Preface

Soil degradation processes such as drought, soil erosion or soil pollution are occurring frequently, and as a result, land fertility or productivity has been declining. The discharge to downstream of agricultural chemicals applied in farmland causes severe degradation in water quality.

Therefore, attention has been focused on more sustainable farming practices. Sustainable farming practices refer to the production of foods and fiber materials in harmony with the natural environment.

Following our earlier publication '*Sustainable Agriculture with Organic Fertilizer*', this guidebook is published with the hope of popularizing sustainable farming practices. Special focus is given on compost, manure, granular compost, liquid fertilizer, bio-pesticide, charcoal and wood vinegar, conservation tillage, buffer strip, agro-forestry and settling pond, as easily adoptable techniques.

We hope this guidebook is useful for promoting sustainable farming practices through the extension activities by facilitators of universities or NGOs and for enhancing the deeper perception of local farmers or school children concerning the benefits of sustainable agriculture.

1 February, 2009

Machito MIHARA and Akimi FUJIMOTO

Editors in Chief

Editors in chief

Machito MIHARA and Akimi FUJIMOTO

Tokyo University of Agriculture, Japan

Associate Editors

Tokyo University of Agriculture (TUA)

Keishiro ITAGAKI, Hiroki INAIZUMI, Aqil MUHAMMAD,

and Collin ANKERSON

Institute of Environment Rehabilitation and Conservation (ERECON)

Takashi UENO and Chika ISHIYAMA

Kasetsart University (KU), Thailand

Thawansak PHAOSANG

Khon Kaen University (KKU), Thailand

Vidhaya TRELO-GES and Mongkon TA-OUN

Association of Environmental and Rural Development (AERD), Thailand

Lalita SIRIWATTANANON and Jeeranuch SAKKHAMDUANG

Royal University of Agriculture (RUA), Cambodia

Bunthan NGO and Chenda SENG

Authors

Akimi FUJIMOTO (TUA, Japan): Chapter I

Yohei HASHIMOTO (Gifu Univ., Japan): Chapter II

Hiroki INAIZUMI (TUA, Japan): Chapter III

Keishiro ITAGAKI (TUA, Japan): Chapter I

Sei KAWAMURA (TUA, Japan): Chapter II

Machito MIHARA (TUA, Japan): Chapters I, II, III

Aqil MUHAMMAD (TUA, Japan): Chapters I, II, III

Bunthan NGO (RUA, Cambodia): Chapter II

Hiromu OKAZAWA (TUA, Japan): Chapter II

Thawansak PHAOSANG (KU, Thailand): Chapter II

Yu SAITO (TUA, Japan): Chapter II

Jeeranuch SAKKHAMDUANG (AERD, Thailand): Chapters I, II, III

Lalita SIRIWATTANANON (AERD, Thailand): Chapters I, II, III

Kiyoshi TAJIMA (TUA, Japan): Chapter II

KotaroTAKARADA (TUA, Japan): Chapter II

Mongkon TA-OUN (Khon Kaen Univ., Thailand): Chapter II

Julian TORILLO Jr. (TUA, Japan): Chapter II

Vidhaya TRELO-GES (Khon Kaen Univ., Thailand): Chapter II

Kenji YOKOTA (TUA, Japan): Chapter II

(Listed alphabetically)

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I. Introduction

1.1 Environmental problems of recent farming practices

Remarkable changes in agricultural systems have occurred in developing countries as many governments have subsidized agriculture to ensure an adequate food supply. As a result, the majority of farmers came to apply agricultural chemicals, such as chemical fertilizer, herbicide or pesticide, to maintain high levels of crop yields. However, the overuse of agricultural chemicals has damaged the long-term fertility and productivity of farmland.

Agricultural chemicals that are released from farmland cause the degradation of the water environment. This degradation is progressively accelerated with the transport of soil particles caused by soil erosion (Fig. 1-1). Soil erosion also causes deterioration in soil quality by washing off humus of the topsoil. The nutrients from the eroded sediments then move downstream and pollute water courses and water bodies.

Fig. 1-1 Soil erosion features

Pesticides are generally composed of toxic components, and some nutrients such as nitrogen or phosphorus are causing eutrophication (Fig. 1-2). Eutrophication is the process whereby water bodies receive excess nutrients that stimulate rapid growth of plankton and other living things in water bodies. This enhanced growth reduces dissolved oxygen and can cause other organisms to die.

Fig. 1-2 Eutrophication of pond

The practice of burning (Fig. 1-3) carried out by small-scale farmers is deemed necessary, as this is a very cheap and easy method to clear residues and to prepare for the next cultivation. However, heat during burning kills various beneficial microorganisms or soil animals. Also the nutrient components in plant residues are lost through burning.

Fig. 1-3 Burning practices

The application of herbicides and pesticides (Fig. 1-4) without understanding safe usage results in severe problems, such as the contamination of agricultural products or human diseases, especially skin cancer (Fig. 1-5). Thus, guiding local farmers to the safe usage of chemical pesticide must be given high priority (Fig. 1-6).

Fig. 1-4 Spreading pesticide without safety precautions

Fig. 1-5 Skin cancer

Fig. 1-6 Guidelines for safe usage of chemical pesticide

1.2 Principles of sustainable farming practices

Sustainable agriculture constitutes three main factors of natural environment, economic profitability and social equity (Fig. 1-7). Although an agricultural system depending on agricultural chemicals may increase food and fiber production in a short period, it causes various environmental problems. Also this system allows fewer farmers to produce the majority of food and fiber.

