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 HANDBOOK

Regenerative Coconut Agriculture Project (ReCAP) is created to help farmers develop necessary knowledge, skills, and attitudes for the farm transformation into the regenerative organic practices. The training is conducted through different approaches, i.e., lecture, study visit, and hands-on practices, with the support of the trainers and the use of this handbook.

In this handbook, there are eight modules explaining step by step how to make farms more sustainable; therefore, either during or after the training, farmers are able to consult this handbook and apply to their farms the knowledge or the practices presented in the handbook.

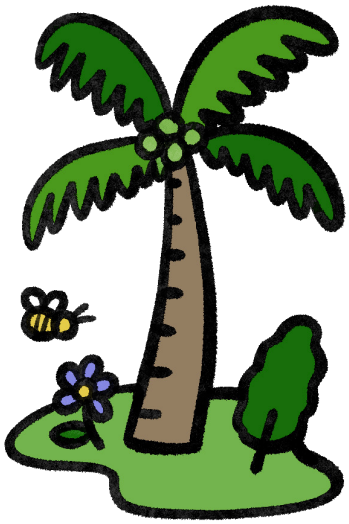
Module 0	**Introduction and overview**	**1 h 30 min**
	1. How to use the Handbook for Farmers	5 min
	2. Introduce yourself and your farm	15 min
	3. Aromatic coconut situation	35 min
	4. About ReCAP project	20 min
	5. Overview of the training program	10 min
	6. Summary	5 min
Module 1	**Regenerative organic 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	5 min

Module 2	**Soil health**	**4 h 30 min**
	1. Definition of soil health	5 min
	2. Soil heath 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	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	5 min
Module 4	**Integrated pest management**	**6 h**
	1. Major pest insects in coconut farms	15 min
	2. Major diseases of coconuts	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	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	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	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

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 regenerate 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.

LINKS

https://kisstheground.com/

https://regenorganic.org/

https://rodaleinstitute.org/

KEY MESSAGES

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

LECTURE

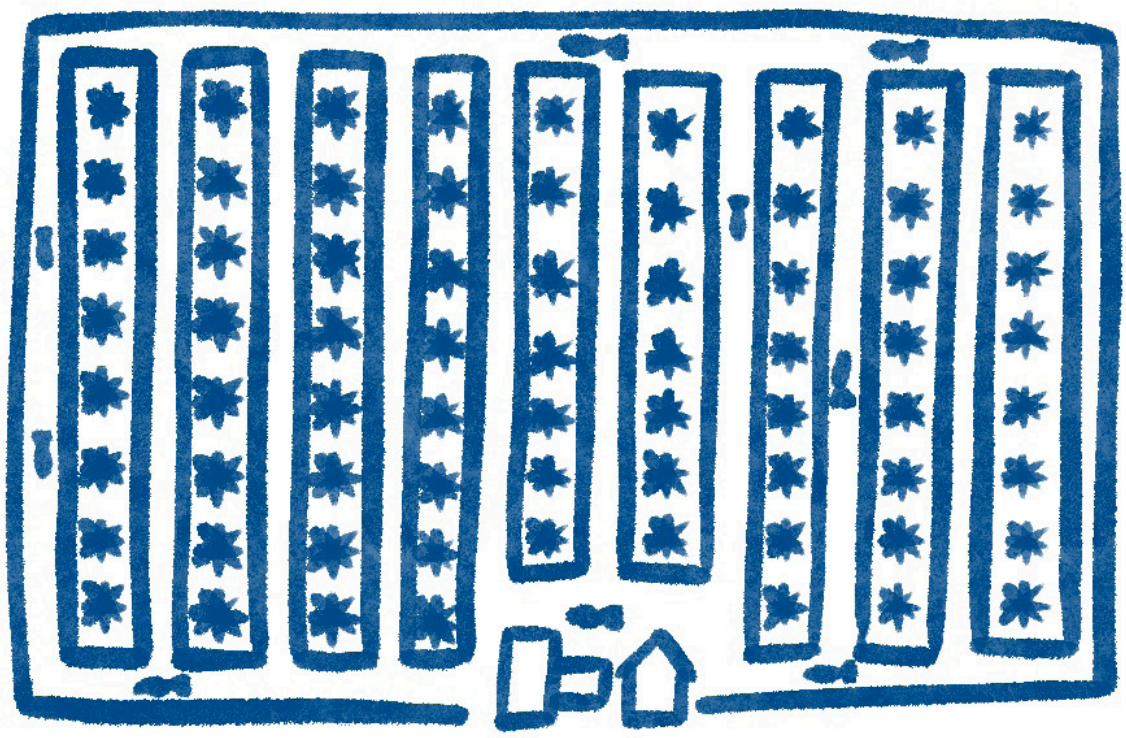
1. How to use the Handbook for Farmers

The Handbook for Farmers 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, etc., and at the end of every module, some blank pages are provided for taking notes during the training.

2. Introduce yourself and your farm

To improve farms towards regenerative organic practices, it should start by knowing the current condition and activities in the farms. Then you as a farmer owning the farm can visibly realize what should be maintained or added in your farm.

The example of farm drawing below clearly shows that there are only coconut trees and fish in this farm.



Now it is your turn to think of your farm and draw it on the next page. Please include every crop and activity in your farm. You can use simple symbols as shown in the example to represent the details.

DO THIS

Exercise 1: Draw your current farm

Name_____ Address_____ Area _____ rai

3. Aromatic coconut situation

Thai aromatic coconut is not only tasty and nutritious, but it also has special fragrance produced from the substance called 2-AP. The main area for aromatic coconut is mainly grown in the central part of Thailand, namely Ratchaburi, Samut Sakhon, Samut Songkram, Nakhon Pathom, Chachoengsao and Pathum Thani. In 2017, growing area of aromatic coconut is about 120,000 rai and the amount of the growing area seemingly increases in every part of Thailand.

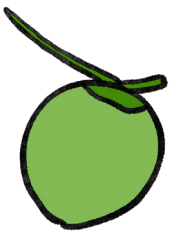
The main market of aromatic coconut is export market, accounting for 80% of the fruit produced, while the domestic market absorbs only 20%. However, the demand of both markets is increasing continuously. Thai coconut importing countries include China, USA, Hong Kong, Australia and many countries in Europe. Among the exported coconut, even though organic coconut shares a small part, their value increased from 20 million THB in 2018 to almost 50 million THB in 2019. In 2020, despite the pandemic, the export value is almost 60 million THB. This can be concluded that, there is a big opportunity for organic coconut.

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

Since demand of aromatic coconut has increased, the trend has driven many coconut growers to merely focus on the higher yields; consequently, the coconut farmers are likely to mismanage their farms by using more chemicals. The agricultural practices relying on chemical substance are not only costly, but also harmful to the farmer's health and the environment in the long term.

Also, other inappropriate practices, such as monocropping (growing a single crop), no cover cropping, and no farm recording or accounting, will inhibit the success of coconut business in the long run.

Thus, it is suggested to change from chemical or conventional farming to regenerative organic practices that prohibit chemical application and apply to the farms other good practices, e.g., cover cropping and intercropping, for the sustainable benefits of farmer's health, farm income, and environment.



Challenges in aromatic coconut business

Challenge 1:
Low yield in some periods

Lower yield in some periods is a huge challenge for aromatic coconut production. It is caused by several factors, two of which are the poor health of the palm trees and the failure of pollination that will be discussed in detail below.

In general, the low-yield period occurs in the dry season around March to May, and unpredictably shifts in some years.

Solution

1. Rearing pollinators like stingless bees: 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.

2. Maintaining healthy coconut trees: it is likely that healthy coconut trees produce good yields. Regular application of organic fertilizers, i.e., compost or manure, helps maintain and enhance your coconut trees in good condition. How to make your own organic fertilizers is shown in Module 3.

Besides, adequate irrigation is necessary for coconut trees. Growing cover crops will keep soil moisture longer than bare soil and may decrease the need of irrigation. Cover crops in coconut farms is shown in Module 2.

Challenge 2:
Inappropriate farm management

1) Using chemical substances

The chemicals are not only expensive, but also harmful to farmer's health and environment in the long term.

Solution

Change from chemical to organic practices, such as organic fertilization, biological control, etc.

2) Monocropping

Growing a single crop, coconut as an example, is not good for soil health. It easily leads to soil erosion, damages soil structure, and decreases soil fertility. Also, monocrop farming might put farm income at risk, especially in the situation of price fluctuation or low-yield period.

Solution

There are three possible solutions for monocropping:

1. Cover cropping, e.g., roundleaf bindweed, pinto peanut (See in Module 2: Soil health). The practice can help 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.

2. Application of organic fertilizers, i.e., compost, manure, and vermicompost. These organic fertilizers do not only improve health of coconut trees, but also increase soil fertility. We will learn about the soil health in Module 2 and about organic fertilizers in Module 3.

3. Intercropping or growing other crops among coconut palms. The practice decreases soil erosion by providing a variety of living root system and depth, and provides additional sources of farm income, especially in the situation that the coconut price has fallen. The detailed explanation for intercropping is in Module 6, and how to choose intercrop species for your farm in Module 2.

Possible solutions for inappropriate farm management: cover crops, e.g., roundleaf bindweed (top left), pinto peanut (top right); intercropping (bottom left); and organic fertilizers (bottom right)

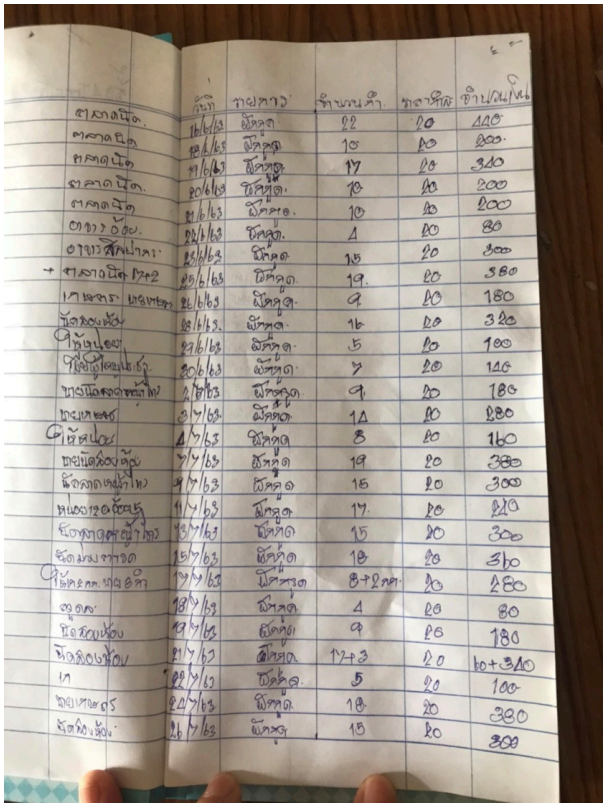
3) Lack of farm records

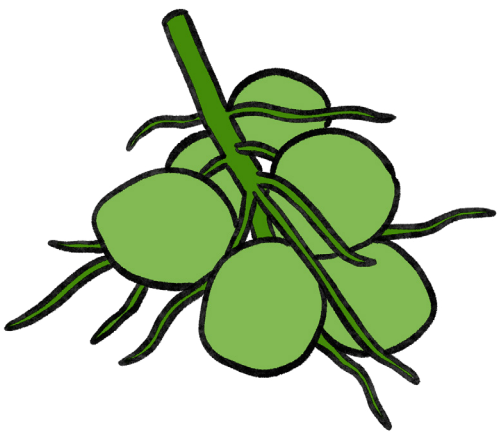
Another important practice in farm management overlooked by farmers is to record farm activities and accounting.

Solution

Record necessary things like farm management and farm accounting. This will help farmers to effectively manage their farm and resources.

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





Challenge 3:
High competition in young coconut business

Since the global demand for young coconuts is still high, the competition in the production of young 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 also extend their growing areas.

Solution

Transform farms from the conventional agriculture to the regenerative organic practices. This transformation helps improve your farm potential to compete with others with higher-quality yields.

Conclusion on challenges and solutions for aromatic coconut farming

Challenges

1. Low yield in some periods
2. Inappropriate farm management
   - 2.1. Using chemical substances
   - 2.2. Monocropping
   - 2.3. Lack of farm record
3. High competition in young coconut business.

Solution

1. Rearing pollinators like stingless bee
2. Applying regenerative organic practices to farms
   - 2.1. Using organic inputs or fertilizers
   - 2.2. Cover cropping; intercropping; application of organic fertilizers
   - 2.3. Managing farm as a business that farm record and accounting should be conducted
3. Adopting regenerative organic practices to produce high-quality products

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.

5. Overview of the training program

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	**Color 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	

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

Summary

Even though there has been high demand for aromatic coconut, many challenges have occurred in the aromatic coconut farming. To respond to the trend and challenges, a number of farmers have adopted inappropriate and unsustainable practices, i.e., monocropping, leaving soil uncovered, relying on chemical inputs to increase coconut yields in the short period. These practices will eventually result in several negative effects on farmer's health, farm income, and environment in the near future.

Therefore, the regenerative organic agriculture is highly suggested to farmers, particularly the coconut farmers, for the practices do not only prohibit using chemicals to protect farmers' health, but also integrate other farm activities, such as cover cropping, intercropping, etc. to mitigate risk of farm income and sustain the environment.

Applying regenerative organic practices will help the farmers to overcome these challenges.

Note

Note

Note

Note

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, economy, and society, emphasizing on reduction of off-farm inputs and recycling of farm biomass resulting in a balance in the ecosystem and sustainable crop production.

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

What is organic agriculture/ farming?

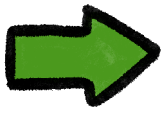
Nowadays, agriculture practices focus on the use of technology and inputs to maximize the crops' yields without considering the impact on the environment and ecosystems resulting in an imbalance in soil nutrients and physical properties, which directly affects the growth and health of plants. While organic farming practice bases on natural processes without toxic or chemical residues and avoids chemical contamination in soil, water, and air in order to restore the ecosystem and environment balance.

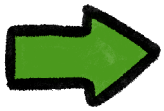
USDA Organic Crop Standards

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

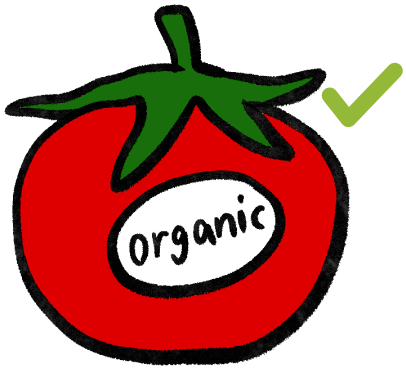
Soil fertility and crop nutrients will be managed through tillage and cultivation practices, crop rotations, and cover crops, supplemented with animal and crop waste materials and allowed synthetic materials.

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.



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).**

CONVENTIONAL

Generally, conventional farming relies on the use of chemical intervention-pesticides, herbicides, synthetic fertilizers-and genetically modified organisms (GMOs) to grow crops.

REGENERATIVE

Regenerate farming aims to enrich the soil, but lacks any standards prohibiting the use of conventional pesticides, herbicides, synthetic fertilizers, and GMOs.

ORGANIC

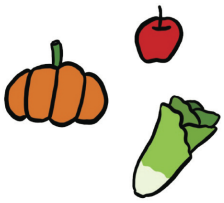
Organic farming does not use chemical intervention or GMOs because it prioritizes building healthy soil. Instead, natural methods such as composting are relied upon, for the growth of healthy food.

REGENERATIVE ORGANIC

Regenerate farming is rooted in organic farming. It abides by a high standards of land management to sequester carbon in the soil, and prioritize welfare of farm animals and fairness for farmers and workers.

Pesticides & herbicides

Synthetic fertilizer



GMOs

No GMOs

Biological pest control

Compost

Quiz

Match the sentences that are most relevant to each other

_____Using organic waste in the farm or organic fertilizers as a source of nutrients for plants

_____Planting bush/shrub around farm to prevent the contamination

_____Record farm activities and expense use in the farm

_____Control weed growth instead of using herbicide

_____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 bindweed and legume

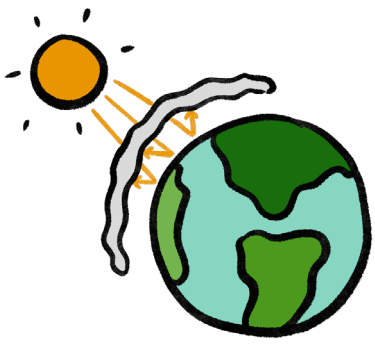
D. Release nutrients slowly but helps to improve soil structure

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

1.2 Greenhouse effect and global warming

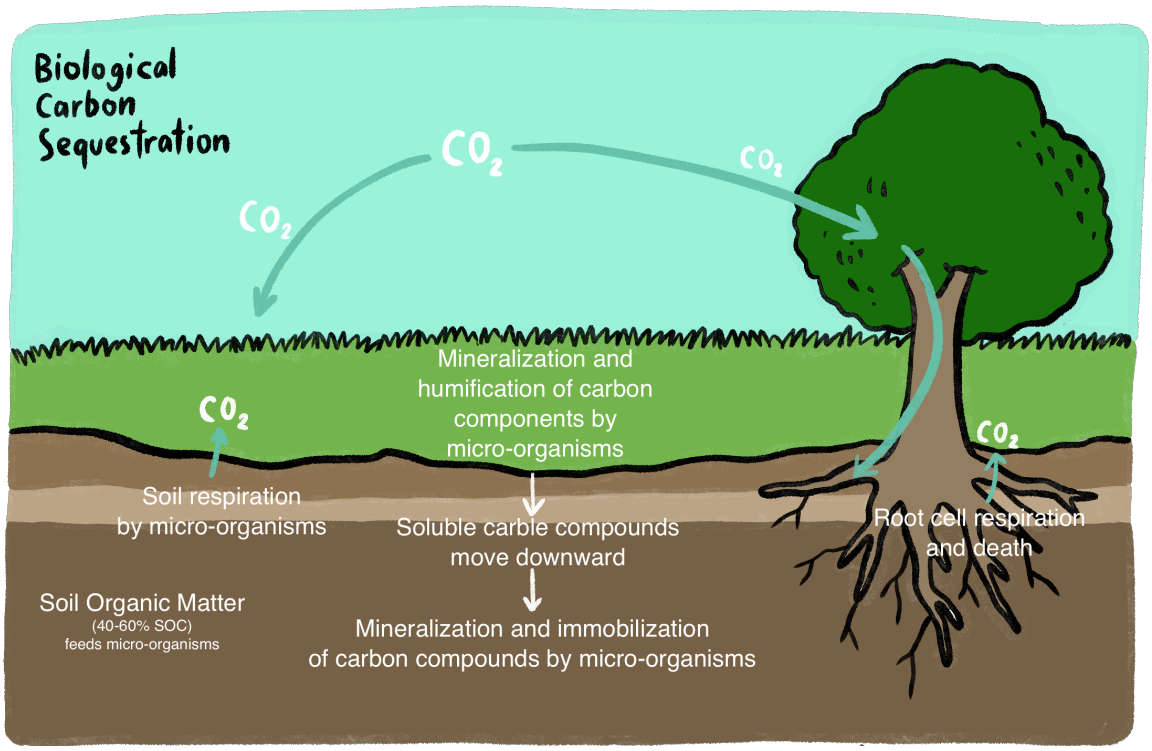
Our planet is enveloped with the atmosphere consisting of gas layer that helps to maintain the earth's temperature like the greenhouse condition making the world temperature suitable for life, but excessive greenhouse gas makes the heat from the sun trapped on the surface of the earth causing the global 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.



Carbon sequestration

Carbon sequestration is a process of capturing and storing atmospheric carbon dioxide in plant and soil through biological processes. The carbon molecule is part of the greenhouse gases such as carbon dioxide, carbon monoxide, water vapor, methane, nitrous oxide. Planting trees or 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

Regenerative organic agriculture focuses on the restoration and enhancement of the ecosystem, not only the practices that do not harm the environment, like avoiding the use of toxic inputs (pesticides, herbicides and chemical fertilizers, etc.). The practice focuses on 3 pillars below:

Soil health relates with the practices that promote soil organic matter and fertility, cultivation that is safe to the environment, biodiversity, and sequestration of excessive carbon, which will be the solution for climate change problem in the long-term.

Animal welfare relates with the human practices to build the appropriate environment and condition in the husbandry or animal production from raising until slaughtering.

Social fairness mentions labor, rights, equality, and other benefits of farmers and workers to build the economic stability and social fairness.

Benefits of regenerative organic agriculture

Conventional farming systems degrade human health by using toxic inputs and quicken soil degradation. Regenerative organic farming system eliminates toxic inputs and focuses on initiating regeneration of the soil to improve soil health and increase the availability of nutrient-dense foods optimal for our health for healthier future.

KEY PRINCIPLES

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.

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.

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

Increase soil organic carbon levels, resulting in greater soil structure and water-holding capacity to maintain crop production during periods of climate uncertainty including with promote microbial populations diversity through natural soil fertility such as compost and green manures.

Consider humane practices in the raising and handling of animal that intend to be sold. Partnership and relevant people along the supply chain must be treated in ethical and respectful manner.

1.4 Case study

These below cases may be found during coconut production. As a regenerative organic farming participant, do you think these practices comply or not with ROC requirements and why?

Case 1 : Mr. Daeng wants to apply chicken manure to his farm (organically managed) so he decides to buy manure from the peddler truck.

- Comply
- Not comply

Reason

Case 2 : 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).

- Comply
- Not comply

Reason

Case 3 : Mr. Dam use 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.

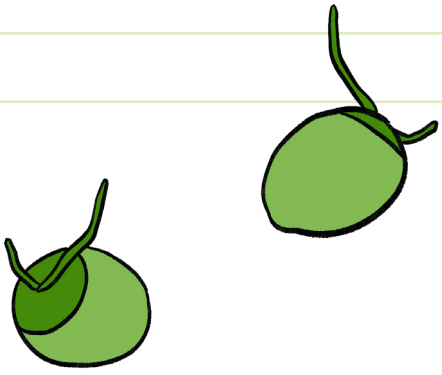
- Comply
- Not comply

Reason

Case 4 : Mr. Jo hired 14-year-old boys to harvest and do other farm activities (watering & cleaning farm) with 250 THB/day wage.

- Comply
- Not comply

Reason



1.5 Regenerative organic practices and solution for ongoing problems

The practices you need to implement in your farm in order to be eligible to join ROC program are listed below:

1. Grow intercrop or 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.

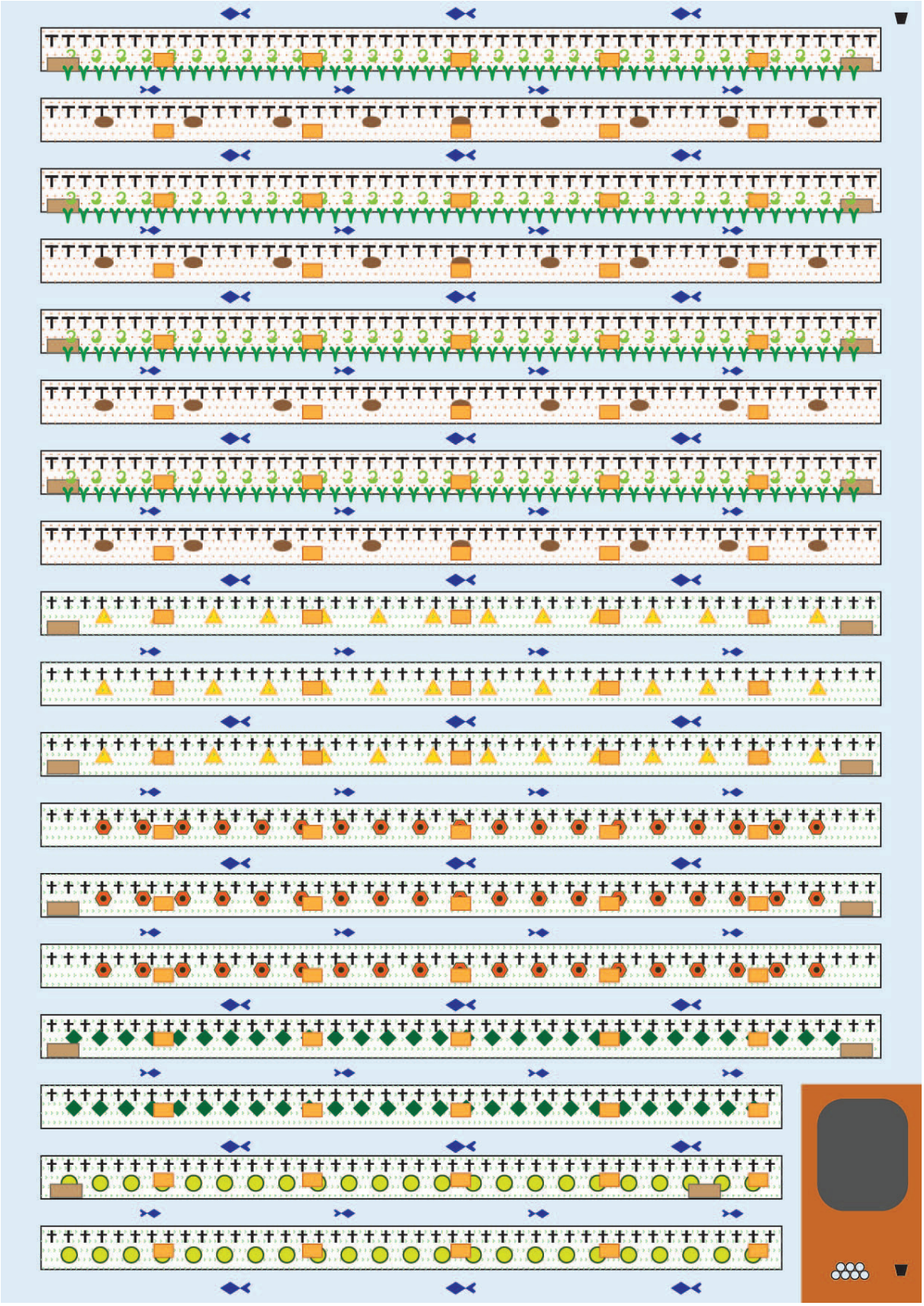
These practices should be documented with photos and records, 3–5 practices should be implemented.

