Appendix-8: Promotion Manual for Coconut Intercropping (for Extension Workers)


PROMOTION MANUAL for
COCONUT INTERCROPPING
FOR EXTENSION WORKERS
(Based on the Experience in Mercedes, Eastern Samar)

Foreword

This Promotion Manual for Extension Workers was formulated based on the 'Coconut Intercropping Manual for Farmers' which serves as a guide to revive the typhoon-stricken coconut farms by practicing intercropping suitable for a natural and social environment. The extension workers may refer to this manual to fully understand the farmers learning needs, constraints, priorities, and opportunities when facilitating farmers.

Coconut trees are more resistant to natural disasters that constantly affect the Philippines such as typhoon, flood, drought, and climate change. However, it may take a long time for the coconut trees damaged by natural disasters like Typhoon Yolanda to fully recover and return to production. Thus, agricultural diversification is essential in the restoration of the coconut production and in the improvement of the farmers' livelihood. For that purpose, an intercropping farming trial project was implemented in Mercedes, Eastern Samar as a Quick Impact Project within the "Program for Rehabilitation and Recovery from Typhoon Yolanda" financed by JICA (Japan International Cooperation Agency).

This manual was developed based on the experience of the trial project and by referring to the local environmental condition and useful modernized farming techniques and recommendations through various documents from the Department of Agriculture of Region 8 and The Philippine Coconut Authority (PCA)

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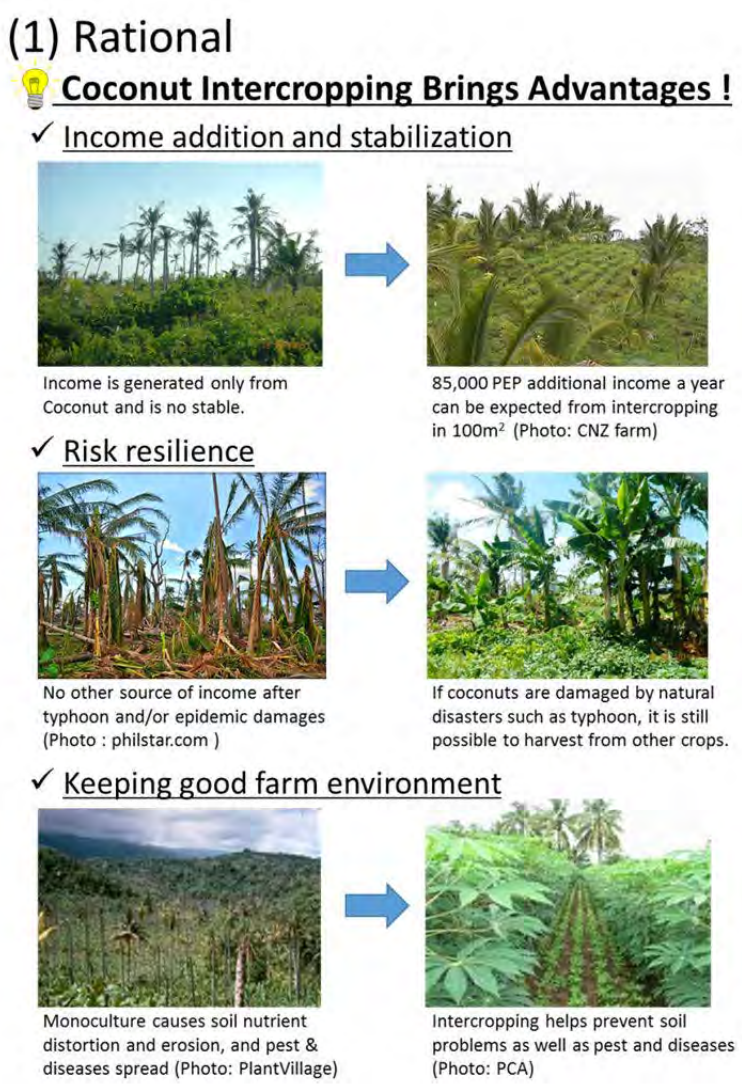
Chapter 1 Formulation of coconut intercropping plan

Coconut is the main source of income in certain areas in the Philippines. It is a large palm that grows over 10m, but has a smaller root area of around 2m radius, and the leaves that are grown only on top of the tree can penetrate sunlight, which makes it relatively suitable crop for intercropping. However, intercropping is barely practiced in some areas in Eastern Samar, Mercedes neither.

The intensity of natural disasters, such as typhoon, in Eastern Samar is higher compared to other areas in the Philippines which is why typhoon susceptible horticultural crops are less cultivated in the area. It is also difficult to introduce and practice intercropping due to weather and soil conditions that inhibit good production in the area. However, sustainable horticultural production is possible in such areas if appropriate and improved crop management techniques are introduced and practiced. Farmers must be educated of the importance of horticultural production and its positive impact to their livelihood. Horticultural crops are more susceptible to natural disasters; however, the damage is limited to one cropping season. Super typhoon is not expected to hit every single year, so the coconut is still the most suitable crop for the region. However, there are high possibility that the super typhoon equal to Yolanda may damage the area every once a while. Settling appropriate intercropping in a coconut farm with horticultural crops will alleviate the disaster damage by short term recovery.

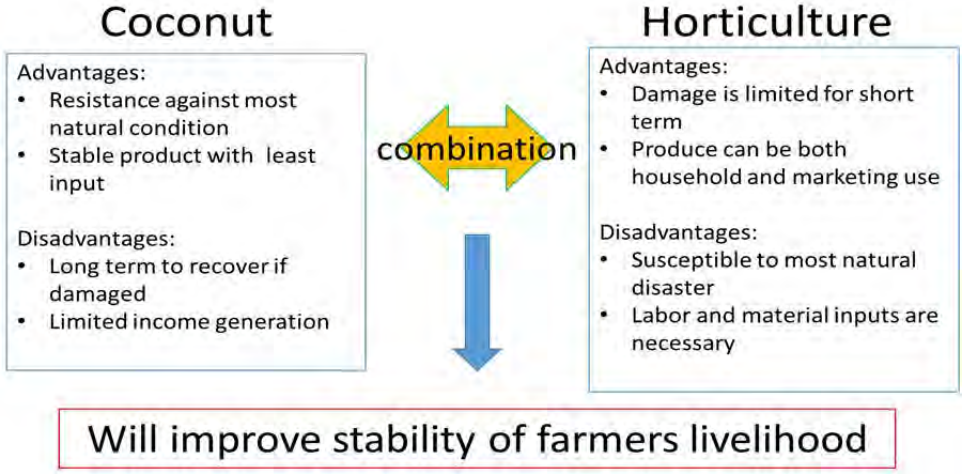
It is also important to introduce appropriate crop rotation with various crop varieties for sustainable continuous cropping in order to utilize limited farm land; therefore, improving the resiliency against natural disasters. The main purpose of this manual is to promote intercropping within the coconut farm, but not to promote shifting the coconut farming in to horticulture; and to reestablish better coconut farming with appropriate intercropping of various crops and cropping systems.

1.1 Why practice intercropping in coconut farm?



<Further information>

As shown below, coconut intercropping has advantages:
Coconut intercropping generates more income and improves the stability of farmers' livelihood.



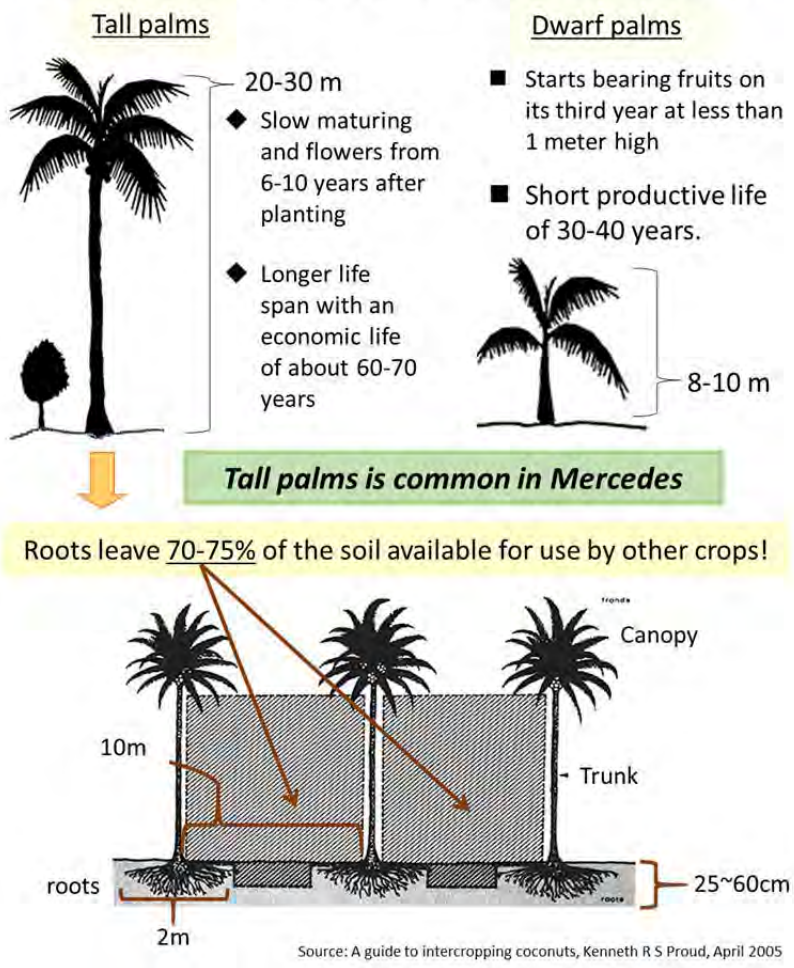
Advantages and disadvantages of the coconut intercropping are described in the following table:

Advantages	Disadvantages
• Increased yields and food production • Care & attention given to management of intercrop regarding agronomic practice • Reducing herbicide • Efficient land use • Provide better condition other crops	◆ Competition between coconut and other crops for water, nutrient etc. ◆ Intercrops may harbor diseases or attract pests harmful to coconuts ◆ Tillage required for intercropping may damage coconut root ◆ Intercropping may demand a higher level of skill from farmers

(2) Characteristics of Coconuts

Coconuts Are Suitable for Intercropping

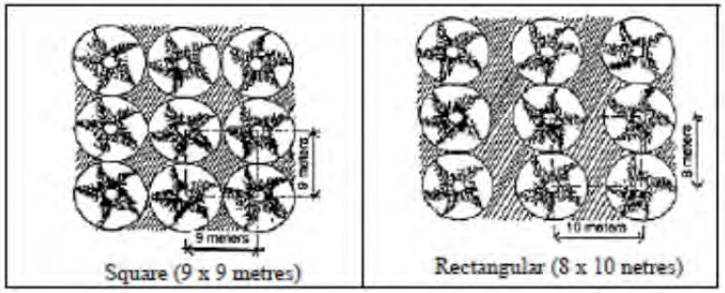
Coconut (*Cocos nucifera* L.) is mainly classified into 2 types:



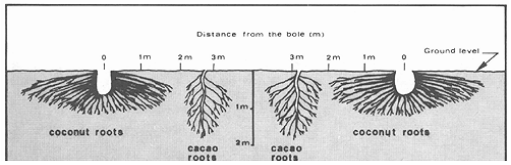
Source: A guide to intercropping coconuts, Kenneth R S Proud, April 2005

<Further information>

Intercropping takes advantage of the nature of the coconut tree's canopy of fronds, and the rooting system.



- On average, 56% of solar radiation reaches the ground, although this varies with the age of the coconut stand, its density, and alignment.
- Over 80% of the active roots occur in the 25–60cm soil layer in a 2m radius around the palm, leaving70-75% of the soil available[1].



Vertical root distribution of cacao intercropped with coconut (Nelliat et al)

Diversifying the farming system by intercropping cash crops, such as cacao, coffee, banana, pineapple etc., and changing to multi-storied cropping systems can generate much higher returns.

[1] A guide to intercropping coconuts, Kenneth R S Proud, April 2005

(3) Types of Coconut Intercropping

Select the type and crops by coconut planted age !

This manual focuses on that!!

1) Intercropping with annual crops

Coconut and Maize
Source: TNAU Agritech Portal

- ✓ Suitable for young age of coconuts; 1-7 years after planting.
- ✓ Possible to utilize sunlight before coconuts grow
- ✓ Planting Annual & biennial crops, such as: sweet potatoes, maize, peanuts, vegetables and fodder crops, etc., but avoid paddy and sugar cane.

2) Mixed cropping

- ✓ Depends on the crops but preferably after 6-7 years.
- ✓ Possible to utilize sunlight between canopies or shade made by coconuts, planting perennial crops; bananas, coffee, cacao, pineapples, etc.

Coconut and Bananas
Source: TNAU Agritech Portal

3) Multi-story cropping

Multi-story cropping with peanuts and pineapples
Source :PCA

- ✓ Growing crops of different heights together based on the sunlight changes of coconuts growth.
- ✓ Any crops can be combined: coconut + peanuts + pineapple, etc.

<Further information>

According to 'PASTURE-CATTLE-COCONUT SYSTEMS' published by FAO (http://www.fao.org/docrep/005/af298e/af298e00.HTM), the cropping system means "the cropping patterns on a farm and their interaction with farm resources, other farm enterprises and available technology".

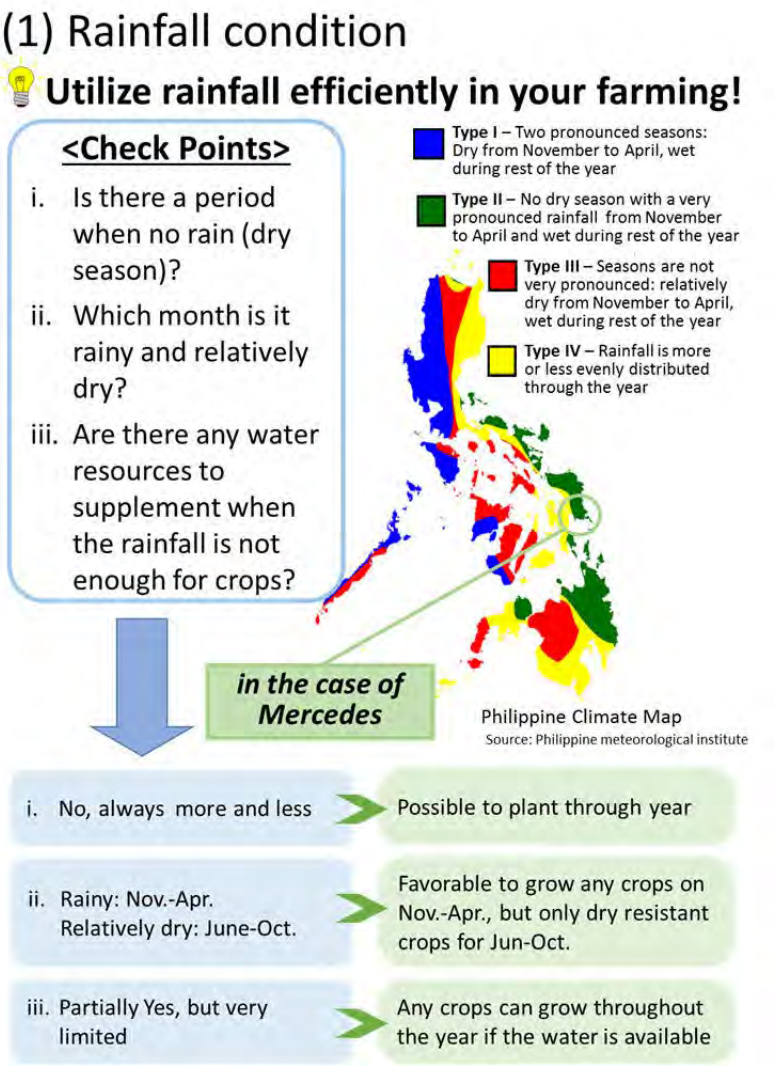
The definitions of various cropping system are summarized as follows:

Type	Description
Monoculture (mono-cropping)	Cultivation of a single species of crop (coconut).
Intercropping	(The space dependent form of multiple cropping) growing two or more crops simultaneously on the same area of land in the same year. i.e. there is intercrop competition and farmers manage more than one crop at a time on the same area of land (e.g. pastures under coconuts, cacao under coconuts, vegetables under coconuts, etc.)
Mixes(Multiple) cropping	Growing of two or more crops simultaneously on the same piece of land, without any definite row arrangement.
Multi-story cropping	Where a combination of different annual and perennial crops is established (between coconuts) so that their canopies exploit different air layers not used by the coconut e.g. clove and guava, pepper, banana, papaya, taro and pineapple.
Sequential cropping	(The time dependent form of multiple cropping) growing two or more crops in sequence on the same area of land in the same year. i.e. there is no intercrop competition and farmers manage only one crop at a time on the same area of land.

Source: PASTURE-CATTLE-COCONUT SYSTEMS' FAO

As for 'Farming', additional different cropping, livestock husbandry and/or processing are combined in one farmer household and group.
When thinking about suitable cropping type and farming style, it is necessary to check the environmental condition and farmers' needs.

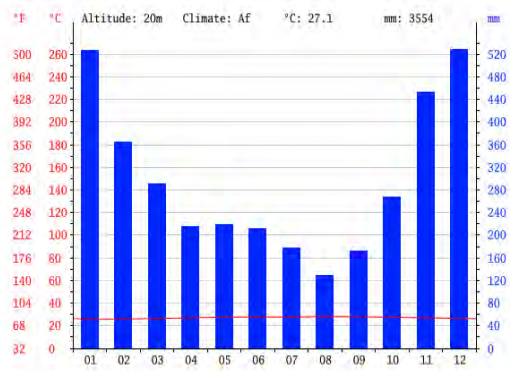
1.2 Environmental factors to be considered for intercropping



<Further information>

Rainfall, a source of water which is a major determinant of crop productivity and quality and required in large quantities for plant growth than any other of the growth factors. Thus, rainfall condition should be checked before introducing intercropping and choosing crops to be planted.

The data presented on the table based on Mercedes' case shows that it rains a lot from November to March, therefore, this period is favorable for rain-fed agriculture; while drought resistant crops can only be grown without irrigation from the month of April to October.



Monthly rainfall in Mercedes (as of 2012)
Source: climate-data.org

However, too much rainfall causes water logging or storms and devastates crop growth so it is necessary to consider the characteristics of crops and drainage situation. For instance, taro and sweet potatoes can be chosen in the waterlogging area because they can survive under such condition for certain days.

(2) Temperature

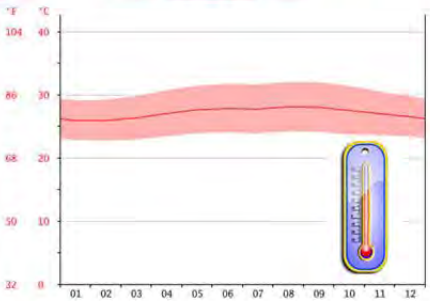
Select crops by temperature!

<Check Points>

i. Which month is the hottest or coolest?

ii. What is the average temperature for each?

Optimum temperature for perennial crops is 15~25°C



Temperature graph in Mercedes

Source: CLIMATE-DATA.ORG
(http://en.climate-data.org/location/985533/)

in the case of Mercedes

i. Hottest: Aug.-Sep.
Coolest: Dec.-Mar.

Easy to grow leafy vegetables such as pechay during the coolest period.

ii. Hottest: avg. 28.1°C
Cooler: avg. 25.9 °C

Choose heat resistant crops such as camote during the hottest period.

<Further information>

By controlling, temperature influences all physical activities namely: Photosynthesis, Respiration, Flowering, Fruit set, Rate of maturation, and senescence etc., thus, determines quality and yield of crops.

The growing crops should be selected according to the temperature. In Mercedes, the temperature is relatively low from December to March due to rainfall condition, so pechay or cabbage may be grown.

