm gets profit **46,751** THB.

DO THIS

Exercise 4: Do your farm accounting of this month

Item	Amount	Price/unit (THB)	Total (THB)
Total Income			
1. Sold coconut			
2. Other crops			
2.1			
3. Others			
3.1			
3.2			
Variable Cost			
1. Labor			
1.1			
1.2			
1.3			
1.4			
2. Management/maintenance			
2.1			
2.2			

Item	Amount	Price/unit (THB)	Total (THB)
3. Materials/input			
3.1			
3.2			
3.3			
4. Utilities			
4.1			
4.2			
4.3			
Fixed Cost			
5.1			
5.2			
5.3			
Profit = Income – (Variable Cost + Fixed Cost)			

DO THIS

Exercise 5: Evaluate your farm

The purpose of this exercise is to evaluate and conclude the final result of what we have planned and implemented.

Example

Indicator	Expected outcome	Actual outcome	Remark
1. Product	20,000 nuts	15,000 nuts	No irrigation in dry season
2. Price	10 THB	8 THB	Low price due to small fruit
3. Income	200,000 บาท	120,000 บาท	Decrease since yield and quality drop
4. Variable cost	10,000 THB	15,000 THB	Price of chemical fertilizer and others increased
5. Profit	190,000 THB	105,000 THB	Income decreases but input increase

According to the same example, the evaluation shows that the real income is lower than estimated since the size of coconut yields are small. Thus, the next-year plan of this farm has to focus on solving the smaller size of coconut fruits, probably by more watering or applying more fertilizer.

The ReCAP team can support you after the training to finalize this exercise if you need more time or have more question.

Indicator	Expected outcome	Actual outcome	Remark
1. Product			
2. Price			
3. Income			
4. Variable cost			
5. Profit			

DO THIS

Exercise 6: Profit and loss of conventional farm vs ROC farm.

Given 2 aromatic farms as an example. One is conventional farm that has income from selling coconut only. The cost is high due to the use of chemicals. Another farm followed the ROC practices and has income not only from selling coconut, but also other products while the cost is not expensive.

Please sum up the total amount of each content to calculate whether each farm gets profit or loss and how much.

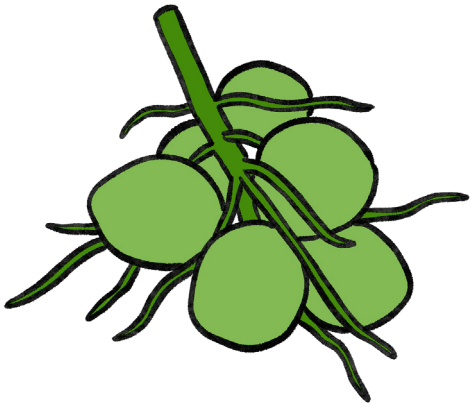
Normal farm				ROC farm			
Content	**Amount**	**Price/ unit (THB)**	**Total (THB)**	**Content**	**Amount**	**Price/ unit (THB)**	**Total (THB)**
Income				Income			
1. Coconut	5,000	10		1. Coconut	5,000	10	
				2. Honey	20	120	
				3. Vegetable fern	20	30	
				4. Pandan	100	20	
				5. Vermicompost	50	20	
Total income				Total income			
Cost				Cost			
1. Chemical fertilizer	20	400		1. Compost	100	20	
2. Herbicide	2	300		2. Cover crop	50	8	
3. Hire labor to spray herbicide	1	300		3. Compost	10	100	
4. Insecticide	15	250		4. *Bracon* wasp	200	5	
Total cost				Total cost			
Net Profit				Net Profit			

As shown in the next table, conventional farm has total income of only **50,000** THB while the cost is **12,650** THB. Thus, this farm has only **37,350** THB in profit. Meanwhile the other farm, who follows the regenerative organic agricultural practices (ROC farm), earns higher income from intercropping (**56,000** THB), pays lower cost (**4,400** THB) by cutting chemical inputs, and consequently gets higher profit (**51,600** THB).

Normal farm				ROC farm			
Content	**Amount**	**Price/ unit (THB)**	**Total (THB)**	**Content**	**Amount**	**Price/ unit (THB)**	**Total (THB)**
Income				Income			
1. Coconut	5,000	10	50,000	1. Coconut	5,000	10	50,000
				2. Honey	20	120	2,400
				3. Vegetable fern	20	30	600
				4. Pandan	100	20	2,000
				5. Vermicompost	50	20	1,000
Total income			50,000	Total income			56,000
Cost				Cost			
1. Chemical fertilizer	20	400	8,000	1. Compost	100	20	2,000
2. Herbicide	2	300	600	2. Cover crop	50	8	400
3. Hire labor to spray herbicide	1	300	300	3. Compost	10	100	1,000
4. Insecticide	15	250	3,750	4. *Bracon* wasp	200	5	1,000
Total cost			12,650	Total cost			4,400
Net Profit			**37,350**	Net Profit			**51,600**

Module 7

TRANSFORMING YOUR FARM TO A REGENERATIVE ORGANIC FARM



OBJECTIVES

To plan with farmers how to transform their farms step by step to be regenerative organic

ACQUIRE KNOWLEDGE

Participants:

Learn how to plan to transform their farm to regenerative organic agriculture

ACQUIRED SKILL

Participants can:

Adjust their farm to be a regenerative organic farm

ACQUIRED ATTITUDES

The participants understand and have good attitude on regenerative organic agriculture for sustainable crop production

RELEVANCE T SUSTAINABLE COCONUT FARMING

Practicing organic regenerative agriculture makes coconut farm become sustainable

METHODS

Hands-on practices and discussion for 180 minutes

TRAINING SUPPLIES, TOOLS, AND MATERIALS

1. This Manual for Trainers containing practice guidelines and worksheets for Module 7

2. The Handbook for Farmers containing the practice worksheets for Module 7 and blank pages for taking notes

3. Flipchart

4. Markers

DURATION

Main topics	Period (min)
1. Identify problem you found in your farm	30
2. Regenerative organic solutions	30
3. Activity plan of transforming your farm to ROC	40
4. Draw and and present your future farm	80
Total time of training in Module 7	**180 (3 h)**

KEY MESSAGES

How to adjust conventional practices to comply with Regenerative Organic Certification requirements for balance of the ecosystem and sustainable coconut production.