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

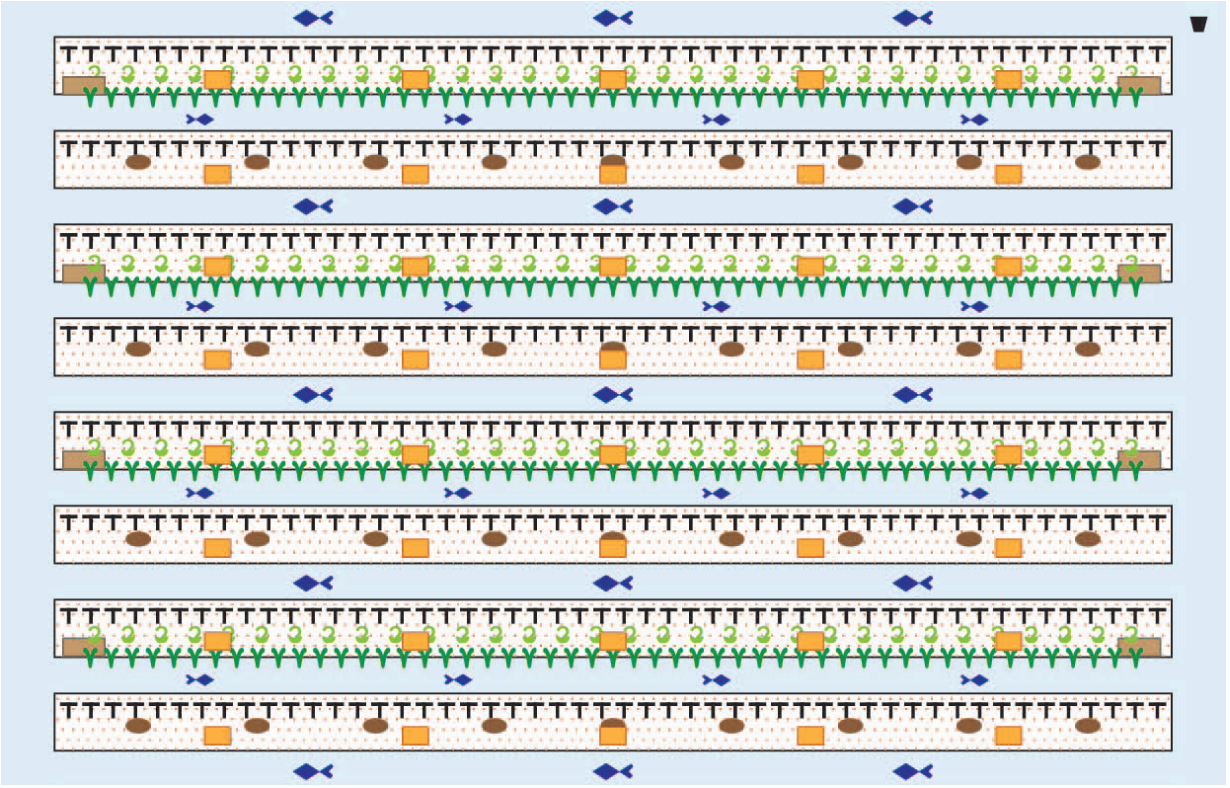
Example of ROC farm (20 rai)

Ideal Regenerative Organic Certified coconut farm under 20 rai, implemented with intercrops, cover crops, organic compost, bio-control for pest management and pollinators such as bees and stingless bees, and fish raising in canal as alternative income.



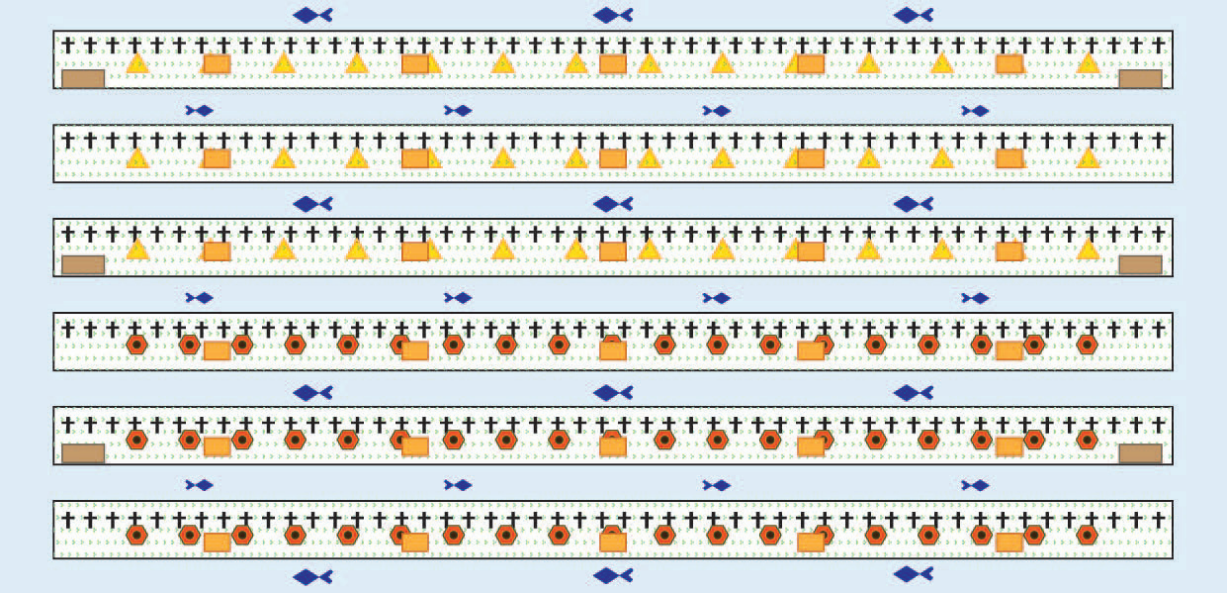
Tall coconut palm
Young coconut palm
Banana
Papaya
Lime
Guava
Coffee
Vegetable fern
Pandan
Pheromone
Bracon
Stingless bee
Metarhizium
Manure
Roundleaf bindweed
Brazillian peanut
Fish

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.



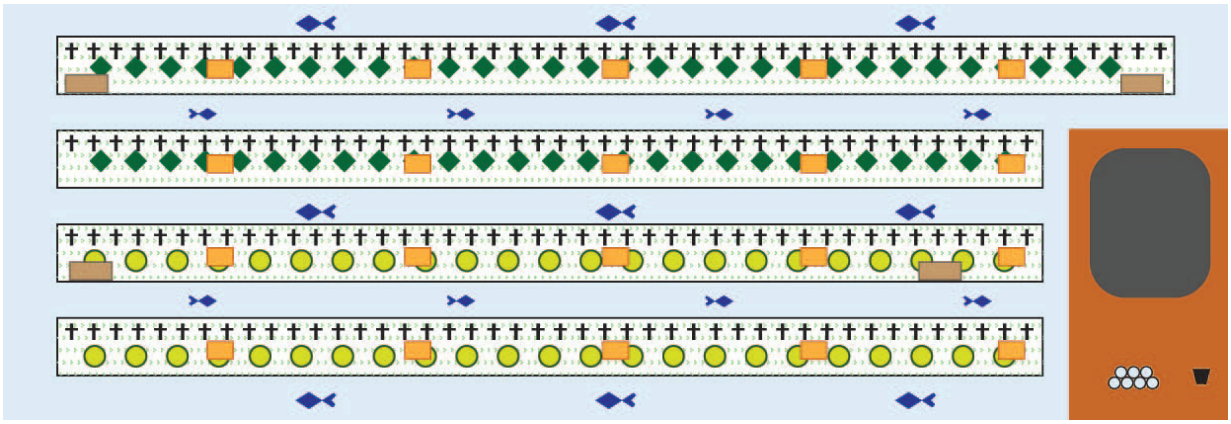
Tall coconut palm
Coffee
Vegetable fern
Pandan
Pheromone
Bracon
Stingless bee
Metarhizium
Manure
Roundleaf bindweed
Brazillian peanut
Fish

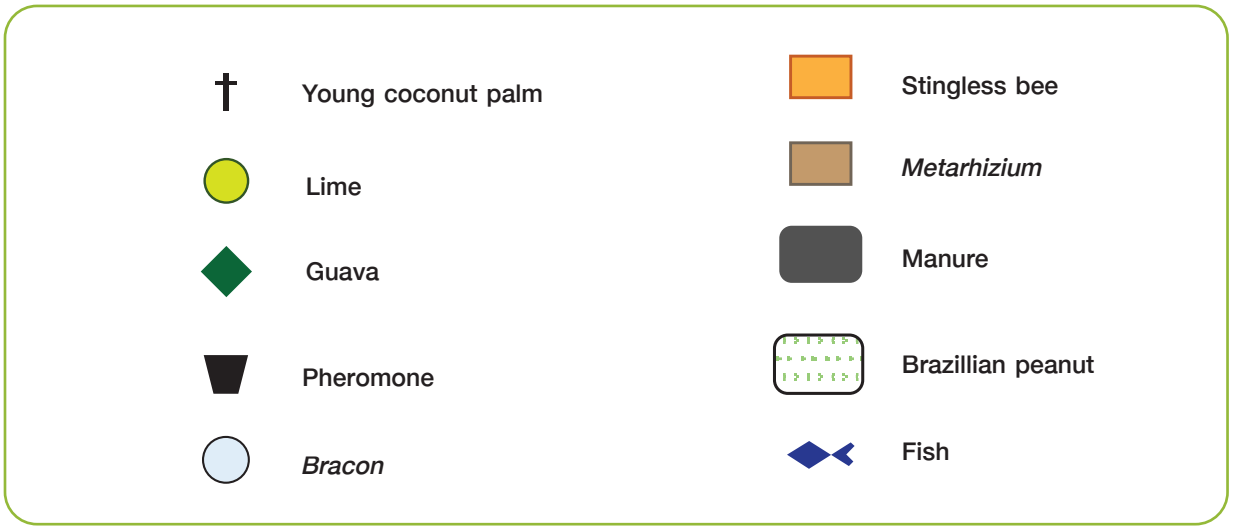
Small coconut trees are grown in rows 9–11 as the main crop, with banana as an intercrop. In rows 12–14, papaya is used as an intercrop. Roundleaf bindweed or pinto peanut may be grown as a cover crop, with fish farming as an extra income.



Young coconut palm
Banana
Papaya
Pheromone
Bracon
Stingless bee
Metarhizium
Manure
Brazillian peanut
Fish

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 and expenses in the table on pages 41–42 in this 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 incomes & expenses on estimate (example)

Input cost	List	Unit × THB	Yr 0 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 1 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 2 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 3 (THB) (Nov.19-Oct.20)
Cover crop									
Round-leaf bind-weed 10 rai	Seedling cost Planting cost Weeding cost	25,600 bags × 6 2days × 300 12 days × 300	-153,600 -600 -3,600						
Pinto peanut 9 rai	Seedling cost Planting cost	23,040 trees × 1 2 days × 300	-23,040 -600						
Intercrop									
Banana 2 rai	Seedling cost Planting cost	80 trees × 20 1 days × 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 days × 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 days × 300	-1,440 -300	3 rai × 40,720	122,160	3 × 40,720	122,160	3 × 40,720	122,160
Lime 2 rai	Seedling cost Planting cost	80 trees × 40 1 days × 300	-3,200 -300					2 × 191,250	382,500
Vegeta-ble fern 4 rai	Seedling cost Planting cost	7,680 trees × 2 1 days × 300	-15,360 -300	4 rai × 28,600	114,400	4 rai × 28,600	114,400	4 rai × 28,600	114,400
Pandan 4 rai	Seedling cost Planting cost	1,920 trees × 1.8 1 days × 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 days × 300	-800 -300						

Input cost	List	Unit × THB	Yr 0 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 1 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 2 (THB) (Nov.19-Oct.20)	Unit × THB	Yr 3 (THB) (Nov.19-Oct.20)
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
Water-ing	Labor cost	96 days × 100	-9,600	96 days × 100	-9,600	96 days × 100	-9,600	96 days × 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
Phero-mone		6 pieces × 500	-3,000	6 pieces × 500	-3,000	6 pieces × 500	-3,000	6 pieces × 500	-3,000
Metar-hizium	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
Sting-less 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

Details about 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	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/seeds)	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/plants	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 the same ~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 rai/ month	7 boxes/month	50 THB/box	350 THB/month
- Pheromone	1 set/10 rai/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)

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 compare to the farm that grow only coconut and use chemicals.

Summary

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

Note

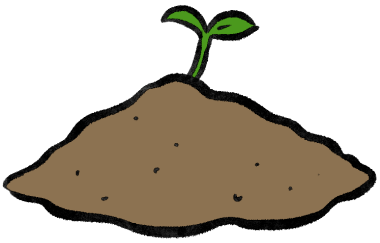
Note

Note

Note

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 inter-cropping for soil health. (Compost will be described in the dedicated module 3 on organic fertilizers.)

ACQUIRED SKILLS

The participants can:

1. Differentiate between 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 floating risk and increasing carbon sequestration.

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, float, 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 like for irrigation or weeding, increase income and secure business with diversification.

A. LECTURE

Question: What does soil do for plant?

Answer: _____

_____

_____

Soil provides root anchorage, water and nutrients to plants. It also creates a living ecosystem fo 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 atmosphere**.

Gases in the atmosphere, i.e., carbon dioxide (CO_2), have the property of trapping heat to keep the earth warm. This is the natural process called the **Greenhouse Effect.** However, the 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, economies.

Soil can store carbon, a key component of greenhouse gases, about 3-4 times more than the atmosphere and from 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.

In conclusion, 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.

2.1 Definition of soil health

What is soil?

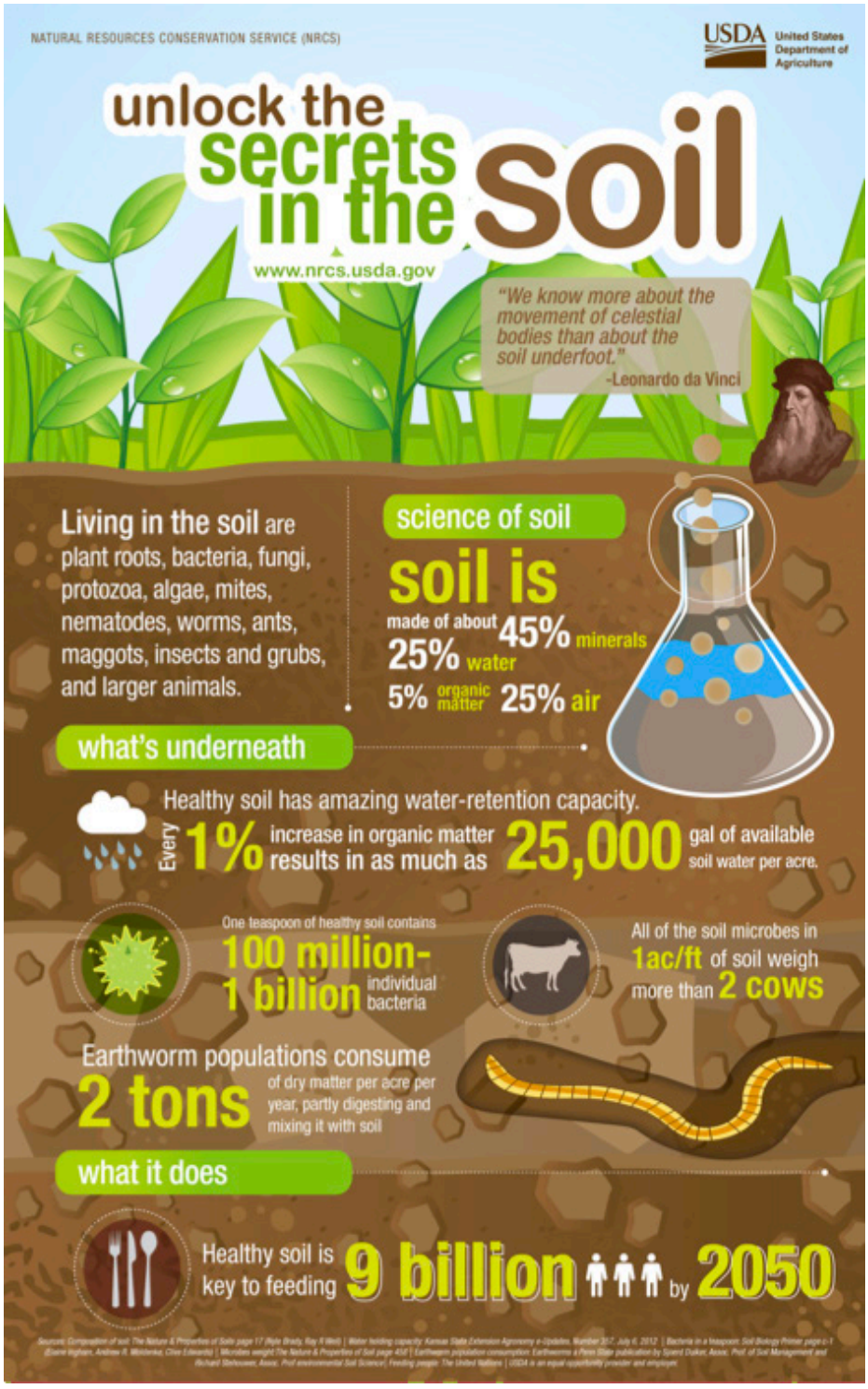
Question: Is soil alive?

Answer: _____

_____

_____

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.



Source: Natural Resources Conservation Service, United States Department of Agriculture (NRCS-USDA); https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1186187.pdf

Soil is a living ecosystem. Think of soil as a living thing. Having life, having 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.

What is soil health?

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

DO THIS

2.2 Soil heath test

Demonstration: soil health tests

These soil tests demonstrate the importance of soil aggregates in two components: 1) the link to the soil erosion and 2) the water absorption. Two tests are demonstrated. Soil aggregate stability test compares between stability of soil aggregate in healthy soil and common soil with low organic matter content. Rainfall simulation test compares infiltration of the two soil samples. The tests will show that soil aggregates (abundant in healthy soil filled with organic matter) keep the soil in good structure, not fallen apart easily, and help the soil to have better infiltration and water holding capacity.

1) Soil aggregate stability test; slake test

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

Method:

Place a soil clod gently in a wire mesh basket so that the clod is well under the water level in the container (Fig. 2.1A). Observe changes happening to the soil in both bottles (Fig. 2.1B)

Fig. 2.1 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).

Result

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.

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** for the whole clod to break apart, the aggregate stability is **excellent**.

2) Rainfall simulation test

Objective: To compare infiltration of soil samples of different aggregate stability.

Method: From the rainfall simulator set up by the trainer, observe infiltration of the soil samples, and evaluate the time for the drain water to be 100% in the drained container.

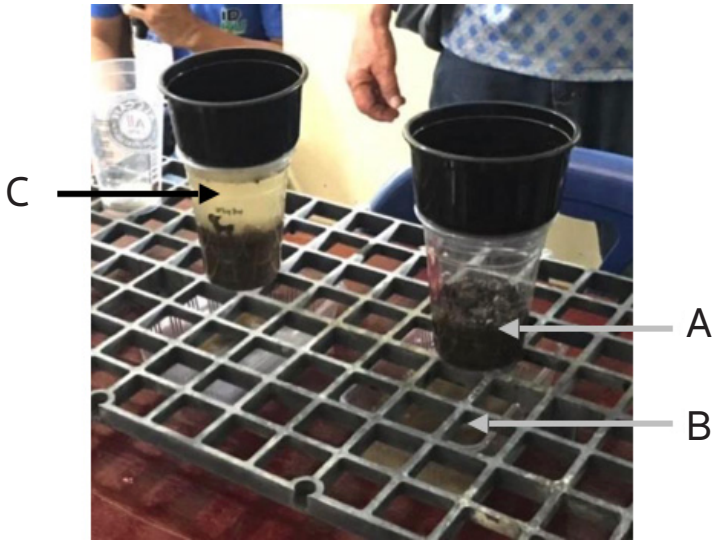


Fig. 2.2 Comparison of infiltration rate between soils of different aggregate stability. Healthy soil sample holds water evenly (A) and drained excess water out into a container (B). Infiltration of common soil is very slow, retaining water above soil surface (C).

Result

Result interpretation: The importance of soil aggregates

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. 2.2A). Excess water that soil sample can no longer hold will drain out by gravity (Fig. 2.2B).

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 pack and seal the surface of the soil; as a result, infiltration is very slow or the water is retained above the soil surface (Fig. 2.2C). 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 the erosion and losses of topsoil, including nutrients, organic matter, and death of soil microorganism.

Soil in poor health

Soil in good health

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

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

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

Answer: _____

_____

_____

_____

Farm activities disturbing 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

- Maintains soil aggregates and helps protecting soil particles from water and wind erosion
- 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
- Reduces evaporation rate and increase the amount of water entering the soil profile from precipitation and irrigation
- Increase soil carbon sequestration

3) Maximize biodiversity

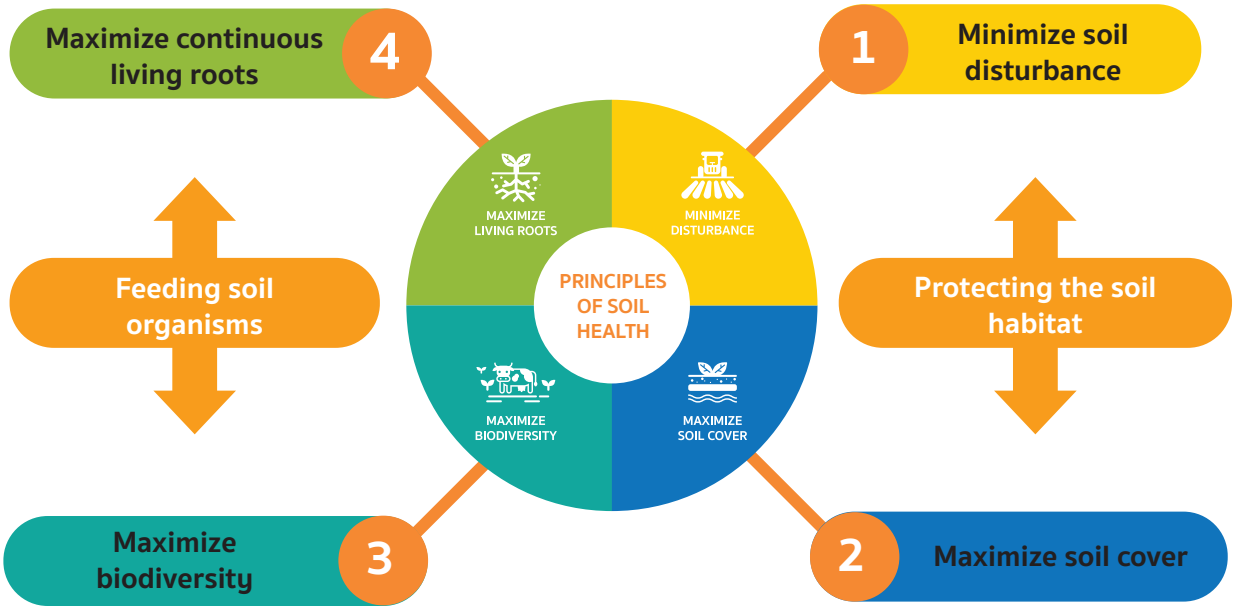
- Maintain the chain of food, energy, and water among different plants and other organisms
- Break disease cycles and provide habitat for pollinators

4) Maximize continuous living roots

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

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

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



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

Answer

2.5 Good practice to improve soil health

2.5.1 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 benefits, e.g., nitrogen fixation (legume)

Question: Do you grow any cover crops in your coconut farm ?