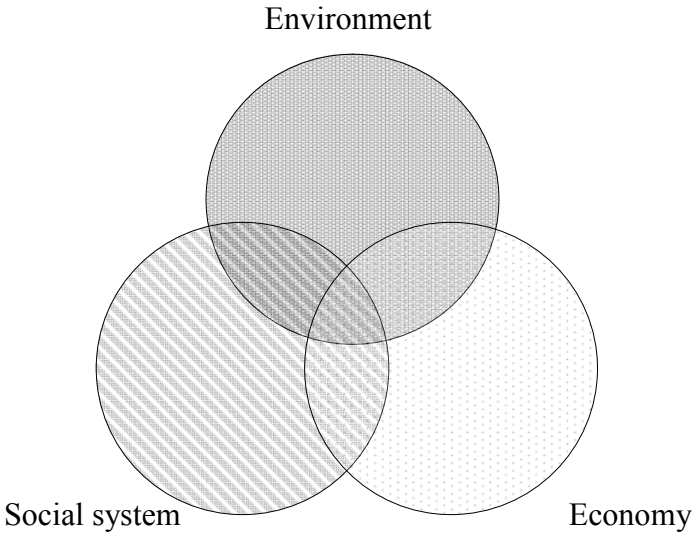


Fig. 1-7 Three important factors of sustainable agriculture

As environmental awareness increases, many farmers in different areas are starting to change to more sustainable farming practices. Although it is difficult to define “sustainability” in agriculture, there are many farming practices that lead to sustainable agriculture, such as organic farming, alternative agriculture, integrated farming, agro-forestry or sufficient agriculture.

The benefits of sustainable farming practices may be summarized as follows.

1) Sustainable farming practices are based on the use of renewable and/or recyclable resources. The application of renewable resources in the farming system can be advantageous for the environment. For example, plant and animal residues can be used to make compost which can replace chemical substances.
2) Sustainable farming practices protect the whole environmental system so that natural resources can continually regenerate. The rotation farming system practiced by a minority of farmers in mountainous area allows the forest to re-grow, by cutting only small shrubs and keeping larger trees.
3) Sustainable farming practices improve the quality of life of individuals and communities. In order to conduct sustainable agriculture, farmers practice many activities that help generate income with lower expenditure.
4) Sustainable farming system is profitable. To pass on knowledge about the sustainable farming practices from one generation to the next is beneficial for young people. Discussing sustainable farming practices between different communities also strengthens the integration of knowledge among local people.

II. Sustainable farming practices

Sustainable farming practices have been focused and implemented to achieve sustainable agriculture and environment. Nowadays, there are many sustainable farming practices being studied and proposed. The following sustainable farming practices, such as compost, manure, granular compost, liquid fertilizer, bio-pesticide, charcoal and wood vinegar, conservation tillage, buffer strip, agro-forestry and settling pond, are applicable at farmland by local farmers. However, these practices may be changed or modified to fit with local materials or custom.

Fig. 2-1 Sustainable farming practices applied in sloping area, Chiang Rai, Thailand

2.1 Compost

Compost, a kind of organic fertilizer made from plant residue, is an effective material for improving physical and chemical properties of soils. The decomposition process with microorganisms takes 1 to 3 months. During fermentation, the temperature of the materials may increase to 50 to 70 degrees Celsius. Compost is advantageous for increasing soil organic matter, enhancing aggregation and conserving soil moisture.