HANDS-ON PRACTICE

Benefits from transforming your farm to ROC

The trainer gets the attention by briefly concluding benefits from transforming farm to ROC and starts the module: "After the training, participants should understand the how to change your farms to regenerative organic practices. Adopting them in your farm is not only good for your health, but also for the soil in your farm. Your farm will be fertile and sustainable for many years to come. In addition to the development of health and environment, the regenerative organic practices will help you to diversify your income and reduce input costs. Also, other activities, i.e., growing intercrops, potentially increase your farm income. In this module, you will plan the steps needed to transform your farm. The ReCAP team will assist you in achieving your goal."

→ **See Page 213 in the Handbook for Farmers**

7.1 Identify problems you found in your farm

DO THIS

Before we start to plan, farmers should first identify what the problems are that they experience at their farms. **(See Page 214 in the Handbook for Farmers)** In the table below, the trainer should ask the participants to tick ✓ in the box of the problems that they observe at their farm. Tell the participants that after identifying the problems, then we will find solutions.

What problems do you see at your farm?

Name: _____ **Location:** _____

Farm size: _____

Questions (@ farmers: "✓" tick the box that fits best)	**Strongly Disagree**	**Disagree**	**Un-changed**	**Agree**	**Strongly Agree**	**Comments: By how much?**
1. Has the width of your bund decreased over the past years?						
2. Have your input costs increased over the past years?						
3. Did you have a pest infestion in the last 12 months that impacted your production? (yield, extra labor costs, etc.)						
4. Have your yields decreased in the past years?						
5. Did you suffer from the draught in the past 2 years?						
6. Are you dependent on market fluctuations of coconuts?						
7. Do you have to dig your canal to put back the soil onto the bund?						
8. Do you spend much labor/cost on weeding?						
9. Are the roots of your trees visible on the side of the bund?						
10. Has your or your family's health been negatively affected by pesticides?						

After having identified the problems at their farms, ask the farmers as a group about what regenerative organic solutions they have learned to tackle the challenges. Through this quiz you can check how much the farmers have learned during the training, and help them realize, that regenerative organic farming can help solve many of the problems they experience.

7.2 Open plenary quiz: Regenerative organic solutions

Problems	Consequences	Possible Solutions
Soil erosion	• Organic matter is going into the water • Less space for feeding the trees (roots) • Bund size decreases • Digging canals to add soil to the bund (extra labor/cost)	✓ Cover crops
Poor soil	• Decreasing yields • More input costs • Increase erosion risk • Less moisture in soil	✓ Intercrops ✓ Cover crops (especially nitrogen fixing crop) ✓ Compost
Single source revenue	• Dependent on market price fluctuations • High risk business model (e.g., cut trees because of pest)	✓ Intercrops ✓ Honey from insect pollinators ✓ Fish
Reduction in yields	• Less profit • More input costs	✓ Bees for pollination ✓ Intercrops ✓ Compost
Pests and diseases	• Loss yields • Low quality yields • Loss of income	✓ Biocontrol ✓ Insect trap ✓ *Bracon* wasp, etc.
Climate change	• Changing weather patterns (drought, flooding, etc.)	✓ ALL practices above

After you share the answers with the farmers, ask your participants to write down a plan for what they want to implement in each topic within a specific timeframe. **(See Page 216-217 in the Handbook for Farmers)**

7.3 Activity plan of transforming your farm to ROC

DO THIS

Transforming your farm to a regenerative organic farm!

Name: _____ Location: _____

Farm size: _____

TOPIC	Current Farm mm/yyyy:		Future Farm mm/yyyy:	
	(Tick "✓" if yes)	Please specify (type and amount)	(Tick "✓" if yes)	Please specify (type and amount)
Cover crop				
Intercrop				
Compost				
Bees				
Pest management				
Waste management				

DO THIS

Transforming your farm to a regenerative organic farm (continued):

Write down the monthly plan of your farm in the table below

Activity	Month																		Expected outcome
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

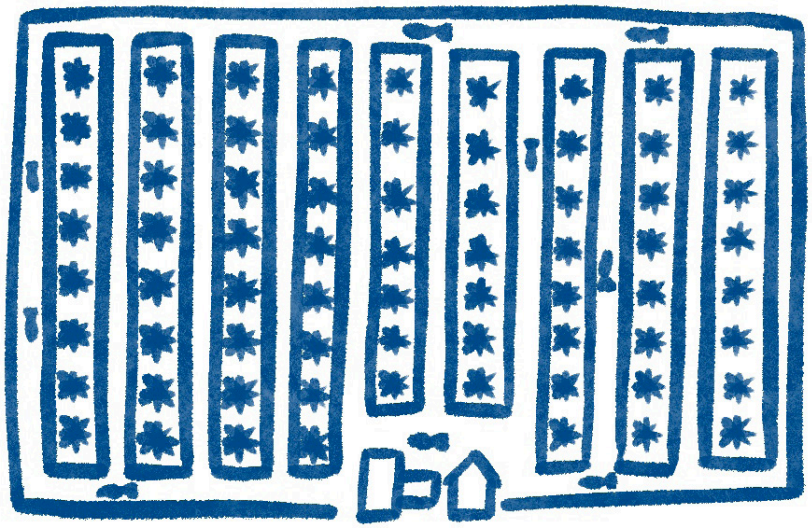
Once the farmers have made their plans, ask farmers to draw their “dream” or “visionary” farm.