Answer

Question: Do you see any differences in the farm from before you grow cover crops?

Answer

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

Answer

Benefits of cover cropping

- Preventing/reducing soil erosion and limiting the need to rebuild the soil surface
- Reducing water runoff, 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.**

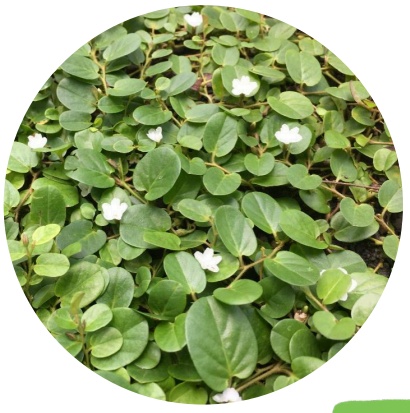
Cover crop examples (★ A red star is given to cover crop species with nitrogen fixation providing additional benefits to soil health)

(1) Roundleaf bindweed

- Herbaceous, perennial plants; creeping with roots at nodes
- 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

To grow 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. 4Around 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.

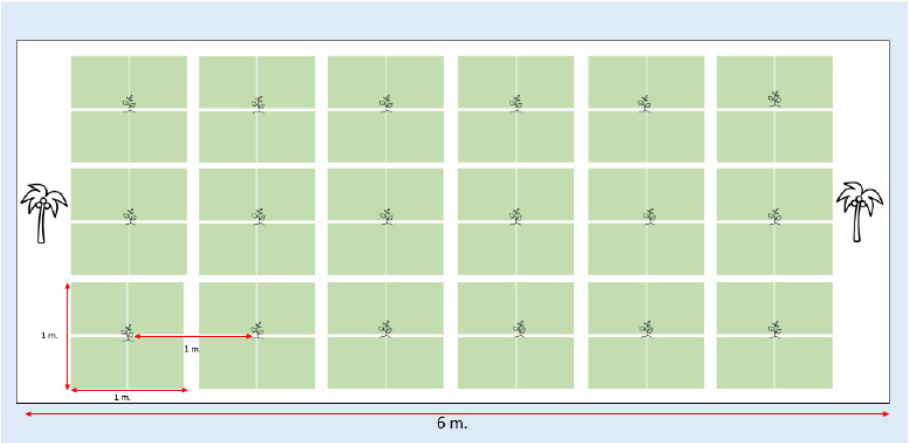
• If you are not transplanting them on the same day, spray the fresh roundleaf clumps with water 1–2 times per day to keep them moist. Keep in mind to transplant the clumps within 3 days.

• Loosen the soil gently and place the roundleaf clumps on the soil 1 m apart from another.

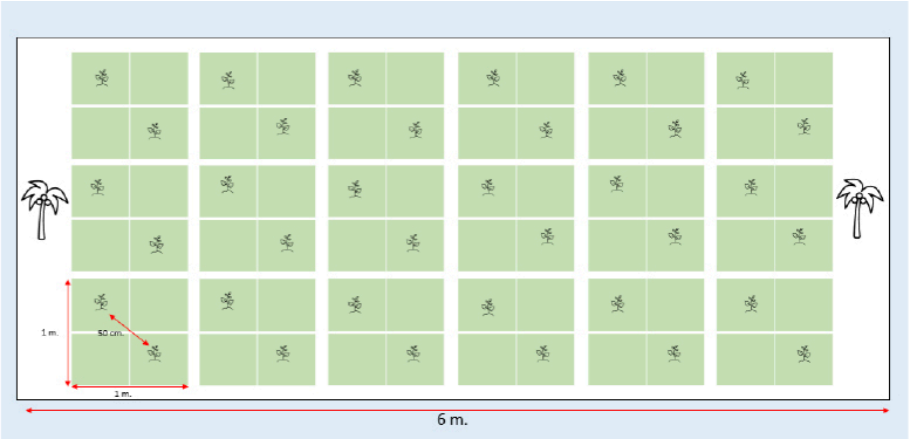
• Place soil in the middle of the clumps.

• Don't forget to protect the roundleaf from direct sunlight and rain with coconut leaves.

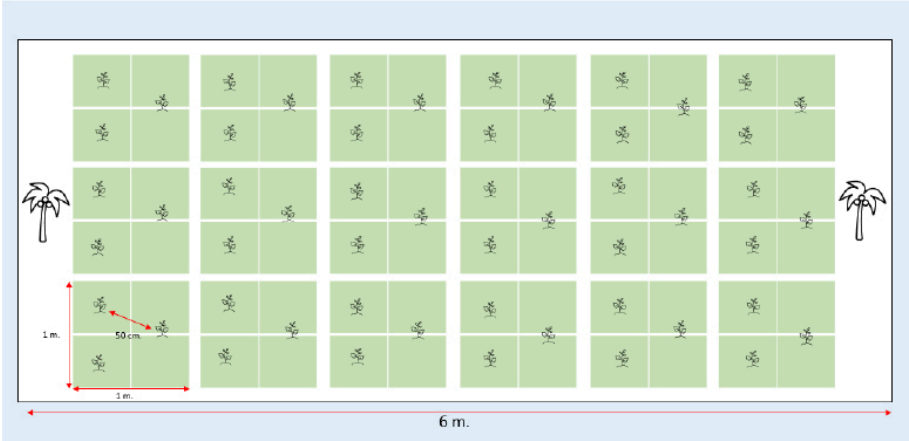
Planting roundleaf for 25% coverage



Planting roundleaf for 50% coverage



Planting roundleaf for 75% coverage



Planting roundleaf for 100% coverage

(2) Pinto peanut ★

- Herbaceous, perennial plants; creeping covers 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

To grow 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 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: around 1 THB/2" bag of seedlings – 2,560 THB/rai, and around 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 ★

- A mat-forming creeping herb in the 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 sq. m 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

- 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

To grow chickenweed as a cover crop

- 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 m away from the coconut canopy
- Avoid letting them climbing onto the coconut plants and be overgrown housing rodent pest of the coconut

Additional information on cover crops is available.

1. Academic publication on control and weeding in fruit crop area 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 a 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***

2.5.2 Intercropping

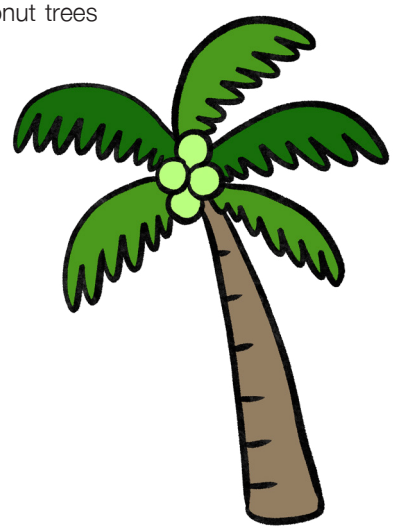
Intercropping means the practice of growing two or more crops together in the same row or in rows in a beneficial manner and for efficient use of light, nutrients, and water.

Benefits of intercropping for soil health

- Increase soil cover, reduce soil erosion
- Increase quantity and variation of root exudates enhance soil fauna
- Improve soil nutrient cycling and plant nutrient uptakes
- 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



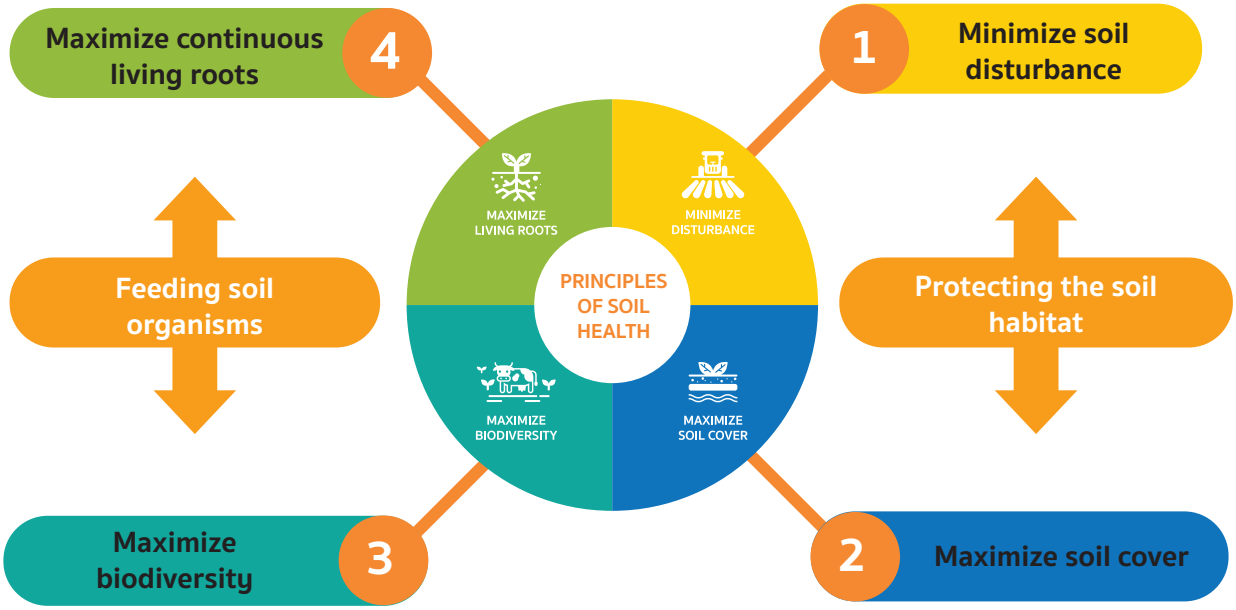
Question: Which soil health principles would intercropping conform to ?

Answer _____

_____

_____

_____



How to choose intercrops?

Intercrop species 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

Intercropping 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 (during the first 3–4 years)

(1) Banana

- 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

- Banana suckers cost 20–30 THB/plant
- Grow banana in early rainy season
- Plant them at 4x4 m 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

- 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

- Guava air-layered tree costs 10–15 THB/tree
- Plant guava air-layered plant at 3x3 m 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 3x3 or 4x3 m 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-drainage soil
- High price during dry season
- But, become productive a little late at 3 years old

Cultivation

- Use 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)

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. These can be found in the academic publication "Knowledge Management on Coconut Production Technology" (in Thai) (page 58) is available at

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

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

- 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, wild betel leaf, etc.

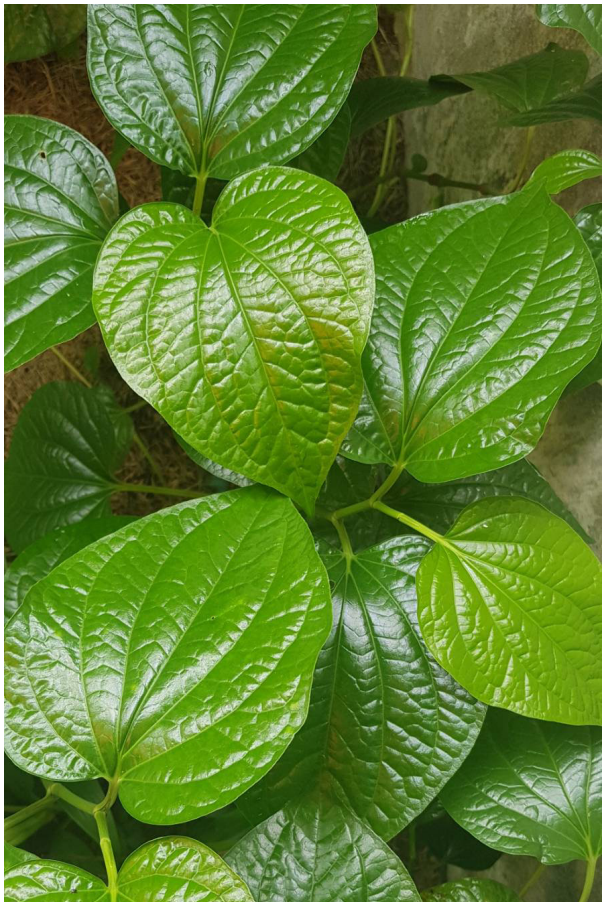
Intercrop examples: For coconut in mature, productive period (4–12 years old)

(1) Pandan

- 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.
- Cost: ~5–15 THB/plant (from cutting, rooted in bag)
- Harvest the leaves with stalk 3 months after planting.

Intercropping for older coconut (12 years old and up)

- 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 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 and available
- Thrive in shading area with moisture
- Young shoots are consumed as vegetable; become productive 6 months after planting

Cultivation

- 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
- 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!

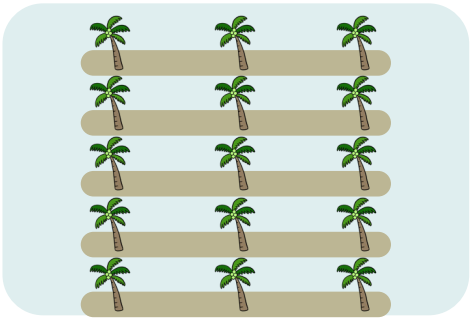
"There is an increasing market for organic products, so by growing other intercrops I can increase my income sources. Besides, I look forward to tasting the new products that my farm can grow!" - Bandit

Lessons learned by pilot farmers — Closing the canals

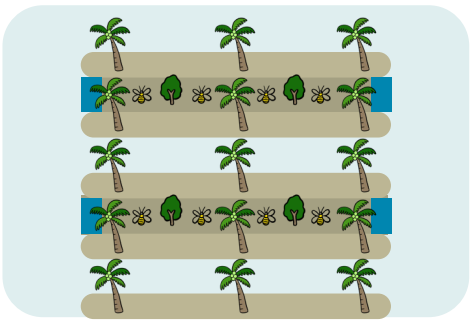
To increase the space on your farm to grow intercrops and other plants, you may think about closing some of your canals.

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 stingless 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

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

Important messages about soil health include:

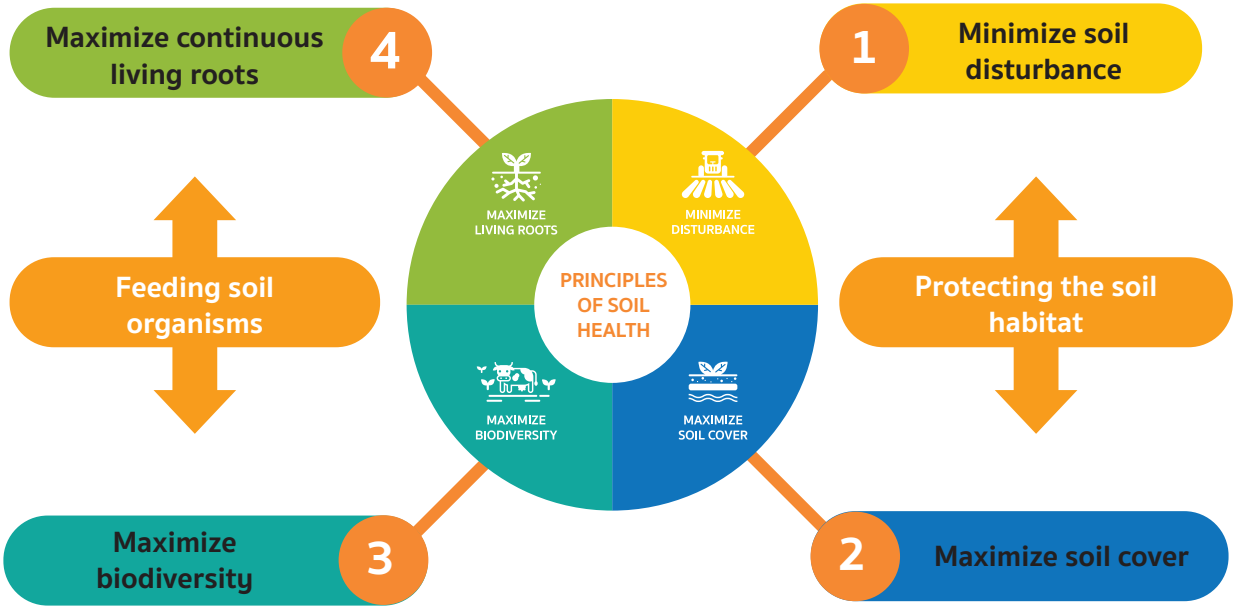
Soil: A living ecosystem, think of soil as a living thing

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

The four soil health principles include:

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

Practice farm activities that comply with the soil health principles would help maintain and improve soil health.



Cover cropping and intercropping are in line with the soil health principles. They help improving soil health, reduce coconut-farming problems, reduce cost, and increase income.

Questions:

1. Which practice(s) will you adopt to perform in your aromatic coconut farm?

Answer _____

_____

_____

_____

_____

2. How do those practices benefit soil health?

Answer _____

_____

_____

_____

_____

B. STUDY VISITS

Coconut farm with cover cropping

Some interesting points:

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

Note

Coconut farm with intercropping

Some interesting points:

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

Note

Note

Note

Note

MODULE 3

ORGANIC FERTILIZER

OBJECTIVES

Understanding the importance of organic fertilizer, principle, 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.

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.

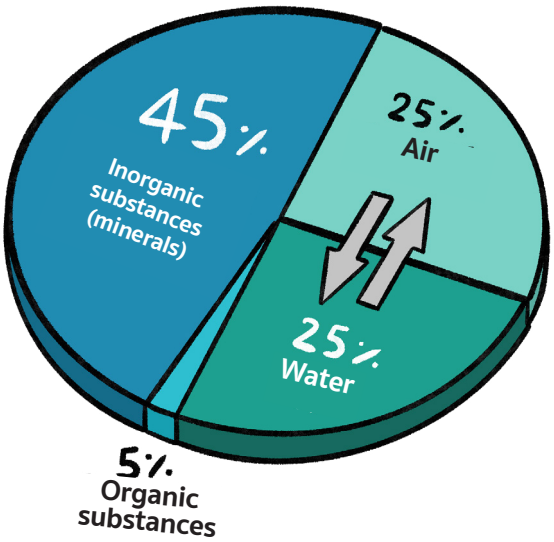
A. LECTURE

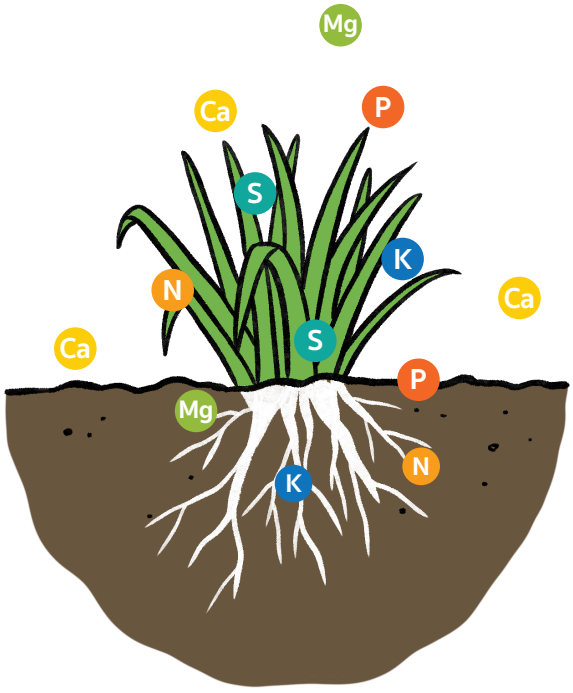
3.1 Importance of organic fertilizer

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.

What is a good soil? 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.**

Plant food: Plant food is certain 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 to plants as carbon dioxide gas (the gas exhaled), oxygen gas (the gas inhaled) and water. The other 13 nutrients are nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum and chlorine. There 13 nutrients are available in the orchard soils, soil organic matter, chemical fertilizer or organic fertilizer. **A plant root takes these 13 nutrients from soil in a water-soluble form no matter what sources they come from.**





An aromatic coconut tree grows continuously all year round. It produces a new frond and an inflorescence almost every month. Therefore, it requires continuous supply of plant nutrients otherwise it will show abnormal symptoms, have poor growth, low fruit yield and poor fruit quality. Examples of the symptoms include leaf scorching by potassium deficiency (A), leaf chlorosis due to nitrogen deficiency (B), wrinkling and abnormal leaf expansion of the top leaf due to boron deficiency (C), and cracking of fruit and shell, abnormal fruit due to boron deficiency (D).

A

B

C

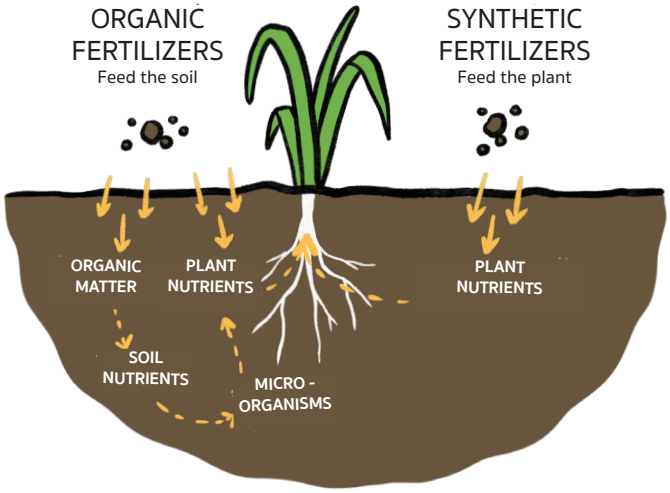
D

Abnormal symptoms due to insufficient supply of potassium (A), nitrogen (B) and boron (C), (D).

What is fertilizer? Why do I need to fertilize my trees?

Fertilizer is any substance (organic or inorganic substances) that provides plant nutrients. This also includes microorganisms that make plant nutrients available or promote better uptake of plant nutrients. Fertilizer is applied to feed the soils when plant nutrients are in low level or the soils cannot release enough nutrients to match with 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, which makes plant nutrients.



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

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

A variety of organic fertilizer is available. The most common organic fertilizer is farmyard manure of cow, pig and broiler chicken. Broiler chicken manure composes of excretion and rice husk using as bedding. It is the most popular organic fertilizer for aromatic coconut production in Thailand. Other organic fertilizers include compost, green manure, bio-fertilizer such as *Azolla*, aquatic ferns with nitrogen fixation capability, mycorrhiza (beneficial soil fungi associated with plant roots and enhance nutrient uptake), vermicompost, bone meal, liquid organic fertilizer and wood ash. Each farm should select what is applicable to their farm based on their soil properties and availability in the area.

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, Thailand. 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 authority in charge of organic production standard regulation.

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


Cow manure


Chicken (broiler) manure


Compost


Green manure


Azolla: nitrogen fixation


Mycorrhiza: beneficial soil fungi that promote phosphorus uptake

Manure
Nitrogen 1.9 - 3.8%
Phosphorus 0.5 - 1.9%
Potassium 0.7 - 1.8%


Vermicompost


Bone meal


Liquid organic fertilizer


Wood ash


LDD composting accelerator

Organic fertilizer contains small amount of plant nutrients and they slowly release.

Farmyard manure had total concentrations of nitrogen, phosphorus and potassium less than 10% by weight and these nutrients gradually release after organic substances have been decomposed. In contrast, nutrients in chemical fertilizer can release much faster.

A handful of 16-16-16 fertilizer has nitrogen, phosphorus and potassium of 48% in total. A handful of chicken manure and cow manure have 7 times and 12 times lower nutrient concentrations than those in the chemical fertilizer.

This is the main reason why plants respond to chemical fertilizer much faster than organic fertilizer.

However, when large amount of organic fertilizer is sufficiently applied and time is allowed for its slow decomposition to occur, it will provide enough nutrients for plants' need with additional advantages including the supply of organic matter and beneficial soil microorganisms for improvement of soil health. In contrast, chemical fertilizer only provides plant nutrients but not help improve the soil conditions.