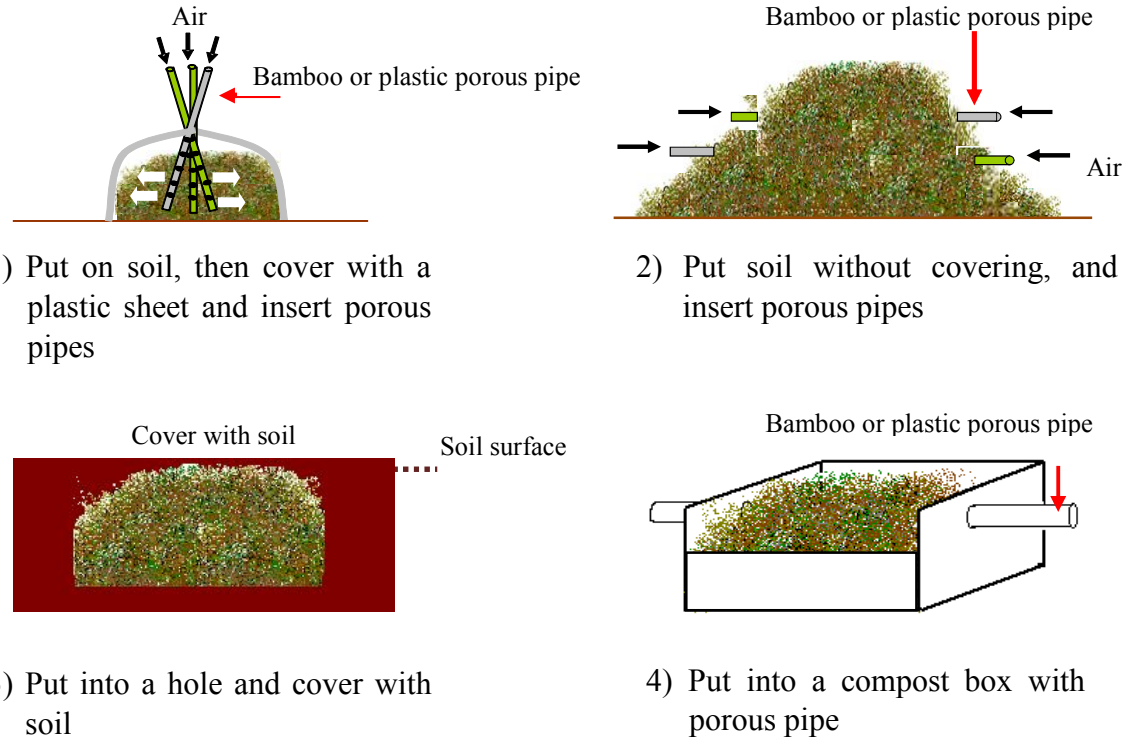
2.1.1 Materials for making compost

- Plant residues such as rice straw, sugar cane leaves, bean residues, sawdust, corn residues, grass, leaves, etc.
- Healthy soil (dark, fine and moist)
- Farmyard manure
- Effective microorganisms for composting

Fig. 2-2 Plant residues as material for compost

2.1.2 How to make compost

There are many styles for making compost. Fig. 2-3 shows popular composting ways among local farmers.



1) Put on soil, then cover with a plastic sheet and insert porous pipes

2) Put soil without covering, and insert porous pipes

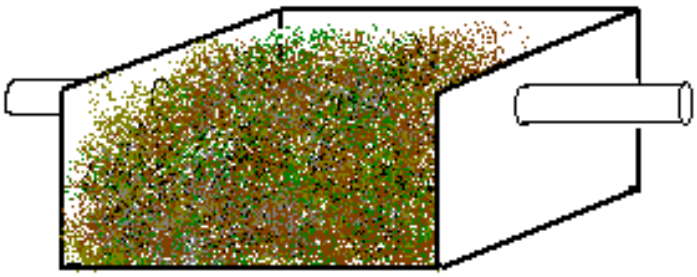
3) Put into a hole and cover with soil

4) Put into a compost box with porous pipe

Fig. 2-3 Various composting styles

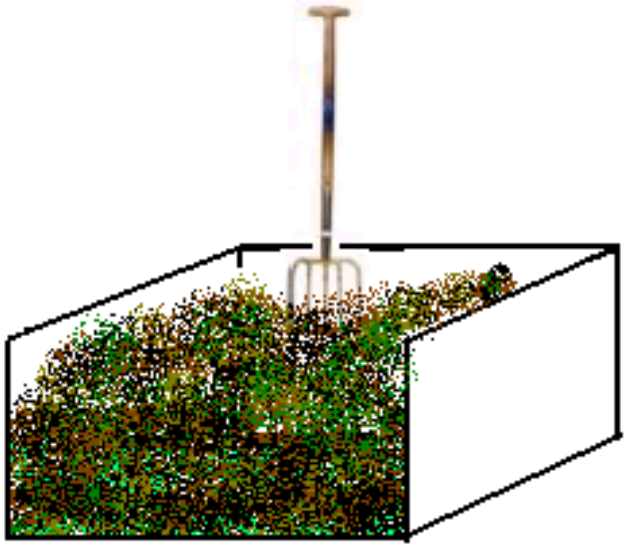
2.1.3 Procedure for making compost

1) Arrange plant residues, soil and/or farmyard manure into compost box



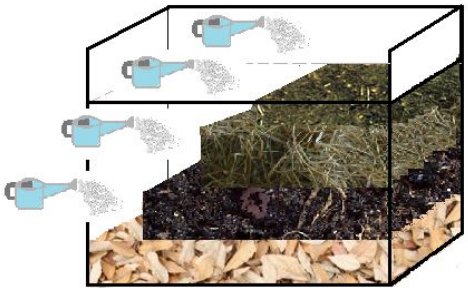
2) Supply water to the materials until moist and compaction, and then cover the compost box to avoid rainfall

3) If there is no air pipe, mix the materials every week



2.1.4 Composting technique

Type 1: Make layers according to type of materials and supply water to every layer



Type 2: Mix all materials, and then supply water to the materials until moist

Remarks:

- Nutrients in compost and fermentation time vary depending on raw materials.
- Effective microorganisms added to raw materials speed up the fermentation process.
- Raw materials with higher nitrogen content help speed up fermentation.
- Three important factors to enhance decomposition are moisture, air and microorganisms.

Fig. 2-4 Making compost in compost boxes in Kompong Cham, Cambodia

2.2 Manure

Excreta of livestock such as cow or chicken dung include rich nutrients and organic matter. Through the fermentation process, the excreta turn into good organic fertilizer called manure. However, improper treatment of livestock excrement may lead to a serious environmental problem such as the outflow of nitrogen, phosphorus, pathogen or pest, in addition to odor pollution.