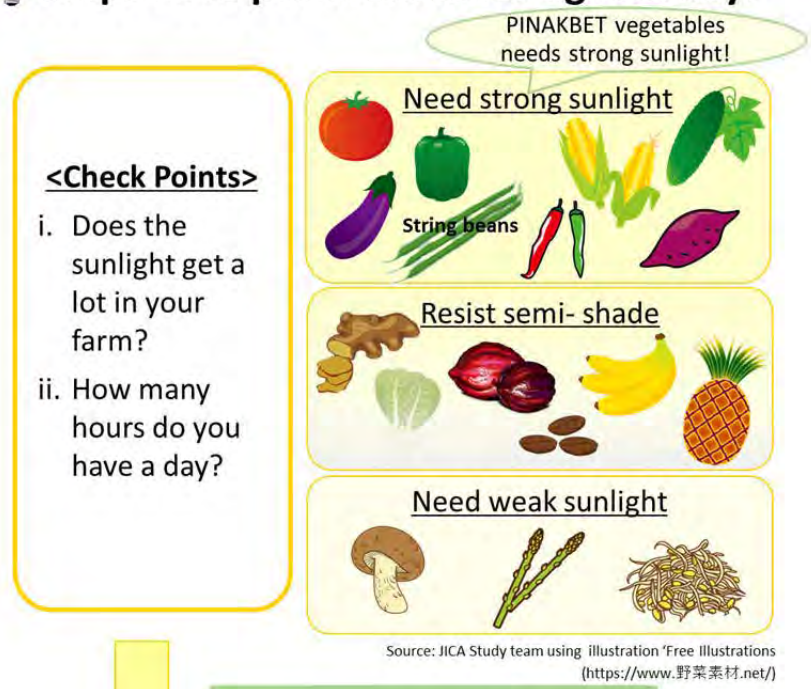
Temperature Comparison of Cool Season and Warm Season Crops

Temperature for	Cool Season	Warm Season
Adaptation crop	pechay, cabbage, broccoli etc.	tomatoes, peppers, squash, okra, eggplant etc.
Germination	4°C to 32°C, 27°C optimum	10°C to 20°C,27°C optimum
Growth	Daytime • 18°C to 27°C preferred • 4°C minimum Nighttime • >0°C, tender transplants • > mid-6°C, established plants	Daytime • 30°C optimum • 16°C minimum • A week below 13°C will stunt plant, reducing yields Nighttime • >0°C
Flowering	Temperature extremes lead to bolting and buttoning.	• Nighttime <13°C, non- viable pollen (use blossom set hormones) • Daytime >35°C by 10 a.m., blossoms abort
Soil	• Use organic mulch to cool soil. • Since seeds germinate best in warm soils, use transplants for spring planting, and direct seeding for mid-summer plantings (fall harvest).	• In order to cool down soil temperature, use black or silver plastic mulch to warm soil, increasing yields and earliness of crop

Source: Plant Growth Factors: Temperature, Colorado State University

(3) Sunlight and Day Length

Crops have preferences for light & day!



Source: JICA Study team using illustration 'Free Illustrations (https://www.野菜素材.net/)

In the case of Mercedes

i. Yes, the strongest period is Aug.-Oct. → Fruit-bearing crops can grow well all year round but 'pechay 'and ginger grow better during the months of Dec.-Jan.

ii. Almost same hours throughout the year: avg. 11h'28-12h'45 → There is no problem for most of the crops except Chinese radish

<Further information>

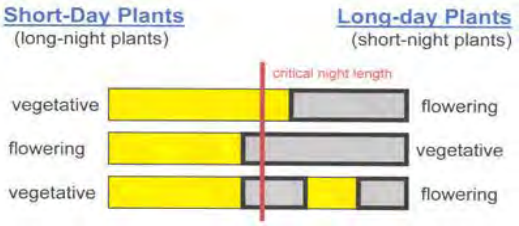
Photosynthesis uses light. Light intensity and duration are important for crop growth and development. Low light causes plants to be long, spindly, small leaves, bud blades, poor pollination, and poor fruit quality. But the plants differ in light requirements as shown in the figure on the right.

Plants differ in light (day length) requirements. For example:

- Light affects pollen viability and fruit set.
- Certain seed requires light to break dormancy e.g. lettuce.
- Some horticultural crops are sensitive to *photoperiod.*

Photoperiod is the length of uninterrupted darkness which controls the flowering response of many plants. There are three types of photoperiod:

Type	Description	Examples
Short day plants	Flower in response to long periods of night darkness	single-crop strawberries
Long day plants	Flower in response to short periods of night darkness	Chinese radish, onions and spinach.
Day neutral plants	Flowers without regard to the length of the night, but typically flower earlier and more profusely under long daylight regimes.	Most of vegetables; Tomato, Eggplant, Peppers, Bitter gourd, Maize, Sweet potato, Beans, etc.



Source: Plant Growth Factors: Light, Colorado State University

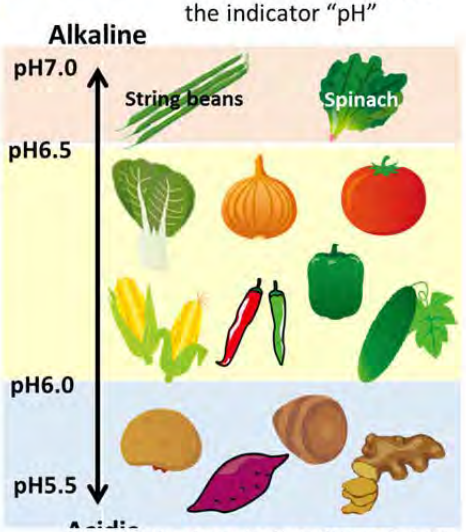
(4) Soil condition

Soil condition influences crop health

<Check Points>

i. What is **acidity***?
ii. What is the soil's physical type and humidity? Wet or dry?
iii. What kind of crops were grown before?

*Acidity is estimated by the indicator "pH"



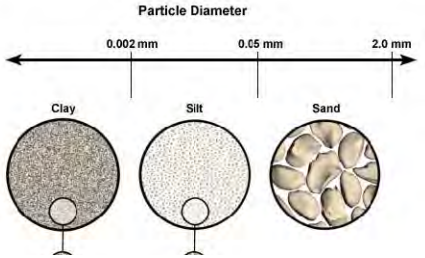
Source: JICA Study team using illustration 'Free Illustrations (https://www.野菜素材.net/)

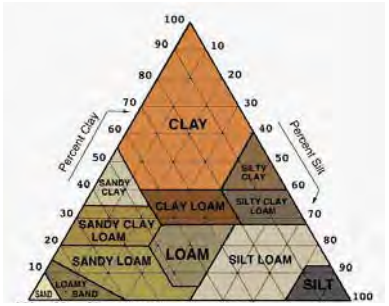
In the case of Mercedes

i. pH5.5~6.7 depends on the planted crops	pH5.5~6.0: Roots crops are good pH6.0~6.7: PINAKBET is good
ii. Sandy and dry and sandy-loam and wet	Sandy and dry: string bean, maize, tomato Sandy-loam and wet: Soya, camote
iii. Coconuts, camote, and Cassava	Any crops can grow except the previous perennial ones.

<Further information>

The soil textures distinguish the soil particle sizes, while the soil types are classified by the proportion of each texture as shown in the following figures.

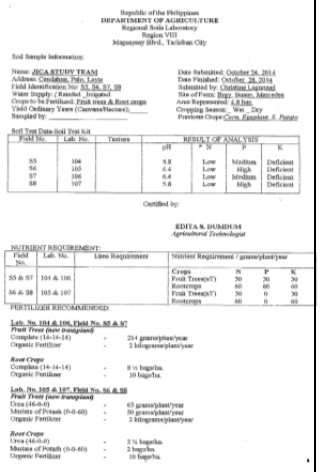




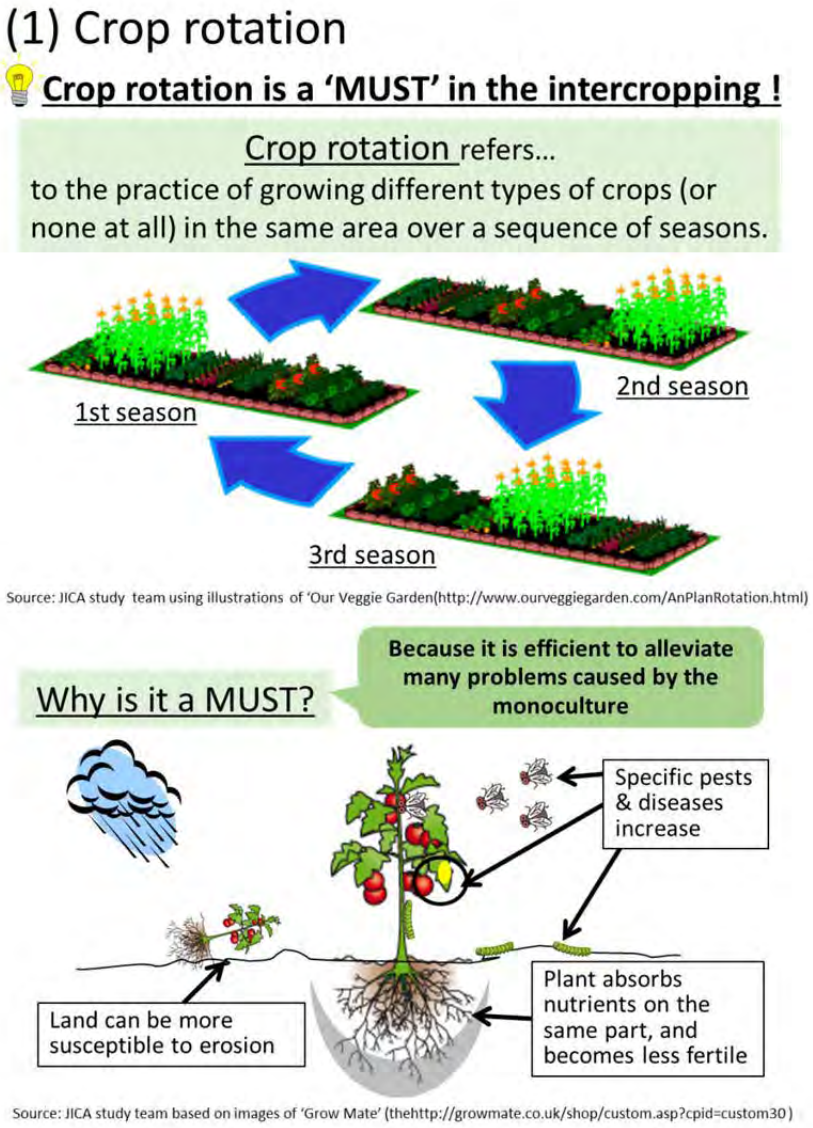
Source: Soils and Water: Soil Profile (http://napervilleccgrounds.blogspot.jp/)

Most crops prefer silt-sandy soil to clay except eggplant and onion. Unlike the soil type, each crop has an optimum pH as shown on the left.

Fertilizer application varies according to the pH level and types of crops grown. In order to understand pH, soil analysis should be done. There is a soil laboratory in the region, Bureau of Soils and Water Management (BSWM), where everybody can request soil analysis. The laboratory gives the results together with the fertilizer recommendation by crop type as shown in the 'Soil Sample Information' on the right.



1.3 Crop rotation and combination



<Further information>

Crop rotation is a farming practice that has various benefits on crop production.

Problems	Causes	Benefits of rotation
Pests and diseases outbreak	Related crops are prone to the same soil-living pests and diseases	Moving them around in an organized rotation helps to prevent the build up of problems.
Land becomes "tired" and less fertile (Physiological disorder by deficiency nutrient)	Growing single type of plant cause to absorb specific nutrient which may consequently lead to bias the soil nutrients and corruption of bacteria	Different types of plants require different types of nutrients from the soil. Changing crops routinely allows the land to remain fertile, since not all of the same nutrients are being used each season. For example, planting a legume, such as soybeans, helps to replenish necessary nitrogen in the soil.
Land can be more susceptible of erosion	Same plant height and deep roots are weaken the soil stability due to deficiency nutrient	Rotating crops helps to improve soil stability by alternating between crops with deep roots and those with shallow roots.

Source: JICA team based on 'Why Is Crop Rotation Important?' (http://wonderopolis.org/wonder/why-is-crop-rotation-important/)

It can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants which can lead to healthier soil.

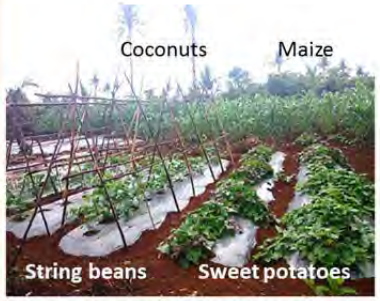
In Mercedes, coconut monoculture is a common practice, and such problems may occur in the field. Thus, intercropping rotation should be introduced to generate more income, enhance disaster resilience, and develop sustainable livelihood in the area.

(2) How to practice crop rotation?

Formulate cropping pattern according to the features of the crops

1) Principles of crop rotation:

- ✓ Do not grow same crops and same family crops consequently (ref. Table-1)
- ✓ Plan growing crops in accordance to the necessary interval (ref. Table-2)
- ✓ Select and combine 'compatible' crops and avoid 'incompatible' ones (ref. table-3)



Intercropping in Mercedes

Table-1 Classification of Crop Family

	Classification (Family) and Crops	Characteristics
	Legume: String/Wing beans, Peanuts, Soy beans, Cow pea	Turns nitrogen in the air into nutrients the plant uses
	Solanum Fruits: Tomatoes, Egg plant, Belle/Hot peppers	Disease prone, advisable to move together
	Cucumber Fruits: Bitter gourd (Amparaya), Gourd (Pemo), Pumpkin	Do not require much additional fertilizer
	Brassica leaf : Pichay, Cabbage, Radishes	Require high level of nutrients
	Root / Tuber: Cassava, Sweet potatoes, Taro, Carrot, Ginger, Onion, Leeks, Leaf onion	Do not require much additional fertilizer
	Others: Maize, Sudan grass, Okura	Depend on the crop

Source: JICA Study team based on 'Getting Down and Dirty in Your Allotment' (https://allotmentadvice.wordpress.com/)

<Further information> for planning crop rotation[2]

Know the family where your crops belong to make sure that the next set of crops that you grow in the next cropping season belong to a different family. The table below shows specific crops and their classification.

Scientific Family	Classification (Family)& Crops
Legume	Legume: String/Wing beans, Peanuts, Soy beans, Cow pea
Solanaceous	Solanum Fruits: Tomatoes, Egg plant, Belle/Hot peppers
Cucurbit (Gourd family)	Cucumber Fruits: Bitter gourd (Ampalaya), Gourd (Pemo), Pumpkin
Crucifer (Brassica)	Brassica leaf : Pechay, Cabbage, Radish
Root crops	Root / Tuber: Cassava, Sweet potatoes, Taro, Ginger,
Carrot family	Carrot
Allium	Onion, Leeks, Leaf onion
Poaceae family	Maize, Sudan grass,
Mallow family	Okura

Source: JICA Study Team based on PAN Germany, ISAT

[2] PAN Germany, ISAT
(ttp://www.oisat.org/control_methods/cultural_practices/crop_rotation.html)

(2) How to practice crop rotation?

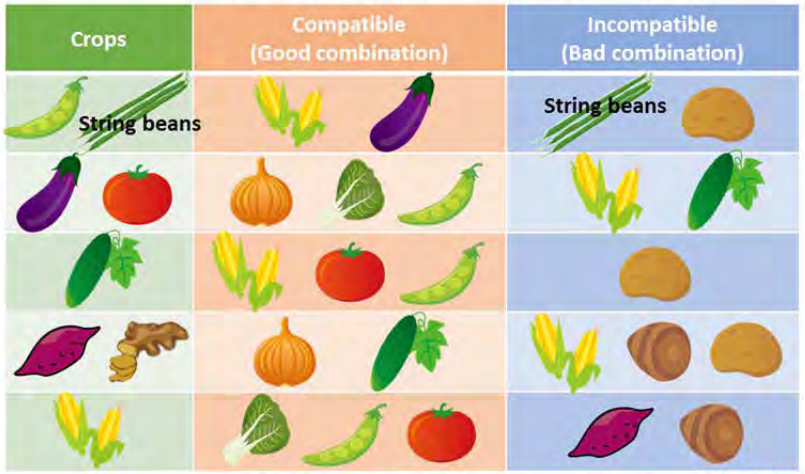
Table-2 Necessary interval by crop family

Necessary Interval	Classification (Family) and Crops
0 (possible to grow continuously)	Pumpkin , Sweet potatoes, Onion, Carrot
More than 1 year	Maize, Pechay, Okra, Cabbage, Radishes
More than 2 years	Taro, Ginger, Leeks, Leaf onion
3-4 years	Bell/Hot peppers, Bitter gourd (Ampalaya), Gourd (Pemo)
5-6 years	Tomatoes, Egg plant, String/Wing beans, Soy beans, Cow pea, Cassava

Source: Vegetable Growing Environment (in Japanese)
(https://www.pref.kagoshima.jp/ap11/chiiki/kumage/sangyo/nougyou/gijutsu/documents/02yasaidukurigaiyou.pdf)

All crops that belong to the same family are incompatible

Table-3 Crop combination



Source: JICA Study team using illustration 'Free Illustrations '(https://www.野菜素材.net/)

<Further information>

How long should the rotation be?

The longer the rotation the better, but the usual length is 4 years. This means that crops return to their original state after 4 years. If the soil is already infected with persistent problems try to extend the rotation of susceptible crops even further.

Compatibility between families and varieties

Compatibility is also an important factor in designing a crop rotation plan. Crops from different families may cause adverse effect by compatibility. For example, legumes, such as string beans fix nitrogen; thus, potato should not be planted after legume since excess nitrogen may inhibit tuber development. Maize is good after legume because maize needs a lot of nitrogen.

Moreover, the physical condition of crops should also be considered. Maize (from the Poaceae family), grows strong taproot deep into the soil and will improve the soil condition physically by breaking plow sole. Poaceae should be included in the crop rotation despite low profitability. Some forage grass have effects in suppressing nematode and bacterial diseases, therefore, these non-profitable crops should be included in the crop rotation.

(3) How to combine other crops?

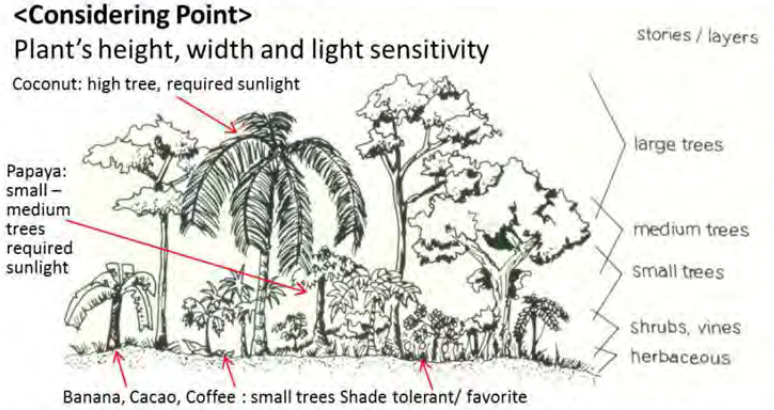
Select crops by your farming style

Refer to the chapter 3 for further information

1) Fruit-bearing crops

<Considering Point>

Plant's height, width and light sensitivity

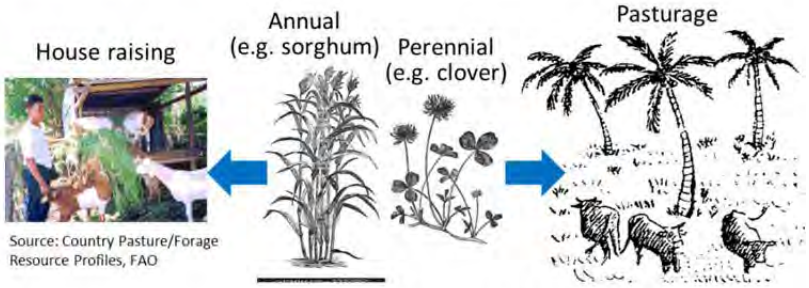


Source: World Agroforestry Center (http://www.worldagroforestry.org/)

2) Fodder crops

<Considering Point>

Type of raising animal: grazing, domestic, etc.



Source: Country Pasture/Forage Resource Profiles, FAO

Source: World Agroforestry Center (http://www.worldagroforestry.org/)

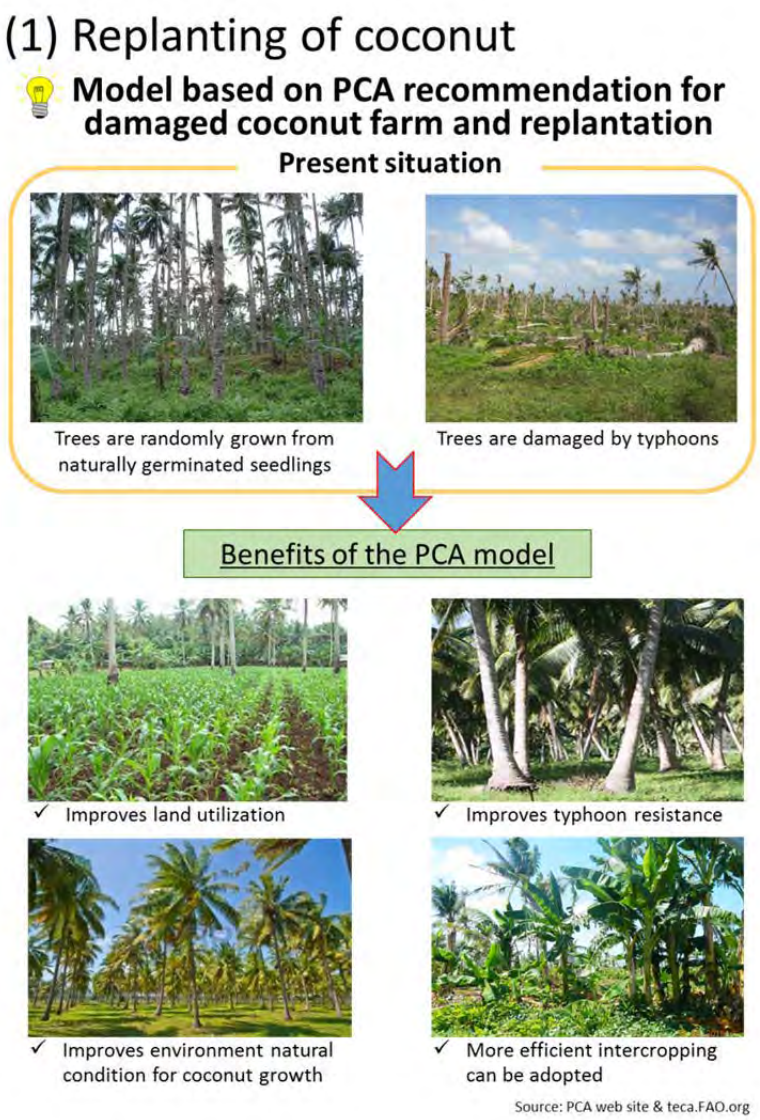
<Further information>

Intercropping may include the mixed and/or multi-storey cropping with biannual/perennial fruit trees and fodder crops. If those long period crops are introduced, other than environmental adaptability and crop combination, additional several factors should be considered as described in the following table.