DO THIS

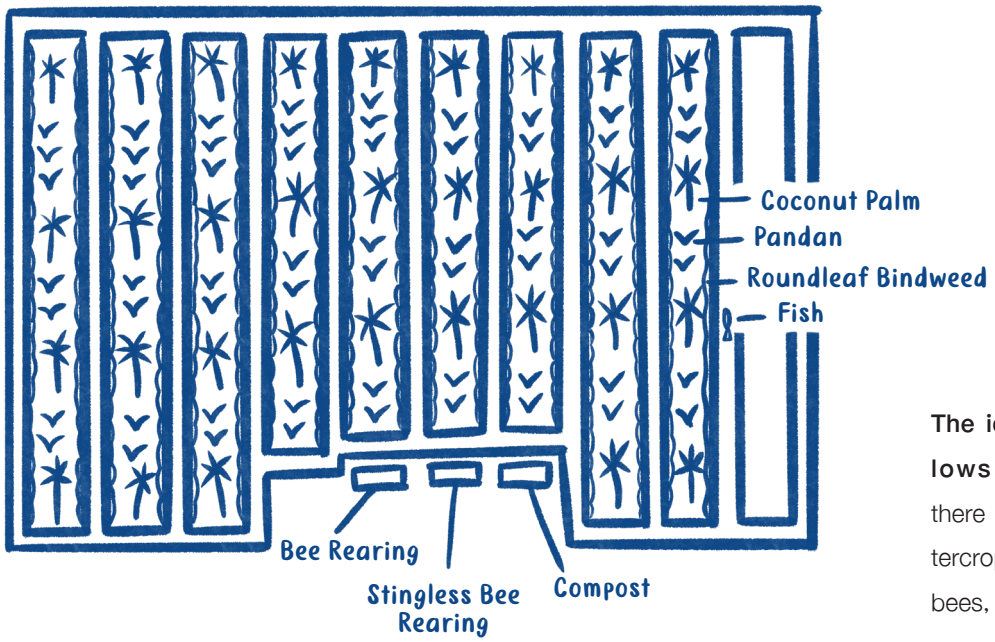
7.4 Draw your farm

The trainer asks the participants to draw the picture of their coconut farm again. This time, it should be how they want their farm to look like after having attended the training on regenerative organic practices. They may wish to add cover crops, the stingless bees, growing 2–3 kinds of other crops or add fish to their canals to get a higher income. Then compare this farm to the one that they drew at the beginning of the training on Day 1. Ask them how the second one is better than the first one. **(See Page 218-219 in the Handbook for Farmers)**

Example: The upper picture is the coconut farm before attending the training. There are only coconut and fish in the farm. The lower picture is the ideal farm that follows regenerative organic practices. There are cover crops, intercrops, rearing of stingless bees, etc.



The coconut farm before taking ROC practices: there are only coconut and fish in the farm.



The ideal farm that follows ROC practices: there are cover crops, intercrops, rearing stingless bees, etc.

DO THIS

Each farmer should then show their drawing of their future farm to other participants, highlighting what they will change and what they look forward to the most.

You may ask each farmer the following questions:

- What are the main changes to your farm that you will make?
- What steps are you most excited about?
- When will you start making the first changes?

Also try to understand the blocking points if the farmer is not convinced or reluctant to try some of the new practices. Try to re-explain the reasons about their importance.

- Why do you not want to do (e.g., cover crop) in your farm?
- What issues do you think it will create? And why?

You can propose to the farmers to try the practice in a small part of their farm to test it before implementing everywhere.

After each farmer has presented their drawing and plans to the group, the training is completed.

Closing words of the training to farmers

"Congratulations! You have completed the first part of your journey to transforming your farm to regenerative organic agriculture. After having attended the training, you now know how to take care of your soil, about how you can mitigate market risks, and increase your resiliency against a changing climate. Moreover, you may have realized that **everything is interconnected:** Waste of your coconuts can be turned into compost; compost strengthens the health of your soils; fertile soils enhance plant growth; intercrops provide a playground for bees; bees pollinate your coconut trees; and pollination improves your yields.

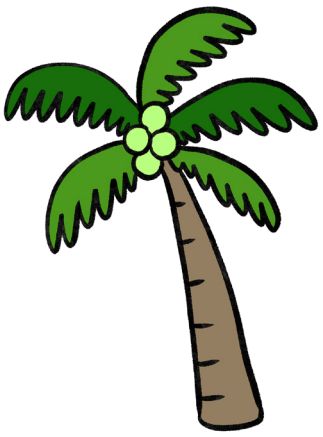
Farming is not an easy occupation, but it is and always will be one of the most important professions. To help solve your daily challenges, we have shown you in this training that there are ways to deal with them in a regenerative and organic manner. Whether you see your yields drop, your canals widen, or coconut rhinoceros beetles take over your coconut trees, we have provided you with resources to make your own informed decisions that are best for your farm. Just remember, it is important to **farm with nature.**

Whatever stage your farm is at currently, whether you are a conventional farmer, have some experience with organic farming or are already certified, you now know the next steps for your farm, so that you can turn your vision into reality. Welcome to the **team of pioneering farmers**, who will pave the way for a more sustainable future of coconut farming in Thailand!"

"Rehabilitate nature. Respect people.
Revitalize farming."