2.2.1 Materials for making manure

- Any kind of livestock excrement such as cow or chicken dung

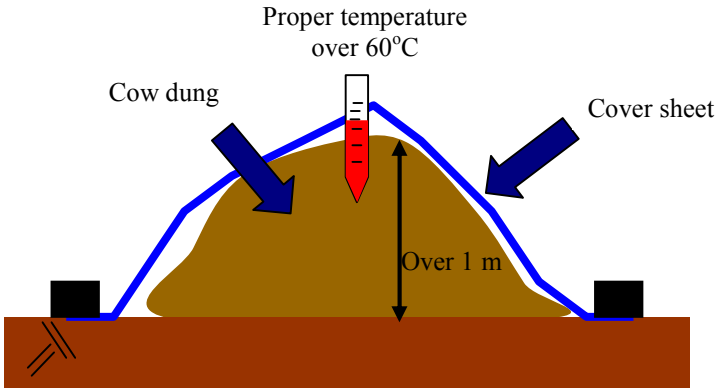


Fig. 2-5 Heap of livestock excrements

2.2.2 How to make manure

Livestock excrement should be put together to make a heap higher than 1 m and covered with a plastic sheet to increase the temperature during fermentation (Fig. 2-5). Generally, it takes a month to make fermented manure.

Fig. 2-6 Cow dung before and after 1 month fermentation

Remarks:

- Fermentation process is important for eliminating pathogens or dangerous microorganisms such as E.coli.
- Addition of effective microorganisms speeds up the fermentation process.
- There are 3 important factors to enhance the fermentation of livestock excrement; moisture, air and microorganisms, as well as plant residue composting.

Fig. 2-7 Heap of cow dung

2.3 Granular compost

As the density of conventional compost at around 1.9 g/cm^3 is smaller than soil particles at 2.7 g/cm^3, rainfall or surface runoff may wash off compost easier than soil particles. To increase the resistance against rainfall or surface runoff and to make compost remain on soil for long time, granular compost is beneficial. Also, granular compost makes it easier for farmers to transport and broadcast organic fertilizer on farmland compared with applying conventional compost, as its shape is granular.

2.3.1 Materials for making granular compost

- Any kind of compost made from plant residues or livestock excrement
- Clayey soil
- Molasses

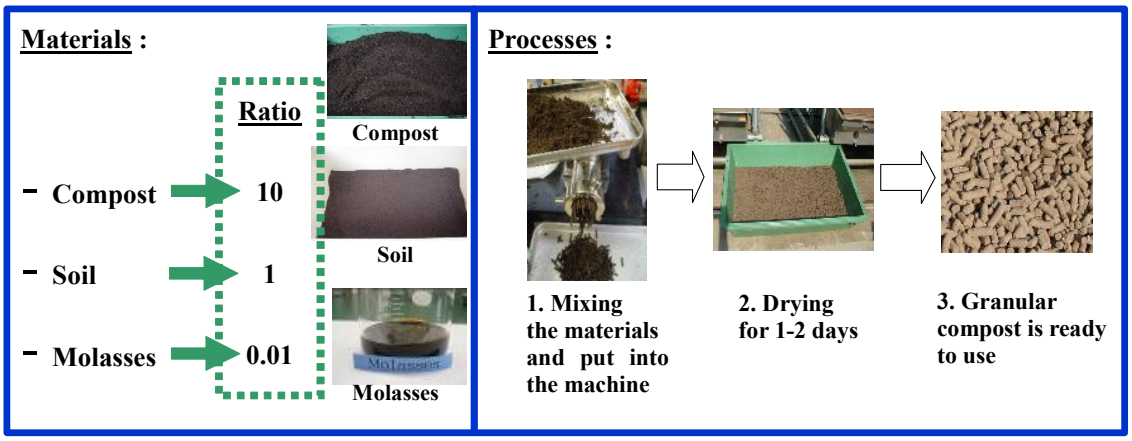


Fig. 2-8 Materials and processes for making granular compost

2.3.2 How to make granular compost

The mixing ratio among compost, clayey soil and molasses should be

10 : 1 : 0.01 as shown in Fig. 2-8. Clayey soil and molasses work as a binder of compost. Also, water may be added to the process of making granular compost.

There are 2 ways to make granular compost; one is by hand and the other by mincing machine (Figs. 2-9, 2-10). Mincing machine of extruder type helps to make granular compost faster.

Fig. 2-9 Granular compost produced by hand

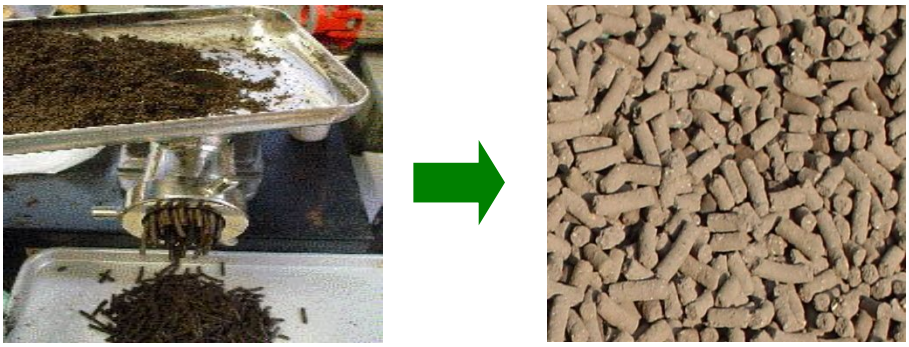


Fig. 2-10 Granular compost produced by mincing machine

Remark:

- Attention should be paid to amounts of molasses added. Plant growth may be restricted if more molasses is added than the ratio mentioned above.