Factors	Description	Remarks
Environmental adaptability	Rainfall (water condition) Temperature Light/ day length requirement Soil condition	Priority factors to be considered
Crop combination	Family and variety Compatibility of combination	Possibility of allelopathy*
Height and root diameter	Whether no competition with other crop with its height and root development	Possibility to disturb or efficiently use for other crops is important too
Harvest cycle	Duration until first harvest Harvest interval	Possibility to supplement by other crops as for food or cash?
Usage/Marketing	Whether the future marketing can be expected or not	If a crop is just temporarily demanded, the introduction should be reconsidered

*Allelopathy: Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, from the release of biochemical, known as allelochemicals, from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems (by University of Florida IFAS Extension)

1.4 Model of Coconuts Intercropping

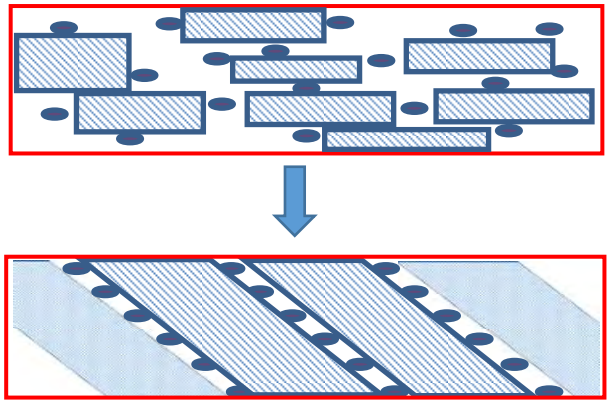


<Further information>

It is important to replant coconuts at appropriate density and interval in order to optimize coconut production and to introduce or practice efficient intercropping.

Generally, coconuts are planted randomly in individual coconut farms and coconuts are quite vulnerable to natural disasters like typhoon. Thus, PCA intercropping model is highly recommended to develop the coconut industry and at the same time improve the farming techniques of those who want to replant coconut seedlings and those farmers whose coconut trees were damaged due to consecutive typhoons.

Tree will be fallen down by strong storm



Random planting:
There are lots of dead spaces. Less than half of the farm land can be utilized

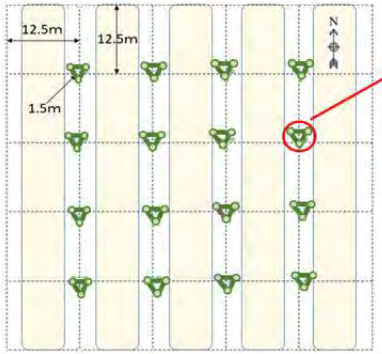
Straight row planting:
More than 80% of the farm land can be utilized for intercropping under straight planting

(1) Replanting of coconut cont.

Make straight rows to improve land utilization for efficient intercropping!

- Within 2 km from coast line

PCA developed a more resilient coconut planting model combined with intercropping against super typhoon like Typhoon Yolanda.

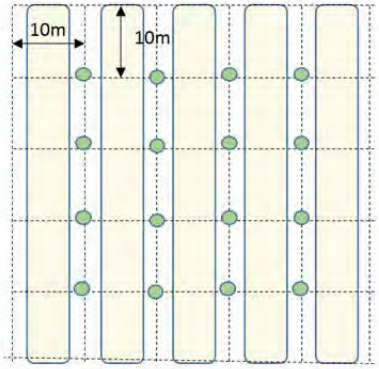


- 12.5 m interval
- 3 trees at one place with 1.5 m interval
- 192 trees /ha

➢ Plant **3 trees** at a single place in triangular location to improve tolerance

Trees can stand by supporting each other!

- Farther than 2 km from coast line

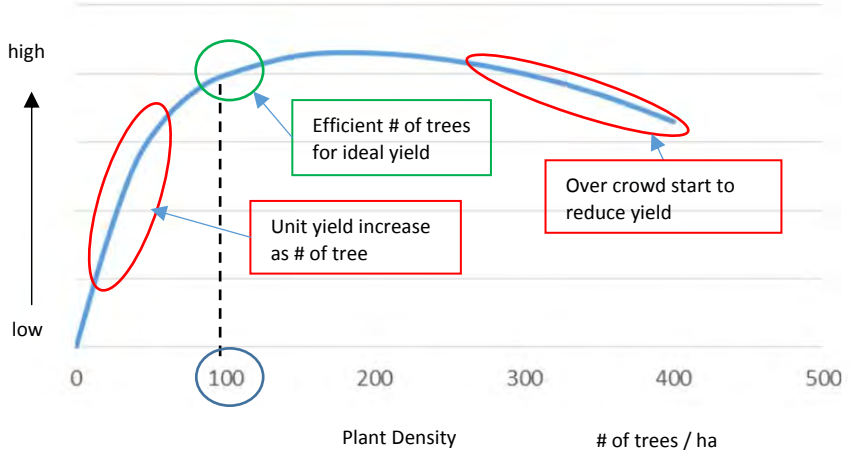


- **1 tree** for 10m x 10m interval
- 100 trees / ha

Source: PCA

<Further information>

Plant density and unit yield



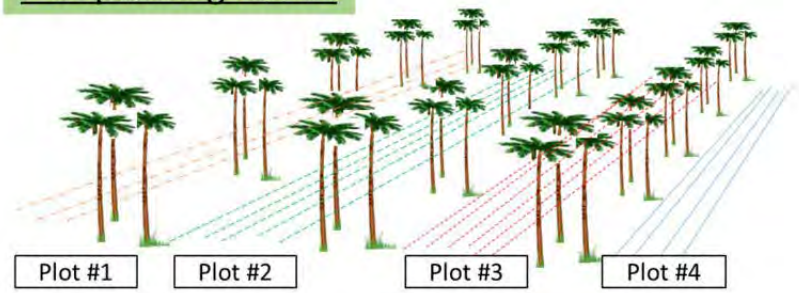
- ➢ 100 trees/ha with 10m interval is the most efficient planting pattern for yield
- ➢ Unit yield will be lower when the density are both too high and too low
- ➢ Plant density should be uniform for all part of farm to attain better yield

Random planting may cause lower yield by combination of too low and too high densities within a one farm → Important to maintain not only appropriate density but also interval to attain the best yield

(2) Intercropping Model

Combine PCA model with intercropping to improve your income and resilience against natural disasters!

PCA planting model



Example-1: Vegetable intercropping in Mercedes

Season	Plot #1	Plot #2	Plot #3	Plot #4
Wet and cool season (Nov.-Mar.)	Pulse (String bean)		Root (Camote)	Cucumber (Ampalaya)
Plan A	Cucumber fruits (Ampalaya)	Pulse (String bean)	Brassica (Pechay)	Root (Camote)
Hot dry season (Mar.-Oct)	Cucumber (Ampalaya)	Malvaceae (Okra)	Cereals (Maize)	Solanaum (Tomato)
Plan B				

Possible to organize the crops and follow crop rotation by season (Plan-A) or to plant different crops (Plan-B)

<Further information>

Intercropping is now ready to be introduced to the farmers.

The intercropping plans shown as an Example-1 on the left was carefully planned and different factors such as the environment and social condition including the marketing and crop botanical family were considered. When making an extension workers plan prior to recommending a cropping plan, it is important to consider those factors above and discuss them with the farmers. However, if the famers want to do the planning by themselves, the facilitation should be done by following the steps below:

How do you plan a rotation?

1. Make a list of all the vegetable types and number of plants that you want to grow.
2. Group the plants according to their botanical families (see table-1).
3. Draw a plan of the growing area. Divide into equal sections in the spaces of the coconut farm. You need as many sections as the number of years you want the rotation to last. So, for four cropping season rotations you need to have four sections.
4. Decide which crops are grown in which area. Families should be together, but if you have more than one crop for an area, then, choose plants with similar growing needs.
5. Keep records of what actually happens, not just what you planned. Use this information for future plans.

[5] A guide to intercropping coconuts, Kenneth R S Proud, April 2005

(2) Intercropping Model cont.

Combine PCA model with intercropping to improve your income and resilience against disasters!

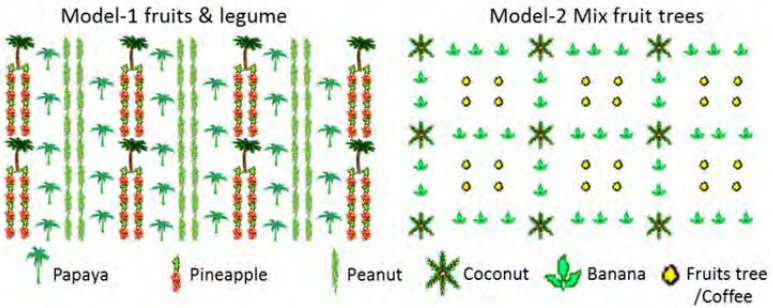
Example-2: Root crops and forage intercropping for less fertile land

Year	Plot #1	Plot #2	Plot #3	Plot #4
1st year	Root (Cassava)	Legume forage (Centro)	Root (Sweet Potatoes)	Cereal forage (Napier Grass)
2nd year	Napier grass	Cassava	Centro	Sweet potatoes
3rd year	Sweet potatoes	Napier grass	Cassava	Centro
4th year	Centro	Sweet potatoes	Napier grass	Cassava

Source: http://www.feedipedia.org/node/321

Back to the 1st year's order

Example-3: Mix cropping models



Source: PCA, Severino S. Magat,

Refer to Chapter 3 for further information

<Further information>

The Example-2 shown on the left is an example of an intercropping wherein livestock husbandry, particularly cattle and buffalo, is practiced or when fodder crops is in demand. Such kind of intercropping practice is better when the farm soil is poor or when farmers prefer extensive agricultural practice for some reasons. A fodder crop, *Centro*, belongs to the legume family which fixes nitrogen while growing, and it works better as a replacement for cassava and poaceae family crops like maize or sorghum in the next cropping season.

Centro (*Centrosemapubescens*):

It is a leguminous climbing grass with excellent viability which is suitable in the tropical zones with more than 1,500mm rainfall, although the dryness-resistance is high and grows well even in the acidic soil.

Example-3 shows two different mix cropping models recommended by PCA. Model-1 is an example of mixing annual crops and perennial fruit crops. While growing papaya, peanuts can be harvested and then pineapples are to generate income. The peanuts can be replaced by other crops but crops from the legume family are better as they utilize the nitrogen fixing efficiently. Model-2 is a kind of multi-storey farming which utilizes the shade produced by coconuts for the bananas and those two crops for coffee.

Chapter2 Agricultural Practice Recommended for Coconut Intercropping

The agricultural practices recommended in this chapter were based on the study and experiences in the intercropping pilot project in Mercedes, a part of the Quick Impact Project for JICA's 'Rehabilitation and Recovery from Typhoon Yolanda'.

It was said that horticulture production could not be practiced as an income generating activity in Mercedes due to the town's climate and soil condition. However, as a result of the detailed farmers study, the possibility to attain profitable production was realized. After the implementation of the pilot project, some techniques were verified and some others are to be modified. This chapter contains all agricultural farming techniques focusing on vegetable production which can be promoted and practiced in the country.

Some techniques may not be adapted in certain places like Mercedes even under erratic natural condition. Whereas, the other techniques may be directly adapted or may serve as a guide for better intercropping. All agricultural practices, as well as coconut intercropping, should be reflected in the past cropping and improved for the next cropping season even though the practice has been conducted in the same place.

2.1 Field preparation

<Further information>

Coconuts are tall and sturdy palm that inhibit insects and weeds from multiplying. Generally, coconut monoculture requires lesser labor and land preparation is never considered a critical factor in transplanting coconut seedlings. However, if intercropping is to be implemented, an appropriate type of land must be selected since horticultural crops are sensitive to their growing environment and the management level is high.

Farms located in plains are appropriate for easier and convenient farm management and are suitable for livestock grazing than the ones located in plateaus or mountain side. Areas near the water sources such as streams, rivers, and ponds are absolutely favorable for any crops and may also serve as irrigation.

In order to achieve successful intercropping, one must focus on the land preparation. The field needs to be cleaned by cutting weeds and shrubs, removing, and/ or burning them (not necessarily the slash-and-burn).

After cleaning up the field, cultivation and fertilization is the next step to be done. Land cultivation for vegetable crops is necessary in order to have a good harvest. Once ridges or holes are made, sowing or plantation follows.

<Further information>

1) Weeding

Weeds become a perfect nest and/or an ideal evacuation shelter for all kinds of pests. If the land is left unclean prior to transplanting and the pesticide loses its effectiveness, the insects will return and infect the nearby weeds causing diseases to spread and affect the growth development of crops. Thus, weeding is essential and burning the weeds on the ground can help prevent the insects from multiplying.

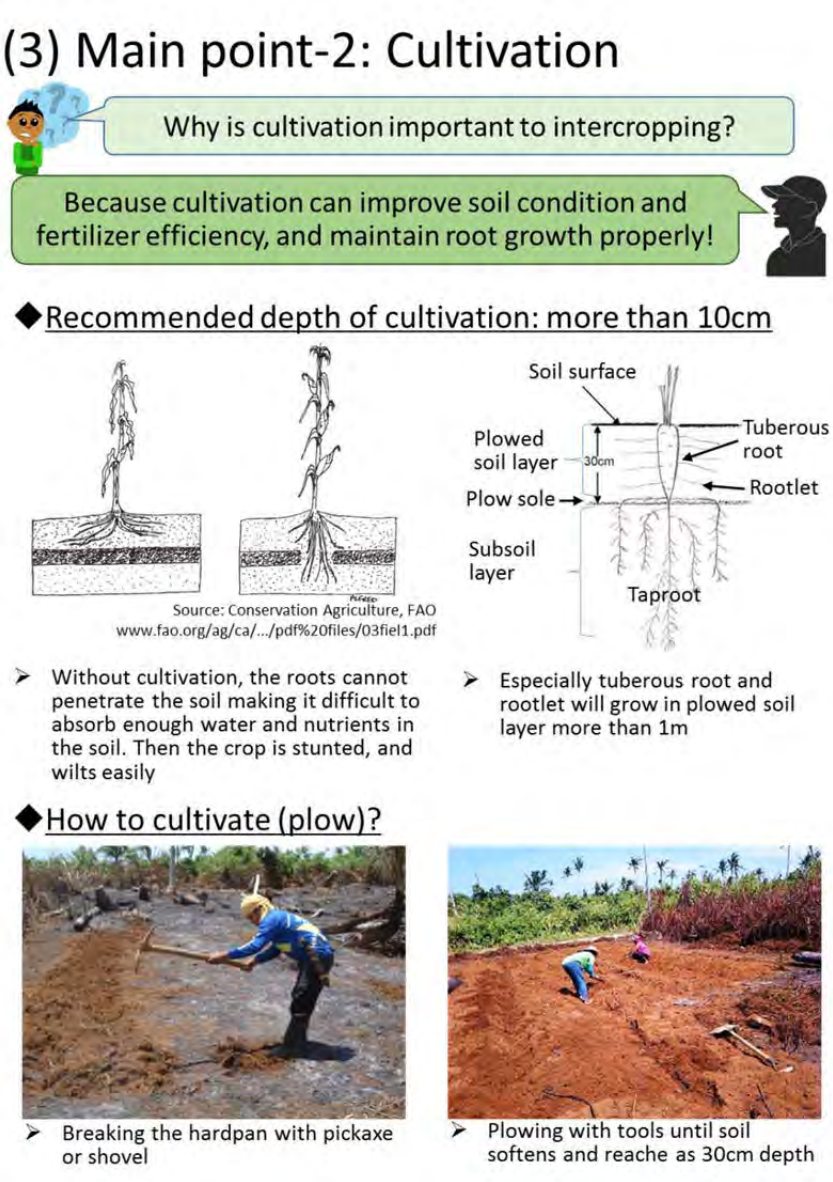
2) Removing rocks and dead roots

Arable land is limited in the region, particularly in Mercedes, since there are huge rocks, dead corals, and shrubs scattered on the ground that make cultivation more difficult, may interfere plant root growth, and making straight plots for horticultural production becomes inefficient.

3) Cultivate the ground

Most farmers in Mercedes practice traditional farming techniques. They practice direct sowing without cultivating the land and plant vegetables even without straight ridges. Soils are compacted too hard that it barely develops appropriate area for healthy root growth of vegetables; and makes it even more difficult to mix fertilizers properly into the root area.

Appropriate tillage also needs to be practiced in order to improve efficiency of limited land and inputs.



<Further information>

1) Ideal depth of tillage

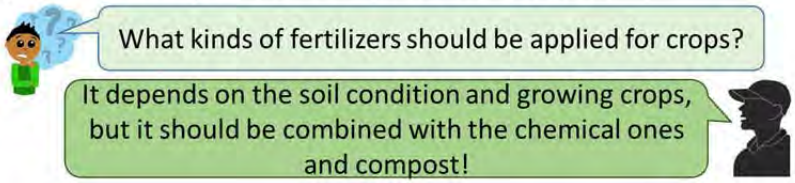
Cultivation is done to bring up the fertile soil among the soil layers. If the weeds and shrubs or other crops are growing well and the leaves are piled on the ground, fertile soil is visible in the surface. In that case, the depth of tillage needs to be approximately 10cm and not turned over in the first year. The depth of tillage can be deeper year after year – 15cmin the second year and 20cm in the third year.

But tuber crops like sweet potato (camote) are recommended to be plowed around 30cm depth to maintain good root area for camote. Soil in the area is relatively coarse and well drained, so flooding is not expected to be a big issue.

2) Formation of top soil

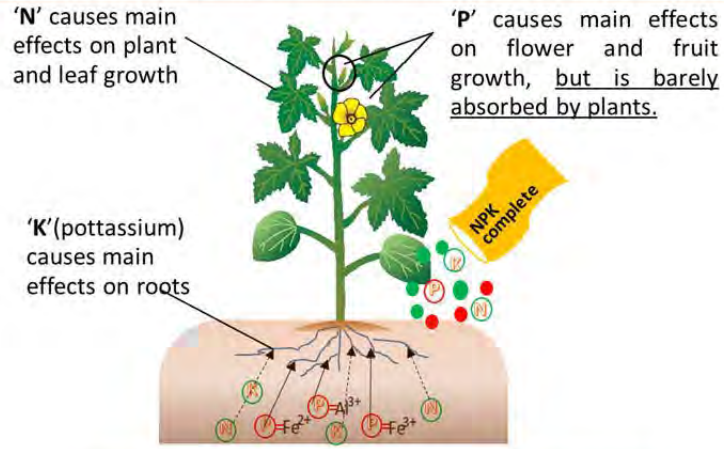
The soil in the area seems to be composed by oxidized metals from eroded organic materials. The efficiency of horticultural production may be improved by developing the formation of top soil which can be achieved by applying organic matters such as composts and organic fertilizers.

(3) Main point-3: Fertilization



- Chemical fertilizer – helps crops become more productive

Chemical fertilizer is compounded 'NPK' which stands for nitrogen(N), phosphorus(P), and potassium (K: *Karium* in German) which are main elements for plant growth.



Chemical fertilizer available in Mercedes

Urea (46% of N)
-Efficient
-Especially good for cereals

NPK complete (14-14-14)
-Possible to use in all plants
-A bit expensive

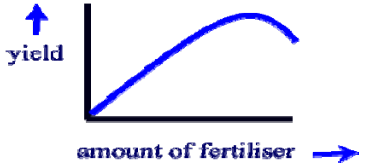
Photo: ROMGO International Corporation (http://www.ramgoseeds.com/products.do?item_id=435)

<Further information>[1]

Plants need nutrients, as well as carbon dioxide and water for photosynthesis. Macronutrients are needed in relatively large quantities e.g. nitrogen to make amino acids. If plants lack these nutrients when they are growing they show specific deficiency symptoms.

Nutrient	Use	deficiency symptoms
nitrogen	growth, production of proteins and nucleic acids	stunted growth, brown older leaves
phosphorus	proteins, nucleic acids, ATP	poor root growth, dead yellow spots on leaves
potassium	enzyme activator	poor growth, dehydration, small purple leaves

Chemical fertilizer has an instant effect on the crop growth and does NOT destroy soil environment if applied properly. Fertilizers need to be applied in appropriate quantity. It should be noted that applying more fertilizer will not produce more yield, but may cause physiological disorder instead. Excess nitrogen is a result of overdosed chemical fertilizer.