Evaluation

After the training, ask the farmers to fill out evaluation forms **(Annex A on Pages 229-233 in the Handbook of Farmers)** so that the trainer team knows what should be improved in future. There are also evaluation forms for the trainer team **(Annex A on Pages 251-254 of this Manual of Trainers).**



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ANNEXES

ANNEX A EVALUATION FORMS
แบบประเมินผลการฝึกอบรมภายใน

Regenerative Organic Agriculture Training – Evaluation Form for Trainers
โครงการ การฟื้นฟูด้วยเกษตรอินทรีย์ “Regenerative Organic Agriculture Training for Coconut Farmers”

(To be filled out by the trainer team after each training day and submittedby training team

5 questionnaires per each batch) กรอกข้อมูลหลังการฝึกอบรมในแต่ละวัน โดยทีมผู้ฝึกอบรม (5 คำถามต่อชุด)

วันที่ Date: _____ วันที่ฝึกอบรม Training day (1 – 5): _____

สถานที่ฝึกอบรม Training Venue: _____

จำนวนผู้เข้าร่วมอบรม Number of Participants in Training: _____

ชื่อ Name (Trainer): _____

คำถามแนวทางสำหรับทีมฝึกอบรม

Guiding Questions for the trainer team

1. ข้อสังเกตทั่วไป
General Observations

	ข้อสังเกต Observations	คำแนะนำเพิ่มเติมสำหรับการฝึกอบรม Recommendation for training enhancement
ความพึงพอใจเกษตรกร - เกษตรกรชอบการอบรมอย่างไร / ผลตอบรับเป็นอย่างไร? **Satisfaction** - How did the farmers like the training / how was their feedback? เกษตรกรเห็นประโยชน์จากการฝึกอบรมหรือไม่ / ได้รับอะไรบ้าง? Did farmers see the benefit of the training? “What was in it for them?”		

1. ข้อสังเกตทั่วไป
General Observations

	ข้อสังเกต Observations	คำแนะนำเพิ่มเติมสำหรับการฝึกอบรม Recommendation for training enhancement
ประสิทธิผลและความเกี่ยวข้อง เช่น ตรงกับวัตถุประสงค์ผู้เข้าร่วมคิดว่าทักษะที่ได้เรียนรู้มีประโยชน์ต่อการทำงานหรือไม่? **Effectiveness and Relevance** e.g. in relation to learning objectives: Do participants think that the skills they have learned can be helpful for their work? **เวลาที่กำหนด** เหมาะสมหรือไม่ **Timing** Was the prescribed time kept?		
ความเข้าใจ ผู้เข้าร่วมอบรมเข้าใจง่าย เอกสารประกอบการฝึกอบรมชัดเจน สื่อที่ใช้มองเห็นได้ยิน ชัดเจน หรือไม่ วิทยาการสามารถอธิบายรายละเอียดในหัวข้อที่สอนได้ **Comprehension** – was the subject matter easy for the learners to follow and understand; was the wording in the training materials clear; were the multi-media materials visible and audible?; was the facilitator/trainer able to explain the topic in a way that the participants can relate to?		
การมีส่วนร่วม เกษตรกร และวิทยากรมีปฏิสัมพันธ์กันอย่างเพียงพอ? **Engagement** – how satisfiedwere farmers and trainers with the interactivity of the sessions? **Was the training participatory enough?**		
ความเหมาะสมของอุปกรณ์ที่ใช้ในการฝึกอบรม **Visuals and materials** – were the presentationsunderstood well? **เอกสารประกอบการฝึกอบรม** มีความเหมาะสมหรือไม่?(สั้น หรือยาวเกินไปไหม) Is the **workbook** good already (or too long/short etc.?) สถานที่จัดงานเป็นอย่างไร? How was the **venue?**		

1. ข้อสังเกตทั่วไป
General Observations

	ข้อสังเกต Observations	คำแนะนำเพิ่มเติมสำหรับการฝึกอบรม Recommendation for training enhancement
เกษตรกรมี**ความสนใจ**ในหัวข้อการอบรมใดมากที่สุด **Interest:** In which topics were farmers most interested? **หัวข้ออื่นๆ** เกษตรกรมีการพูดถึงเฉพาะเรื่องที่อยากฝึกอบรมหรือไม่? **Other topics:** Did farmers mention specific training needs they want to learn about?		

2. ผู้ฝึกอบรม
Trainers

	ข้อสังเกต Observations	คำแนะนำเพิ่มเติมสำหรับการฝึกอบรม Recommendation for training enhancement
การปฏิบัติงานของวิทยากร และทีมงานโครงการเป็นอย่างไร? **How was the performance of the trainer and project team?** ผู้ฝึกอบรมยึดตามหลักสูตรหรือไม่? Did trainers stick adequately to the curriculum? ผู้ฝึกอบรม มีส่วนร่วมกับผู้เข้าอบรม (ผ่านคำถามหรือ แบบฝึกหัด) หรือไม่? Did trainers actively involve the audience (through questions / exercises etc.) sufficiently?		
มีส่วนใดที่ต้องแก้ไขหรือไม่? Are there any deficits that need to be addressed?		

3. ข้อสังเกต และหัวข้ออื่น ๆ Other observations and topics		
	ข้อสังเกต Observations	คำแนะนำเพิ่มเติมสำหรับการฝึกอบรม Recommendation for training enhancement
คุณต้องการลดหรือเพิ่มหัวข้อในวันฝึกอบรมหรือไม่? Would you remove or add any topics of the training day?		
หัวข้อการอบรมน่าสนใจหรือไม่? Did the session trigger interest in the topic?		
สังเกตเห็นสิ่งที่เกี่ยวข้องอื่นๆ หรือไม่? Which other relevant things did you observe?		

บอก 3 อย่าง ที่คุณชอบในหลักสูตรนี้ (ในทางที่ดี)
Name 3 things you enjoyed about the course / which went well:

3 แนวทางในการปรับปรุงให้ดีขึ้น
Name 3 ways in which the learning experience could be improved:

ข้อสังเกตข้อคิดเห็นคำแนะนำอื่นๆ
Any other observations / comments / hints:

ก. แบบประเมินผลการฝึกอบรม

Regenerative Organic Agriculture Training – Evaluation Form for Farmers

โครงการ การฟื้นฟูด้วยเกษตรอินทรีย์ “Regenerative Coconuts Agriculture Project (ReCAP)”

กรอกข้อมูลหลังการฝึกอบรม (To be filled out by the participating farmer after the last training session)

ชื่อ Name (farmer): _____วันที่ Date: _____

ที่อยู่ Address: _____

1. สรุปความคิด และแนวทางปฏิบัติ (ให้เกษตรกรทำเครื่องหมาย “✓” ในช่องที่เหมาะสมที่สุด)

Feedback on Topics (@ farmers: “✓” tick the box that fits best)

หลังการอบรม คุณมีความเข้าใจเกี่ยวกับหัวข้อเหล่านี้หรือไม่...?
After having attended the training, have you gained a good understanding on these topics?