2.4 Liquid fertilizer

Liquid fertilizer is the liquid material obtained from decomposed plant or animal residues through the fermentation process with aerobic or anaerobic microorganisms. In the fermentation process, it is necessary to add molasses or sugar to feed the microorganisms.

There are various compounds from plant and animal cells, such as carbohydrate, protein, amino acid, plant nutrients, enzyme or plant hormone, that are available for liquid fertilizer.

2.4.1 Materials for making liquid fertilizer

There are many formulas of liquid fertilizer to suit the farmers' purpose or to adapt. Available local materials are as follows.

- Plant residues
- Animal residues
- Ripe fruits
- Waste from kitchen or food scraps
- Molasses or sugar

2.4.2 How to make liquid fertilizer

Liquid fertilizer is made from fermented plant or animal residues under aerobic or anaerobic conditions. Adding effective microorganisms may enable faster decomposition of raw materials. Besides the addition of effective microorganisms, certain amounts of molasses or sugar are necessary as microorganisms' food.

1) Chop each material into small pieces

2) Mix all chopped materials with molasses or sugar. Effective microorganisms can be added here

3) Put all mixed materials into fermentation tank with added water, and mix well

The decomposition process takes around 30-60 days. After completing the process, brown colored liquid smelling like alcohol (Fig. 2-9) remains in fermentation tank. When it smells bad or strange, the fermentation process is not completed. More molasses or sugar should be added.

Fig. 2-9 Liquid fertilizer

Remarks:

- During the fermentation process, do not close the container too tightly.
- To increase the oxygen level, mix the materials every 3 days.
- After making liquid fertilizer, keep the container in the shade.
- Liquid fertilizer is a concentrated one. Dilute 10 to 100 times with water before applying to crops.

Appendix:

Some formulas for making liquid fertilizer are shown as follows.

Formula 1: bamboo shoots 2 kg, banana shoots 2 kg, morning glory 2 kg, bean leaves 2 kg, molasses 3 kg, microorganisms 1 pack and water 50 liters

Formula 2: ripe banana 2 kg, ripe papaya 2 kg, ripe pumpkin 2 kg, molasses 3 kg, microorganisms 1 pack and water 50 liters

Formula 3: morinda's leaves and fruit 5 kg, ripe papaya 5 kg, ripe pineapple 5 kg, brown sugar 5 kg and water 15 liters

Formula 4: Fish residue 12 kg, molasses 7 kg, microorganisms 1 pack and water 15 liters

2.5 Bio-pesticide

The awareness of disadvantages of agricultural chemicals pushes farmers to find natural materials for making bio-pesticide in order to control pest or plant diseases in farmland.

In local areas, people used some kinds of trees, herbs or spices to protect agricultural crops from pest or plant diseases. These practices, called indigenous knowledge, are now being studied by scientists to develop more effective bio-pesticide.

2.5.1 Materials for making bio-pesticide

There are many kinds of plants or herbs that have effective substances which can protect crops from pests or diseases.

- Some plants or herbs that contain effective substances for protecting crops from pests or plant diseases, such as neem (*Azadirachta indica*), siam *weed (Eupatorium odoratum*), tobacco plant (*Nicotiana tabacum*), eucalyptus, bitter vine (*Tinospora crispa*), marigold (*Tagates erecta*), citronella grass (*Cymbopogon nardus*), turmeric (*Curcuma longa*), chili or lemongrass

Fig. 2-12 Plants or herbs for making bio-pesticide

2.5.2 How to make bio-pesticide

According to the objective and location, the materials applied for making bio-pesticide can be changed. The process of extracting effective

substances from the materials can be divided into 2 ways as follows.

1) Some materials can be applied immediately. Chop materials into small pieces and broadcast around crops on farmland
2) Some kinds of substances need fermentation. The period of fermentation is around 30 to 60 days to extract the effective substances from the materials. According to the substance, alcohol can be added for easier extracting

Fig. 2-13 Preparing materials for making bio-pesticide

Fig. 2-14 Fermentation of materials for 30 to 60 days

Remarks:

- Bio-pesticides give less damage to environment and humans.
- Fermented bio-pesticide is concentrated. Dilute 10 to 100 times with water before applying to crops.

Appendix:

Some formulas for making bio-pesticide are shown as follows.

Formula to prevent Stenchaetothrips: eucalyptus leaves 2 kg, neem apical 1 bucket, galangal 2 kg, bitter vine 2 kg, effective microorganism 1 glass, molasses 3 kg and water 30 liters (20 days for fermentation)

Formula to prevent Cutworm: turmeric 1 kg and water 40 liters (crush turmeric well then put into water for a few days)

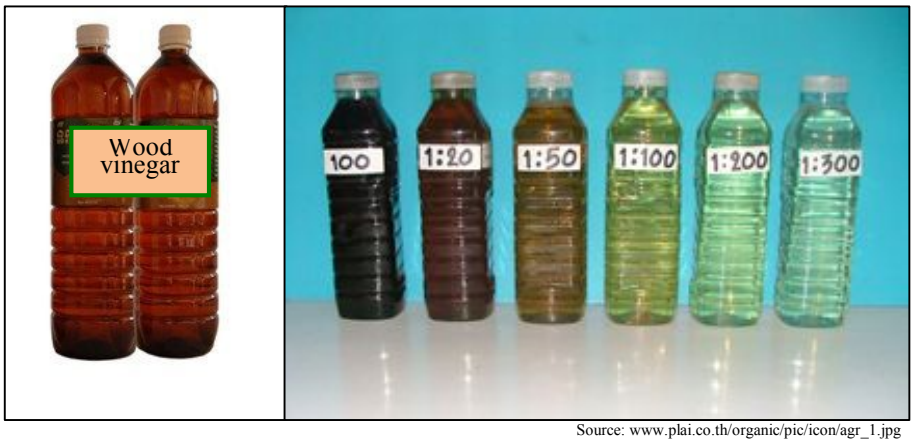
Formula to prevent Aphid: dry chili 1 kg and water 10 liters (crush dry chili well then put into water for one night)