After applied certain quantityof fertilizer, the yield decreases

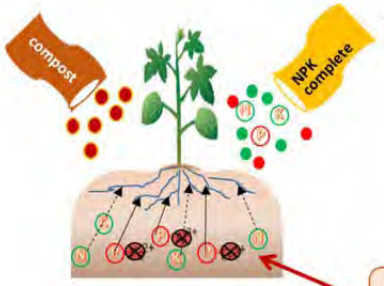
Nitrogen deficit:
Leave color turn yellow

Overdosed nitrogen:
Stem rots and decrease

[1]Modified the information and referenced a website;
http://www.cix.co.uk/~argus/Dreambio/fertilisers%20and%20crops/fertilisers.htm

(3) Main point-3: Fertilization cont.

- Compost – contributes to the healthy plant growth



◆ Compost can improve:

- Soil structure and drainage
- Contribute plant growth providing some nutrients
- Efficiency of chemical fertilizer, especially 'P'

by holding elements which hinder plant absorption of fertilizer

See the details on Chapter 3

- Other materials – e.g. Coco ash

Coco ash is useful in adjusting the acidity level and acts as a source of potassium

e.g. Mercedes case: utilized the by-product of charcoal production

Charcoal production — Coco ash from charcoal

- Ash in the kitchen or residues are also efficient like the coco ash.
- Coconut and sweet potatoes, the main crops in Mercedes, require high potassium.

<Further information>

Soil, specifically the acidic soil, is composed of relatively infertile eroded organic matters with oxidized metals. Metallic matters such as iron and aluminum absorb excess phosphate can cause fertilizer inefficiency. The Humic acid in compost can alleviate such problems as shown in the figure on the right.

It is recommended to apply 20 tons of compost per ha besides chemical fertilizer. It could be used to hold phosphorous fertilizer to be easily absorbed by plants even in lower quantity at 1/10 of the recommendation. Compost can be an effective material by applying together with fertilizer as a holding agent of nutrients.

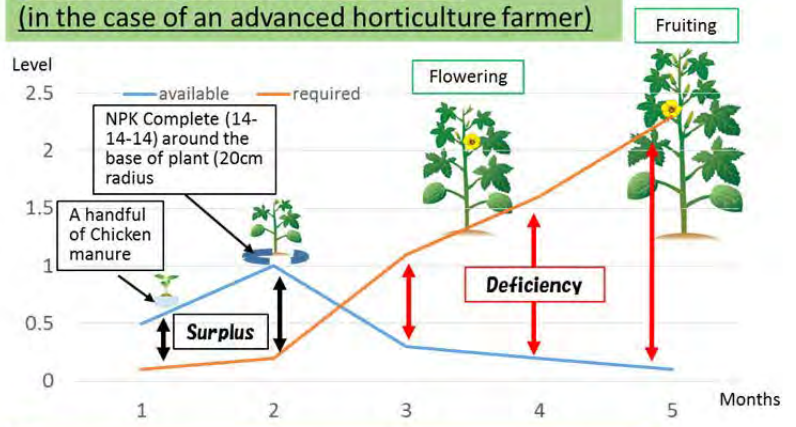
Ash can be is used to neutralize acidic soil because of its lime content. Coco ash can be an efficient input material as a potassium fertilizer and also a soil neutralizing agent. Traditionally, charcoal is often produced from coconut husk after copra production which means that coco ash is available all year round in the area and can be used in improving the soil condition.

(3) Main point-3: Fertilization cont.

- Appropriate fertilization

Most of coconut farmers do not apply such for veggies!

A traditional fertilization in Mercedes
(in the case of an advanced horticulture farmer)



So, apply fertilizers according to plant requirement!

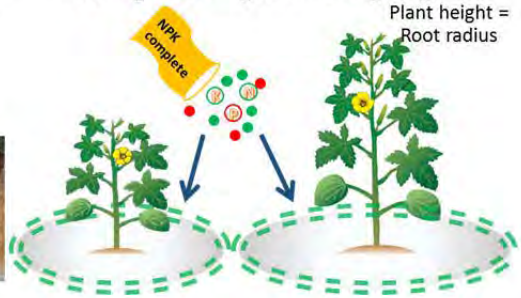
Basal fertilization

<before planting >

Apply all basal fertilizers (compost, plant ash, NPK) evenly, and then mix the fertilizer evenly within the plowed layer.

Topdressing

<during flowering and fruiting stage>

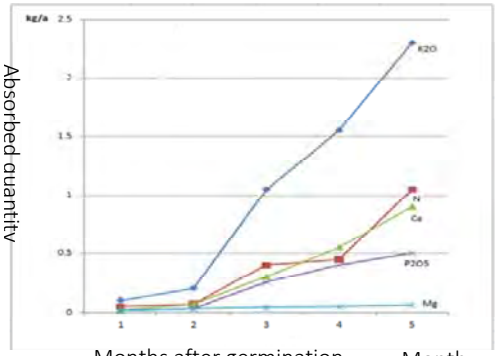


Apply fertilizers in active root area = root radius! (See more detail in 2-3 for topdressing)

<Further information>

Inappropriate application method of fertilizer together with adverse soil condition is causing inefficiency of fertilizer. Introduce appropriate fertilizer application method to improve crop yield and quality.

Absorption of fertilizer by growth stage: Carrot

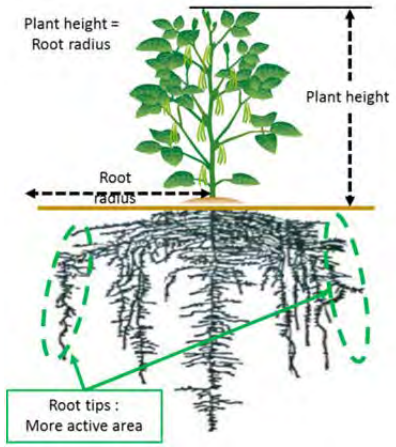


- ✓ The required amount of fertilizer increases as the plant grows.
- ✓ Different amounts of fertilizer need to be available for each growth stage
- ✓ Application of fertilizer should be done according to each plant's requirement

Point to be noted when topdressing:

Fertilizer needs to be available at the growing root tip.

- ✓ The root grows outside
- ✓ The requirement of fertilizer increases as the plant grows
- ✓ More fertilizer is required during flowering and fruiting stage



2.2 Crop Production in the Early Stage

<Further information>

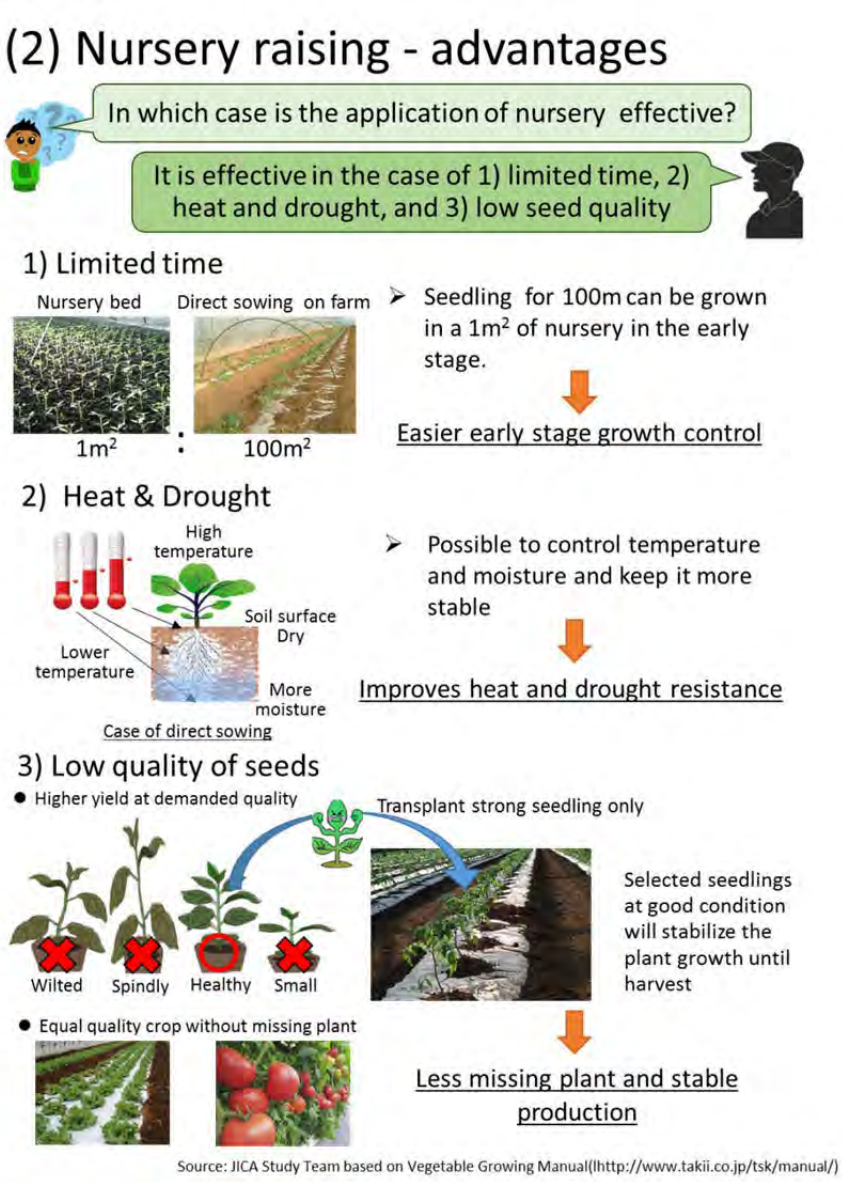
Nursery raising of horticultural crops must be promoted once intercropping is introduced in the area in order to improve the utilization of limited arable land and input materials. Direct sowing or free care nursery is common in certain coconut farms in the Philippines.

Direct sowing and dried up plants

Sem-free case nursery in Mersedez

In Japan nursery raising is practiced and it is believed that the “seedling quality determines half of the crop yield”.

The photos shown on the left (Image 2) are taken in Japan. The effectiveness of the nursery can be observed; the leaves look healthy and the fruits are big and of good quality. In the Philippines some farmers do not practice nursery raising since it requires extra work; however, the extra nursery work may reduce the time and labor after transplanting and may generate more benefit for the farmers.



<Further information>

Indeed, nursery raising requires more time and labor than the conventional way, but has many advantages such as:

1) Limited time- Minimize the time for caring seedlings

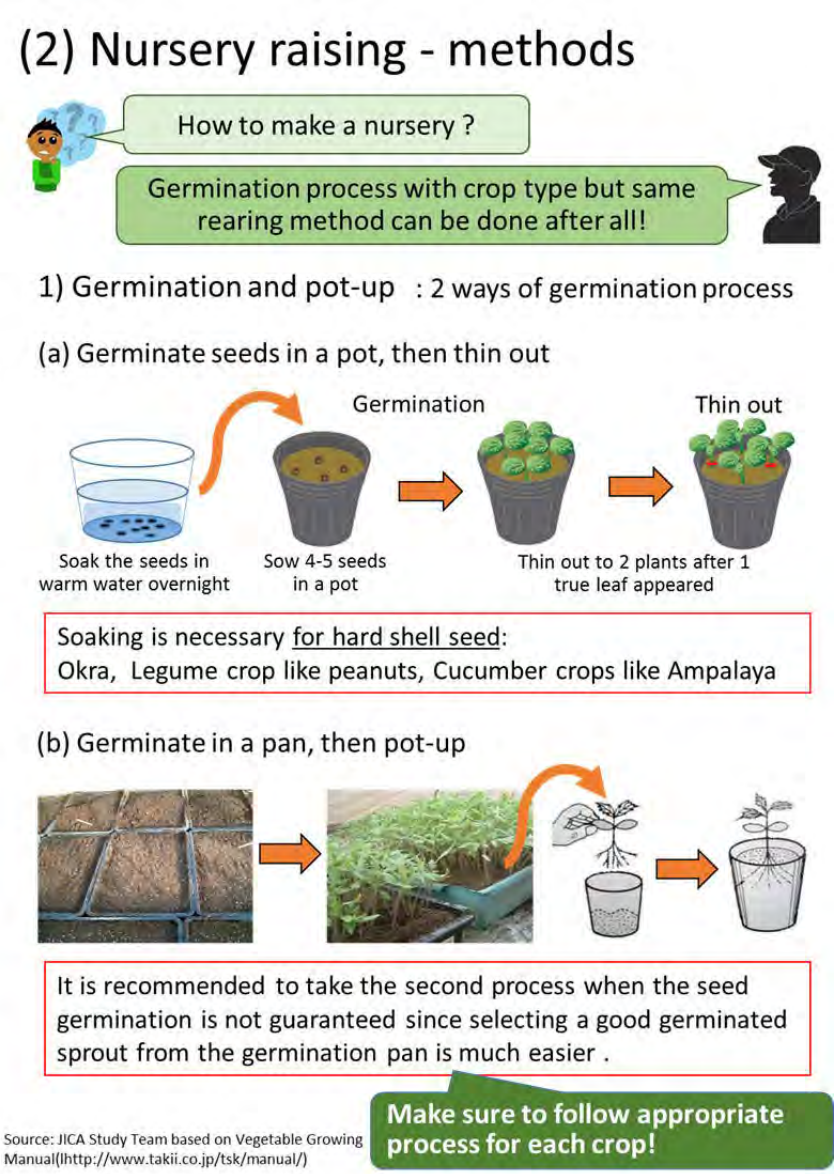
Nursery raising can manage a number of plants than the conventional way. It is more effective to manage seedlings during their very sensitive period of early stage growth. If the seedlings are well managed, they become more tolerant or resistant to the unfavorable environmental conditions.

2) Heat and drought- Improve plant resistance to harsh environment

Young seedlings are more susceptible to heat and drought so it's better to practice nursery raising in a narrow space. Additionally, appropriate raising of seedling improves the tolerance to such damages after transplanting.

3) Low seed quality - Improve quality and quantity by uniform growth

The survival rate of seedlings and the uniformity of plant growth will improve in the nursery. Generally, germination rate will not reach 100% even if the selected seeds were used. Thus, if farmers sow more than the quantity intended for the transplanting area, the optimal number of plant can be attained and the area will be used efficiently.



<Further information>

1) Germination and pot-up

1.5 to 2 times more seeds need to be sown when germination rate is not 100% for most selected seed.

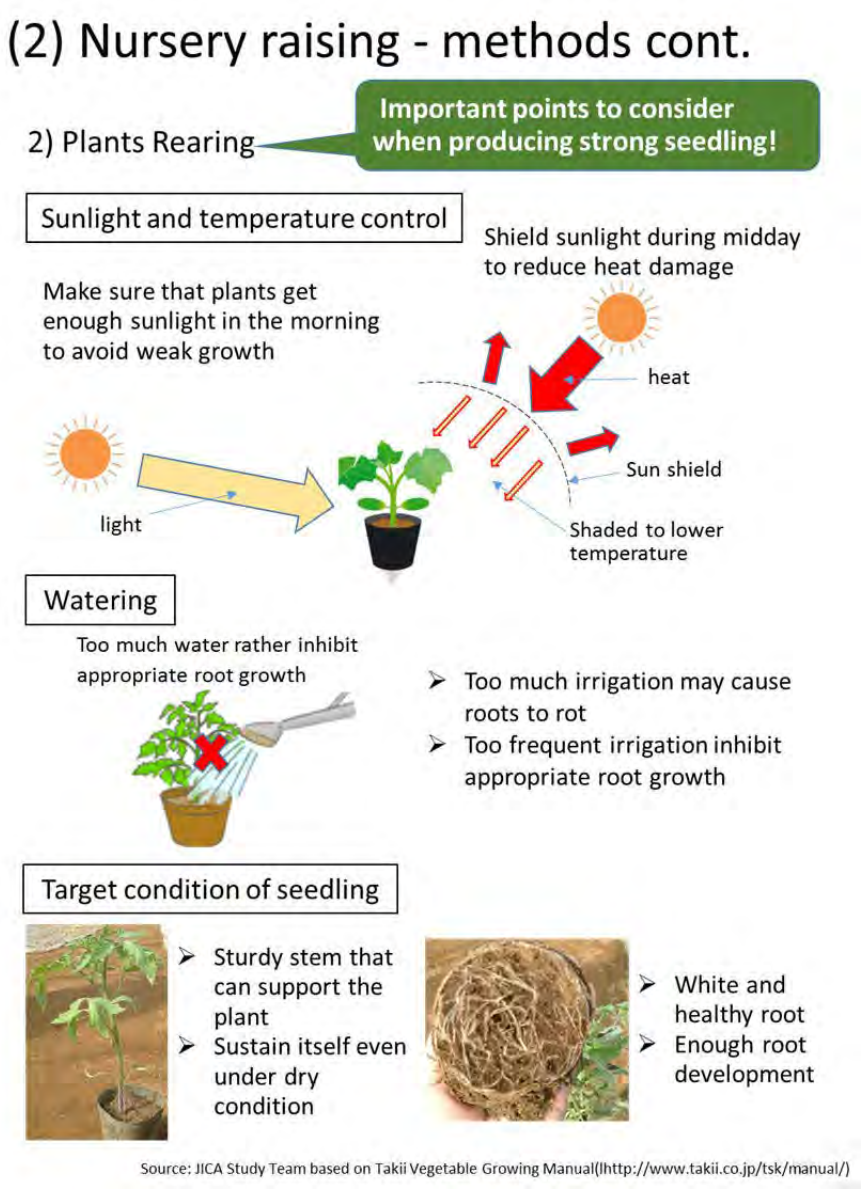
Depending on the crop type, the germination methods are different: (a) hard-shelled seeds such as bitter gourd (ampalaya) or okra; and (b) soft-shelled seeds such as tomato and eggplant. Treatments are different for each type of seed, so make sure to check appropriate procedure by crops.

(a) Germination in a pot

Hard-shelled seeds should be pre-treated by soaking in water to improve the uniformity of the germination timing. When seedlings are directly sown to the pot, after a certain period, some plants are to be thinned out leaving 1 or 2 healthier plants. Once the appropriate size is achieved, the seedlings can be transplanted in the main field.

(b) Germination in a pan and pot up

Appropriate sprouts germinated at uniform size should be selected for pot-up. Pot sizes need to be determined according to the ideal size of the seedling that will be transplanted. If the seedling grows approximately 5~7cm (depending on the crop) after sowing them, they can be transplanted to the pots. And then, the seedling should be raised until it reaches its appropriate size before transplanting to the main field.



<Further information>

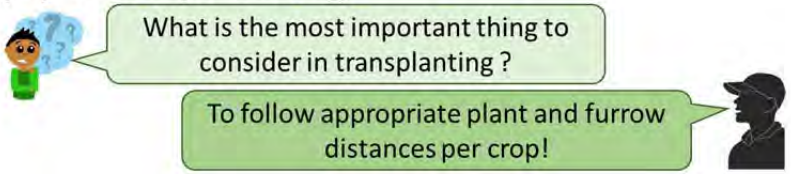
2) Plant rearing

Seedlings are more susceptible to the outside environment during early stage of growth – from germination up to young seedling. Shielding them from sunlight is recommended, especially during midday when the temperature is too high. However, appropriate sunlight needs to be assured to avoid spindly growth even during early stage growth. Also, selecting an ideal location where seedlings can get morning sunlight is very important. Watering is also an important factor in developing appropriate root growth; however, too much irrigation during nursery period suppresses the root growth. It is important to irrigate least amount of water so not to wilt as well as to induce better root growth since high temperature rather suppresses root growth during nursery period.

If seedling pots are very expensive or out of stock, you can make them with plastic drink bottles or recycled papers. As for the plastic bottle, after cutting it half and drilling some holes at the bottom, you can use it as a nursery pot. For paper use, please refer this web site:http://allourdays.com/2012/03/sturdy-recycled-newspaper-pots-tutorial-origami-fold.html.

Source:http://www.instructables.com/id/Recycled-Plastic-Bottle-Plant-Pot/ and above URL.

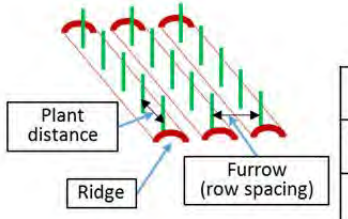
(3) Transplanting

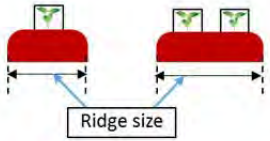


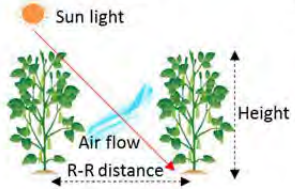
<Basic Points >

1) Follow appropriate distances of furrow and between plants
2) Prepare straight ridge row according to the required distances
3) Prepare seedlings at the right condition

1) Appropriate distance by crop :Plants need a certain space!