According to the organic production standard, certain inorganic materials such as dolomite, gypsum and sulfur powder are allowed to use to provide plant nutrients. Sources of such materials must be approved by authority in charge of organic production standard regulation.

Manure vs. Compost: Which one should I apply?

Livestock manure is the organic fertilizer most commonly 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 flie
- 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

How to make your own organic fertilizer

In this training, the principle and methods of making selected organic fertilizers are introduced. Composting of fresh farmyard manure before using, making of compost tea, compost of plant residues and vermicompost are discussed.

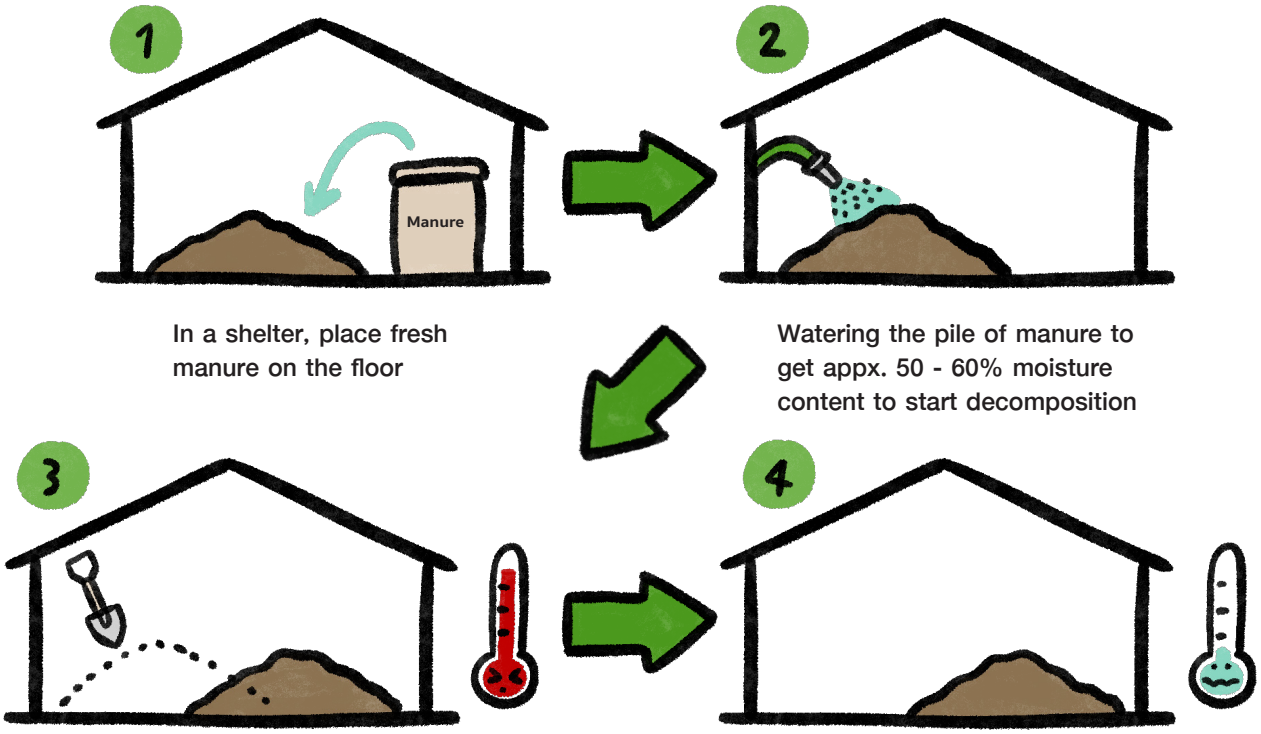
(★ A red star is given to the techniques or recipes recommended by the ReCAP project)

3.2.1 Composting of farmyard manure

Materials

Fresh manure with high moisture content or dry manure, open space for composting and water

How to compost manure



In a shelter, place fresh manure on the floor

Watering the pile of manure to get appx. 50 - 60% moisture content to start decomposition

Decomposition generates heat in the manure pile. Turing the pile every 3 - 4 days

It takes about 15 days for decomposition and thereafter, the composed manure is safe to use

Note: 50-60% moisture content of manure is simply measured by touching. It should feel damp but not soggy or like a feel of wrung-out sponge.

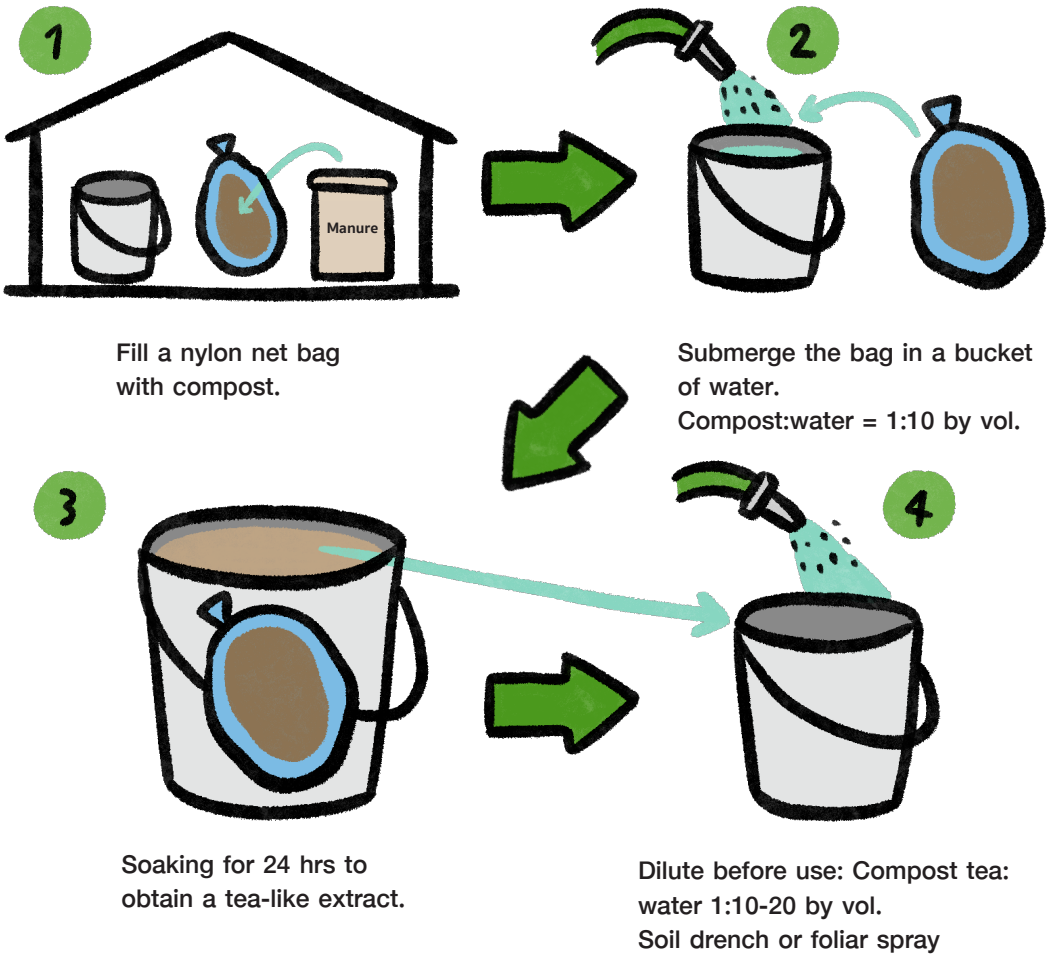
3.2.2 Making compost tea

Materials

1. Organic fertilizers such as dry manure, compost and vermicompost as a source of plant nutrients and beneficial microorganisms
2. Nylon net bag
3. Plastic robe
4. A plastic bucket
5. A brick to top on the bag to prevent floating
6. Clean water for extraction

Mixing ratio: 1 part of organic fertilizer: 10 parts of water

How to compost tea



3.2.3 Making compost of plant residue

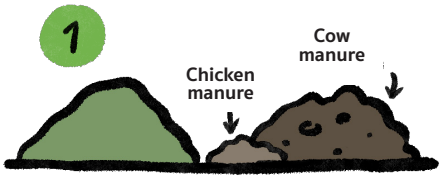
Materials

1. Plant residues such as leaves, rice straw, water hyacinth, grass/weeds in orchard
2. Farmyard manure used as a source of decomposing microorganisms and plant nutrients
3. Open, flat area for making a compost pile
4. Water

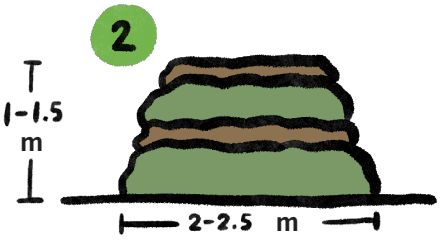
Mixing ratio: 3 – 4 parts of plant residues: 1 part of farmyard manure

Size of a compost pile: The base is 2.5 m wide. The height is 1.2 – 1.5 m. The length depends on the amount of plant residues. Making a pile of this height allows better ventilation and maintains moisture level inside the pile which is suitable for decomposing microorganisms.

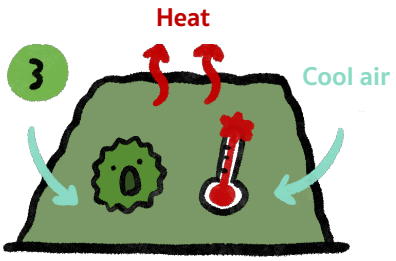
How to make compost ?



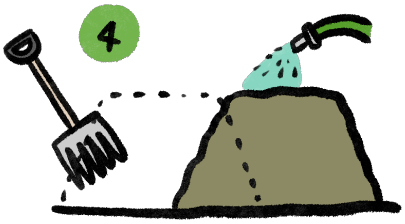
Prepare plant residues (straw, leaves, etc.), manure and an open area to make a compost pile.



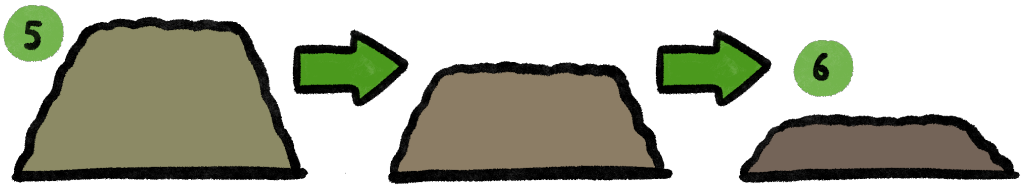
Place plant residues in a layer. Place manure on top. Ratio of plant residues: manure = 3-4:1 by vol. Repeat the process till the pile is 1-1.5 m high and 2-2.5 m wide



Decomposition generates heat in a compost pile. Heat moves upward. Cool air moves in from both sides.



Keep the pile moist but not damp. Turn up the pile speeds up decomposition. Plant residues become darker and softer.



The compost pile is cool down but decomposition by microorganisms and macroflora continues (= curing). The pile shrinks and gets smaller.

Decomposition stops. The compost is ready to use. The whole process takes 2 months or more.

Compost is ready to use: Decomposed plant residues are dark, tender and stable with earth smell with the carbon: nitrogen ratio of 20:1. Seeds can normally germinate in this compost.

Another type of compost which has become popular is called 'Bokashi'. It takes much shorter time in making as compared to a typical compost pile from plant residues. To make Bokashi, plant residues, manure and other organic materials are mixed with EM (efficient microorganisms) under optimal moisture conditions. Rice bran and molasses are added to the mixture as feed for EM. In contrast to a common compost pile, it is not necessary to have good ventilation during the Bokashi making process. The process therefore is likely a fermentation and it also generates heat in the early stage. Bokashi compost may not have as tender texture as common compost because it is made by different process and by different types of microorganism and it takes shorter time to make.

In this handbook, additional compost recipes are presented to provide idea and guideline for making your own compost corresponding the local conditions and availability of raw materials.

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.**

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:

The ReCAP team actually tried out a fourth formular with coconut waste (28.5%) and pig dung (71.5%%), however the CN ratio did not pass the organic criteria, so we do not recommend this formular.

ReCAP Compost formulars

Type of compost	Ingredient % by weight			
	Coconut waste	Chicken dung	Cow dung	Pig dung
ReCAP21 compost	38.5	30.5	15.5	15.5
ReCAP Cow compost	33.3		66.7	
ReCAP Chicken compost	33.3	66.7		

The ReCAP team actually tried out a fourth formular with coconut waste (28.5%) and pig dung (71.5%%), however the C:N ratio did not pass the organic criteria, so we do not recommend this formular.

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.

To make 1 ton of compost, you will need:

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

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.

Cost

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

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.

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.

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

Remarks: * 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.

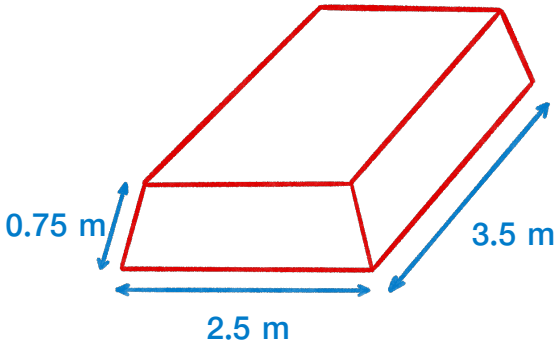
For all USDA organic certified farmers, you have to keep in mind that fresh manure is not allowed to be used as fertilizer on your farm. The manure you use on your farms must be composted for 90 days: **https://www.ams.usda.gov/sites/default/files/media/Compost_FINAL.pdf**

Methods

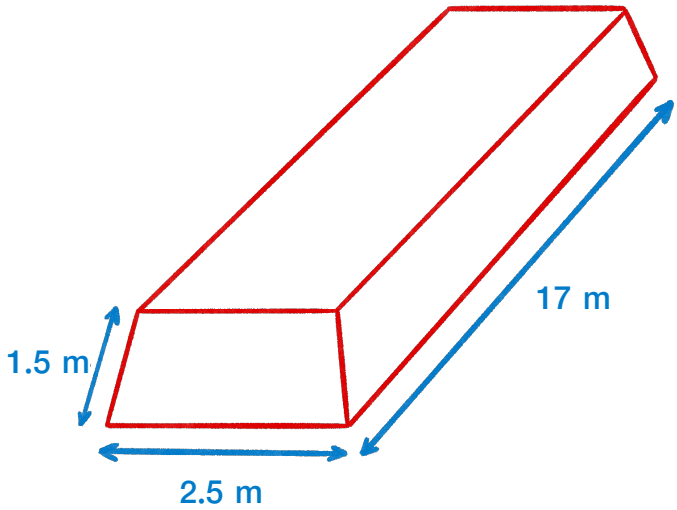
There are two methods of making the composts: Aerated and Windrow method. You can use either method for all compost formulars. The aerated method requires you to invest in a blower machine but will save you labor costs by not having to turn the compost pile. For the windrow method you will need to have 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 2.5 m x 3.5 m length and a height of 0.75 m. For 10 tons of compost, the pile could have a width of 2.5 m x 17.5 m length and a height of 1.5 m.



Sample of 1 ton of compost



Sample of 10 ton of compost

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.

Equipment

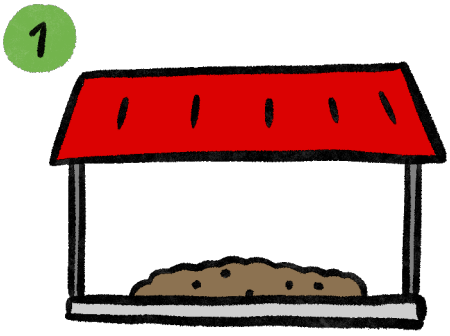
You will need:

- Moisture recorder
- Temperature recorder
- Fork hoe
- Shovel

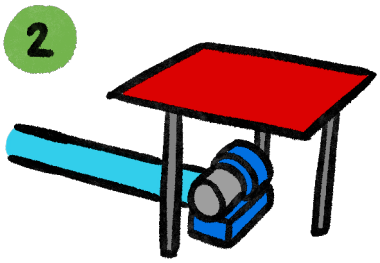
Additionally, for the Aerated method you will need:

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

ReCAP Compost with Aerated Method (1 ton)

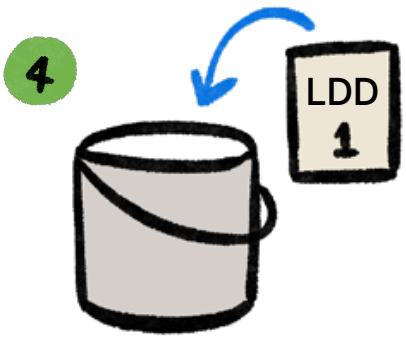


Clear space for compost making area. Ideally with concrete floor and a roof.

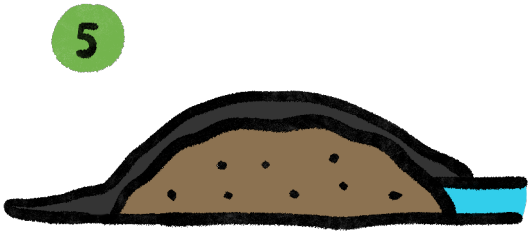


Set the aerate system outdoor by connecting the blower with the plastic pipe. This is to add air to the compost pile.

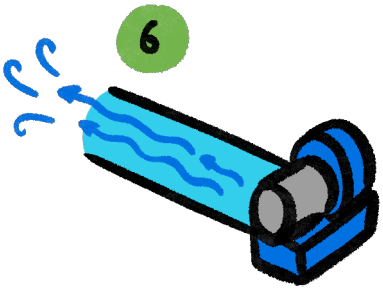
Mix coconut waste with manure (depending on compost formular).



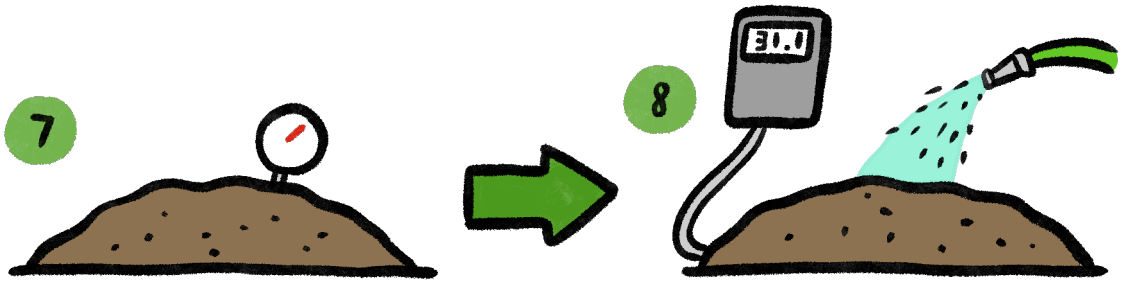
Mix LDD1 (100g) with water (20 liter) and pour over compost pile.



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



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



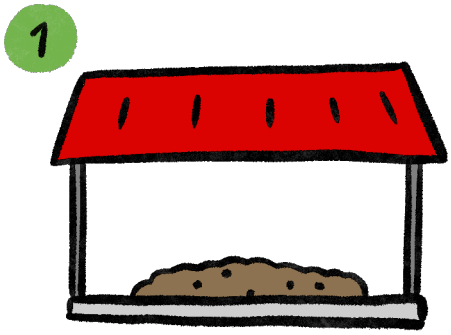
Measure the temperature of the compost every day. Throughout the 90 days, the compost must reach 55°C for at least 3 days continuously.

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.

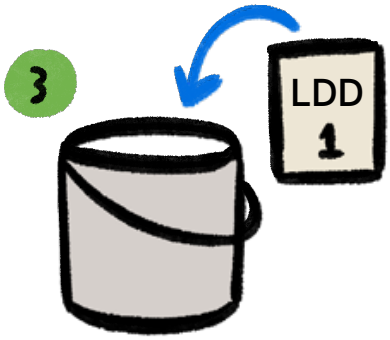
10. Compost will be completed after 90 days. It should have a rich dark brown color, smell not as strong as manure, and have a crumbly texture. The finished compost can be used immediately or it can be stored in bags.

ReCAP Compost with Windrow Method (1 ton)

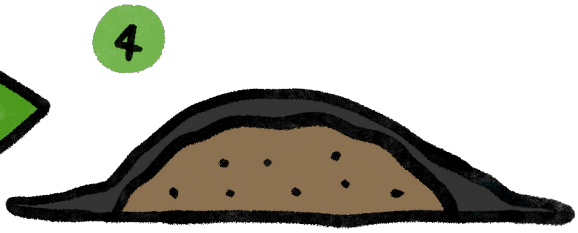


Clear space for compost making area. Ideally with concrete floor and a roof.

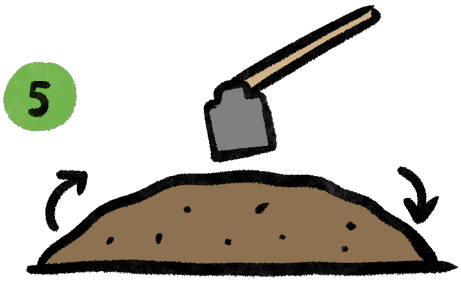
Mix coconut waste with manure (depending on compost formular).



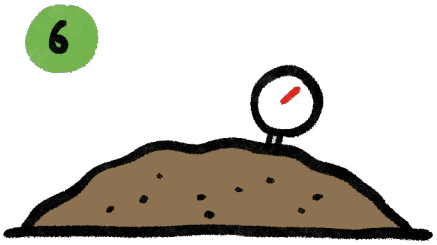
Mix LDD1 (100g) with water (20 liter) and pour over compost pile.



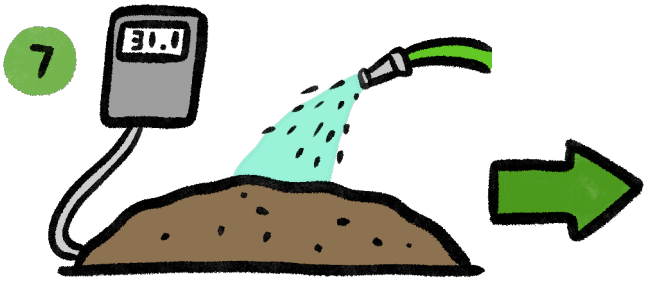
Make a compost pile according to available space, with a height of no more than 2.4 m. Cover with plastic sheet.



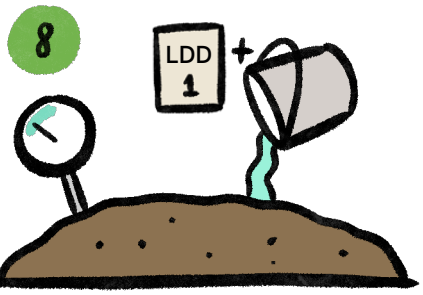
After 15 days, turn the pile to increase Oxygen and reduce the heat. The pile needs to be turned every 15 days (5 times in 90 days).



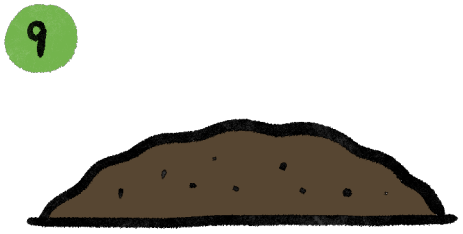
Measure the temperature of the compost every day. Throughout the 90 days, the compost must reach 55°C for at least 15 days continuously.



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.



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



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.

Hua Ao Compost

This Bokashi type compost is made by putting raw materials in a fertilizer sack or feed sack (breathable woven poly sack) instate 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, Thailand. Hua Ao compost has been certified by the Land Development Department (LDD), Ministry of Agriculture and Cooperatives, Thailand for commercial purpose.

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 composting 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.

Hua Ao compost recipe

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

Note: Due to its making process which differs from a regular composting and the raw materials used, Bokashi compost has not been mentioned and approved by USDA Organic, according to the USDA Guide for Organic Crop Producers.