Formula to prevent Brown planthopper: neem seed 1 kg and water 20 liters (crush neem seed well then put into water for one night)

2.6 Charcoal and wood vinegar

Wood vinegar is the liquid obtained from charcoal making in burning process under airless conditions. During the burning process, the smoke is condensed to a brown liquid called wood vinegar (Fig. 2-15).

There are many applications for wood vinegar such as deodorizer, sterilizing agent or for use in medicinal fields. For agricultural purposes, farmers can apply wood vinegar to control pests, to accelerate plant growth or to regulate plant growth.



Source: www.plai.co.th/organic/pic/icon/agr_1.jpg

Fig. 2-15 Samples of wood vinegar

2.6.1 Materials for making charcoal and wood vinegar

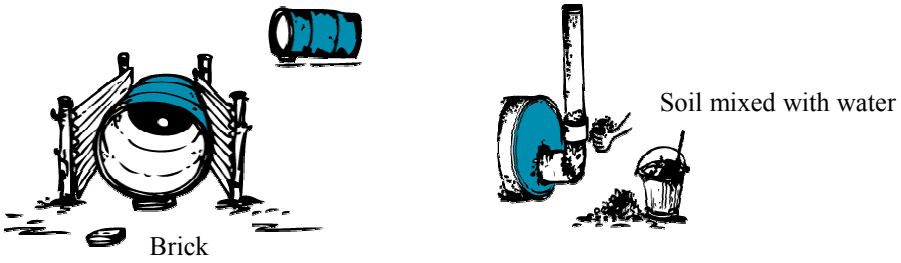
- Any kind of wood
- 200 L tank for furnace
- Curving pipe (10 cm in diameter)
- 1 m long pipe (10 cm in diameter)
- 5 concrete blocks
- Brick

Fig. 2-16 Samples of furnace

2.6.2 How to make charcoal and wood vinegar

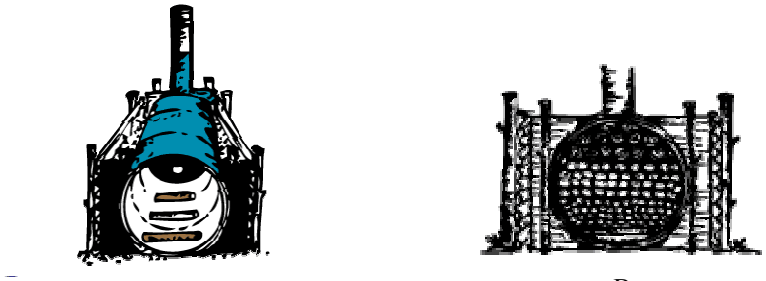
A furnace is necessary for making charcoal and wood vinegar.

1) Put tank on brick and make walls

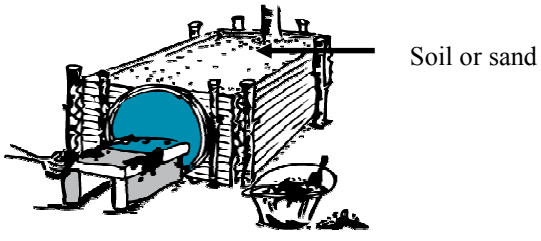


2) Connect pipes with tank by using soil as a fixer

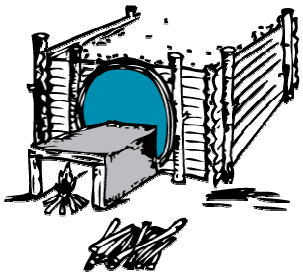
3) Put wood or bamboo into the tank as shown in A and B

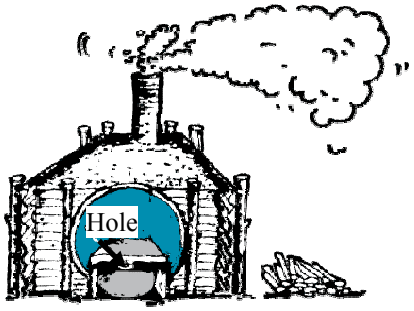


4) Put concrete blocks for making fire in front of the tank



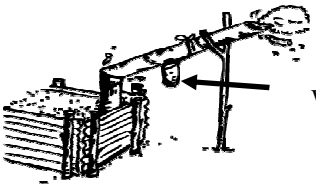
5) Start the fire





6) Let the fire burn until smoke color changes from white to gray, then decrease the fire by controlling the input of air by adjusting the hole

7) After decreasing the fire for 30 min to 1 hr, the smoke color becomes white with shallow yellow. Then start to collect the wood vinegar



8) After collecting wood vinegar, the color of smoke becomes white with blue. After that, open the hole for 20-30 min. The color of smoke becomes clear blue, so close the hole and pipe. After 12-15 hr have passed, open to collect charcoal

Remarks:

- In order to get high quality wood vinegar, the burning temperature must be in the range of 300 to 425 degrees Celsius.
- Wood vinegar consists of 80-90 % of water and 200 kinds of organic substances.
- The pH of good quality wood vinegar is around 2.0-3.2 and the specific gravity is around 1.007-1.024.