Appropriate distance (Example)

crop	Furrow (cm)	Plant distance (cm)
Sweet potato (Camote)	90	25-35
Better gourd (Ampalaya)	150-270	80-90
String bean	120-200	30-40
Okura	100-150	25-35
Tomato	180	25-50

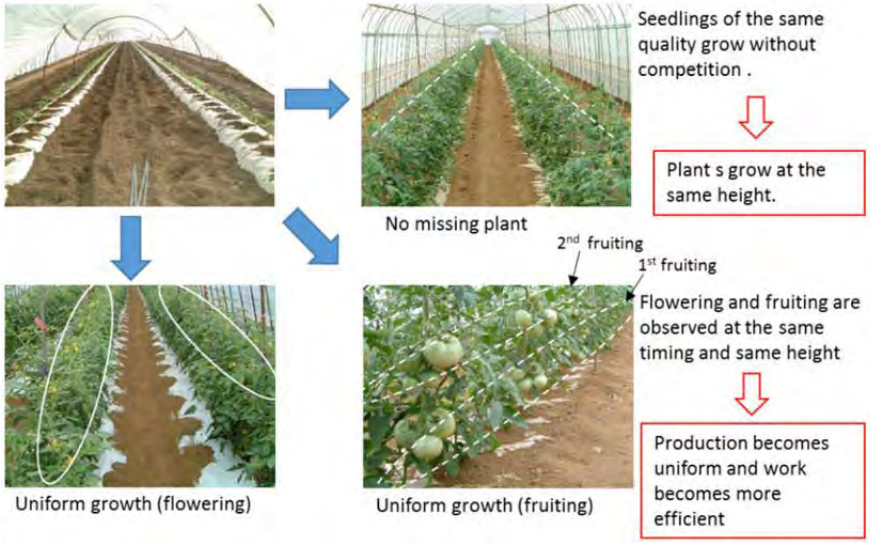
- Furrow distance should be equal to the plant's height to improve growing environment; sunlight and air

Plant height ≒ Furrow distance

Source: JICA Study Team based on Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

<Further information>

Growing seedlings up to a certain size is recommended to improve later growth even if the nursery period is extended. Non-uniform growing condition caused by missing plant may lead to non-uniform quality of crop which will cause to lower yield and profitability.



1) Appropriate distance by crop

Planting density is determined to attain the highest yield per unit area. Appropriate distances by crop are shown in the table on the right. Generally, furrow (row spacing) distance should be equal to the plant's height so it would be easier to decide the plant's distance.

Transplant cont.

(3) Transplanting cont.

2) Ridge preparation

Prepare straight ridge rows following appropriate distance per crop

Cord or string is very useful in making straight ridges

Well done!

3) Seedling preparation transplanting

Choose a cloudy day or cooler time of the day like evening for transplanting

Soak seedlings in the water before transplanting in order to absorb adequate water for rooting

Un-pot the seedling carefully without breaking pot soil

Dig a deep planting hole and put the plant to be visible leaf parts above ground).
Cover planting hole with soil firmly.

Source: How to Grow (Lots of) Tomatoes Organically (http://commonsensehome.com/grow-tomatoes-organically/)

Appropriate preparation of ridges can improve plant rooting system and growth of plant !

<Further information>

2) Ridge preparation

The size and shape of ridges depends on the type of crop and planting pattern. Thus, making ridges is also important in raising healthy plants and obtaining a good yield. The ridge should be straight to be able to grow plant homogeneity and healthy crops by taking advantage of sunlight and aeration. Also, straight row ridges allow plant management: easier weeding, training, or pest &disease control etc.

3) Seedling preparation and transplanting

Transplants become less stressed when they are set out on a cloudy calm day due to the humidity in the air at that time; and no wind means lesser chances of the new seedlings getting dried out.

The cooler time is different by season but it is normally during late afternoon when the sun is not so hot, and the wind has calmed down.

By taking advantage of this time of day, the new plants have overnight to acclimate. Strong heat and wind have negative effects on new transplants unless you water them carefully and provide shelter against such factors that may cause wilting.

On the other hand, mulching does help since it lowers the rate at which water evaporates from the soil and controls the soil temperature; therefore, it is more beneficial if you plant in the middle of the day.

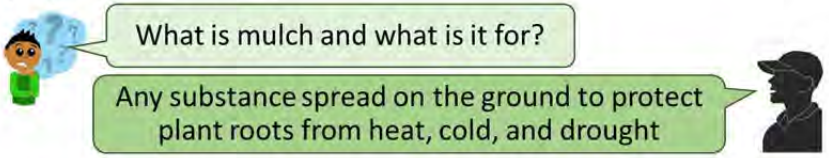
2.3 Plant Management

<Further information>

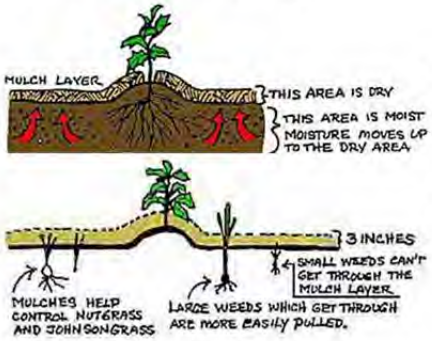
Plant management is important in the horticulture production, especially vegetables, in order to grow plants of good quality and productivity.

Mulching is considered as a plant management practice which aims to control soil moisture, temperature, and several harmful phenomena after transplanting. Weeding, a primary task to prevent concurrence of nutrient and to control pests and diseases should be started a few weeks after transplanting. If the shoots and vines are growing, training must be practiced so not to grow them thickly and raise the plant healthier. Tip dressing, as mentioned in 2.1 'Fertilization', is important to complement fertilizer when the plants need it more. Pest and disease control is indispensable management to maintain certain product in good quality.

(1) Mulching



◆ Benefits of mulching



- ✓ Retains moisture /Reduces water loss from the soil
- ✓ Control weed
- ✓ Fertilizer conservation
- ✓ Prevent soil erosion
- ✓ Keep the soil cooler or warmer depending on the type of mulch used.

◆ Selection of Mulches

Consider the following factors when selecting materials:

- ✓ **Cost of the material:** Do not spend money on mulching material when suitable materials are available at little or no cost.
- ✓ **Used crop:** Never use material from the crop that is to be protected. E.g. do not use potato vines to mulch.
- ✓ **When the mulch is to be used:** Select light-colored mulch during the hot season to reflect heat. Use dark-colored mulch in early rainy season to help warm the soil and to hasten early growth.

Source: Resource Manual on Integrated Production and Pest Management (IPPM9 in Vegetables, World Education (INGO), Philippines, Inc.

<Further information>

Mulch is any material spread on the ground to protect plant roots from heat, cold, or drought and keep fruits clean. Mulching the garden shows that a farmer or gardener really care about the plants. A well-mulched garden can yield 50% more than a non-mulched garden of the same size. There are many benefits of mulching as described on the right. The details of the main ones are explained below:

1) Retain moisture

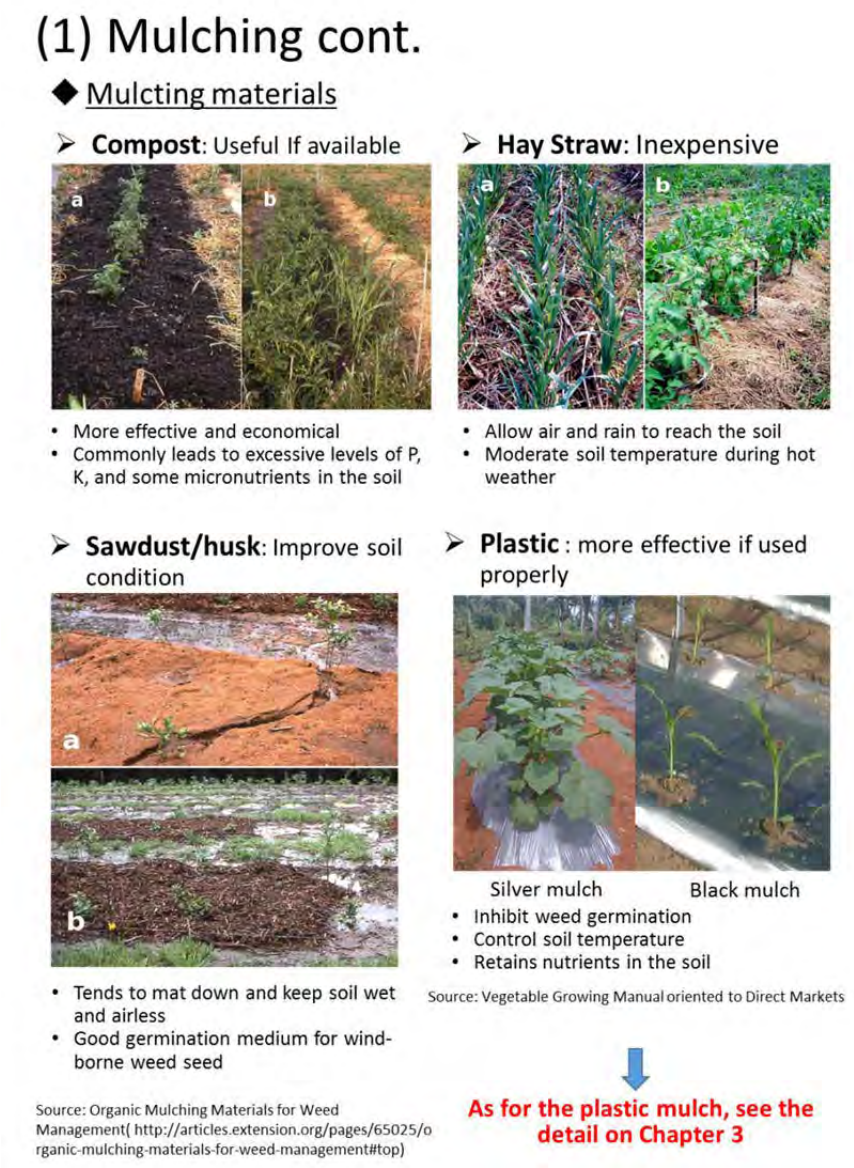
Mulching the area will conserve water and reduce the rate of water loss from the soil. The mulch layer on the soil surface allows the soil to soak up more water; thus, mulching is important in dry and rain-fed areas.

2) Weed control

Weeds grow vigorously even after weeding and burning before cultivation in the local climate. Mulching, especially by plastic sheet, inhibits the sunlight underneath so the weed growth can be suppressed under the mulch.

3) Fertilizer conservation

Fertilizer can be washed out by rain water especially in high concentrated heavy raining area. Mulching over the fertilized soil will protect it against soil erosion and at the same time prevent fertilizers from being washed off by heavy rain.



<Further information>

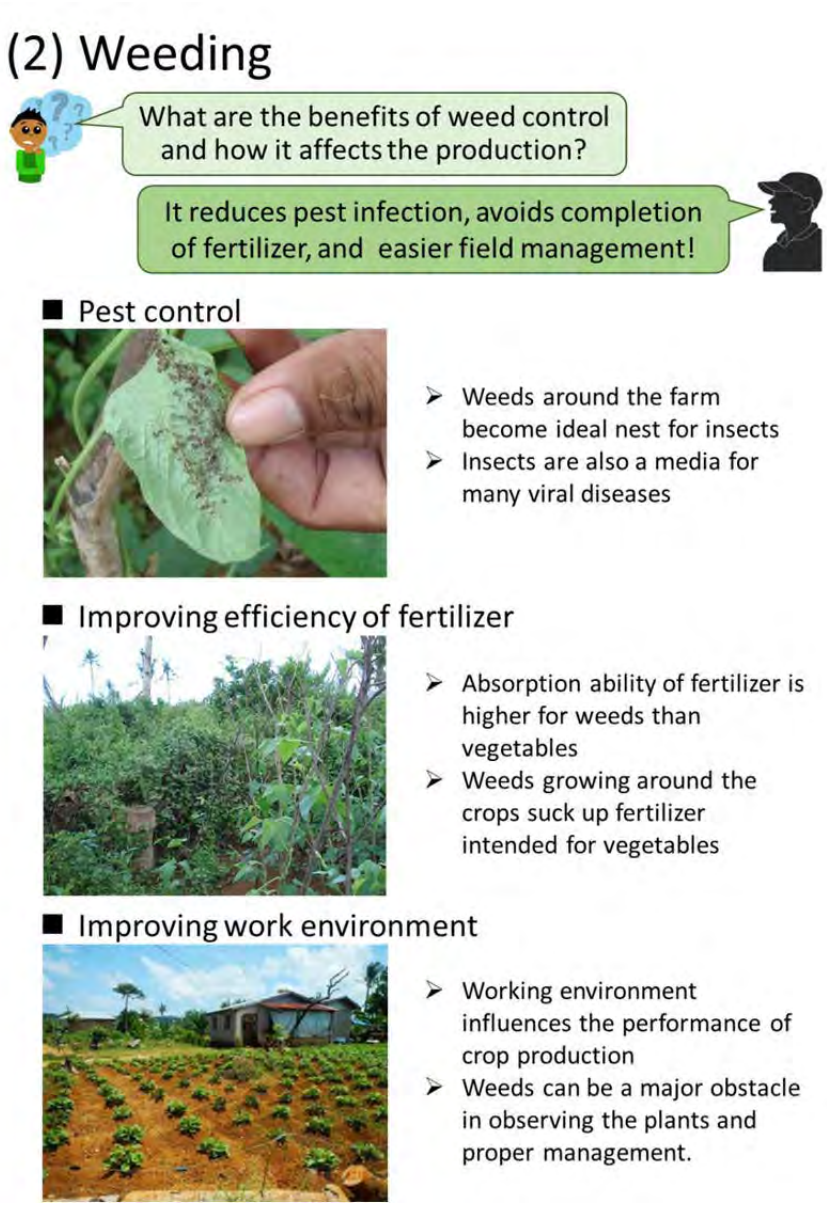
Mulches are classified as organic and inorganic. The organic ones include compost, hay straw, sawdust (husk), and similar materials, while the inorganic includes plastic, rocks, rock, chips and other non-plant materials; but generally the plastic one is commonly used in vegetable gardens.

Organic materials:

- *Compost* is generally the best mulching material for the home garden. It is usually free of weed seeds and is economical if you can prepare it properly using the materials in your farm.
- *Hay straw* is a short-termed type of mulch and has a rough texture. More straw is needed for the same effect as compost or lawn clippings. Generally, less finer-textured materials are required to provide a 10 cm layer of mulch after settling.
- *Sawdust or husk* can be a good mulch to retain moisture if well managed. It may provide a good germination medium for wind-borne weed seeds.

Inorganic materials= Plastic mulch:

- It can be effective if used properly. Use black plastic in spring time and early summer to warm the soil. Black plastic keeps light from the soil and prevents weeds from growing. Clear plastic warms the soil, but weeds can grow beneath the plastic. One of the disadvantages of plastic is that it cannot be mixed into the soil at the end of the season.



<Further information>

The effects of weeds growing on the ground are relatively low for the coconuts because of its height. Weeding in coconut farms is a minimal task under traditional monoculture. But in the case of horticulture production, weeds cause serious damages to cropping plants in terms of pest, nutrient concurrence, and work environment.

■ Pest reduction

Weed is one of the major causes of pests as it serves as a perfect nest and shelter to all kinds of insects. The insects are also major sources or carriers of many diseases. Leaving insects in the nearby weeds also increase the chance of acquiring infections caused by diseases.

■ Improve efficiency of fertilizer

Weeds that have a strong absorbing ability of nutrients can grow even on a very infertile land. Fertilizers may be absorbed by weeds before cultivating crops, so the necessary fertilizer applied may not be available for the crops.

■ Improve work environment

Weeding is part of proper plant care management. Grown weeds become not only an ideal nest for pests but also inhibit appropriate aeration to deteriorate the good growing environments for crops. Grown weeds also disturb the appropriate work environment which will lead to deterioration of crop quality.

<Further information>

Training, including pruning and trimming, is barely practiced by coconut farmers who also grow vegetables. Some of them said that they do not want to do so for fear of wilting plants due to the stress applied by training. But, if it is done properly and practiced at the right timing, the plant stress is minimized; on the contrary, the plant will become vigor and more productive. The details of the benefits which extension workers should explain to the farmers are described as follows:

- Improving utilization of space and husbandry efficiently

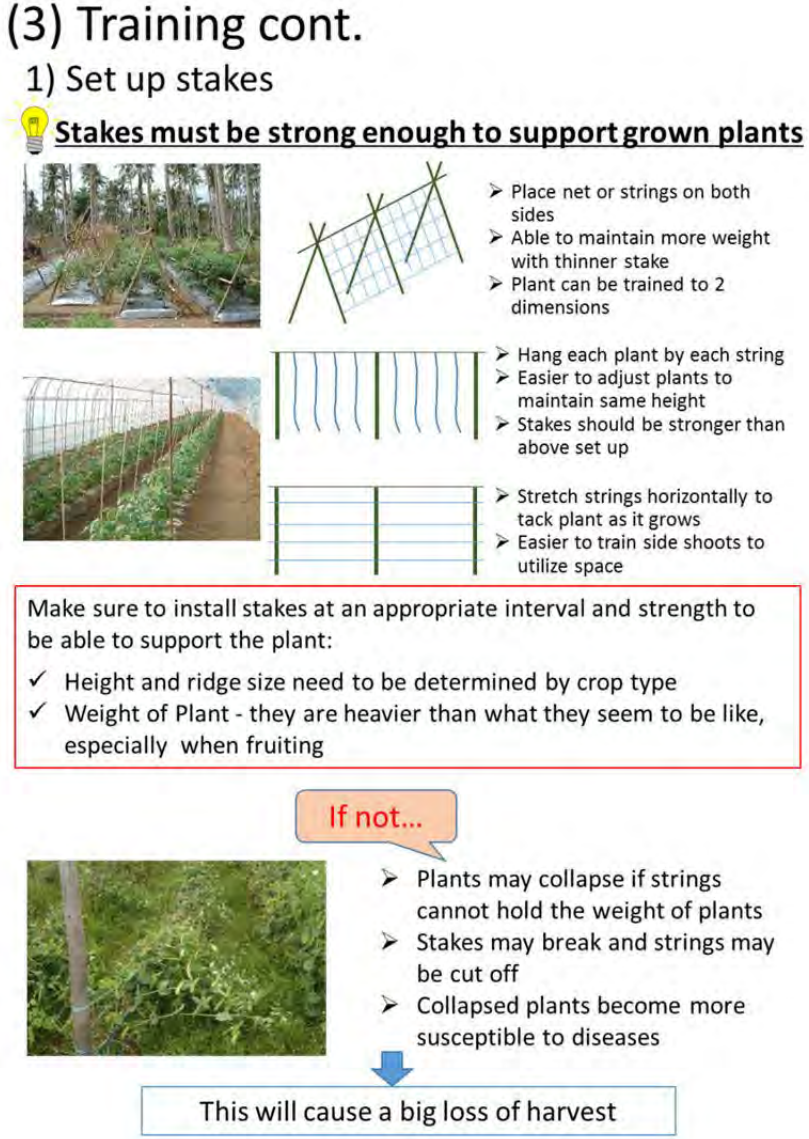
Appropriate training by utilizing stakes, strings, and nets can clean furrow (row space between ridges), and will make plant parts more visible for easier husbandry work in order to have a good harvest.

- Improving condition against disease infection

Appropriate training will also improve aeration and sunlight penetration. This improvement in growing environment increases plant vigor and improves tolerance against pests. Appropriate training will directly contribute to the development of healthy growing environment.

- Stabilization of quality and quantity

Buds and growth points become visible by appropriate training make management of plants a lot easier for farmers; therefore, uniform growth condition will also be attained. Uniform growth will increase the possibility to produce more demanded quality and also target yield. Improved management will help farmer to stabilize the production for planed sales which will improve the profitability.



<Further information>

This section describes the general method of training. Before the training method, stakes (trellis) should be selected and set up.

1) Set up stakes

First of all, a suitable trellis should be selected according to the characteristics of plants you want to grow. Deciding which kind of trellis to use can depend upon what vegetable crop you want to grow on it.

Many different types of trellises:

- ✓ small tree branches
- ✓ nylon string mesh tied between metal poles
- ✓ bamboo poles
- ✓ twine wrapped between supports
- ✓ welded wire fence
- ✓ Fishing net (it was used as trellis for Ampalaya in Mercedes)

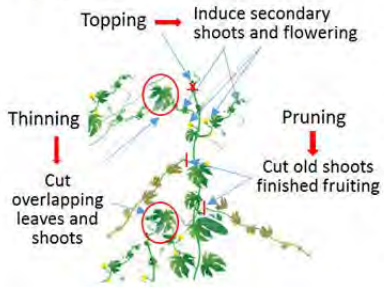
Using recycled fishing net and tree branches for ampalaya. The holes of the net were too small to make vines pass through them, but tearing some parts of the net makes it possible.

(3) Training cont.