Mae Jo Engineering 1 compost

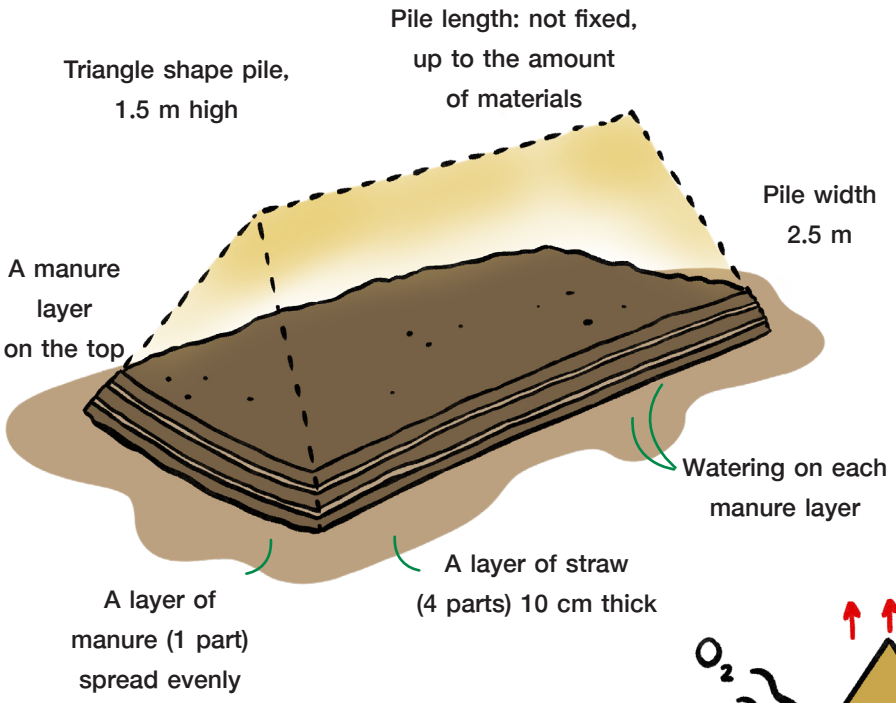
The main ingredients of this compost are plant residues such as rice straw, dry leaves, dry husk and cob of corn (for animal feed) and manure.

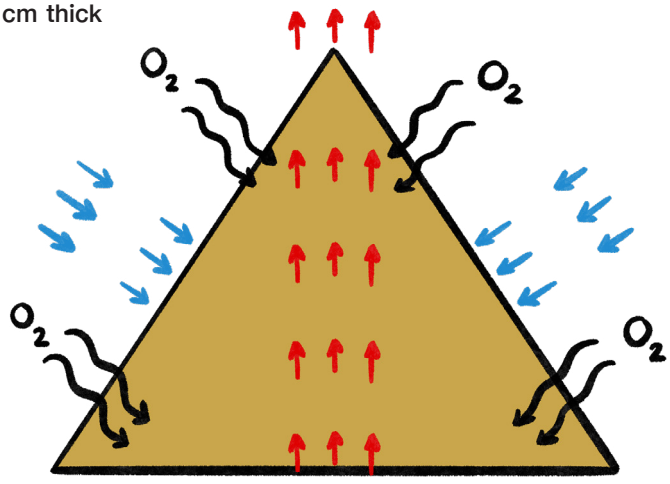
A compost pile is made in layers, a plant residue layer alternated by a manure layer, to form a triangle-shape pile with 2.5 m wide base and 1.5 m high. The pile length is not fixed depending on the amount of ingredients available. The shape of compost pile promotes chimney convection allowing heat to 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.

Mae Jo Engineering 1 compost recipe

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





Oxygen circulation within a compost pile by chimney convection.

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

Songkhla Thepa DOAE90 compost

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

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.

Songkhla Thepa DOAE90 compost recipe

Ingredient	Amount
1. Rice husk	200 kg or 10 sacks
2. Animal manure	160 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. LDD1*	0.1 kg or 1 pack

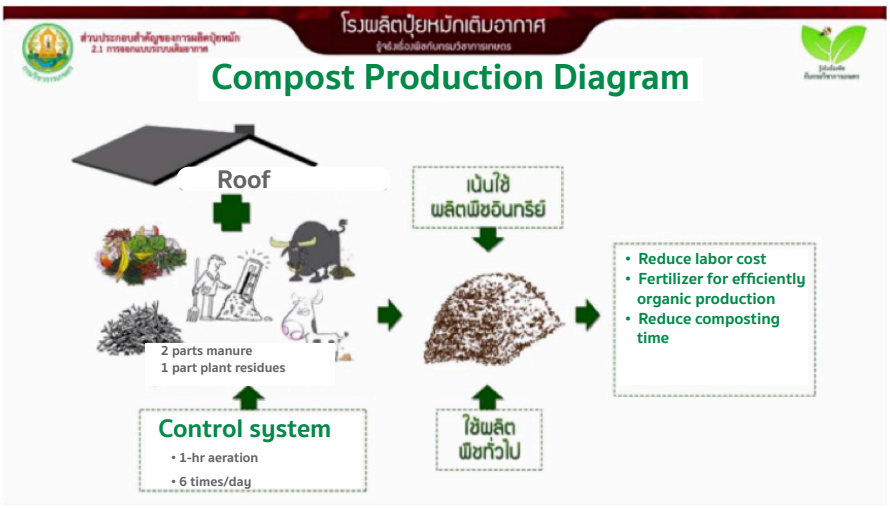
Aerated static pile compost

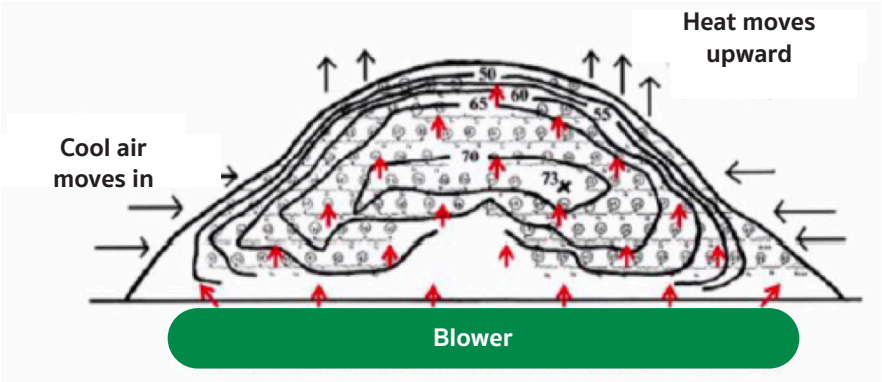
In this system, air is forced into

Aerated static pile composting system

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. 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.

Aerated Static Pile Composting System



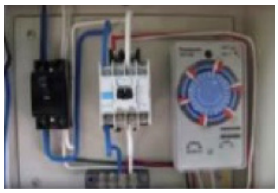


Source: https://www.doa.go.th/hort/page_id=1101 choose "โรงปุ๋ยหมักดินอากาศ" (in Thai)

Main apparatus

Air vent

10-inch blower



Auto timer

Aerated static pile compost recipe

	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

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. 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.

DOA compost recipe

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

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 m. 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

Compost Activity

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

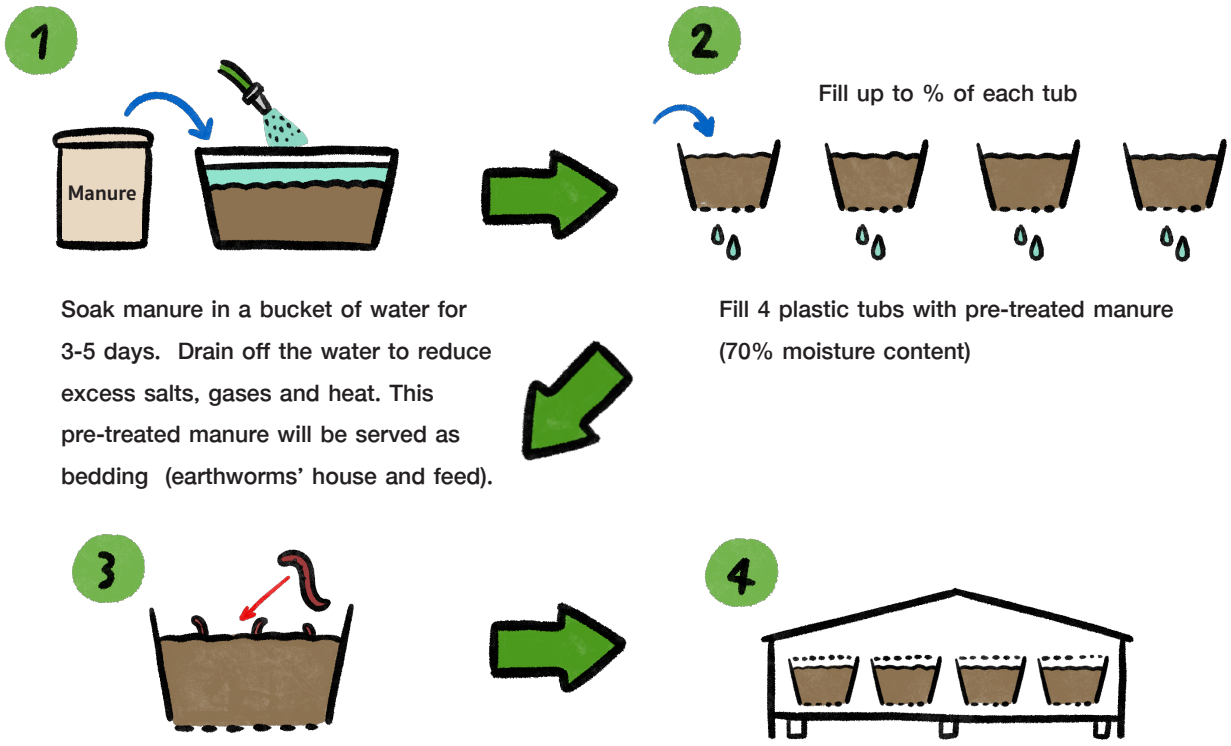
Sources: http://www.compost.mju.ac.th/aerated/prod/default.htm (Research project on knowledge transfer to the community about the technology of the aerated static composting for the industrial production by Teerapong Sawangpanyangkura, from the Department of Agricultural and Food Engineering, at the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

3.2.4 Making vermicompost (the initial set) ★

Materials

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)
5. Wire screen for mouse protection
6. Stand or table for placing earthworm houses
7. Clean water
8. Shelter providing shade and rain protection

Methods



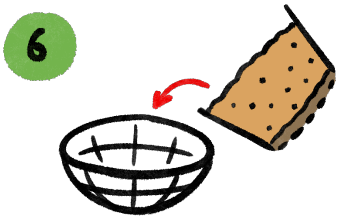
Soak manure in a bucket of water for 3-5 days. Drain off the water to reduce excess salts, gases and heat. This pre-treated manure will be served as bedding (earthworms' house and feed).

Fill 4 plastic tubs with pre-treated manure (70% moisture content)

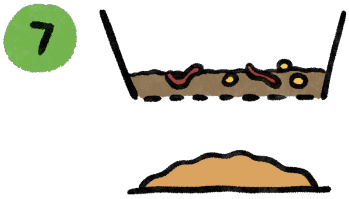
Load 250 g of earthworms on bedding surface. They will go down into the bedding thereafter.

Place tubs on a stand so that earthworms cannot escape and ants cannot attack. Put a screen on top of the tub to prevent rats.

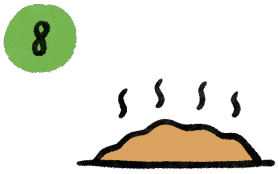
Water everyday to keep bedding moist but not damp. Earthworms release excrement daily and it accumulates on the bedding surface. After 20 days of culture, stop watering.



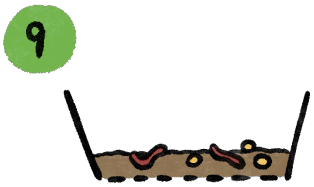
For 30 days of culture, bedding is all consumed. Vermicompost and earthworms are separated by sieving.



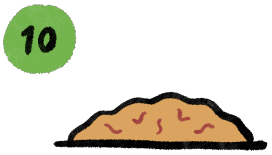
Mature earthworms, babies, eggs and bedding residues are kept on sieve while vermicompost is passed through the sieve.



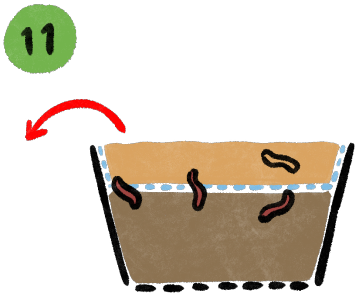
Allow vermicompost to dry out under shade and it is ready to use or store in a bag.



Earthworms, babies, eggs and bedding residues on a sieve can be used for the next round of culture.



Tiny babies can pass through the sieves with vermicompost. Separation is needed



A tub with new bedding. Place a blue nylon net on the bedding surface.
Place vermicompost with babies on the net.
Babies will move into the bedding later on.

Collect vermicompost without babies.

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

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 fertilizer to aromatic coconut production

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 as suggested by > 80% seed germination index, and contains heavy metals and toxic elements the allowed levels.

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 Principle of organic fertilizer application

Please keep in mind that aromatic coconut is a perennial tree that 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 readily 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.

Organic fertilizer application method and rate

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.

Organic fertilizer is mainly applied to soil on a monthly basis at the rate of 1 – 2 kg/tree (total of 12 – 24 kg/tree/year). A compost tea is applied once a month as supplement.

A compost tea is diluted before application as soil drench, 1 part of compost tea extract: 4 - 10 parts of water. The application rate as mentioned above is based on the practice in successful organically produced orchard that aromatic coconut trees grow well with acceptable yield. If the orchard soil has high fertility, the amount of organic fertilizer to be applied can be reduced.

Application of fertilizer according to soil test results

With orchard soil analysis information, fertilizer can be applied corresponding to a tree's requirement and soil fertility level. Using a soil test kit, a volunteer soil doctor can perform a simple soil test to rank the levels of soil nitrogen, phosphorus and potassium as high, moderate or low. Fertilizer will be applied in large amount when soil has low level of such nutrients or in less amount when soil has high level of nutrients.

Methods

1. Perform a soil test: collect soil samples and submit to a volunteer soil doctor for a simple soil test.

2. Compare the test results with the table to determine fertility levels of the orchard soil and the amount of fertilizer to be applied.

3. Choose the kind of organic fertilizer to be applied. Check % NPK in that organic fertilizer from the table.

4. Calculate the amount of organic fertilizer to be applied.

Soil analysis	Rate (g/tree/year)
Organic matter (%)	Nitrogen fertilizers
<2	1,200
2-3	600
>3	300
Phosphorus (mg/kg)	Phosphorus fertilizer
<15	500
15-45	250
>45	125
Potassium (mg/kg)	Potassium fertilizer
<50	1,000
50-100	500
>100	250

Example The test results indicate that the orchard soil is moderately fertile with high potassium.

According to the table, it means the orchard soil has 2 – 3% organic matter, 15 – 45 mg/kg phosphorus and > 100 mg/kg potassium. The amount of fertilizer to be applied is 600 g nitrogen/tree/year, 250 g phosphorus/tree/year and 250 g potassium/tree/year.

Choose the kind of organic fertilizer to be applied. Let's choose chicken manure which has relatively high nitrogen. 100 kg of chicken manure provides 3 kg (or 3,000 g) of nitrogen fertilizer, 1.9 kg (or 1,900 g) of phosphorus fertilizer and 1.8 kg (or 1,800 g) of potassium fertilizer.

Calculate the amount of chicken manure to be applied to provide 600 g of nitrogen fertilizer/tree

Need chicken manure = (600 x 100)/3,000 = 20 kg/tree/year

Coming along with nitrogen are 380 g of phosphorus fertilizer and 360 g of potassium fertilizer which are a bit more than a tree's requirement. This will create the 'soil nutrient imbalance' conditions (some nutrients are in excess and some nutrients become less available) in the orchard soil if chicken manure is the only source of plant nutrients. This soil nutrient imbalance can

also adversely affect plant nutrient uptake.

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

Organic fertilizers generally contain low nutrients. Their unit prices and the amount of nutrients are different. Using the concept in the example mentioned above to determine the amount of fertilizer to be applied for different organic fertilizers. 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.

Soil analysis values	Rate (g/tree/year) (5 m canopy dia.)	Chicken manure	Cow manure	Pig manure	Bat manure
Organic matter (%)	Nitrogen fertilizers	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	Potassium fertilizer gained			
>45	125	380*	192*	286*	8,140*
Potassium (mg/kg)	Potassium fertilizer				
<50	1,000				
50-100	500	Potassium fertilizer gained			
>100	250	360*	448*	264*	999*
Price (Baht/tree/year)		33	53	51	1,650

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.

Choose to apply chicken manure which contains more nutrients than other farmyard manures at the rate of 20 kg/tree/year. This rate provides 600 g of nitrogen corresponding to the tree's requirement but the coming along phosphorus and potassium are in excess.

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.

3.3.2 Does an aromatic coconut tree get enough nutrients?

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.

Summary

1. 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.

2. Organic fertilizer provides nutrients that plants need and improves soil structure, porosity, water holding capacity and soil health.

3. Various kinds of organic fertilizer are available and they release nutrients slowly through decomposition process by soil microorganisms.

4. How to make your own organic fertilizer: principle and methods.

5. Only organic fertilizer and its ingredients that meet the organic production standard are allowed.

6. Application of organic fertilizer at the right amount, right place and right time will ensure better plant growth, reasonable yield and high fruit quality.

DO THIS

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 fertilizer
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

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

Note

Some questions are suggested to be asked during the demonstration and study visits:

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

Note

Some questions are suggested to be asked during the demonstration and study visits:

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 related cost

Note

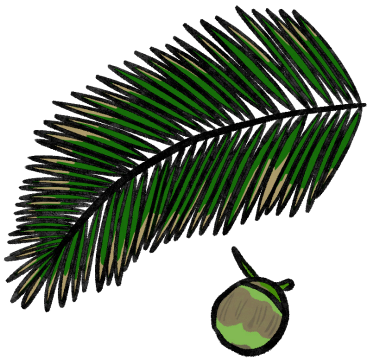
Note

Note

Note

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 SKILLS

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 increase 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 pest control methods will help to minimize potential losses produced by pests, reduce pesticide cost, and protect farmer heath from chemical residue.

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

Plant pest is any organism that can cause significant damage to plants or plant products. Plant pest could be insects, pathogens, weeds or animals.

4.1 Coconut insect pests


1

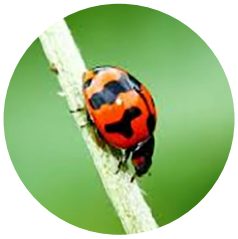

2


3


4


5


6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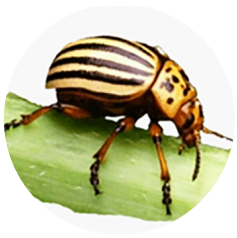
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11


12


13


14


15

Question: Which ones are considered as coconut insect pests?

Answer _____

_____

_____

_____

A

B

C

D

Question: Which pests are able to cause the damages characteristics to coconut as shown in each picture (from A to D)?

Answer _____

_____

_____

_____

The major insect pests found in coconut farm are **black-headed caterpillar, coconut rhinoceros beetle, red palm weevil, and coconut eriophyid mite**. The effective methods to control pests without pesticide are identify pests by the damage characteristics appeared on coconut trees, understand life cycle of pests, know favorable conditions for their distributions, recognize their natural enemies and pest control methods.

4.1.1 Black-headed caterpillar

Damage characteristics

1. Larvae feed and tunnel on the tissue of the coconut leaf and live there until pupal stage.
2. Moth in gray color
3. Only larvae stage infests coconut leaf
4. Usually destroy older leaf first
5. Destroy the abaxial side

Figure 4.1 Damage characteristics from black-headed caterpillar

Outbreak

Black-headed caterpillar (*Opisina arenosella*) widely spreads during the dry season (mating season) but less during the wet season (unfavorable for mating).

Life cycle

One life cycle of black-headed caterpillar takes approximately 50–75 days (1.5–2.5 months), of which the larvae stage (the dangerous stage for coconut) lasts 1.0–1.5 months, and can be divided into four stages as follows:

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.

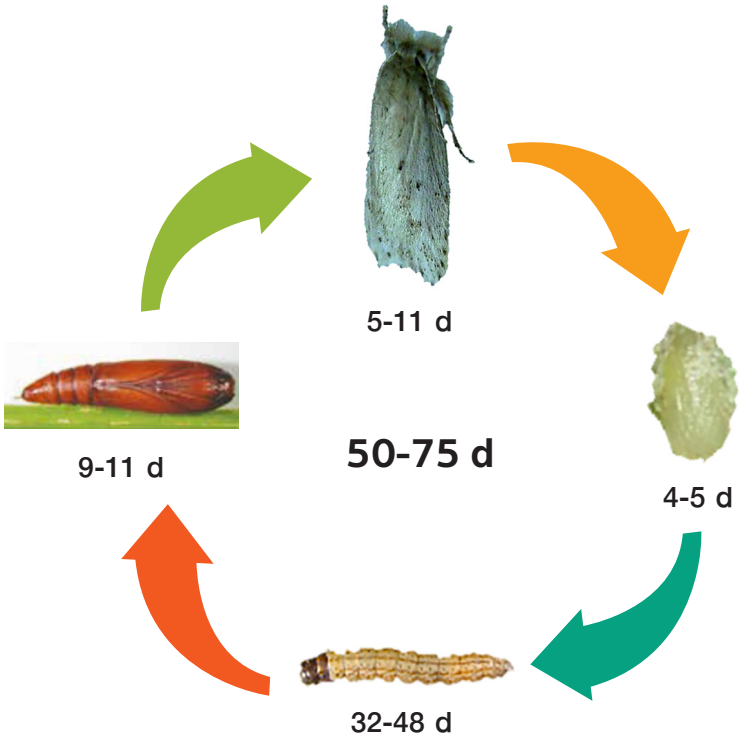


Figure 4.2 Life cycle of black-headed caterpillar

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*.

Trichogramma
(endoparasites of eggs)

***Bracon* wasps**
(ectoparasites of caterpillars)

Earwig (predator)

Larvae of green lacewings
(predator)

Figure 4.3 Natural enemies of black-headed caterpillar

Control methods

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.

4.1.2 Coconut rhinoceros beetle

Damage characteristics

1. Symmetrical cuts on leaves, as well as fronds and trunk having holes are damage characteristics of coconut rhinoceros beetle infestation.

2. Adults stage cause damage to coconut palms.

3. Coconut rhinoceros beetle adults eat the leaves and burrow into the crown, enables the red palm weevil to thrive.

4. While the adult beetle feeds in crown of the palm, they lay eggs into decaying wood where the larvae (grub) develops.

Figure 4.4 Damage characteristics from coconut rhinoceros beetle

Outbreak

Coconut rhinoceros beetles are distributed 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 Jun–July is mating season.

Life cycle

One life cycle of coconut rhinoceros beetle takes approximately 120–270 days (6-9 months), of which 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.

The life cycle of coconut rhinoceros beetle can be divided into four stages:

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 beetles lay eggs several times over their lifetime. Each time, it lays 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.

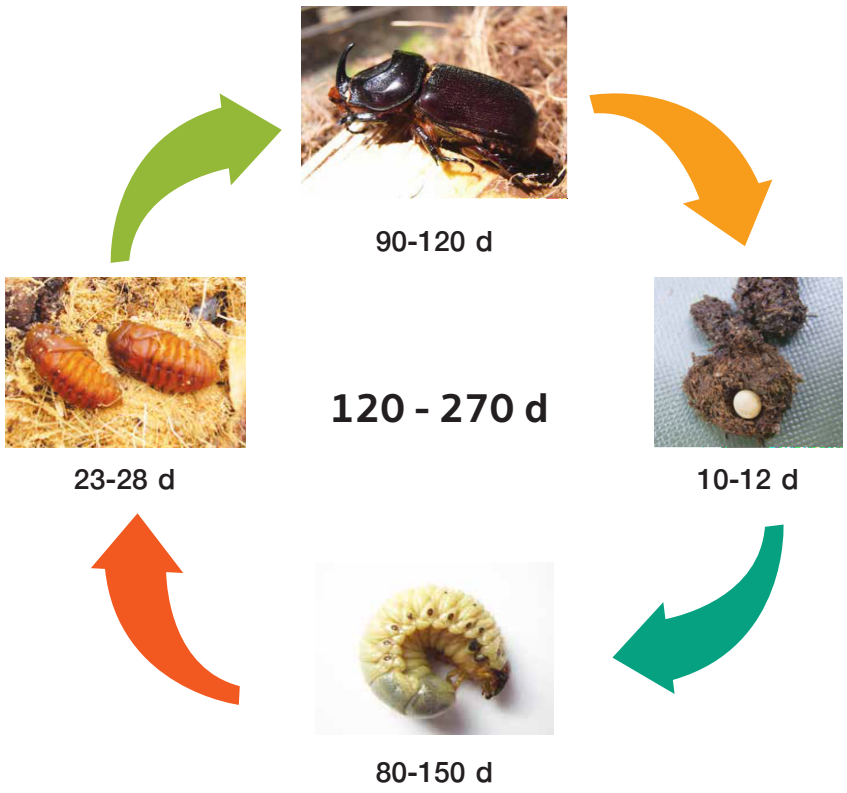
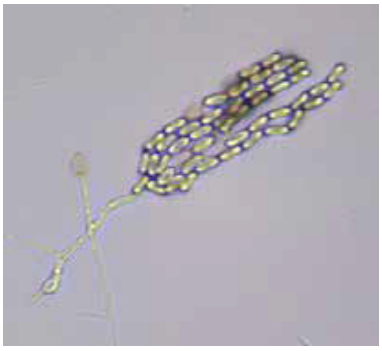


Figure 4.5 Life cycle of coconut rhinoceros beetle

Natural enemies

The fungus *Metarhizium* is used to act as entomopathogens for larval, pupae and adult stages of coconut rhinoceros beetle.