- After collecting wood vinegar from the charcoal burning process, keep for 3 months. Wood vinegar forms 3 layers: first is light oil, second is wood vinegar and the last is tar. Only the second layer is available as wood vinegar.

Fig. 2-17 Charcoal and wood vinegar making with handmade furnace in Thailand

2.7 Conservation tillage

The main roles of tillage are the improvement of crop growth, the facilitation of seeding and weed control (Fig. 2-18). However, the tillage operation can potentially harm the natural ecosystem and the soil productivity, if excess cultivations are performed (Fig. 2-19). In recent decades, conservation tillage has been widely accepted as it may increase water retention and reduce soil loss.

Fig. 2-18 Various tillage systems

Fig. 2-19 Soil erosion on tilled farmland

2.7.1 Materials for conservation tillage

- Weeds or crop residues
- Tool for conservation tillage such as stick or spade

2.7.2 How to make conservation tillage

1) Leave at least 30% of soil surface covered by crop residues or weeds

2) Reduce the amount of tillage

Conventional tillage

Conservation tillage

3) Shaft tillage is also effective

Shaft tillage

Remarks:

- Tillage tool or vegetation management is changeable up to traditional farming customs at the site.
- Weeds or plant residues left on soil surface reduce the amounts of soil loss.

2.8 Buffer strip

Upland fields are highly susceptible to soil erosion, especially in tropical countries where squalls of high rainfall intensity usually occur. The loss of soil sediments and nutrients due to surface runoff from farmland causes serious degradation of water quality in the drainage basin and environment. Buffer strip is an effective way to reduce the loss of soil and nutrients from farmland.

2.8.1 Materials for making buffer strip

There are many kinds of material applicable for making buffer strip.

- Grass or vegetation (for grass buffer strip)
- Coconut husk (for coconut husk buffer strip)
- Woods along river (for riparian buffer)

2.8.2 How to make buffer strip

1) Observe and sketch how surface runoff flows on farmland
2) Select where buffer strip should be installed in farmland. Buffer strip should be set across surface runoff

Fig. 2-20 Grass buffer strip installed in farmland

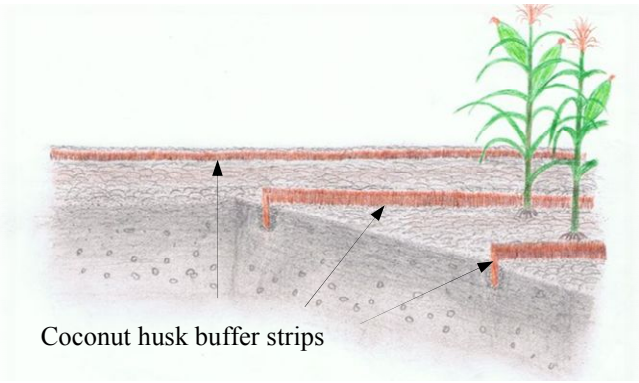


Fig. 2-21 Coconut husk buffer strips in farmland

3) After selecting applicable materials for making buffer strip, set the materials on farmland

Coconut husk before pounding

After pounding

4) For riparian buffer, preserve natural woods along rivers

Remarks:

- Buffer strip may trap 50% to 80% of soil and nutrient loss.
- Buffer strip enhance soil infiltration.
- At least half the height of coconut husk should be buried.

2.9 Agro-forestry

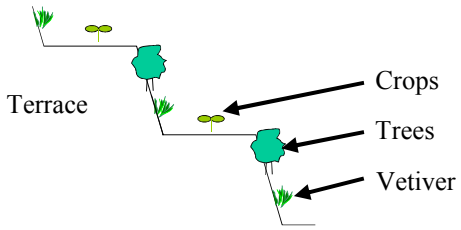
Agro-forestry is a sustainable agricultural system having both direct and indirect benefits, such as decreasing soil degradation, enhancing natural resources circulation, increasing income for farmers and decreasing environmental pollution.

2.9.1 Materials for making agro-forestry

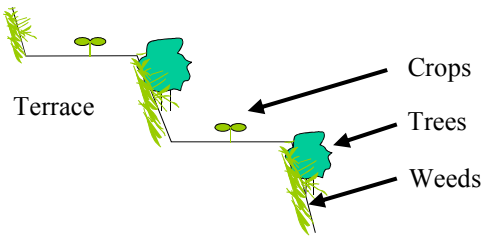
- Any kind of crops, trees or weeds

2.9.2 How to make agro-forestry

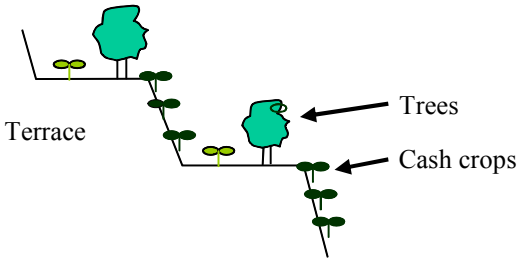
1) Agro-forestry in terrace: Severe soil erosion and associated nutrient losses occur frequently in terraces. Bare soil, especially in sloping area, can be covered with vegetation in agro-forestry