2) Topping, Pruning and Thinning

Necessary to practice for a continuous good harvest

◆ Kinds of training



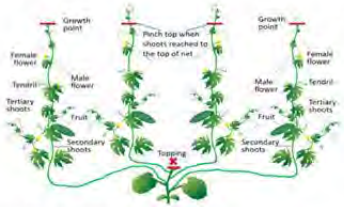
Topping
- Induces secondary shoot growth
- Shifts vegetative growth to reproductive growth

Pruning
- Reduces overcrowded shoots
- Shifts nutrients for new shoots growth with flowers

Thinning
- Improves aeration for better environment
- Improves sunlight efficiency for better photosynthesis

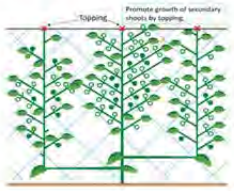
◆ Examples of training

- Bitter gourd (Ampalaya)



- Pinch top before transplanting after 5th true leaves developed
- Main shoot generates less female flower, so induce secondary shoot growth at the beginning
- Pinch top to generate tertiary shoots growth when the shoot reaches the top height of the stake

- String bean



- Maintain main and side shoots to grow at same strength
- Train side shoots to open space for efficient utilization of space
- Pinch top to generate tertiary shoots growth when the shoot reaches the top height of the stake

Source: Vegetable Growing Manual(Ihttp://www.takii.co.jp/tsk/manual/)

<Further information>

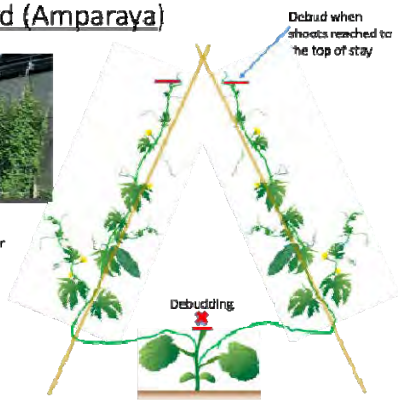
2) Topping, Pruning and Thinning

Each crop has a different method of training, pruning, and trimming. Understand the characteristics of each variety to attain the highest yield and quality. As additional information, examples of trellis and training methods of Okra are described below:

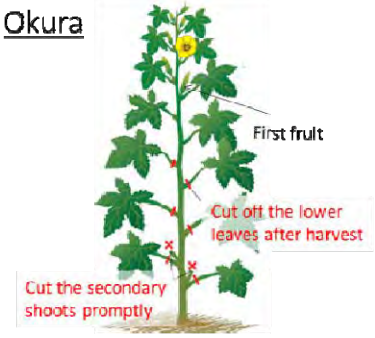
String beans:
2 plants in each hole.
Train to separate plants for each sides

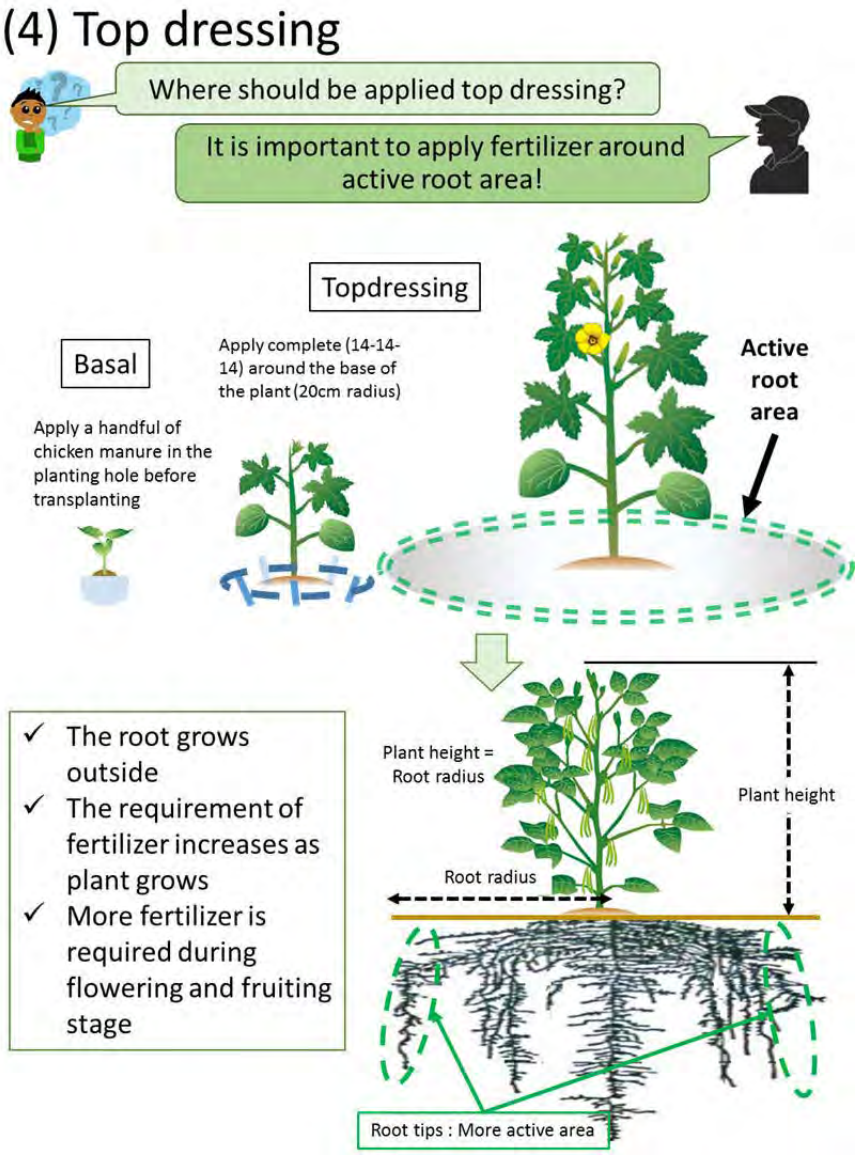
Bitter gourd (Amparaya)

It is possible to grow amplaya as a shade for house



Okura





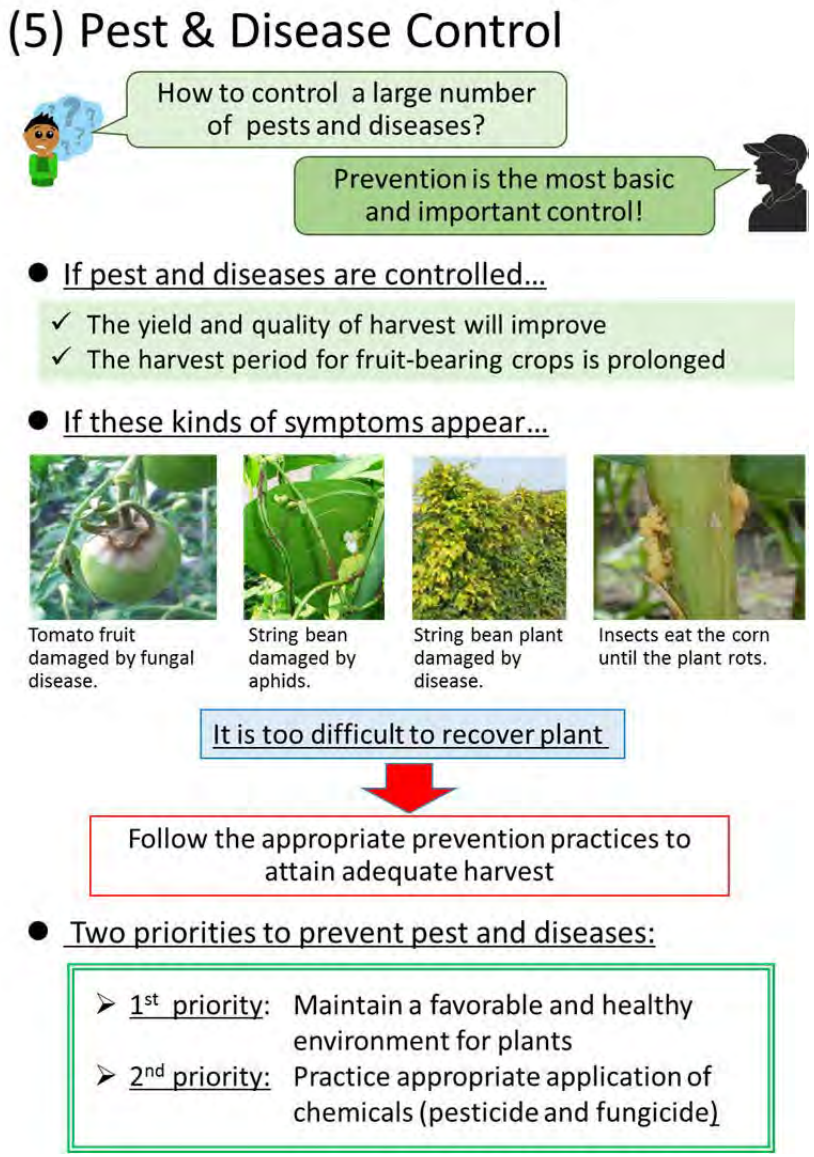
<Further information>

The method you use to apply fertilizer to the intercropping field depends on the fertilizer farmers have chosen, whether it's liquid or granular. If their horticultural farm has fertile soil enhanced by compost and other organic materials, fertilization may not be necessary. However, fertilization is still necessary for some plants, especially vegetables, to speed up growth and improve the harvest.

Top-dressing is when you apply fertilizer over the surface of the garden.

Always follow label directions regarding how much to apply. Too much is not good; you can overdose or burn your plants. Good timing is also important. Usually, you're advised to feed the plants at planting time to get them off to an early and vigorous start. A second midseason application is worthwhile if you're growing a succession of crops in the same row or intercropping.

The manual suggests the place of top dressing; some farmers often apply fertilizer close to the main stem of plants which makes fertilizer ineffective due to misconception. Farmers must understand that the active roots are located around the plants (length distance is the same as of the plant height). If the Plant is as tall as 50cm, topdressing should be 50cm away from the plant.

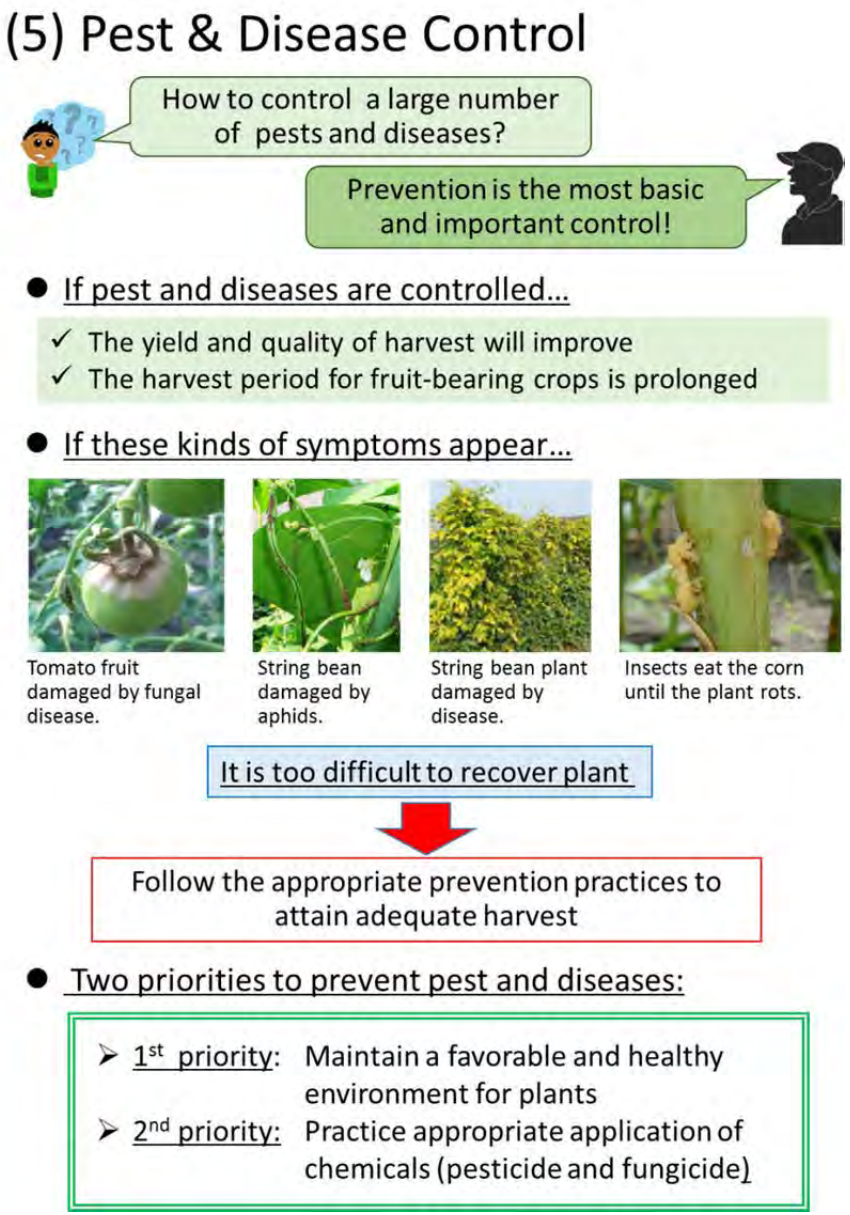


<Further information>

The success of farming depends on the proper management of crop pests and diseases.

Mercedes experiences hot and humid climate causing pests and diseases to damage the plants; and such kind of weather condition makes pest control a critical task for the farmers. When there is less sunlight and too much rain during rainy season, soil borne diseases enhance the damages. Besides pesticide application, farmers should practice all possible countermeasures such as maintenance of vigor, appropriate training, silver mulching, and etc. to maintain a good plant growth.

In general, the control method is divided into 4 categories: biological, physical, cultural, and chemical. The former two control methods are used in killing predators, parasites, or traps which can damage plants. The latter two are mentioned in the farmers' manual as priorities: 1) Cultural control by maintaining a favorable and healthy environment, and 2) Chemical control by applying pesticides properly. It should be noted that the first priority in the above mentioned is the most important control to prevent pests and diseases. If you practice properly, you may not need chemical treatment; otherwise, you may recommend famers to use pesticides.

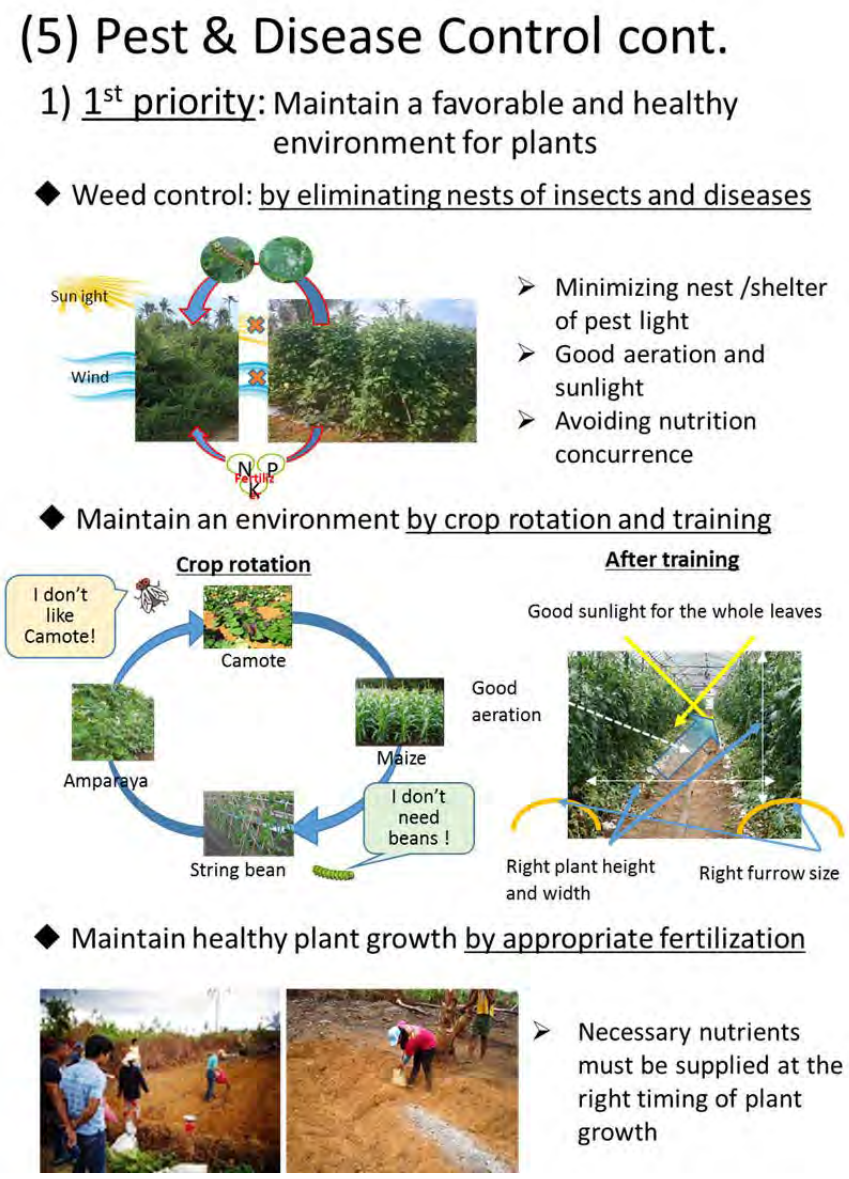


<Further information>

The success of farming depends in part on the proper management of crop pests and diseases.

Hot and humid climate is causing many pests and disease damages all year round. Indeed, in Mercedes which has such kind weather condition, pest control is critical task for farmers, especially when there's less sunlight and rain during rainy season, soil borne diseases enhance the damages. Farmer should practice all possible countermeasures beside pesticide such as maintenance of vigor, appropriate training, silver mulching and so force to maintain a good plant growth.

In general, the control method is divided into 4 categories; biological, physical, cultural and chemical. The former two control methods are used predators, parasites or traps which can kill or attach pests damaging plants. The latter two are mentioned in the farmers' manual as priorities; 1) Cultural control by maintaining a favorable and healthy environment and 2) Chemical control by applying pesticide properly. It should be noted that the first priority as a first step is the most important to prevent pest and diseases. If you practice properly, you may not need chemical treatment. If you con not prevent all, you can recommend famers to use pesticides.



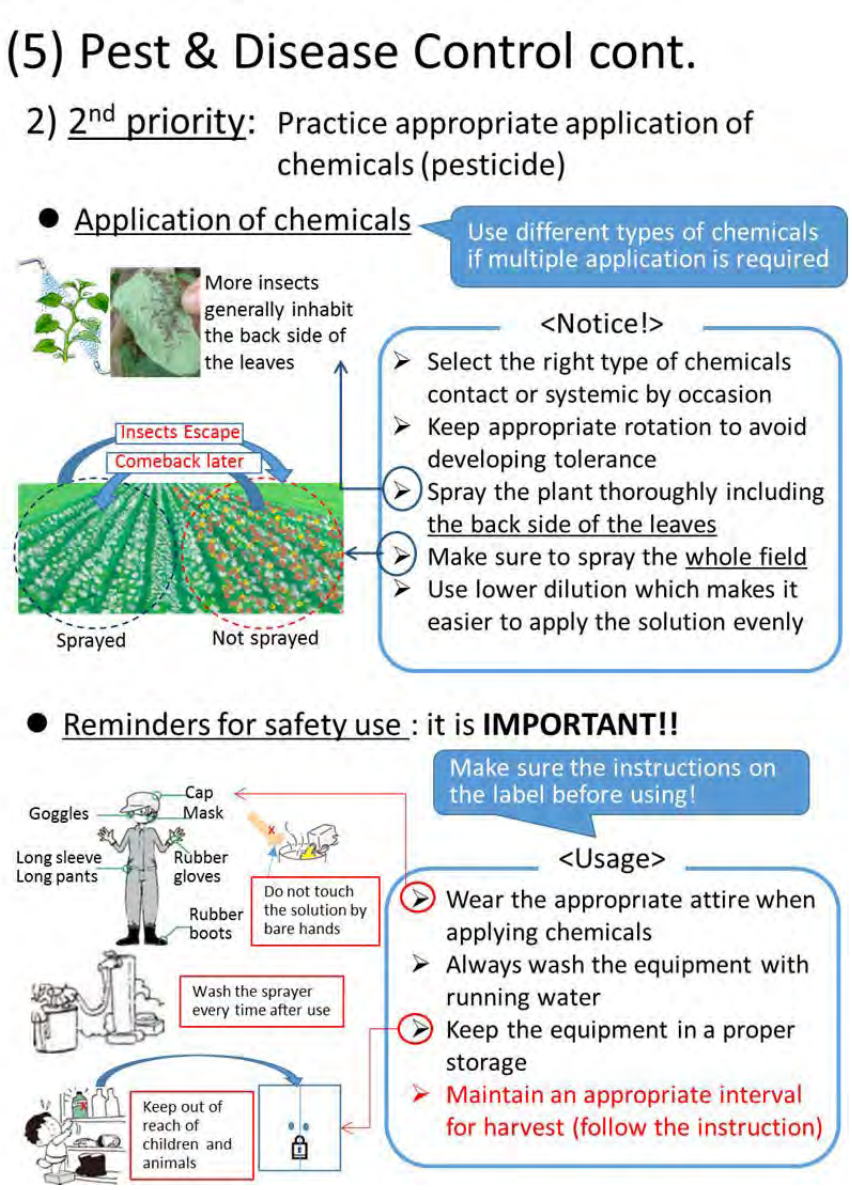
<Further information>[2]

The first priority shown on the right is cultural control which makes the environment less favorable for pest invasion, reproduction, survival, and dispersal aiming to reduce the number of pests in the area. The advantages and disadvantages are listed below:

Advantages	Disadvantages
• Inexpensive or use resources available to farmers, such as labor or indigenous materials. • Adoption of pests against a cultural control practice appears to be a much slower process than that of pesticides • Free from environmental pollution • Compatible with other pest management practices.	• Most methods suppress populations of some pests but can increase some others. • Some practices decreases pests but also decreases yield. • Require community-wide adoption, which may be difficult to achieve

Modification of any crop production practice ultimately affects yield through complex interactions with the crop and environment. All crop production practices affect insect and pest populations either in a positive or negative way. A single practice such as plant spacing during transplanting may produce opposite effects on different pest species, but oftentimes they counterbalance one another. The use of low fertilizer rates or draining the fields is highly effective in suppressing certain insect pests, but may result in lower yield.