หัวข้อ Topics	รู้เพิ่มขึ้น Yes	สับสน/ขัดแย้งกับความรู้เดิม No	รู้เท่าเดิม Unchanged
การจัดการธุรกิจฟาร์ม Farm Business Management			
แนวทางปฏิบัติอินทรีย์แบบฟื้นฟู Regenerative Organic Practices			
สุขภาพดิน Soil Health			
การจัดการศัตรูพืช Pest Management			
ปัจจัยการผลิต Organic Inputs			
การเลี้ยงชันโรง Stingless Bees			

2. ข้อเสนอแนะโดยรวมเกี่ยวกับการฝึกอบรม (ให้เกษตรกรทำเครื่องหมาย “✓” ในช่องที่เหมาะสมที่สุด)

Overall Feedback on the Training (@ farmers: “✓” tick the box that fits best)

ภาพรวมการอบรม Training Overall	พึงพอใจมาก Very Satisfied	พอใจ Satisfied	เฉยๆ Okay	ไม่พอใจ Not satisfied	ไม่พอใจมาก Very unsatisfied	ข้อเสนอแนะ/คำแนะนำ Any comments?
						
ความประทับใจในภาพรวมของการฝึกอบรม Overall impression of the training						
เนื้อหาการฝึกอบรม Training content						
เอกสารประกอบการฝึกอบรม Training materials						
สถานที่ Venue						
เวลา Timing						
อาหาร Food						

3. ข้อเสนอแนะเกี่ยวกับผู้ฝึกสอน (ให้เกษตรกรทำเครื่องหมาย “✓” ในช่องที่เหมาะสมที่สุด)

Feedback on Trainers (@ farmers: “✓” tick the box that fits best)

ผู้ฝึกสอนและการฝึกอบรม Trainers and Training	เกินความคาดหมายอย่างมาก Greatly exceeded expecta-tions	เกินความคาดหมาย Exceeded expecta-tions	ตามที่คาดหวัง Matched expecta-tions	น้อยกว่าที่คาดหวัง Less than expected	น้อยกว่าที่คาดหวังไว้มาก Much less than expected	ข้อเสนอแนะ/คำแนะนำ Any comments?
						
ผู้ฝึกอบรมมีความรู้เกี่ยวเกษตรอินทรีย์ Our trainers were knowledgeable onthe topics						
ผู้ฝึกอบรมสามารถอธิบายข้อมูลที่เกี่ยวข้องได้ดี Our trainers were able to explain relevant information well						
ผู้ฝึกอบรม เป็นแรงบันดาลใจให้ Our trainers inspired us						
ผู้ฝึกอบรมตรงต่อเวลาเสมอ Our trainers were always on time						
ความคิดเห็น อื่นๆ Other comments						

4. ข้อเสนอแนะเกี่ยวกับการฝึกอบรม (ให้เกษตรกรทำเครื่องหมาย “✓” ในช่องที่เหมาะสมที่สุด)

Feedback on Training (@ farmers: “✓” tick the box that fits best)

การฝึกอบรม Training	เห็นด้วยอย่างยิ่ง Fully agree	เห็นด้วยส่วนใหญ่ Mostly agree	เห็นด้วยบางส่วน Partly agree	ไม่เห็นด้วย Do not agree	ไม่เห็นด้วยเลย Do not agree at all	ข้อเสนอแนะ/คำแนะนำ Any comments?
						
ฉันได้เรียนรู้สิ่งใหม่ที่เป็นประโยชน์มากมาย I learned many new and helpful things						
การฝึกอบรมเป็นในเชิงโต้ตอบ (ไม่ใช่แค่การบรรยาย) The training was interactive (not just lecture)						
การฝึกอบรมยากเกินไป The training and exercises were too difficult						
ฉันจะนำสิ่งประโยชน์ที่ได้จากการเรียนรู้ไปใช้ในฟาร์มของฉัน I will apply the learnings for my farming						
ฉันอยากแนะนำให้เพื่อนเกษตรกรของฉันด้วย I would recommend the training to my fellow farmers						

การฝึกอบรมมีประโยชน์กับใครมากที่สุด
For whom is the training most helpful?

- ◯ ผู้หญิง Women
- ◯ ผู้ชาย Men
- ◯ ทั้งสอง Both
- ◯ (เกษตรกรอายุ 17–35 ปี) Youngfarmers
- ◯ (เกษตรกรอายุมากกว่า 35–55 ปี) Middle-agedfarmers
- ◯ (เกษตรกรอายุมากกว่า 60 ปี) Elderly famers

การฝึกอบรมควรเกิดขึ้นเมื่อใด
Should this training happen:

- ◯ 5 วันติดต่อกัน (ใน 1 สัปดาห์) 5 days in a row (one week)
- ◯ กระจายใน 2 สัปดาห์ Spread over two weeks
- ◯ กระจายในหลาย ๆ สัปดาห์ Spread over more weeks

ฉันต้องการเรียนรู้เพิ่มเติมเกี่ยวกับหัวข้อใดบ้าง (เกษตรกรเลือก) เกี่ยวกับการปลูกมะพร้าว
Which other topics do I want to learn about more (@ farmer: tick!)

- ◯ การทำธุรกิจเชิงเกษตร Farm business management
- ◯ การจัดการศัตรูพืช Pest management
- ◯ การปลูกพืชแซม Intercropping
- ◯ ปุ๋ยหมัก Compost
- ◯ การเลี้ยงผึ้ง/ชันโรง Stingless bees
- ◯ การปลูกพืชคลุมดิน Cover crops
- ◯ อื่นๆ กรุณาเขียนด้านล่าง Other (please write down)

_____

_____

_____

ANNEX B DIDACTICAL METHODS - THE ART OF TEACHING

1. Introduction

Didactics in theory is the art of teaching: How to effectively teach or train someone on a subject. In other words, it is not about the content of the training, but it is about how knowledge and skills are transferred.
The value of trainings is often lost when the contents are not aligned to the information level of the participants, when the language used is too technical, or when the sessions are too long and participants simply get bored. Therefore, it is key to convey the contents of this training in an interactive, inspiring and easily absorbed manner.