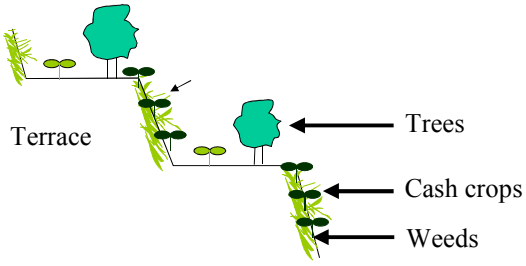
Agro-forestry with vetiver grass buffer strips



Agro-forestry with weeds



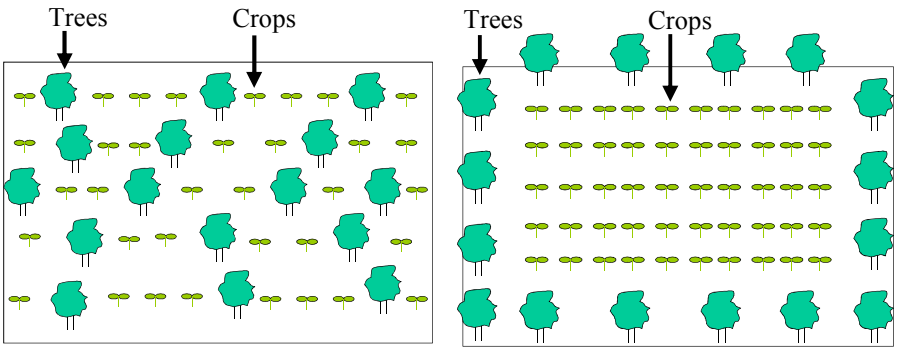
Agro-forestry with cash crops



Agro-forestry with weeds and cash crops

Fig. 2-22 Terrace protected with weeds

2) Agro-forestry in upland fields: Agro-forestry is also beneficial for upland fields in gently sloping or flat area

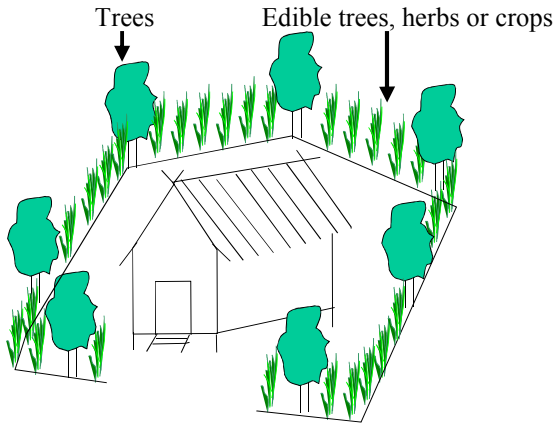


Growing trees mixed with crops

Growing trees at the edge of farmland

Fig. 2-23 Growing trees mixed with crops

3) Agro-forestry in residential area: Around the residential lot, trees inter-cropped with edible trees, herbs or crops provide plenty of organic matter



Remarks:

- Trees having allelopathy are not applicable for agro-forestry.
- Agro-forestry enhances natural resources circulation.

2.10 Settling pond

Settling pond is usually installed in a drainage area or a point of discharge from farmland. Settling pond can be formed by excavating land or by placing an earthen embankment across the drainage swale. The outlet or spillway of settling pond is often constructed using large stones or concrete. It can trap sediments or suspended particles well, but dissolved nutrients. Aquatic plants can absorb the dissolved nutrients.

2.10.1 Materials for making settling pond

- Tool for excavation
- Stones or concrete
- Aquatic plants such as *Phragmites australis*, *Typha latifolia*, *Eichornia crassipes* or *Pistia stratiotes* L.

2.10.2 How to make settling pond

1) Observe and sketch how surface runoff flows on farmland

Fig. 2-24 Gully erosion in farmland

2) Select where settling pond should be installed in or around farmland

3) Excavate the point of discharge or place earthen embankment across the drainage swale

Fig. 2-25 Settling pond under construction

4) Apply aquatic plants to absorb dissolved nutrients

Fig. 2-26 Aquatic plants as *Scirpus mucronatus* (left), *Eichornia crassipes* (center) and *Pistia stratiotes* L. (right)

Remarks:

- Accumulated sediments in settling pond should be removed.
- After aquatic plants grow up, the plants should be collected. They can be used to make compost.

III. Conclusion

Awareness of environmental problems and growing concern for food safety has persuaded farmers to change their agricultural practices to be more environmentally friendly and sustainable. Consumers are also seeking safe products. There are many farming practices that can lead to sustainable agriculture but every practice depends on the balance among environment, economy and social system.

The practice of sustainable agriculture avoids or reduces the use of agricultural chemicals in farmland. Organic products such as compost, granular compost, liquid fertilizer or bio-pesticide can be applied to farmland instead of synthetic ones. Not only general practices like composting, but recent advanced knowledge of the use of microorganisms for pest control or plant pathology control has become widely applied.

Understanding the benefits of sustainable agriculture is necessary not only for farmers but also for consumers. Educating students in elementary schools about sustainable agriculture raises their awareness of environmentally friendly farming practices and consumption of safe food.

This guidebook was produced in the international cooperative program under the collaboration between NGO and university. We do hope this book motivates the facilitators of NGOs or universities to grapple with sustainable agriculture through promoting sustainable farming practices.

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