[2]Resource Manual on Integrated Production and Pest Management (IPPM) in vegetables, Rice World Education (INGO), Philippines, Inc, 2005



<Further information>

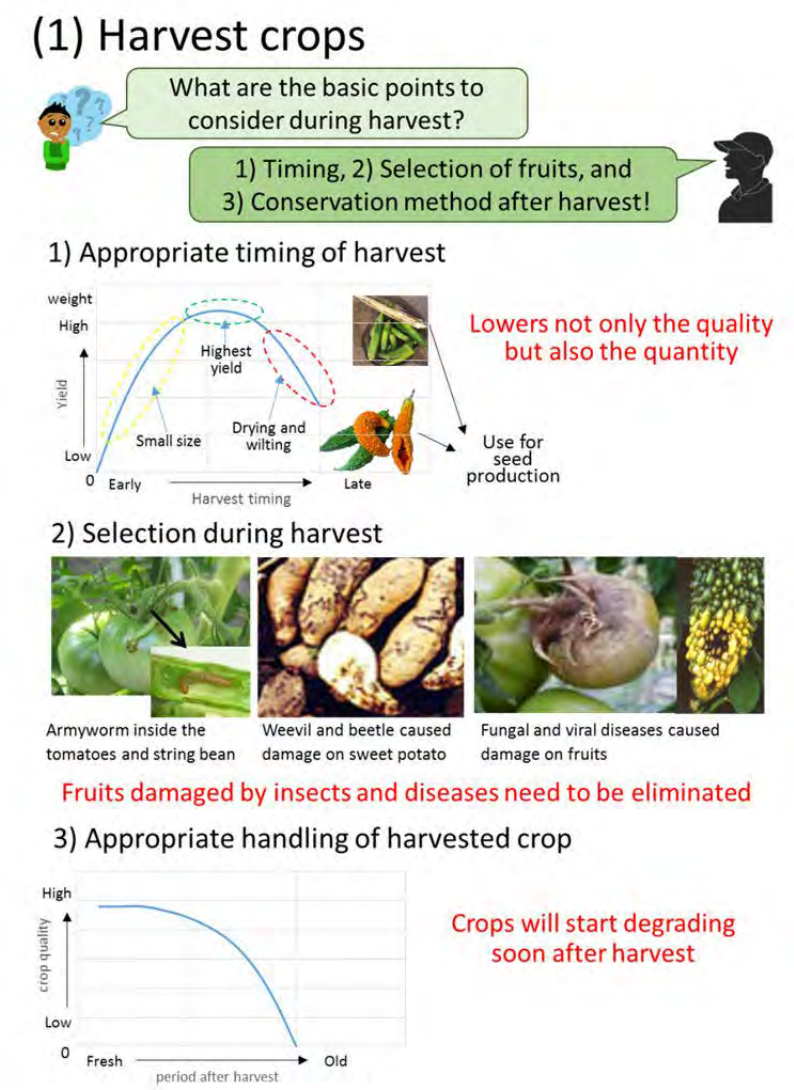
- **Application of chemicals**

After taking all the cultural control, there are still severe pest or disease damages, application of chemicals such as insecticide and fungicide will be required. However, most of the chemicals are preventive, so it is important to apply them while the damage is still in early stage. The effects of insecticides are relatively low against adult insects and some insects are already immune to insecticides; therefore, the application is limited to certain frequencies. Appropriate method and timing should be done according to the guidelines. It should be noted that several types of chemicals are available in the choosing the appropriate one is necessary. For example, the insecticide works only for insects and different insecticide has different effectiveness.

- **Reminders for safety use**

Chemicals may cause severe effect to the human body and safety procedures must be followed not only during the application but also during preparation and storage. Also, each chemical has different scales of allowance for harvest. Make sure to confirm the period to harvest after every application.

2.4 Harvest and Cleaning for the Next Cropping



<Further information>

Basically, there are 2 types of harvest: One time and continuous. The former case refers to the design of fertilization that should be consumed completely at the end of the harvest because excessive fertilizer may cause degradation of crop quality for some varieties. The latter case is important to maintain vigor for continuous harvest by appropriate management, top-dressing, and pruning to attain higher yield.

The important points for harvest are described as follows:

1) Appropriate timing of harvest

Harvesting at the right time may result to highest yield. As shown in the table, fruits and leaves are too small at an early stage and start wilting after certain point.

2) Selection during harvest

Damaged fruits and leaves should be eliminated to avoid spreading insects and diseases to other crops. Aside from that, these damaged fruits deteriorate in quality and taste which can lead to low income.

3) Appropriate handling of post-harvested crops

Harvested crop will degrade as time passes by. Store crops in an appropriate condition to maintain freshness and damaged crops should be removed.

Harvest depends on the market demands. Farmers should communicate with the market vendors to identify the customers' demands and be familiar of the most advantageous size and grade of crops in order to determine the appropriate timing of harvest.

<Further information>

In general, coconut farmers don't practice post-harvest care and just leave their farms until they are covered by weeds and become barren for quite some time. However, if intercropping (vegetable production under the coconut trees) is introduced to the farmers, they will become more responsible and they'll be accustomed to the proper farm management techniques like land cleaning as a preparation for the next cropping.

1) Recovery of reusable materials

Once harvest is done, plants should be uprooted and dried before removing them in the area. After producing vegetable crops for intercropping, several materials (plastic mulch, stakes, and strings) are left and most of them can be used multiple times for a longer period so they should be collected carefully.

2) Appropriate aftercare

After-care like weeding must be done so not to increase weeds, pests, and diseases for the next cropping season. Otherwise, the weed seeds as well as the insects and diseases are spread and will be substantial in the coming days. Thus, weeding should be done repeatedly until the next and/or even during fallow time. If the farm is left without crops, the land can be grown with fodder crops instead, such as maize or Centro, and can be ideal for cattle or buffalo grazing. This will also be beneficial to the farmers since their farms will be naturally fertilized by decaying fodder crops and animal manures.

Chapter 3 Advanced Farming and Agricultural Techniques

This chapter explains the benefits of advanced farming and agricultural techniques for planning and practicing in a coconut farm.

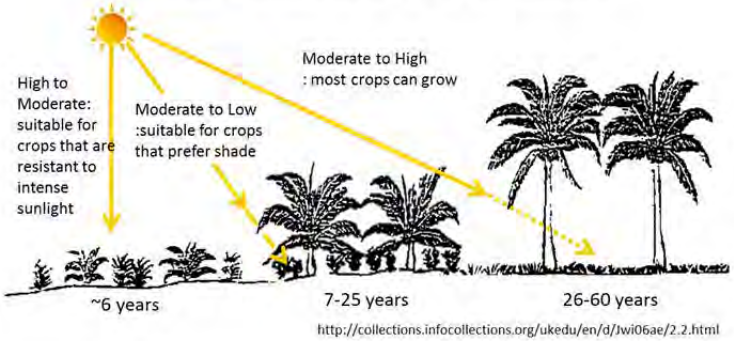
Intercropping is suitable in the area since most farmers are already used to producing vegetables in their own backyard garden. This manual focuses on vegetables as a first step of the intercropping based on the trial in the Mercedes. Intercropping can also be practiced with fruit and timber trees or animal husbandry with fodder crops production. The intercropping system should be according to the different environmental condition and socio-economic situation. It should be noted that in order to achieve successful intercropping results, crops should be changed according to the age of the coconuts.

Various intercropping system are presented based on the PCA's manuals. Some of the advanced techniques which may be useful for all crops are explained briefly upon the request of the farmers in Mercedes. However, it should be noted that these techniques were based in the Philippines, Japan, and other countries and may not be adapted or practiced in all condition and situation.

3.1 Various Cropping/ Farming Type

(1) Suitable crops for advanced farming

Suitable crops varies with the developmental stage of coconuts!



http://collections.infocollections.org/ukedu/en/d/Jwi06ae/2.2.html

<Suitable crops by coconut age after plantation>

Duration	Sunlight	Highly suitable intercrops
Field-planting to 6years	High to Moderate	Cereals - corn, upland rice Legumes - cowpea, peanut, mungbean, sitao, beans Root crops - sweet potato, gabi (taro) Vegetables - tomato, cabbage, PINAKBET vegetables Fruit crops - pineapple, citrus, watermelon, papaya, banana Forage: any tropical grass
7-25 years	Moderate to Low	Root crops :ginger Vegetable: cabbage, pechay Fruit crops :black pepper, cacao, coffee, vanilla, lanzones, durian, rambutan, mangosteen, gmelina (for wood & lumber) Forage: Guinea grass, Para grass, Signal, humidicola
26-60 years	Moderate to High	Cereals - corn, upland rice Legumes - peanut, mungbean, cowpea, beans Root crops - sweet potato, gabi, cassava, ube, ginger Vegetables – PINAKBET vegetables , tomato Fruit crops -cacao, coffee,lanzones, rambutan, durian, mangosteen, citrus (pomelo, calamansi), gmelina (for wood & lumber) Fiber crops - ramie, abaca, Forage: any tropical grass

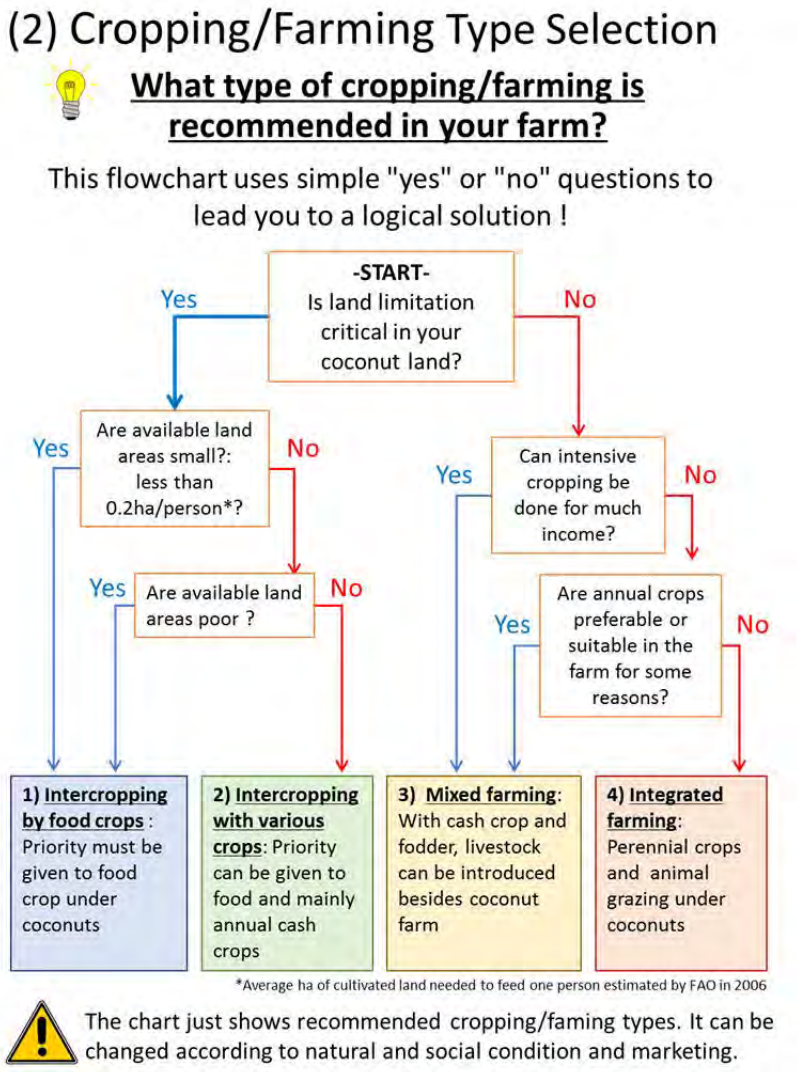
Source: JICA Study Team based on 'Coconut Intercropping Gide No.5 ' Department of Agriculture, PCA,2006)

<Further information>

In order to practice coconut intercropping efficiently, the combined crops should be decided according to the temperature and sunlight condition as well as the canopy development as shown in the figure on the right.

A variety of crops are suitable and productive under coconut stands depending on the age or development stage of coconut. The figure on the left shows the three growth stages and the highly suitable intercrops that correspond to each.

This information should be well examined and the farmers' level of farming, eating habit, marketing and their requests should be considered before extension workers recommend the combination of crops for intercropping to the farmers.



<Further information>

There are several cropping styles mentioned on Chapter 1: intercropping with vegetables, multiple (mixed) cropping, and multi-storey, and etc. In addition to that, the definitions of the 3 main farming styles are described in the following table.

Type	Description
Mixed farming	When animals of any kind are included in the farming system (e.g. cattle grazing pastures under coconuts).
Integrated farming	A farm practice which concurrently utilizes the same unit area of land for the production of animals and crops.
Coconut-based farming systems (CBFS)	the integration of complementary enterprises in coconut farming (e.g. intercropping, livestock integration, processing of coconut products (by-products and intercrops and marketing) to increase productivity per unit area, increase employment opportunities and provide a buffer against low and fluctuating copra prices Growing of two or more crops simultaneously on the same piece of land, without any definite row arrangement.

Source: PASTURE-CATTLE-COCONUT SYSTEMS' FAO

The flow on the left indicates suitable intercropping and farming types chosen based on the different conditions of coconut farmers. The following sections explain the details of those 4 types.

(2) Cropping/farming type Selection cont.

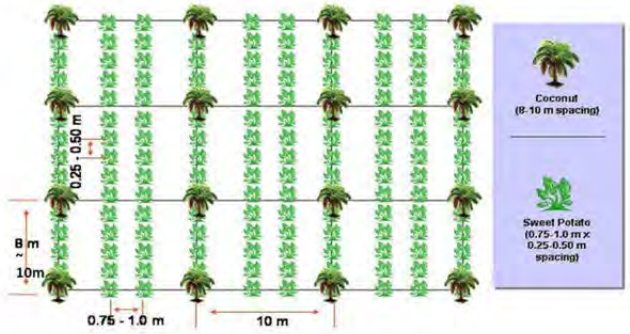
1) Intercropping with food crops

Focus on nutritious food and additional income

◆ Main points

- Generally, root & cereal crops are heavy nutrient eater, hence both crops should be supplied with the required fertilizers
- Root and cereal crops with strong sunlight except Ginger which is tolerant of weak sunlight and cool weather

◆ Example of a Farm Layout (rootcrop)



- Cassava can be replaced with a different crops
- Gabi & Ube can be planted 3 rows at the space 50 X 60-75 cm
- Ginger should be distanced 50 X 50 cm and 2m away from the base of the coconuts
- Maize should be distanced at 0.75 m apart and 2 m away from base of coconut trees

Source: Multi-story cropping with peanuts and pineapples ,PCA

<Further information>

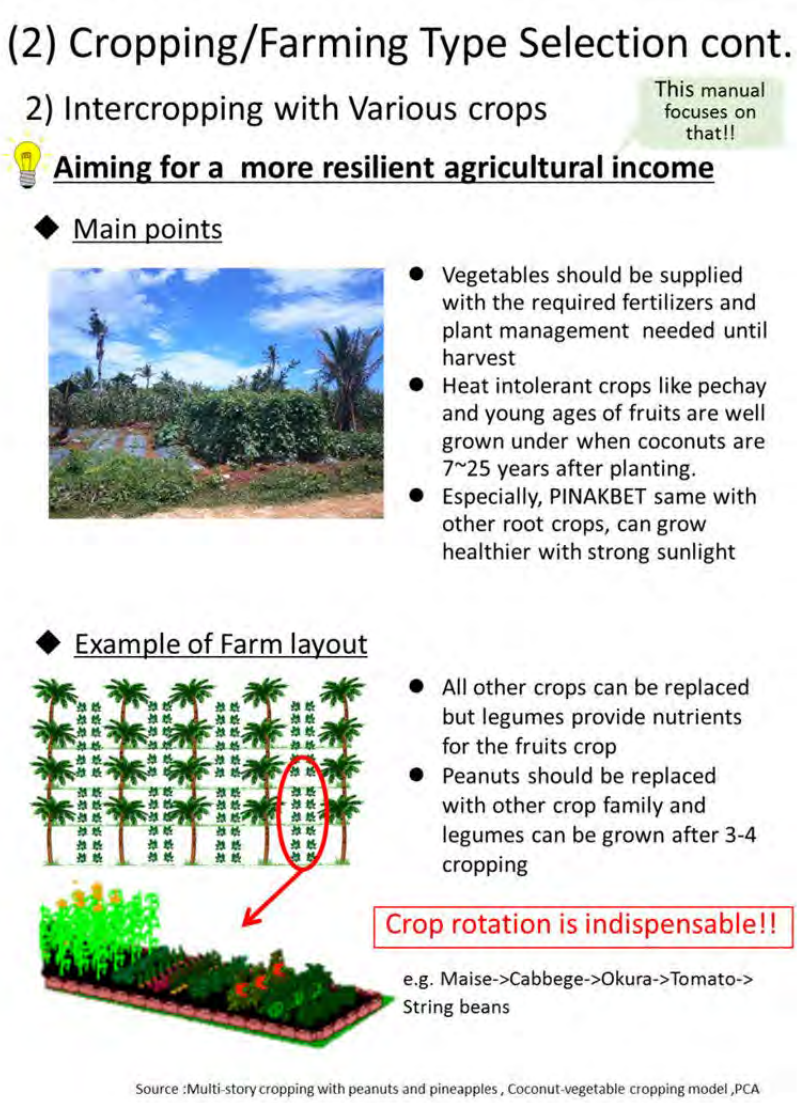
This type is suitable to those farmers who concentrate solely on coconut farming due to climate condition or other reasons.

Food crops refer to root crops such as cassava, gabe, ube, ginger, sweet potato, and cereals such as rice and maize. It is highly recommended to grow such crops under coconuts aged one to six years old or 26-60 years old and 7-25 years for they grow healthier with strong sunlight except for ginger.

The root crops can be grown relatively with extensive farming which does not require extra management; however, the planting interval and leaf trimming should be followed properly to have a good harvest.

As for cereals, particularly maize, can be grown relatively in dry condition like Mercedes; but, it requires proper climatic and soil conditions shown on the following table to optimize the corn yield and achieve maximum economic benefit.

Factors	Coconut	Maize
Temperature (oC)	24-29	18-32
Total annual rainfall (mm)	1500-2500 (well distributed)	>610/cropping (95-100 days)
Typhoon frequency (%)	<20	<30
Soil depth (cm)	>75	>50
Drainage	Moderate to well drained	Well drained
Soil Acidity (pH)	5.5 – 7.5	5.2 – 7.0
Soil texture	Sandy, loamy, clayey (with good structure)	Loamy



<Further information>

This type can be adapted in a wide range of coconuts farmers. Thus, this manual presents farming methods and techniques based on the cropping type. This type is recommended in the areas where natural disasters often occur and in the areas where there are a few choices of livelihood activities out of coconut faming like Mercedes. Growing several varieties of crop diversifies income sources which can improve farmers' lives in general. Moreover, the condition of intercropping can improve naturally by rotating several crops.

You may refer to the previous chapters if you want to learn more about formulation of cropping plan and relevant farming practices. But once again, you should keep in mind when intercropping plan in coconut farm is designed, environment condition, crop characteristics, and market situation must be highly considered. Farmers' customs (habit) and skilled level may be considered as important factors when choosing crops to be introduced in intercropping since plant management is required especially in vegetable farming.

(2) Cropping/Farming Type Selection cont.

3) Mixed farming- livestock raising on nearby site

Introduce fodder in your crop rotation !