Throughout the training, it is your task as the trainer to get all participants on board and assure that the training matches the needs of the participants. The training materials of the Regenerative Organic Agriculture Training (Manual, Handbook, and Presentations) form the base of the training, but it is up to you as the trainer / facilitator to decide which methods to use to convey the content of the materials to your audience. You should select the approaches that best serve the purpose and working style and composition of your group.

This module will give you a short background about how we humans remember information and what teaching methods are available to you. We will then provide you a list of lessons learned from the first pilot training and give some pointers to what makes a professional trainer.

2. Information Retention

Most of us are used to the lecture method; a one channel method where we passively listen to what the teacher says. This works well for some, but not for others. What works best for you: Can you remember information by simply reading it once? Do you prefer to take notes? Or do you need to say it out loud? While we all learn differently, studies have shown that we remember information better through experiences or actions. Illustrated below is a diagram that shows how we remember through different perception channels:

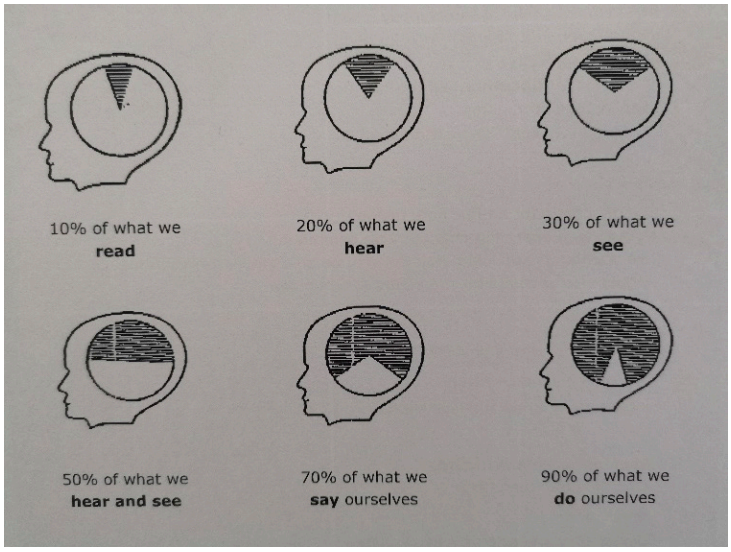


Figure 1. Perception Channels (source: GIZ's Academy for International Cooperation, 2015)

In general, real-life experiences are the most effective. “Action-learning” techniques, which include hands-on trainings or field experience, result in the highest retention percentage. Why? Because these methods are sensory based; the more sensory channels applied (see, touch, hear, taste, smell), the more likely the learning will stick with us.

You are encouraged to use a combination of methods in order to reach as many of your participants and address different learning styles. This can be done via demonstrations, field visits, group work, discussions, experience sharing, etc. The more variety the better, because this increases the likeliness of your students to absorb what you are teaching them. Besides, if you choose only one method, like a lecture, look at what happens to the attention span of students in Figure 2a after a 45-minute lecture:

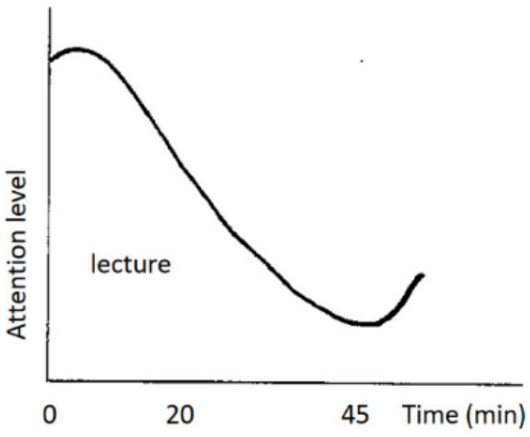


Figure 2a. Learning effects during 45-minute lecture (source: Chunderduri, 2015)

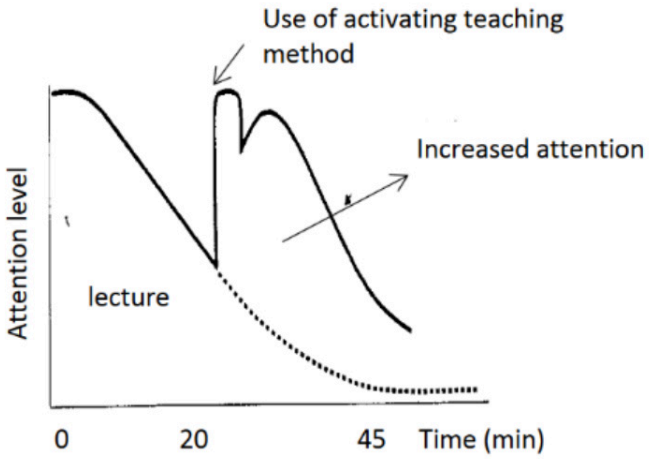


Figure 2b. Learning effects with activating teaching method (source: Chunderduri, 2015)

As seen in Figure 2a, the attention level of your audience will decrease gradually when using one style of teaching method over a period of 45 minutes. However, once you bring in an activating teaching method (e.g. group work, demonstrations, quizzes, etc.), you can raise the learner’s attention span, and thereby increase how much information they can absorb.

As the trainer, it is your task to select various teaching methods that are best suited for your participants. If you can make this training for your participants fun, they are much more likely to learn and apply what they have learnt.

3. Training Methods

There are several training methods available for you to apply during the training. Below is a description of various training methods that you are encouraged to use (but not limited to):

Lectures: This is the most "old-fashioned" method and is good for presenting a large body of material in a structured, concise manner and ensures that all participants get the same information at the same time. E.g. Lecture on Farming as a Business.