***Metarhizium* on culture media**



***Metarhizium* conidia**

Dead larvae killed by *Metarhizium* infection

Rhinoceros larvae tissue infected by *Metarhizium*

Figure 4.6 Natural enemies of coconut rhinoceros beetle

Control methods

Detection of coconut rhinoceros beetles might be difficult due to their nocturnal behavior and habitat inside the trees. However, some visual signs, such as holes at the base of leaves or V-shaped feeding damage, helpfully hint whether or 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 two 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 which normally produced by the male beetle. In breeding sites, the fungus *Metarhizium* could be applied for controlling larval, pupae and adult stages of beetles.

4.1.3 Red palm weevil

Damage characteristics

1. The damage characteristic from red palm weevil is drooping leaves and palm death. The weevil entry the holes that the coconut rhinoceros beetle initially creates.

2. Weevil adults and larvae feed and tunnel on the tissue of the coconut trunk towards the tip.

Outbreak

Red palm weevil widely spreads the entire year. The level of distribution depends on the farm sanitation.

Figure 4.7 Damage characteristics from red palm weevil

Life cycle

One life cycle of red palm weevil takes approximately 75–135 days (2.5–4.5 months), of which 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.

The life cycle of red palm weevil can be divided into four stages:

1. The adult beetles live up to 61–139 days. The adult females lay approximately 30 eggs a day and up to 527 eggs in a lifetime.

2. Adults can excavate holes in the trunks of palm trees to lay eggs. Eggs hatch in 2–3 days on average, then they go into the larvae stage.

3. Larvae are yellow-white, segmented, and legless with dark brown heads, 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 with 80 millimeter long at the base of the tree in 2-3 days. It takes 9–25 days before turning to adult stage.

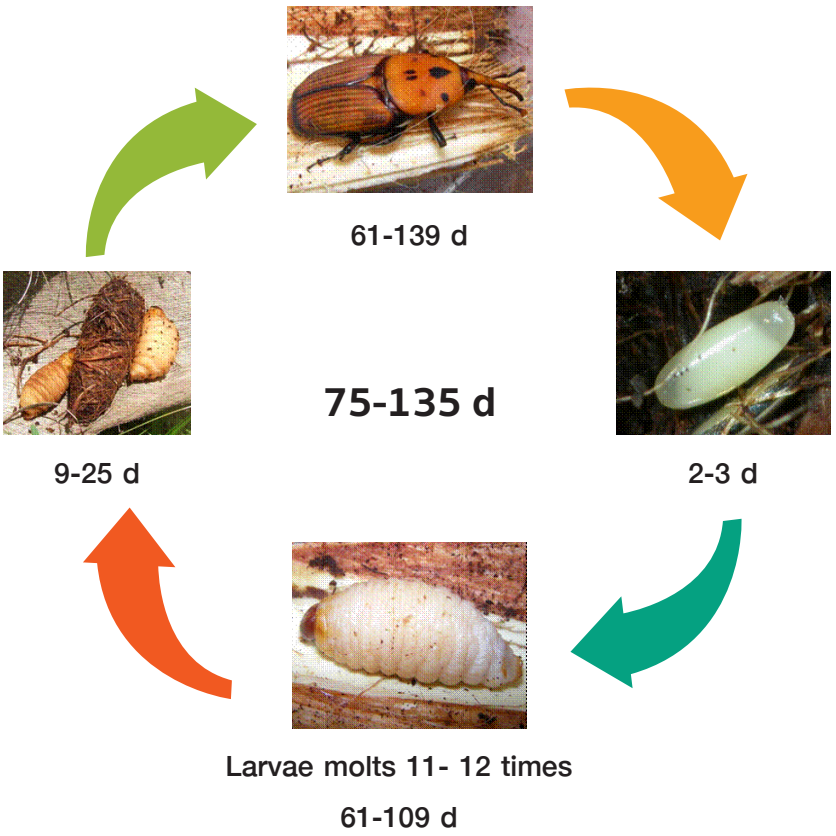


Figure 4.8 Life cycle of red palm weevil

Control methods

1. Control the 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 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.

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/ด้วงงวงมะพร้าว_page-0001.jpg**

4.1.4 Coconut eriophyid mite

Damage characteristics

1. Damage is found from the initial infestation under the perianth. The damage becomes apparent as the fruit develops by corky brown, fissured patches on the fruit surface. Fruit becomes distorted if the damage is on only one side of the fruit.

2. Damage is found under the bracts of fertilized female flowers as mites do not infest the unfertilized flowers. Coconut eriophyid mite contains two pairs of legs and is too tiny in size to see with the naked eyes. Nymph and adult feed below the perianth.

Figure 4.9 Damage characteristics from coconut eriophyid mite. Damage is found from the initial infestation under the perianth (red arrow). The damage becomes apparent as the fruit develops by corky brown, fissured patches on the fruit surface (yellow arrow).

Outbreak

Mites are widely found during the dry season but low during the wet season.

Life cycle

One life cycle of coconut eriophyid mite takes approximately 7–8 days, of which the nymph and adult stage can damage coconut fruit, and can be divided into four stages as follows:

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 in color. It hatches within 2–3 days.

3. Nymphs look similar to the adult stage with the same pale color, but smaller. Two nymph stages will be developed. Each stage lasts around two days.

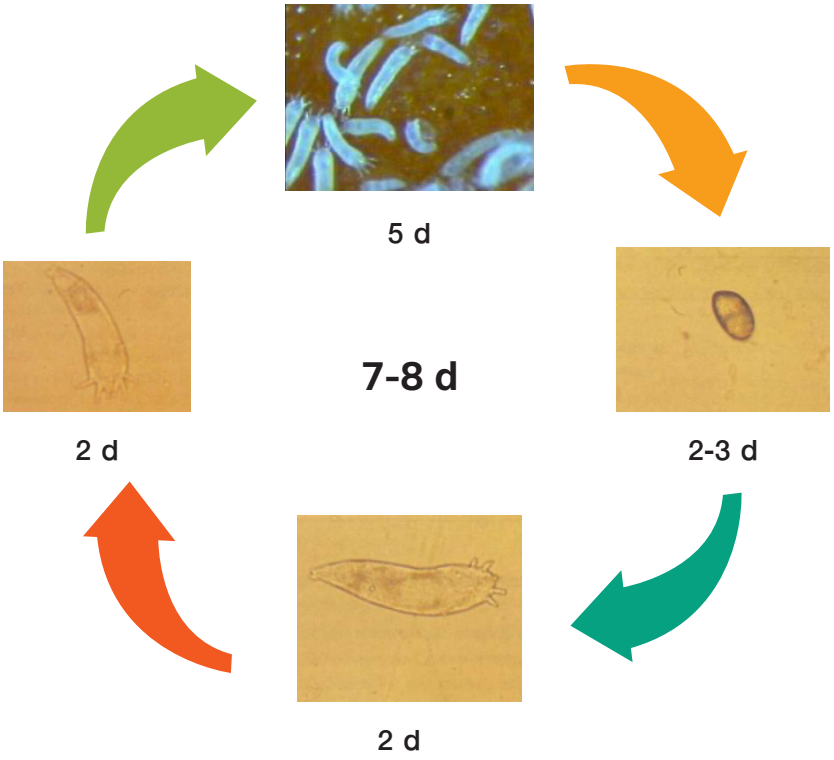


Figure 4.10 Life cycle of coconut eriophyid mite

Control methods

1. Collect and destroy all fallen buttons of affected palms by burying them at the depth of 50 cm, putting them in the plastic bags and drying in the sun for 7 days to avoid their spread.

2. Since mites largely dispersed by wind, windbreak is a potential method to prevent the spread.

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, coconut rhinoceros beetle, red palm weevil, and coconut eriophyid mite.

2. Potential control methods for each pest species are as follows:

- Black-headed caterpillar: use light traps to attract adult moths, use *Trichogramma, Bracon hebetor*, and 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: What diseases occur in your farm?
Or do you know any of these diseases?

Answer _____

_____

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 as following:

1. The seedling stage is susceptible to two diseases: leaf spot and bud rot.
2. The mature stage is often affected by four diseases: 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

Figure 4.11 Symptom of Leaf spot disease

Symptom

First symptom is shown by small, oval and brown spots on leaf; later, they rapidly expand becoming light grey in the centre. 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 doses of *Trichoderma* are
   - 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.

Figure 4.12 Symptom of Bud rot

Diseases of the mature stage
4.2.3 Bud rot and nut fall (caused by *Phytophtora palmivora*)

Symptom

Mostly, by the time the symptoms appear detectable, the disease is in the advanced stage with the rot of bud and inner leaves.

The first sign possibly noticed 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 green leaves. This process takes 3-4 months before leaves dry out and fall.

A foul smell occurs as the bud rots. Nuts can be also infected, leading 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 burn 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

Figure 4.13 Symptom of Bud rot and nut fall

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 from the infected palm 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*.

Figure 4.14 Symptom of Basal stem rot

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 and then black.

In the advanced stages 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.

Spread

Fungi spread their spores by wind and rain.

Prevention and control

1. Avoid wounding the palm trunk.
2. Apply chicken 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.

Figure 4.15 Symptom of Stem bleeding

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 grayish color often appears in the middle of the lesion. Then, the infected leaves turn gray, leading to defoliation. The disease is frequently 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.*

Figure 4.16 Symptom of Gray leaf spot disease

Summary of the coconut diseases

In Thailand, the coconut diseases are less problematic compared to the outbreaks of the insect pests. However, there are six diseases frequently and widely found in the coconut plantation:

Diseases of the seedling stage

- Leaf spot is characterized by small yellowish and brown spot on laminar.

- Bud rot is characterized by bud rot from the top of the fronds without a foul smell.

Diseases of the mature stage

- Bud rot and 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.

- Basal stem rot is characterized by wilting of the older leaf and mature sporophore from the basal region of trunk.

- Stem bleeding is characterized by black sap flow covering the stem surface, often found in the younger tree.

- Gray leaf spot is characterized by small yellowish-gray spots, often found in the older leaf.

Prevention and control of 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) emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms, and suppressing pest population to the acceptable level using physical, biological, and cultural control methods along with regular observation at least once a month.

Pest monitoring

DO THIS

To estimate level of damage produced by pest, monitor and record the healthy leaves on 10 plants per farm and observe the same 10 plants every month. After the record is completed, calculate the average score of the healthy leaves to estimate the level of damage and adopt the appropriate solution:

- If the average score of the healthy leaves is less than 6, it indicates that the farm is facing a serious pest problem. The recommended management is cutting the affected leaves and using *Bracon hebetor*.

- If the average score of the healthy leaves is 6–12, it indicates that the pest population is moderate. The recommended management is cutting the affected leaves and using *Bracon hebetor*.

- **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 is cutting the affected leaves.

- No damage is observed—no sign of infestation

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 amount of 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_____

Therefore, the level of damage from black-headed caterpillar in this example is_____

_____

Form of insect pest monitoring of coconut (weekly based)

Name of owner..... Farm coordinates.....

Address.....

Coconut information

Area of farm.....age..... Survey Date.....

Atmosphere

Temperature.....RH..... ☐ rainy ☐ dry ☐ sunny ☐ overcast ☐ others.....

Pest/Natural enemies	Plant number										Note
	1	2	3	4	5	6	7	8	9	10	
Pest											
Black headed caterpillar											
Rhinoceros beetle											
Red palm weevil											
Natural enemies											

IPM methods

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 control methods.

B. HANDS-ON PRACTICES

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. This control method 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.

4.3.1.1 Rearing of parasitoid *Bracon hebetor* to control black-headed caterpillars

involves two steps: (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.

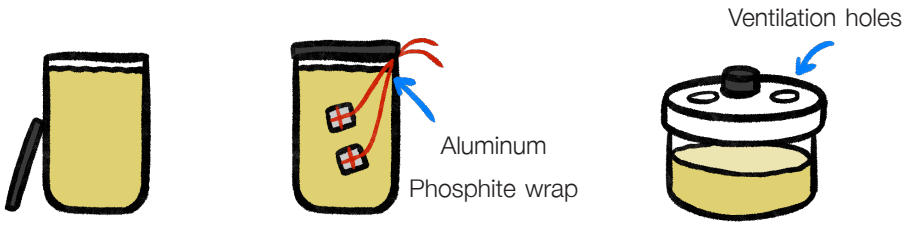
- Mix rice bran and broken-milled rice in 2:1 ratio and fill 1/3 of the tank volume. Place 3-tablets package.

- 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.

Rice bran : broken-milled rice 2:1



150 L tank

Fumigated food tank

Food for rice meal moths

Figure 4.17 Step by step of food preparation for rice meal moth caterpillars

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.

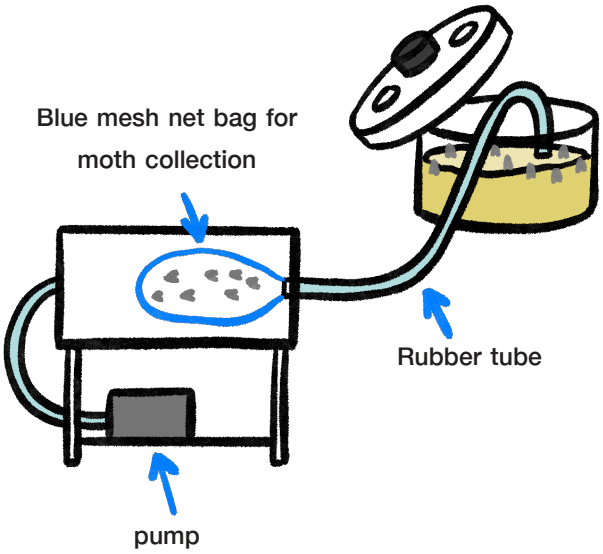


Figure 4.18 Step by step of mating and collecting rice meal moths

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.*

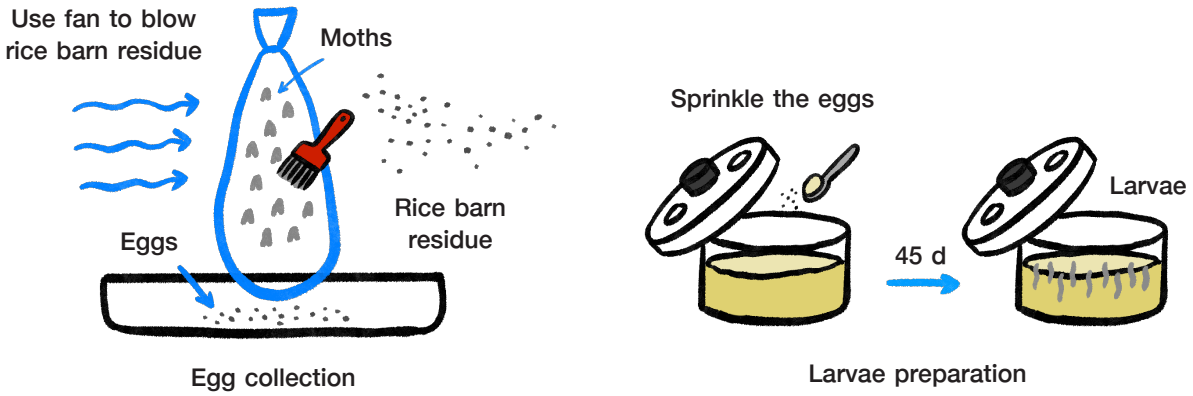


Figure 4.19 Step by step of egg collections from rice meal moth and caterpillar preparation

(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.

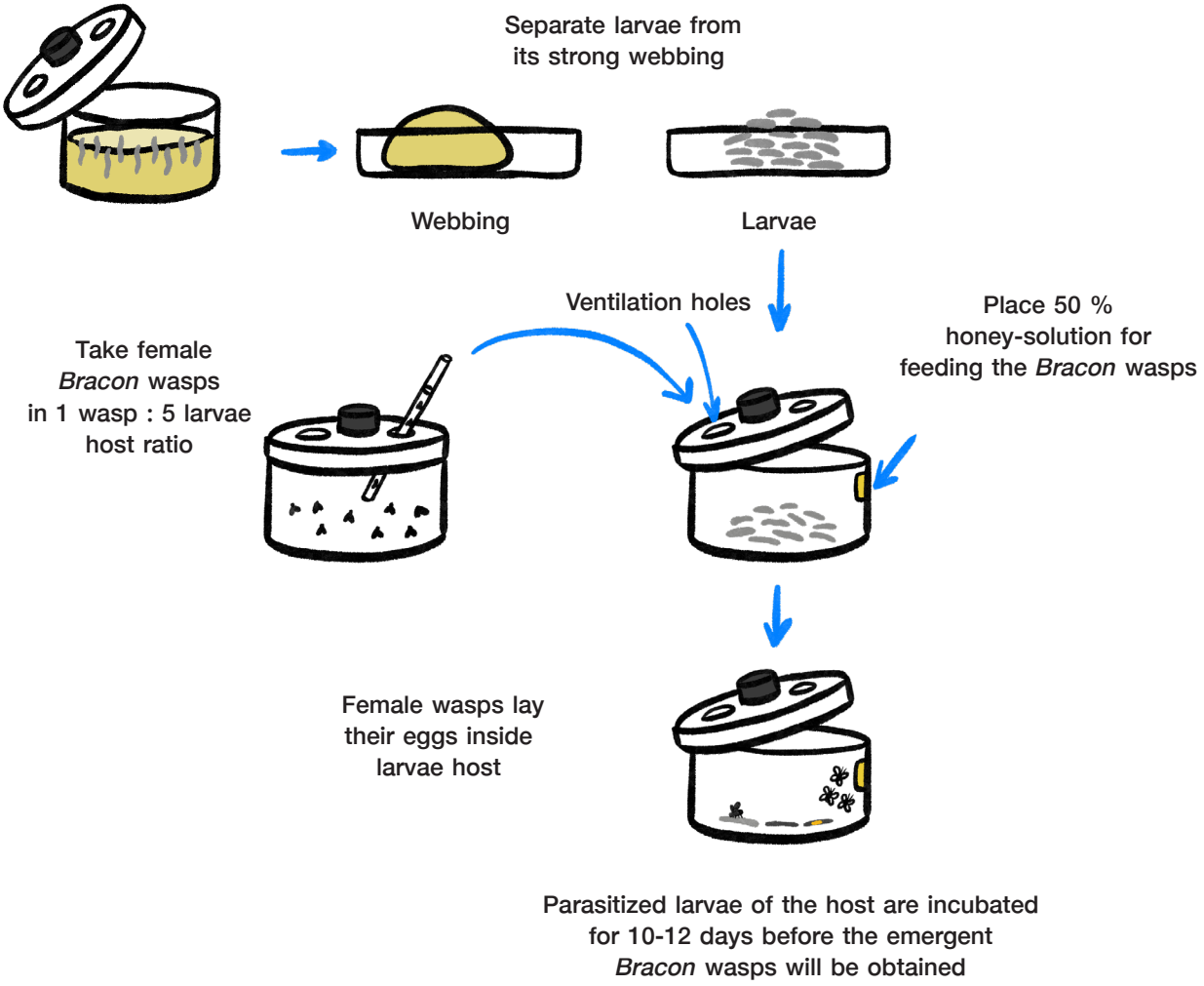


Figure 4.20 Step by step of rearing of parasitoid *Bracon hebetor*

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 methods to control coconut blackhead 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

involves three steps: (A) conidia production, (B) application of *Metarhizium anisopliae*, 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.

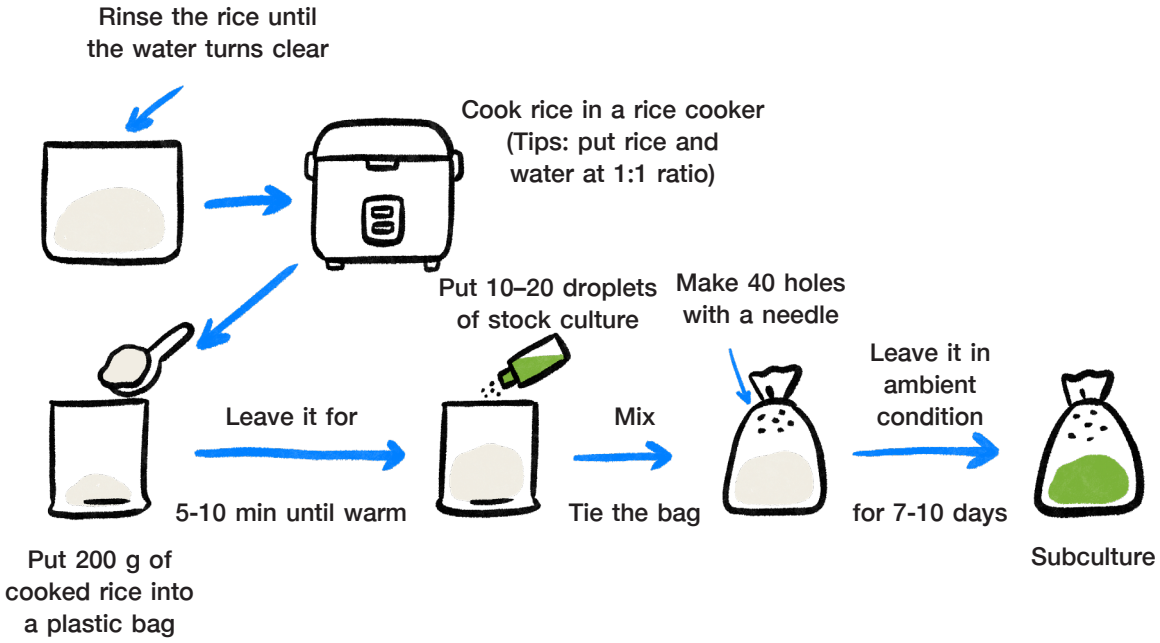


Figure 4.21 Step by step of conidia production

(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* infests 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 is dripping out).

- 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* grows 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.

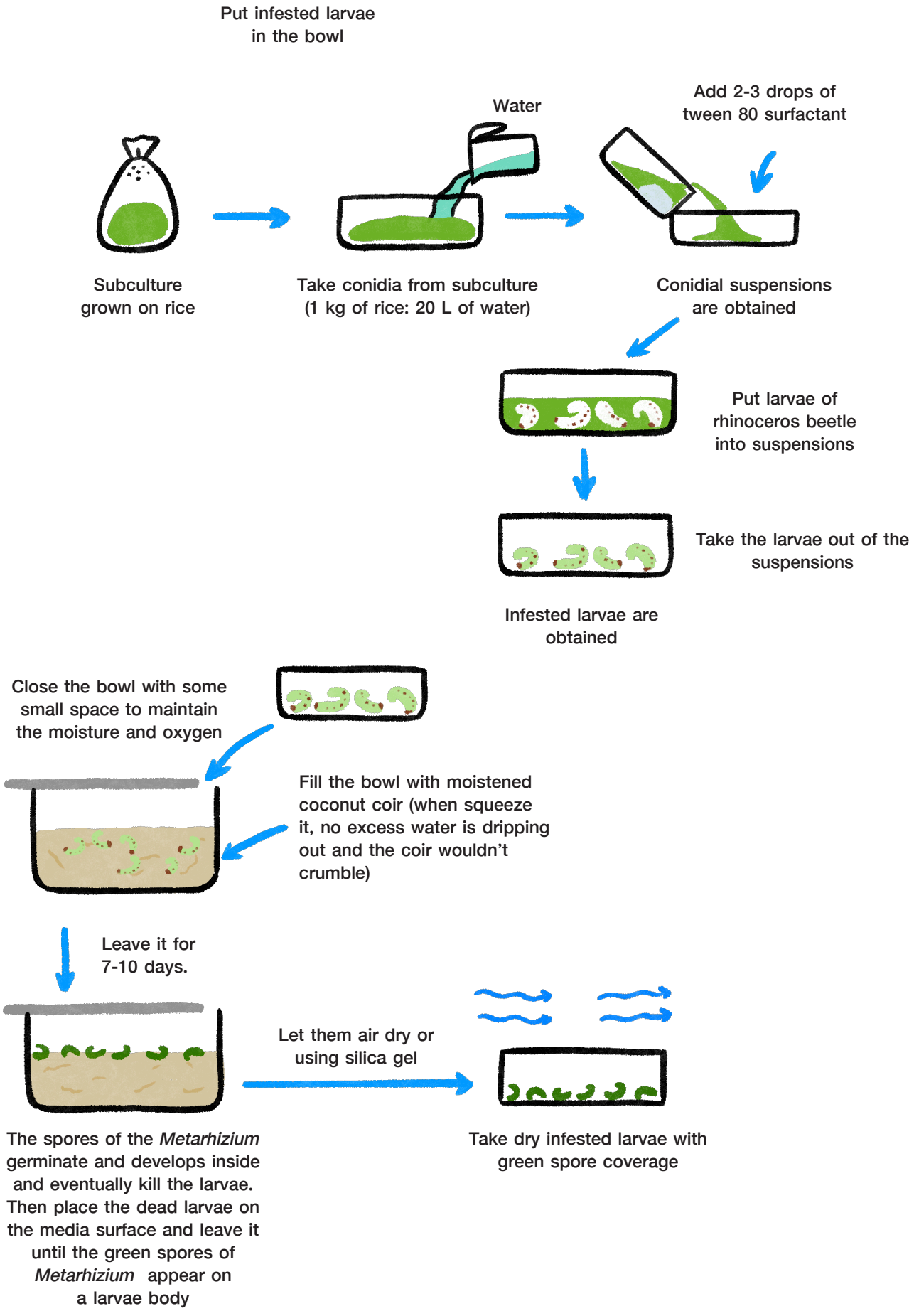


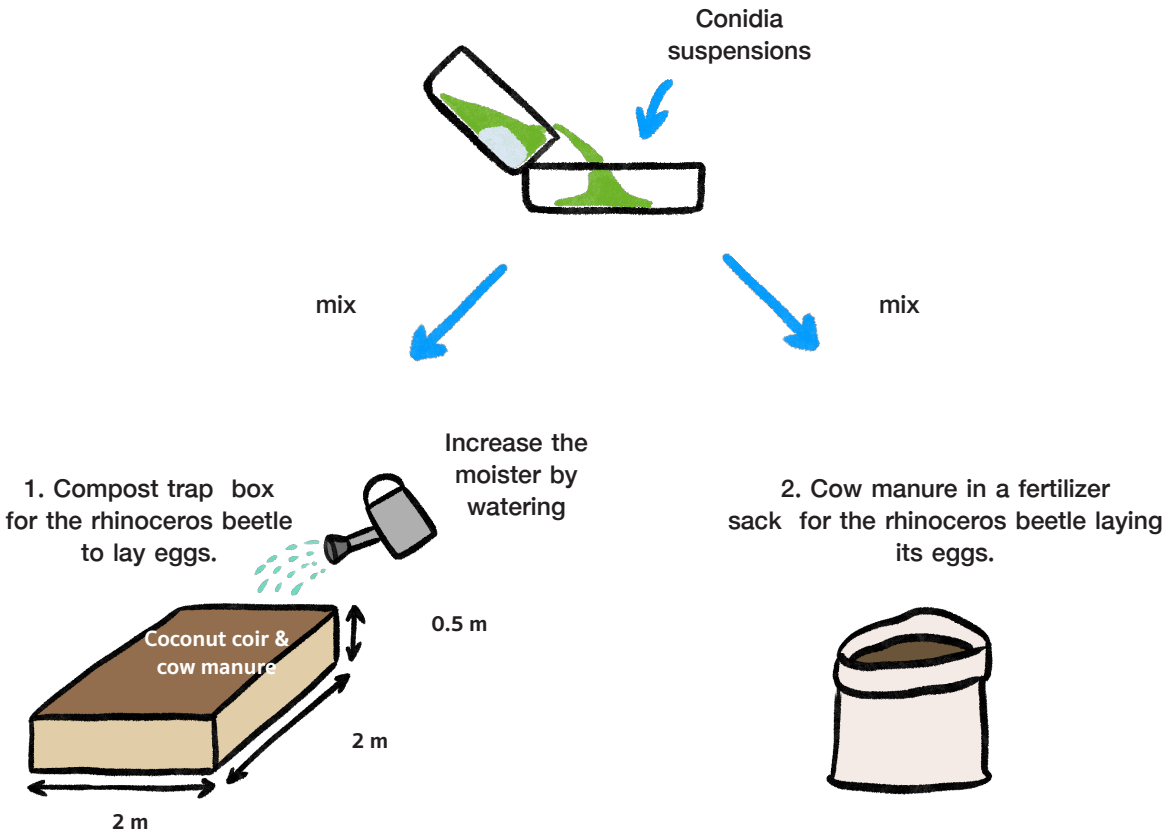
Figure 4.22 Preparation for *Metarhizium anisopliae* fungi culture

(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, and there should be two traps per rai.

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 recommended to place around the farm at 6 sacks/rai.



- After apply Metarrhizium conidia suspension into the trap, Keep the trap moist by watering from time to time.
- Two traps per rai is recommended.

- Soak cow manure sack (12 kg) in water and drain off the excess water.
- After apply *Metarhizium* conidia suspensioninto the sack.
- Trap are placed around the farm at 6 sacks/rai.

Figure 4.23 Preparation of compost baits as the breeding site

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.doa.go.th/plprotect/wp-content/uploads/Publieissue/5.Trichogramma.pdf**

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

is the modification of physical factors in the environment to minimize or prevent pest problem. These following methods are the examples of physical control that can be used in coconut farm:

- 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.

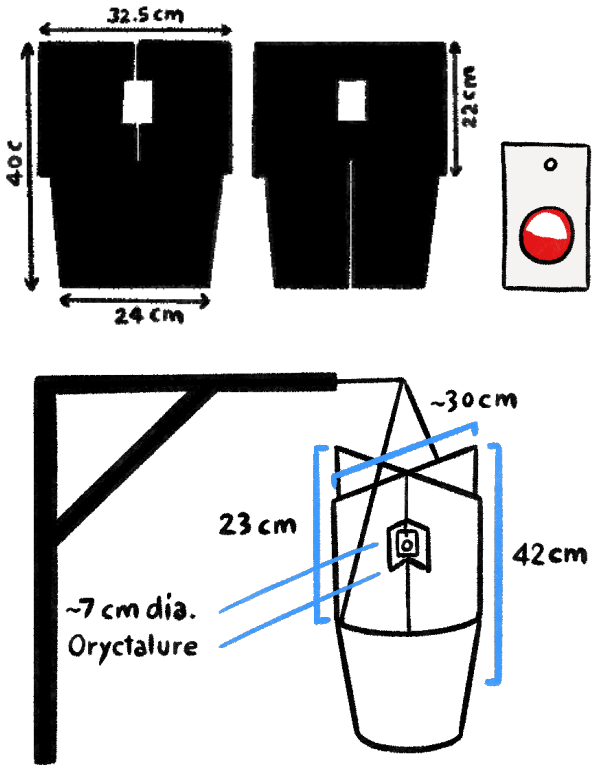


Figure 4.24 Pheromone for trapping the coconut rhinoceros beetle adults

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

is the manipulation of the crop production system or cultural practices to reduce or eliminate pest populations. These following practices are the examples of cultural control that can be implemented in coconut farm:

- 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.

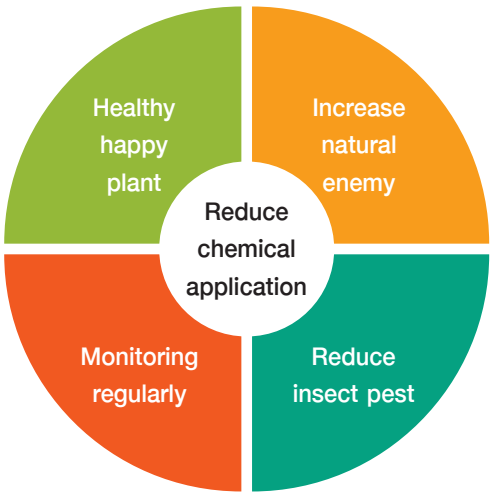
- Adopt intercropping to maintain farm diversification. Please see module 2 for more detail.

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 methods 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 enemy, reduce insect pest, and regularly monitor pest.

B. HANDS-ON PRACTICES

Exercise

Match the damage characteristics to the pest species producing the damage.

A 

B 

C 

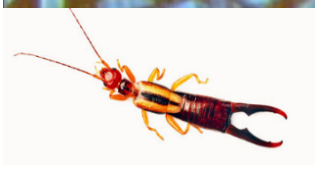
D 

 1

 2

 3

 4

 5

Match the appropriate management method to the given pest species.

A 

B 

C 

1

2

3

4

Note

Note

Note

Note

Module 5

POLLINATORS

OBJECTIVES

To know about insect pollinators, their usefulness for coconut farming, how to cultivate them 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 how to cultivate the two pollinators and use them commercially.

ACQUIRED SKILLS

The participants can:

1. Use stingless bees or Asian honeybees to pollinate coconut flowers

2. Keep stingless bees or Asian honeybees 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.

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

Question: What insects have you seen flying around coconut flower?

Answer: _____

_____

_____

_____

Coconut flower pollination

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

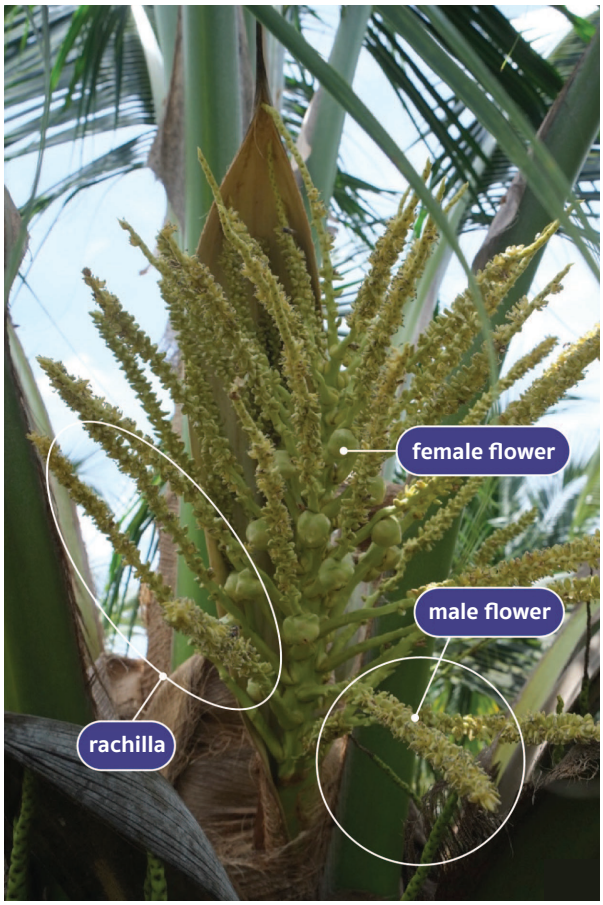
- Female flowers produce nectar with sweet smell attracting insects

- Pollen shed and stigma receptivity happen in the morning which coincides with the time insects are out to find foods.

- 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 possible 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

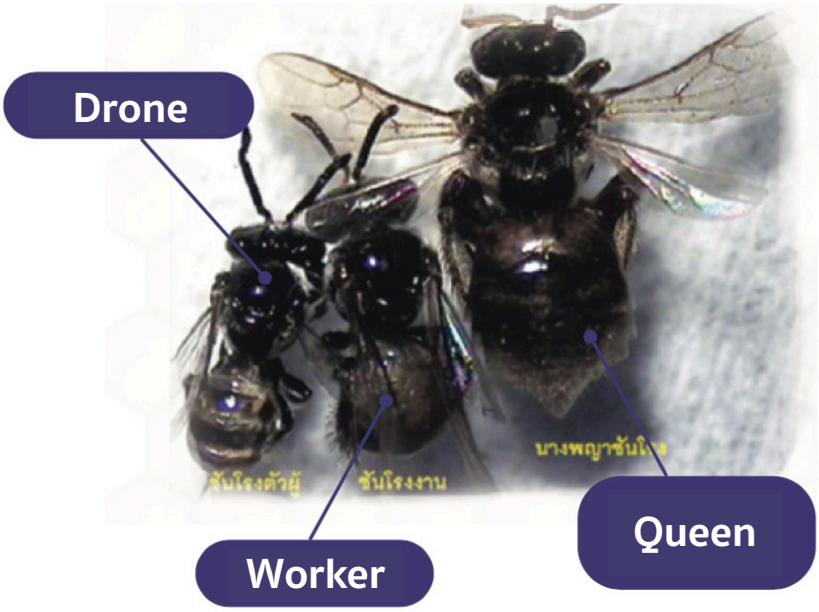
3. Drones (male)—mate with the queen

Stingless bee diversity

- More than 500 species in all tropical parts of the world; about 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

There are 4 stages in stingless bee life cycle:

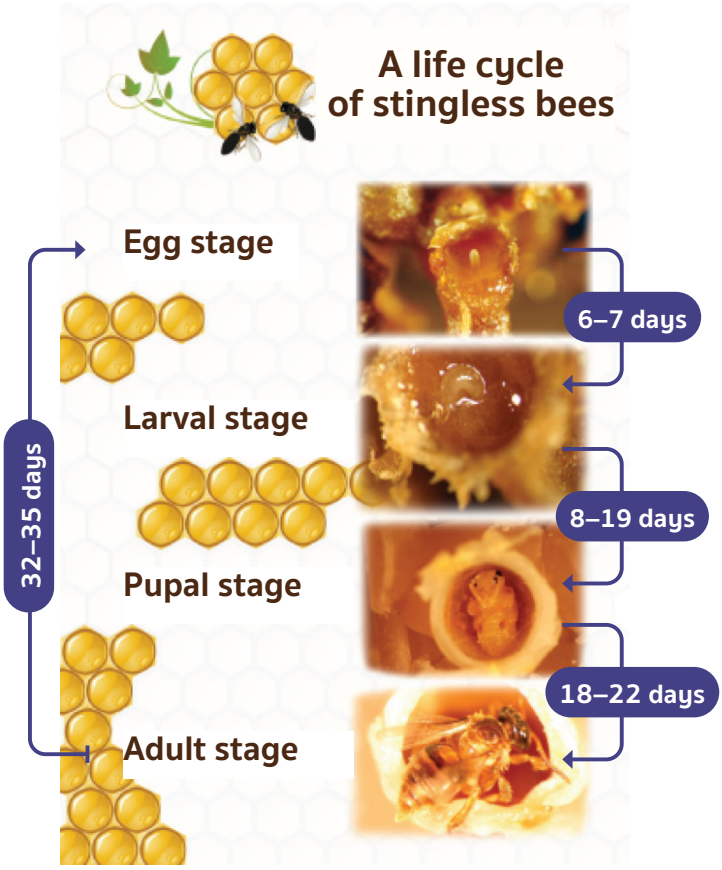
1. Egg stage: it is oval-shaped, lives in jelly; egg cups are in darker color than other stages. This stage lasts about 6-7 days.

2. Larval stage: A larva is C-shaped, floats in the liquid food and 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.

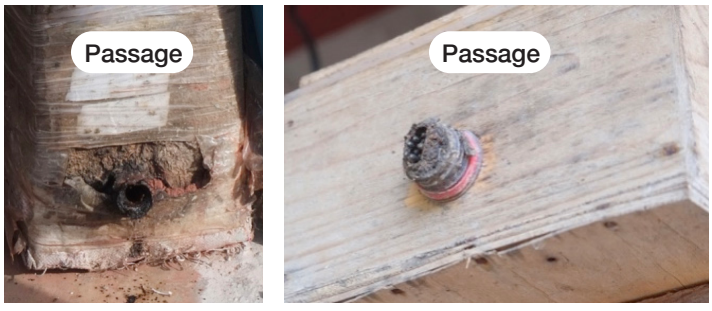
4. Adult stage: an adult punctures through the cup with help from young workers from outside the cup. Young adults are in light color, move slowly, and are darker in color with age. They have age-dependent responsibility. Young workers staying in the hive are responsible for cleaning, building brood cups, storing foods in storage cups. Older workers are responsible for flying out to get foods.

The period of each stage varies by the species of stingless bees.



Stingless beehive 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 bee hive compartments

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 meters 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

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

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.

An artificial hive made from coconut shell with a metal roof hanging above cosmos, a pollen source for stingless bees, and close to coconut trees

(Images: Mongabay https://news.mongabay.com/2020/09/a-philippine-stingless-bee-helps-boost-coconut-yields-and-empower-women)

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

(Image: Mongabay https://news.mongabay.com/2020/09/a-philippine-stingless-bee-helps-boost-coconut-yields-and-empower-women)

5.1.2 Culturing of stingless bees

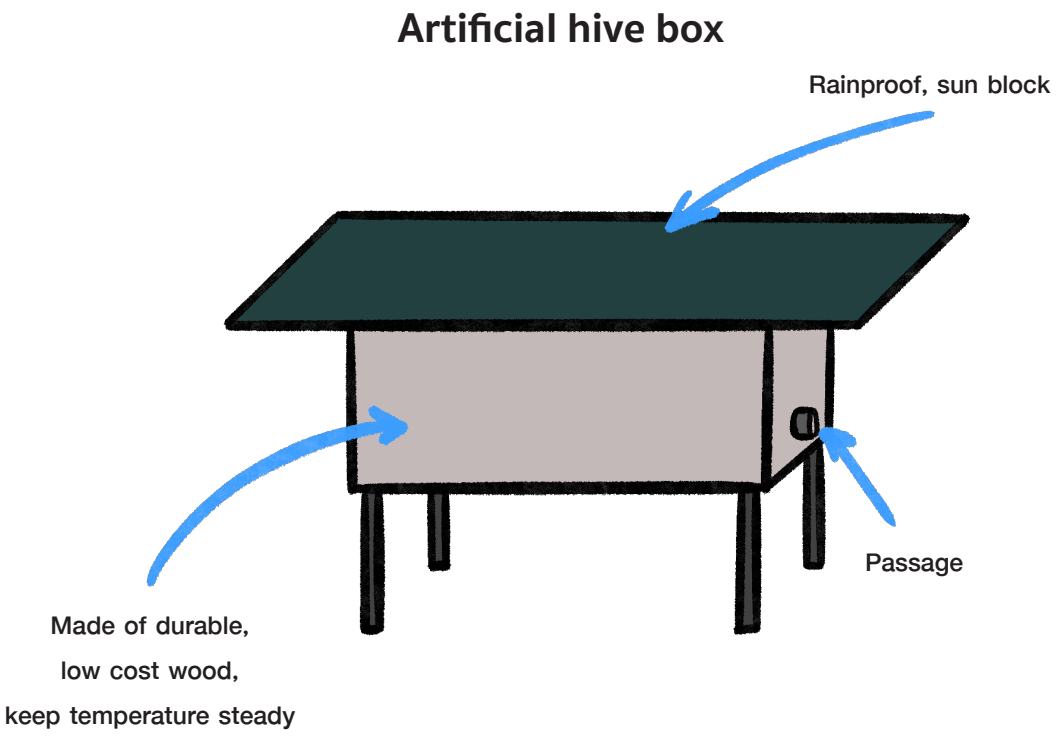
Species/varieties selection

- 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

New artificial box hives made of durable wood, low cost, keep temperature steady



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 spraying chemical in the farm

Hang or place the hives above ground

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

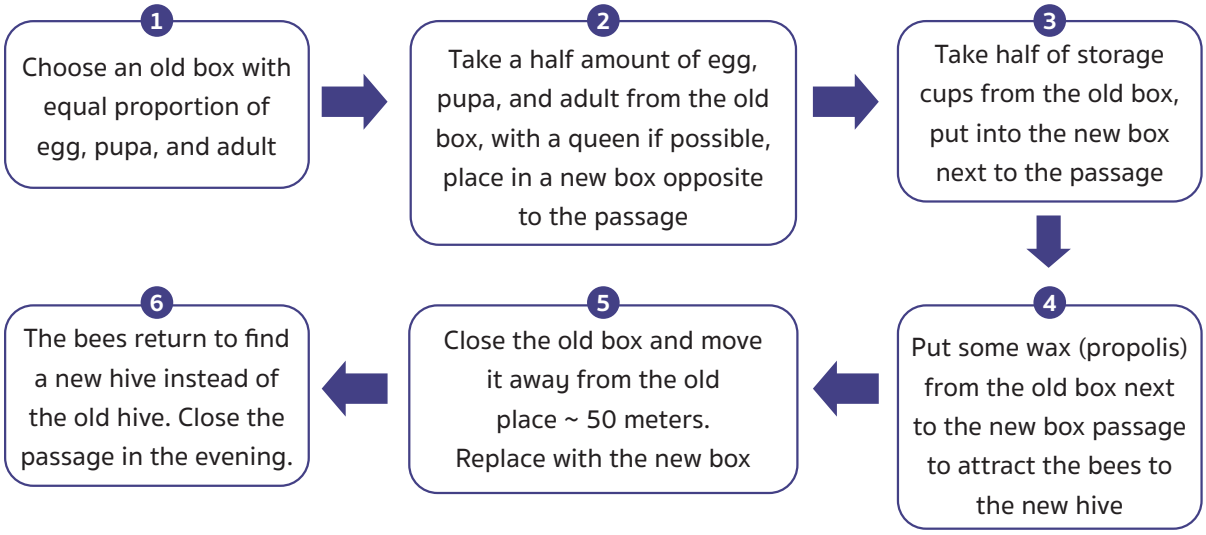
2. Take a half amount of eggs, pupas, and adults from the old box, with a queen if possible, place in a new box opposite to the passage

3. Take half of storage cups from the old box, put into the new box next to the passage

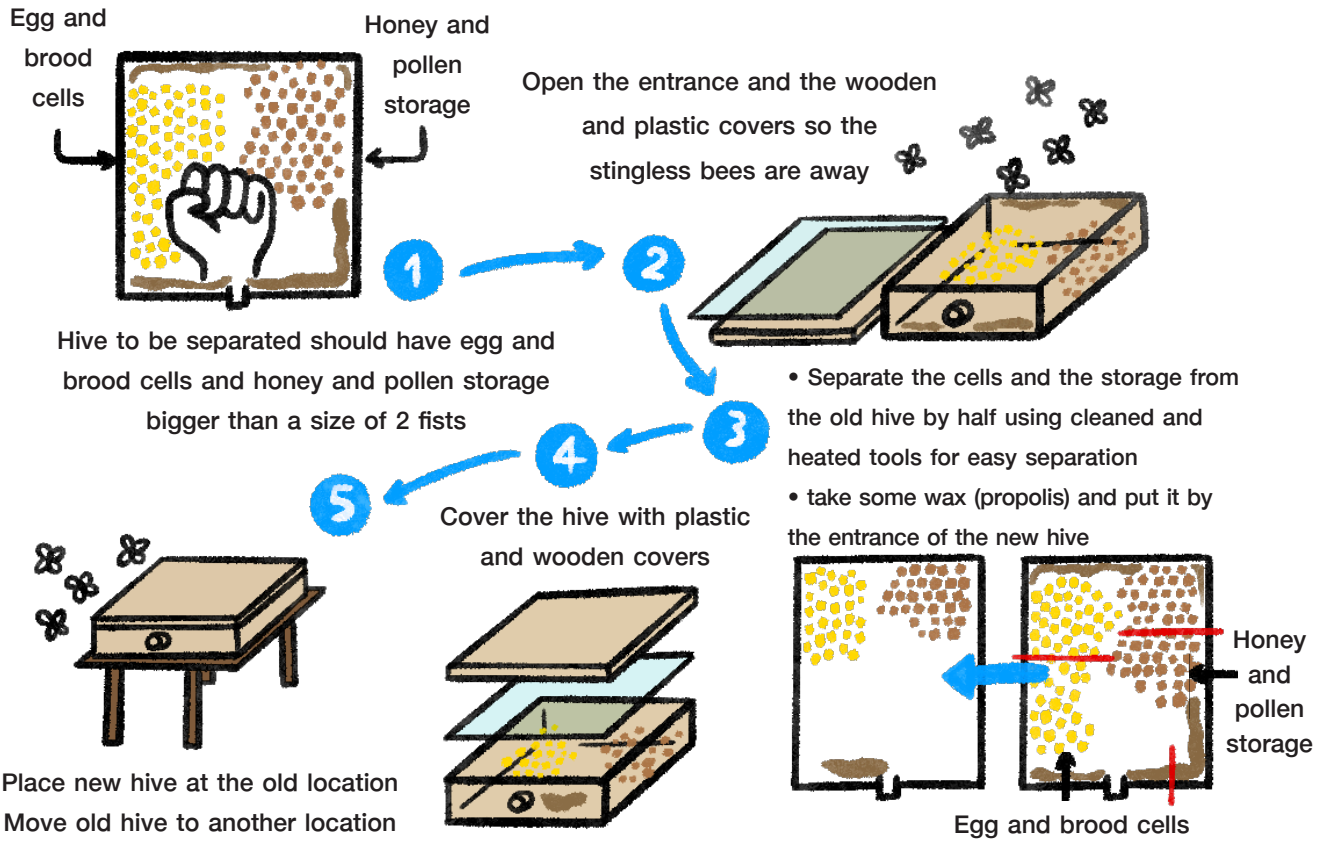
4. Put some wax (propolis) from the old box next to the new box passage to attract the bees to the new hive

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.