Hands-On Training: Allowing participants to practice what is being simultaneously taught is very effective and fun! E.g. Training on how to make vermicompost.

Field Visits: They can facilitate the learning of abstract concepts through real life experience, making the contents of the training more tangible and realistic. E.g. Visit to a farm with cover crops.

Demonstrations: This method is an attention-grabber. They are excellent at showing your audience the steps in a new process. By combining this with questions and answers, this is a very engaging method. E.g. Experiments to show differences between good and poor soils.

Quizzes: This is an excellent opportunity to check how attentive your students were. It also keeps them on their toes and works particularly well on those with a competitive spirit. E.g. What practices are compliant with ROC?

Group Work: Break-out groups can be an effective bonding exercise as well as encourage teamwork among your participants. E.g. Discuss learnings during training day.

Example Schedule

The first pilot training used a combination of these training methods. As you can see, different colors highlight the different approaches of the training (lectures, hands-on trainings, farm visits and group work):

TRAINING SCHEDULE

Day 1 20/10/2020	**Day 2** 21/10/2020	**Day 3** 27/10/2020	**Day 4** 28/10/2020	**Day 5** 29/10/2020
Meeting point: Harmless Harvest Factory	*Meeting point: Ban Hua Ao Community Learning Center*	*Meeting point: Rong Khae Community Pest Control Center*	*Meeting point: Stingless Bee Production Center Ban Suan Phupha*	*Meeting point: Harmless Harvest Factory*
		08:30 – 09:00 Registration		
09:00 – 10:30 Welcome & introduction (Module 0)	09:00 – 10:30 Lecture on organic fertilizer (Module 3) + experience sharing	09:00 – 10:00 Lecture on pest management (Module 4)	09:00 – 10:00 Lecture on stingless bee and honeybee (Module 6)	09:00 – 10:00 Recap of training
		BREAK		
10:45 – 12:15 Farming as a business (Module 1)	10:45 – 12:15 Training on organic fertilizer	10:15 – 12:15 Training on metarhizium biopesticide	10:15 – 12:15 Training on stingless bee production	10:15 – 12:00 Planning with farmers what to implement
		LUNCH		
13:00 – 14:45 Farming as a business cont. + farm accounting exercises	13:00 – 14:30 Training on earthworms	13:00 – 14:30 Training on bracon parasitoid wasp	13:00 – 14:00 Lecture on soil health (Module 5)	13:00 – 14:00 Closing and certificate ceremony + evaluation
		BREAK		
15:00 – 16:30 Regenerative organic practices (Module 2)	10 min drive 15:00 – 16:30 Visit to intercrop farm (Khun Prayat)	Training on bracon parasitoid wasp cont.	40 min drive 15:00 – 16:30 Visit to cover crop farm (Khun Kob)	**Colour Code** Lecture Hands-on Training Farm visit Group work
16:30 – 17:00 Wrap-up day 1	16:30 – 17:00 Wrap-up day 2	16:30 – 17:00 Wrap-up day 3	16:30 – 17:00 Wrap-up day 4	

Feel free to use this schedule as a template for your own training and adjust to what is most appropriate for your context and participants.

4. Tips and Tricks

After our first pilot training in October 2020, we have taken notes of what has worked well and what could be improved. Below you will find some tips on how to make your training as effective as possible:

Before the Training

• Don't underestimate the time needed for preparation. A one-hour course takes a half to full day to prepare.

• Before each training, know your participants well: check the education level of your participants and what their needs are, then adjust your language, content and pace accordingly.

Training facility

• Don't be fixed on a "classroom" setting with tables, chairs, projector, etc. The best lecture we had in the pilot training was at a farm beneath coconut trees. The Manual for Trainers was designed to be flexible, all what the farmers need to have is their handbooks.

Equipment

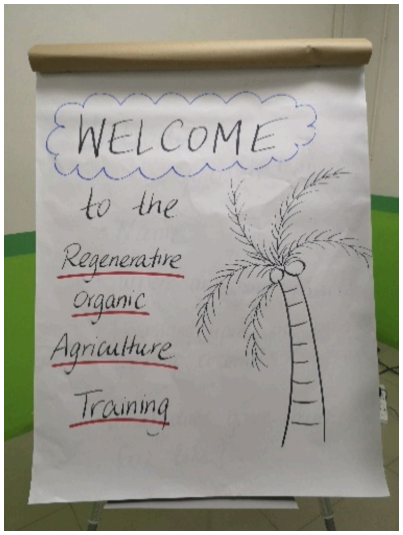
• Projectors may be used indoors in training rooms to show presentations, whereas TVs may be more practical in outside spaces.

• Suggestions for flipchart:

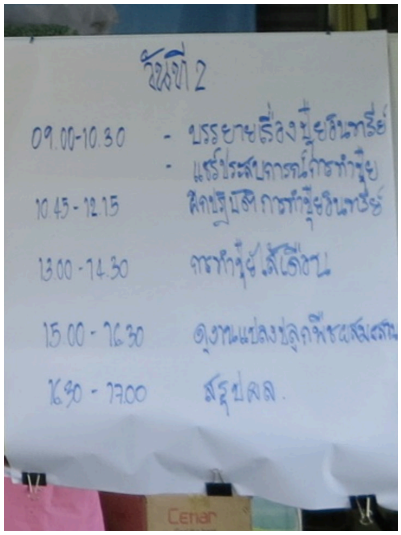
o 1st page: Welcome page (nice drawings are a plus!)

o 2nd page: Agenda of training day (so that all participants are clear on what is happening that day and when breaks are planned)

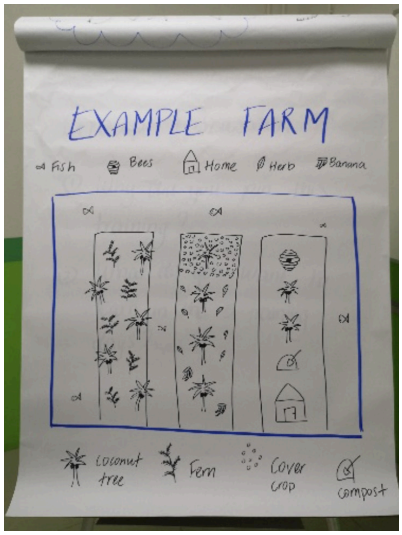
o Further pages: Clear instructions for exercises or group work so that +farmers do not forget or get lost



Example welcome page



Example agenda



Example exercise

Lectures

• Before each lecture, refer to the handbook and tell farmers on which page the module starts and encourage them to take notes.