Artificial box hive division



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.

5.1.3 Stingless bee products

- Honey separate the storage cells from the hive, squeeze for honeys through a clean cloth

- 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 anti-biotic

- 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/ซันโรง/**

5.2 Asian honeybees

5.2.1 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: (Apply protective clothing any time working with Asian honeybees)

1. Buying beehive: less practiced, Asian honeybees do not like being disturbed by humans or 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 follow these steps:

1) Survey for natural hive, or overpopulated box hive

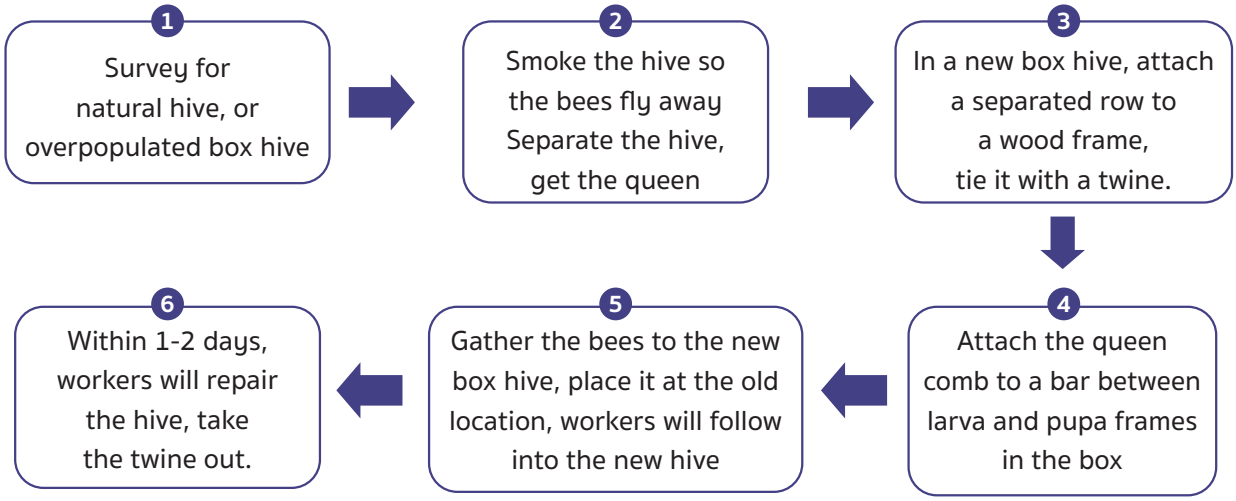
2) Smoke the hive so the bees fly away. Separate the hive, get the queen

3) In a new box hive, attach a separated row to a wood frame and 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.



Transferring of a hive

*** 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

Pollinators

- Stingless bee and Asian honeybee are effective coconut flower pollinators.
- Chemical application, particularly spraying is prohibited. This is perfectly adapted to organic farming.
- Stingless bee and Asian honeybee have different behaviors; farmers may choose one suitable for your farm management.

CLOSING

Questions for the participants:

1. Would you cultivate insect pollinators in your coconut farm?

2. If yes, which pollinator would you choose?

B. STUDY VISIT

Study visit to a commercial stingless bee farm

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

Some interesting points for the learning of the participants:

- 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?

NOTE

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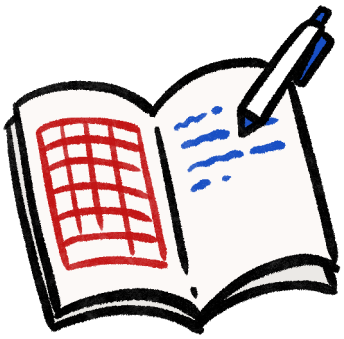
NOTE

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 the regenerative organic practices will make coconut farm sustainable.

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

Which one of these two pictures does look like your farm?

This farm seems to have an inappropriate farm management: untidy and 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.

This farm seems to have better farm management: green, clean and tidy. 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.

Coconut farm as a business

6.1 Business components

Why coconut farm is a business?

All kinds of business are composed of **three parts:**

1. Input factors: factors that are combined to produce output of goods, such as capital, labor, and utilities (water, electricity) etc.

2. Production unit: land, building, from which the products are produced

3. Market: customers, retailers who buy our product.

Apply these three elements of business to the coconut farm:

1. Input factors: capital, labor, fertilizers, pesticides and herbicides, etc.

2. Production unit: coconut farm, from which coconut fruits or other products such as pandan, banana, or fish are produced.

3. Market: collectors, factories or fresh markets, etc.

1) Input factors
Capital, labor, fertilizer, pesticides, herbicides etc.

2) Production unit
Coconut farm, etc.
Yields: coconut fruits and other crops.

3) Market
Collectors, factories, fresh markets etc.

Key dimensions of sustainable business

Successful and sustainable coconut business should take these three dimensions into account:

1. Economic dimension

Farmers have more income from other crops grown together with the coconut or other activities i.e., fish culture.

2. Social dimension

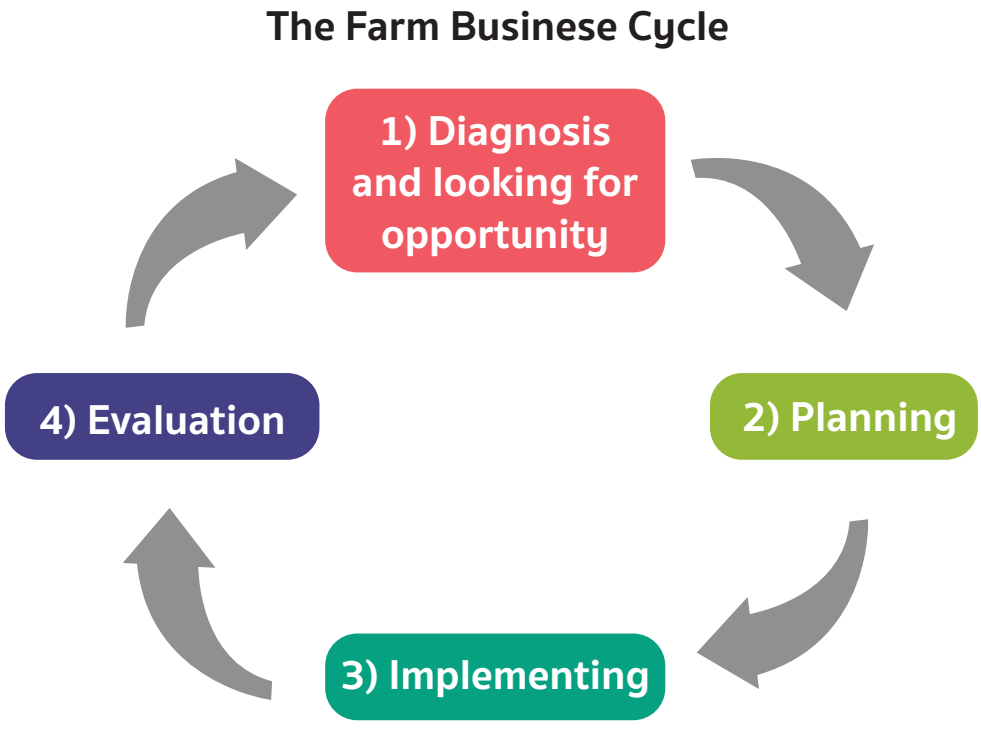
Farmers and people involving in the coconut farming business are healthy and not poisoned by toxic chemicals.

3. Environmental dimension

The environment is not polluted or damaged by chemical substances.

6.2 Business cycle

The farm business cycle is composed of **four steps:**



6.2.1 Diagnosis and finding opportunity

A. Know your farm

At the first step, you should know 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:

Example 1 This picture shows that in this sample coconut farm, there are 28 coconut trees, 12 banana trees, 5 bunches of vegetable fern, 5 bunches of lemon grass, 6 bunches of pandan and 5 fish.

According to the farm information demonstrated through the picture, the strength and weakness of this sample coconut farm can be identified as follows:

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)		

In addition to coconut, the sample farm grows other crops and implements fish culture. This is a farm strength in terms of income: apart from coconut, farmer can create income every week from selling other crops. However, a farm weakness is the smaller size of coconut fruits: small coconut fruits are not good sales or unable to sell in the high price. The farmer should find the appropriate method to increase the fruit size, i.e., watering the coconut palm more often.

In addition, the fishes can sell very well, so farmer may prepare to buy new fishes. At the same time, banana is seemingly difficult to sell, so it should be changed 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

B. Recording

What should be recorded?

1. Farm management:

Record of farm activities and management helps remember what works are completed and plan what and when the remaining works need to be proceeded. Like the sample in this table, you can see that in September 2020 which date you need to water your coconut, put the pheromone for trapping rhinoceros beetle, do weeding and harvest.

Example 2 Farm management table for September, 2020

Date	Irrigation	Fertilizer	Pest management	Harvest	Others
Sept. 1, 2020	/				
Sept. 2, 2020			Pheromone		
Sept. 3, 2020		Manure 20 kg/palms			
Sept. 4, 2020	/				
Sept. 5, 2020				/	
Sept. 6, 2020			Weeding		
Sept. 30, 2020				/	

2. Cost and income:

Financial record or accounting provides accurate data of income and cost to calculate whether the farm gets profits or losses and how much. Also, it is useful for the farm planning, i.e., what cost should be reduced or what crops should be added to gain more profits, etc.

Example 3 This table shows an accounting of a coconut farm. 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.

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 example,

Profit = Income – Cost or input

Profit: The positive gain remaining for a business after all costs have been deducted from income. On the other hand, if income is less than cost, it is called 'loss'.

Income: an amount of money you receive from selling your products or crop yield.

Cost: The necessary expenditures that must be made in order to run a business.

Cost can be divided to 2 types.

a. Variable cost can be varied or changed depending on the amount of yields and products, which may be divided into these following categories:

- Labor: applying fertilizers, weeding, harvesting, cleaning, etc.
- Management and maintenance: boat maintenance, etc.
- Materials or inputs: compost, pheromone, *Bracon* wasp, etc.
- Utility: electricity, water, telephone bill, boat engines, etc.

b. Fixed cost is usually fixed and constant in a period, such as rental fee or land tax.

Example 4 The table below shows how to identify variable and fixed cost and calculate the profit and loss of the farm.

- Variable cost is from hiring labor and purchasing materials (compost and *Bracon* wasp), which costs 5,640 THB in total.

- Fixed cost is from rental fee, which costs 1,000 THB/month.

- Profit is income (78,000) – variable cost (5,640) – fixed cost (1,000) = 71,360 THB.

To conclude, the sample farm gets the profit of 71,360 THB. However, this profit needs to be deducted 20,000 THB for the house consumption. Thus, the real available money of this farm is 51,360 THB.

	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**

	Item	Amount	Price/unit (THB)	Total	Remark
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 next step is to use the information or records for making a new plan to improve farm management and business with higher efficiency and income.

The plans of sustainable farm business should consider these following aspects:

a. Cost reduction: One method to decrease cost is to follow the regenerative organic practices and replace chemical inputs with organic ones. As shown in the example of farm expense record below, if any chemical inputs (red) are cut out, this farm can save a minimum of 3,400 THB.

Items	Price
Cover crops	- Pinto peanut 1 THB/seedling - Roundleaf bindweed 8 THB/bag
Bee	- Stingless bee boxed hive 1,500 THB, 4–5 boxed hives/rai = 4,500–6,000 THB/rai - Purchase only one time at the beginning
Pest management	- *Bracon* wasp 144–240 THB/rai/year, - Pheromone 500 THB/set (4 months), or 1,500 THB/10–20 rai/year - *Metarhizium* 100 g 200 THB, purchase only one time at the beginning (insecticide 1,000 THB/rai/year)
Organic fertilizer	- Compost 30 THB/kg, chicken manure 40 THB/kg - Vermicompost 12 THB/kg (chemical fertilization 2400 THB/rai/year)

Items	Price
Intercrop	- Pandan 20 THB/plant - Vegetable fern 35 THB/bunch - Lime 40–50 THB/plant - Banana 15 THB for sucker or 35 THB for tissue culture - Guava 6–20 THB - Papaya 10 THB/plant, tissue culture (sex determined) 50 THB, grafting 50–70 THB

As shown in the next table, conventional farm has total income of only 60,000 THB, while the cost is 10,800 THB. Thus, this farm still has profit, but of only 49,200 THB. Meanwhile, the other farm, who follows the regenerative organic agricultural practices (ROC farm), earns higher income from intercropping (64,150 THB), pays lower cost (4,100 THB) by cutting chemical inputs, and consequently gets higher profit (60,050 THB).

Conventional farm				ROC farm			
Content	**Amount**	**Price/ unit (THB)**	**Total (THB)**	**Content**	**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. Compost	100	20	2,000
2. Herbicide	1	300	300	2. Cover crop	50	8	400
3. Hire labor to spray herbicide	1	300	300	3. Compost	7	100	700
4. Insecticide	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**

b. Intercropping: Coconut farms should contain other crops, e.g., vegetable, vegetable fern, pandan, etc. and implement other activities, e.g., fish culture or product processing to diversify and potentially increase farm income. The table below shows the example of intercrops grown well with coconut and estimated costs and benefits of each intercrop. You as a farmer need to plan and choose ones that are suitable to grow in your farms. The details of the intercropping will be in Module 2.

Plants	Cost/rai (THB)	Price/rai (THB)	Profit/rai (THB)	Advantage	Disadvantage
Banana	10,407	12,840	2,433	- High demand	- Need supporting
Lemon grass	2,600	10,000	7,400	- Short life - Easy to propagate	- Use a lot of labor at harvest time
Pandan	15,000	21,600	6,600	- Can harvest all year	
Vegetable fern	19,200	28,600	9,400	- Can harvest all year	- Need high humidity
Guava	56,100	135,100	79,000	- High demand	-High investments -Need supporting, bagging

c. Better management: Farms should be regularly maintained and managed in the sustainable way, including removing old leaves, increasing irrigation channels, applying more organic fertilizer, growing cover crops.

6.2.3 Implementation

After having a good plan, the next step is implementation: to act or implement as planned and keep monitoring it. 'Timing' of taking an 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 below.

6.2.4 Evaluation

The last step of business cycle is evaluation: to evaluate and conclude the result of plan implementation and the progress of farm business.

According to the same example, the evaluation shows that the real income is lower than estimated since the size of coconut yields are small. The result suggests that 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.

Indicators	Expected outcome	Actual outcome	Remark
1. Yield	20,000 fruits	15,000 fruits	No irrigation in dry season
2. Price	10 THB	8 THB	Low price due to small fruits
3. Income	200,000 THB	120,000 THB	Decreased due to yields 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 decreased but input cost increased

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 withoutstingless 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

Example 2: 20-rai coconut with fish

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.

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!

B. EXERCISE

DO THIS

Exercise 1: Find your farm's strength and weakness

Write down what you have in your farm in 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 and 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**
Others			
3. Honey	10	120	**1,200**
4. 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+1,100=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			
2.2			
Others			
3.			
4.			
Variable Cost			
1. Labor			
1.1			
1.2			
1.3			
1.4			
1.5			
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**

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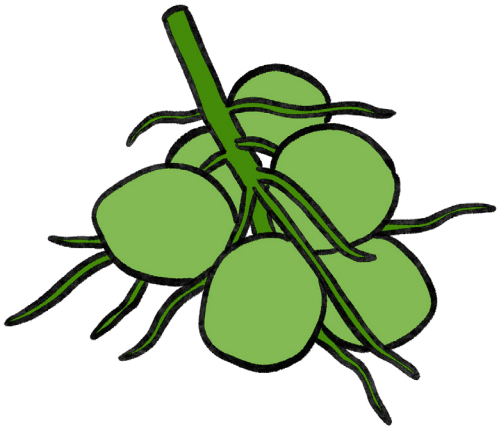
Module 7

TRANSFORMING YOUR FARM TO A REGENERATIVE ORGANIC FARM



OBJECTIVES

To plan with farmers to transform their farms step by step to be regenerative organic.

ACQUIRED KNOWLEDGE

Participants:

Learn how to plan to transform their farm to regenerative organic agriculture.

ACQUIRED SKILLS

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.

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

7.1 Identify problems you found in your farm

DO THIS

Tick ✓ in the box that fits best answers to see the problem in 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?						

7.2 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

7.3 Activity plan of transforming your farm to ROC

DO THIS

Write down what you want to implement in your farm following the given topics within a specific timeframe.

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

Write down the monthly plan of your farm in the table below (continued).

กิจกรรม	เดือนที่																	ผลที่คาดว่าจะได้รับ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

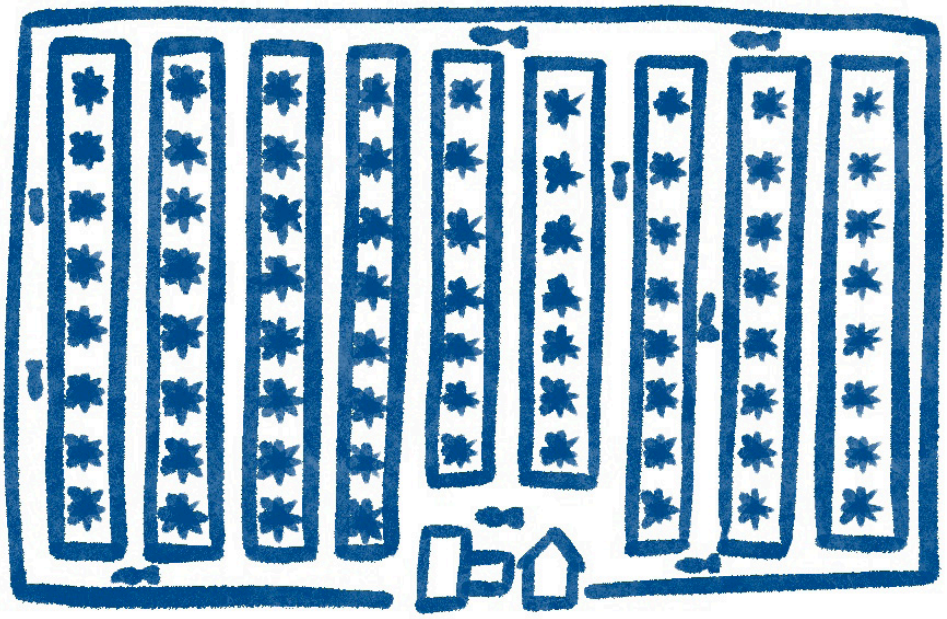
DO THIS

7.4 Draw your farm

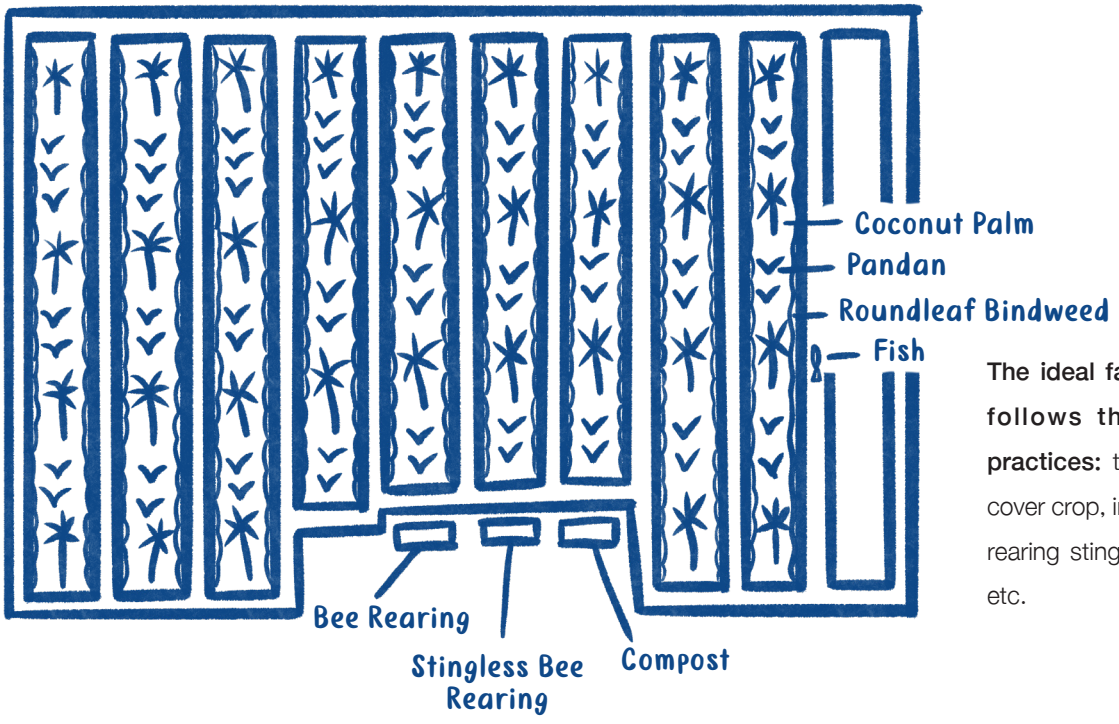
After having learned and practiced about the regenerative organic agriculture, you are encouraged to imagine the ideal farm that you want to transform your current farm into. How is your ideal farm going to look like? What do you wish to apply to your farm, i.e., cover crops, intercrops, stingless bees, etc.? Then draw it on the next blank page.

Having finished drawing your ideal farm, you might compare it to your current farm that you once drew at the beginning of the training to see positive progress that you have gained from the training.

Example: The upper picture is the coconut farm before taking ROC practices. There are only coconut and fish in the farm. Meanwhile, the lower picture is the ideal farm that follows the ROC practices. There are cover crop, intercrop, rearing stingless bee etc.



The coconut farm before taking ROC practices: there are only coconut and fish in the farm.



The ideal farm that follows the ROC practices: there are cover crop, intercrop, rearing stingless bee etc.

DO THIS

Exercise

Draw your coconut farm that you want to have or to transform your current farm into after having attended the training of the regenerative organic practices.

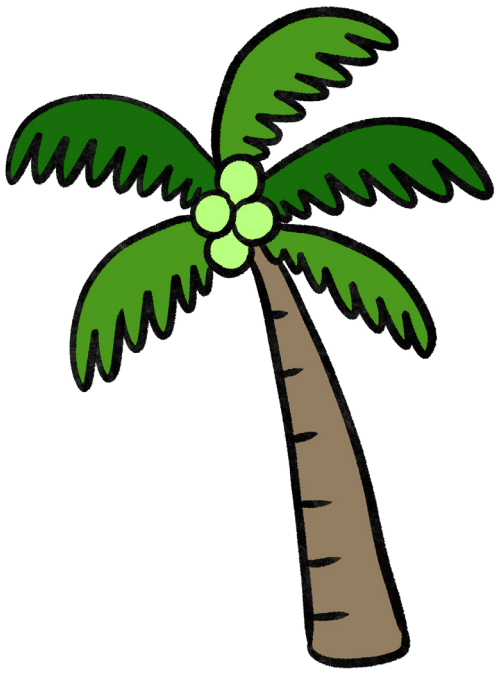
Closing words

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 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.”



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ANNEXES

ANNEX A EVALUATION FORMS
ก. แบบประเมินผลการฝึกอบรม

Regenerative Organic Agriculture Training – Evaluation Form for Farmers

โครงการ การฟื้นฟูด้วยเกษตรอินทรีย์ "Regenerative Coconut Agriculture Project (ReCAP) หรือ รีแคพ"

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
- ◯ (เกษตรกรอายุ มากกว่า 35–55 ปี) Middle-agedfarmers
- ◯ (เกษตรกรอายุ มากกว่า 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)

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