• Allow questions from farmers after each lecture.

• Pure lectures should not last longer than 30 minutes.

Focus on non-lecture learning

• Farmer to farmer learning: If possible, ask one of your farmers to share their experience. Who better to transfer their know-how? They know what to do and what not to do, and most importantly, they speak the same language. This proved to be one of most impactful learning methods.

• Experimental learning: This was perceived by the farmers as the most important part of the pilot training: field visits, demonstrations, hands-on training, etc.

Guest speakers

• Brief your guest speakers well so that it is clear to them what the purpose of their input is.

• Prepare cards with "5 min", "2 min" and "1 min" on them and show them to the speaker to indicate how much time they have left while they deliver their inputs.

Seating

• U-shape with tables: Useful when exercises in handbook are to be filled out.

• U-shape without tables: Encourages more active participation from farmers.

Staging of demonstrations

• When doing demonstrations, be aware of the staging to make sure that all farmers can see (e.g. on stage, split participants into smaller groups, etc.).

At the beginning of each training day

• Check-in with your training participants:

o How is everyone feeling today?

o Do we have any new additional attendees? If yes, please introduce yourself.

o Explain the agenda and purpose for the day.

At end of day of each training day

• Plan some time at the end of every training day to give participants the opportunity to reflect on what they learned on that day (either in an open plenary or in small groups), because:

o Repetition improves memory

o This exercise is a good indication on what was most interesting for the farmers on that day and where more focus needs to be placed

Participants

• Each group of participants will be different. If you are lucky you will get a highly motivated and positive group of people who are keen to learn, but usually you will get a diverse group with mixed levels of enthusiasm. Here are some hints on how to respond to different characters that you may encounter:

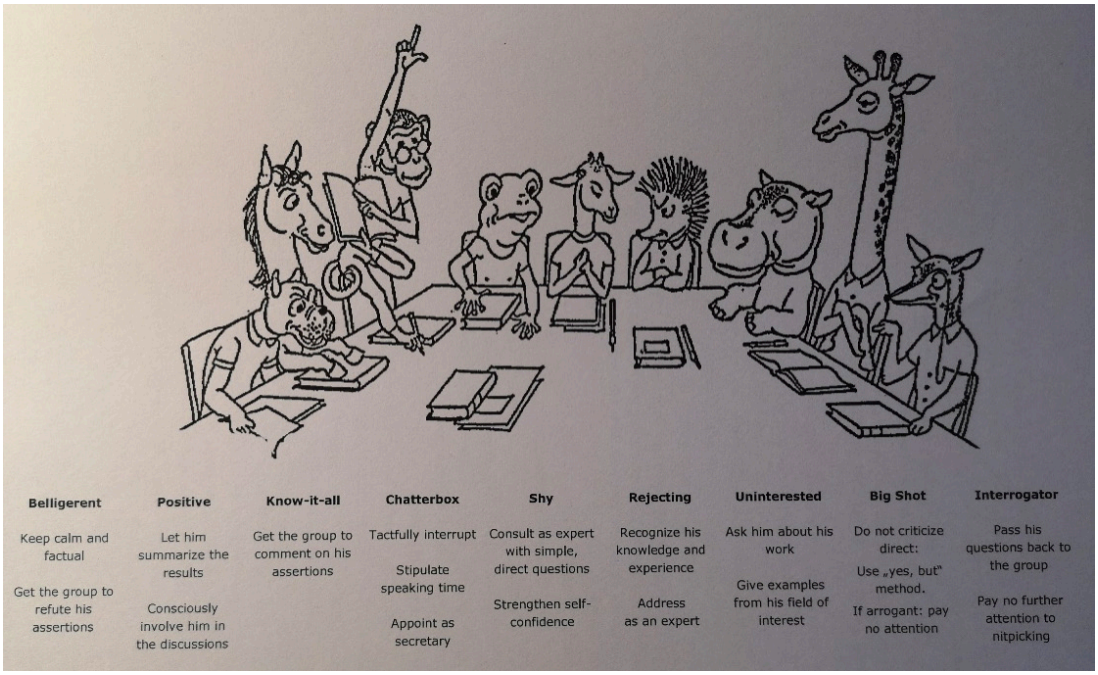


Figure 3. Responding to different types of participants
(source: GIZ's Academy for International Cooperation, 2015)

5. Professional Trainer

Before you start teaching this course, you need to make sure that as a professional trainer of the Regenerative Organic Agriculture Training, you are:

- An expert on the topics covered (in theory and practice);
- Passionate about regenerative and organic coconut farming;
- Willing to exchange your knowledge and skills;
- Prepared to adjust the level of teaching to your audience;
- Able to use a variety of interactive teaching methods; and
- Speak the language of your participants.

Lastly, remember that through this training, you are empowering farmers to become more resilient towards uncertainties that are many are facing: from fluctuating market prices to climate change. Our motivation is to improve the lives of as many farmers as possible, by supporting them with the best solutions that we have found. However, your teaching and facilitation methodology will be just as important to the training, as the contents that we have provided for you. Don't be afraid to try new things! Once you see how excited and motivated the farmers are to start implementation and how we can solve some of their concerns together, this will be a very rewarding experience for you as the trainer. Good luck!

ANNEX C CONTRIBUTORS

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