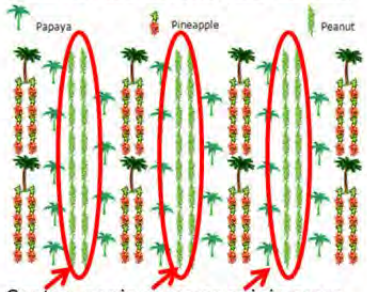
◆ Main points:

- Animal husbandry can generate big additional income
- Possible used straw of cereals such as rice and maize such as forage
- Annual forage can be grown under hot and less fertilize land and introduced in the crop rotation
- Same as fruit trees, perennial fodder trees such as *leucaena* and *gliricida* can be combined under coconuts as an alley crops

Source: Country Pasture/Forage Resource Profiles (source :FAO)

◆ Example of Farm layout

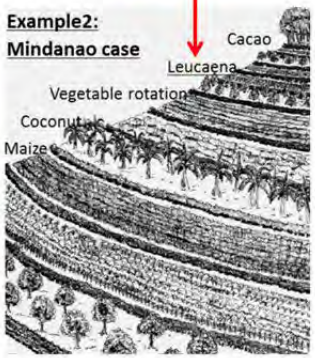
Example1: intercropping with fruit tree



Centro, nepia grass or guinia grass can be replaced Peanuts

Source: World Agroforestry Center, Chapter4: Agroforestry and A Guide to Intercropping Coconuts, Project ALA-97/98

Example2: Mindanao case



Source: Technique agricole pour les terres en pente: technique agroforestière mise au point par une ONG aux philippineshttp://www.fao.org/docrep/u7760f/u7760f09.htm

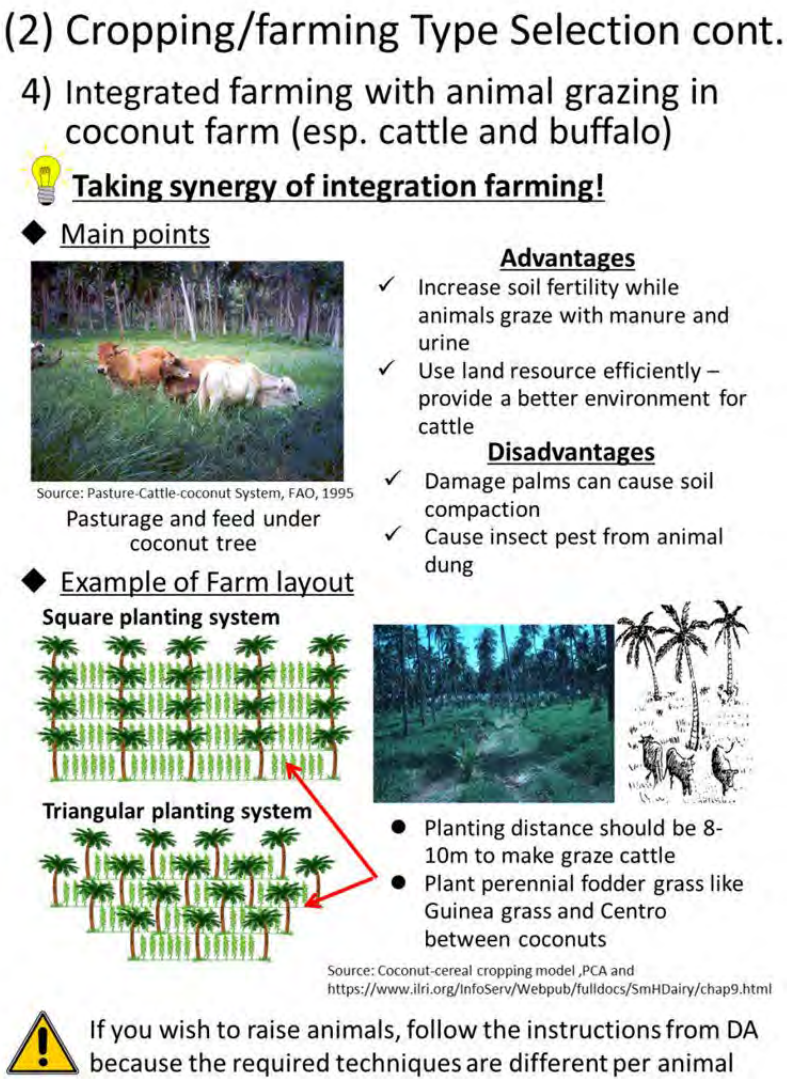
<Further information>

This type is good for integrated farming with small scale livestock due to limited land or manpower like Mercedes.

Other than the main points described on the left, this farming system allows: 1) agricultural practice in the relative bad natural condition; and 2) introduction of fodder crops in the crop rotation cycle with quasi-extensive practice.

In the case of Mercedes, the coconut farmers did not have much experience on 'INTENSIVE' horticulture production and livestock rearing due to their natural condition: unfavorable, dry and hot. Therefore, it is difficult to introduce only vegetables for each plot under coconuts, for example, in an intensive way. In that case, some plots are introduced with fodder crops that can resist such condition. Pigs and some cattle were introduced in Mercedes after Yolanda, except for water buffalos (carabao) due to dry weather.

Suitable fodder crops and livestock are different by environmental conditions and should be well examined before introducing to the livestock husbandry officers and PCA.



<Further information>

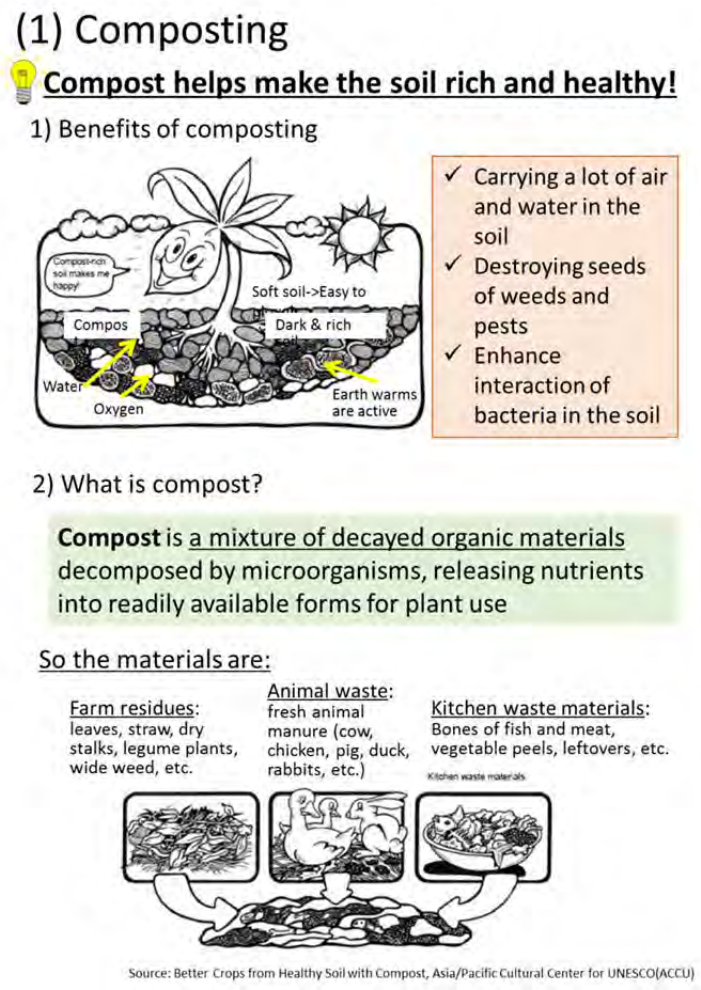
This type is a common in the whole Philippines. With the majority of livestock raised on small farms, the feeding of animals in mixed crop/livestock farming systems revolves around the use of crop residues, weeds, tree leaves, and planted fodder crops.

The kind of crops grown, the intensity of cropping and the extent of land utilization, coupled with environmental, and management factors determine the availability of the feed for livestock production. In small coconut plantations, cattle and buffalos are tethered to graze on native vegetation. Some farmers have established small patches of Napier for cut-and-carry feeding. A number of commercial cattle and coconut enterprises grow guinea, Para, star, signal and humid cola grasses for grazing[1].

This farming style is best with coconut farming combined with other crops, but needs a spacious farmland and intensive caring especially for livestock husbandry. Therefore, it is recommended to start introducing this type with DA after successful attempts.

[1] Country Pasture/ ForageResource Profile Philippines, Francisco A.Moog,FAO, 2006

3.2 Advanced techniques for intercropping



<Further information>

Using compost in all farms is highly recommended in the Philippines in terms of environmental conservation and sustainable agricultural practice. Chemical fertilizers sometimes are considered as 'evil thing' as it always damages soil. Applying too much chemicals may somewhat damage the soil environment, but the combination of compost and chemical fertilizer is the best solution when growing crops in a coconut farm where the soil is infertile like Mercedes. It is important to learn proper composting to achieve good results.

Composting or application of compost has two benefits: physical and nutritional improvement of soil.

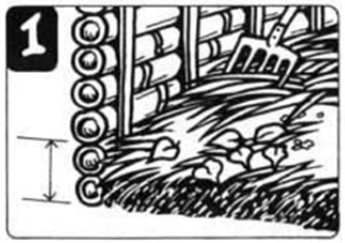
- Physical improvement: Compost carries a lot of air and water so that the roots grow healthy and makes land easier to plough beforehand.
- Nutritional improvement: Compost enhances the interaction of bacteria in the soil, thus nourishing it with various elements[2].

When you make compost, certain materials at home should be collected. The most important materials are animal waste to take the above benefits.

[2]Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO

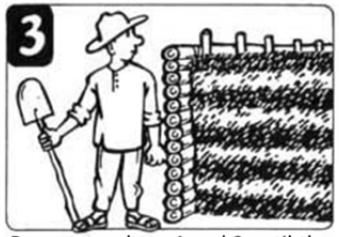
(1) Composting cont.

3) Steps of compost preparation:

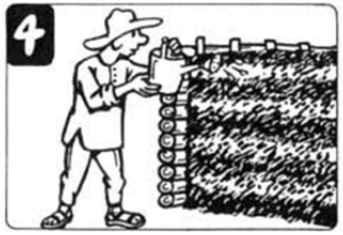


Make a pile of dry farm residue about 1 m x 1m and 30-40 cm high.

Cover the pile with fresh animal waste to about 1/3 to 1/2 the height of number 1 (10-20 cm high).



Repeat numbers 1 and 2 until the pile is 1 to 1.4 m high (up to about your shoulder).



If the surface of the pile gets dry, water to keep it damp.

Spread soil (up to 2.5 cm thick) evenly on top of the pile to speed up the process of compost.

After about 2 weeks, the compost pile will become hot inside (60~70°C). Mix the compost well and if it is dry, water the pile to dampen it.

<Further information>

The basic method described on the left is recommendable for small scale farmers. Two advanced compost making methods are explained briefly below[3].

- IBS Rapid Composting

IBS rapid composting technology involves inoculation of plant substrates that are used for composting with cultures of Trichoderma harzianum, a cellulose decomposer fungus. The fungus that is grown in a medium of sawdust mixed with the leaves of ipil-ipil (Leucaena leucocephala) is termed as compost fungus activator (CFA). The composting time ranges from 21 to 45 days, depending on the plant substrates used.

- Vermi-composting

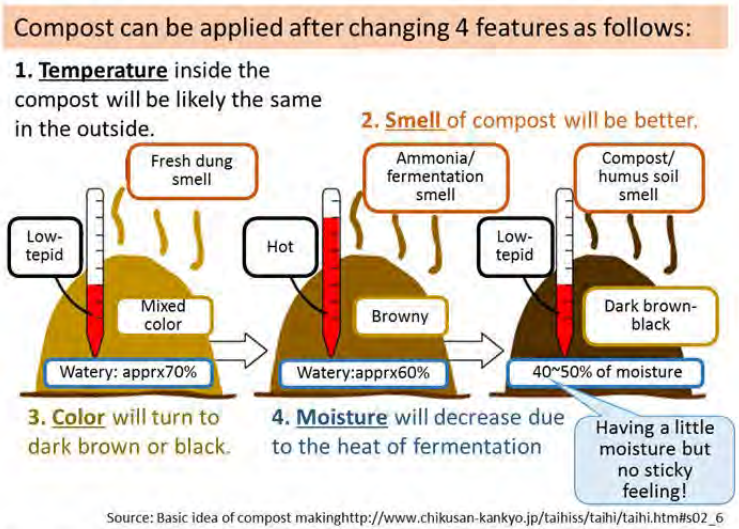
The worms used are *Lumbricusrubellus* and/or *Perionyx* excavator. The worms are reared and multiplied from a commercially-obtained breeder stock in shallow wooden boxes stored in a shed. A bedding material is compounded from miscellaneous organic residues such as sawdust, cereal straw, rice husks, biogases, cardboard etc., and is moistened well with water.

See ON-FARM COMPOSTING METHODS by FAO for further information.

[3] ON-FARM COMPOSTING METHODS R.V. MistraandR.N.Roy, FAO

(1) Composting cont.

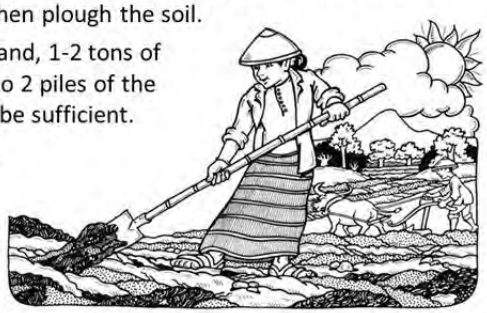
4) Well-matured compost



Source: Basic idea of compost makinghttp://www.chikusan-kankyo.jp/taihiss/taihi/taihi.htm#s02_6

5) Application of compost

- Before planting seeds or seedlings, spread well-matured compost on field. Then plough the soil.
- For 10 hectares of land, 1-2 tons of compost -about 1 to 2 piles of the compost made will be sufficient.
- If you are not using chemical fertilizer, 3-4 tons of well-matured compost are needed.



Source: Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO(ACCU)

<Further information>

In the case of the general method, the compost pile will become hot inside (60-70^{o}C), after about 2 weeks. Mix the compost well and if it is dry, water the pile to dampen it. Make sure that the compost is exposed to fresh air by turning the material over from the top to the bottom every two weeks. The smell of compost is strong at this time but as the materials are decomposed, the smell is better and the color is changed to blackish as shown in the figure. Once the compost is well matured, it should be preserved by covering it with plastic sheet.

When the compost is applied make sure the compost is well decomposed and matured. Otherwise, it may damage the plant you are growing.

(2) Plastic Mulch

Relatively expensive, but it is worth using!

Plastic mulch is generally available in local market but it is expensive....

◆ Nevertheless, which is better?

Without silver mulch in Mercedes: Pechay is damaged by drought, erosion, weed, and insect

OR

With plastic (silver)mulch in Leyte: Pechay grows healthier without damages

◆ Advantages of the plastic mulch

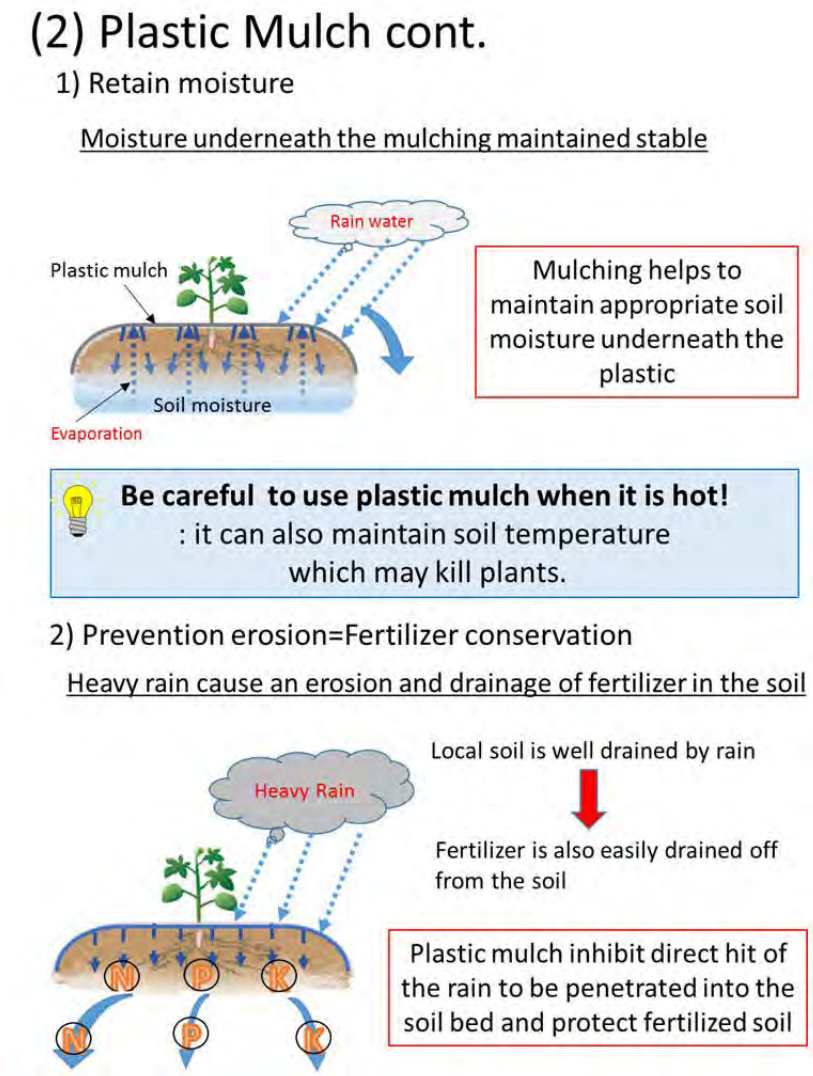
- ✓ Moisture control
- ✓ Prevent erosion=fertilizer conservation
- ✓ Weed control
- ✓ Insect repellency
- ✓ Possible to reuse several times

Cost of plastic mulch < Effects for vegetable production

<Further information>

Silver mulch is already common for the farmers in Leyte, but seems to be uncommon in Eastern Samar. Silver mulch may be an effective material for Eastern Samar considering the similar climatic condition to Leyte. Therefore, the idea is worth promoting to improve productivity!

The material is affordable for farmers as they can buy it in local Agri-vets. Compared to other mulching materials, the silver mulch has advantages which are described in next page.



<Further information>

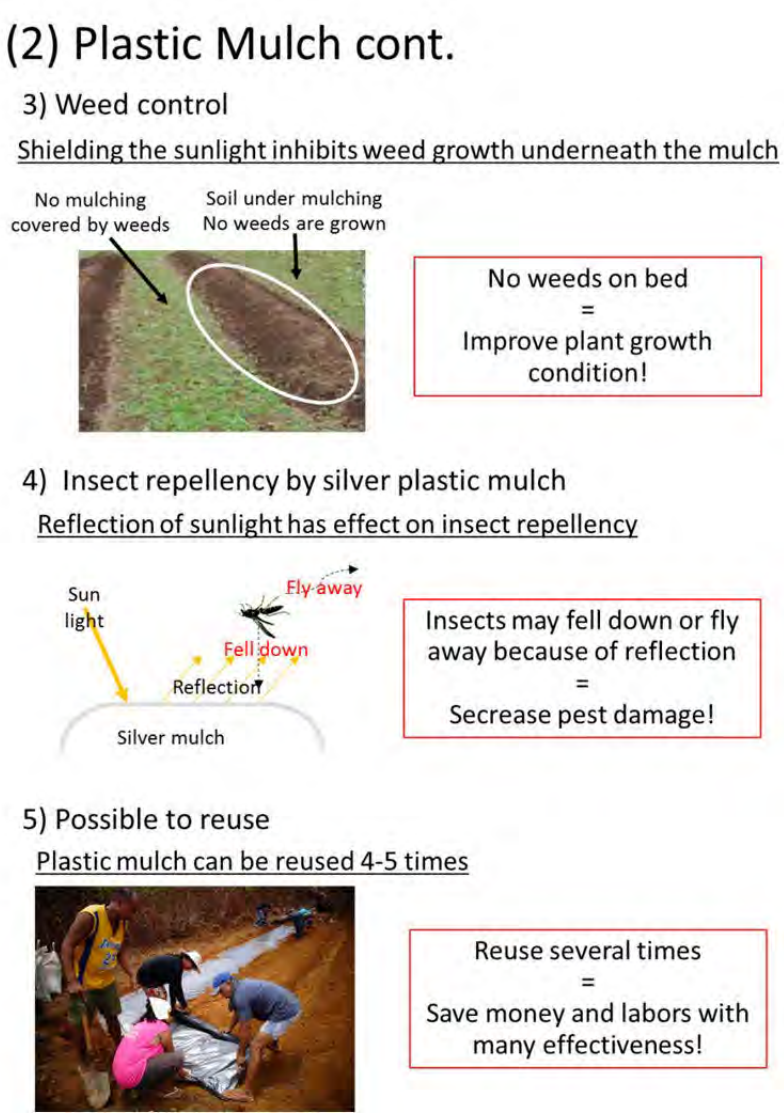
Here are the details of those advantages:

1) Moisture control

Mulching with plastic sheet is effective in retaining moisture during dry and rainy seasons. It shields rain to avoid over flooding during heavy rain and is also effective in inhibiting mud splash caused by rain. Evaporation is reduced underneath the mulch when it is dry. However, too much heat may increase the soil temperature and can kill young plants.

2) Prevention erosion=Fertilizer conservation

When rainwater penetrates into the soil the important elements are washed out especially during rainy season in some parts of the Philippines. Mulching over the fertilized soil will protect soil erosion and fertilizers from being washed off by heavy rain.



<Further information>

3) Weed control

Plastic mulch, especially silver mulch, inhibits the sunlight underneath, so the weed growth can be suppressed under the mulch. Silver mulch is also quite effective in reducing weeds around the plants.

4) Insect repellency

Insect repellency can be expected only by using silver mulch.

Many types of flying insects have no semicircular canal that detects light. Reflection of sunlight from silver mulch has an effect to those insects. For example, some Hemiptera insects lose flying control due to the reflection from the ground and some insects mistake the reflection as a water surface.

5) Possible to reuse

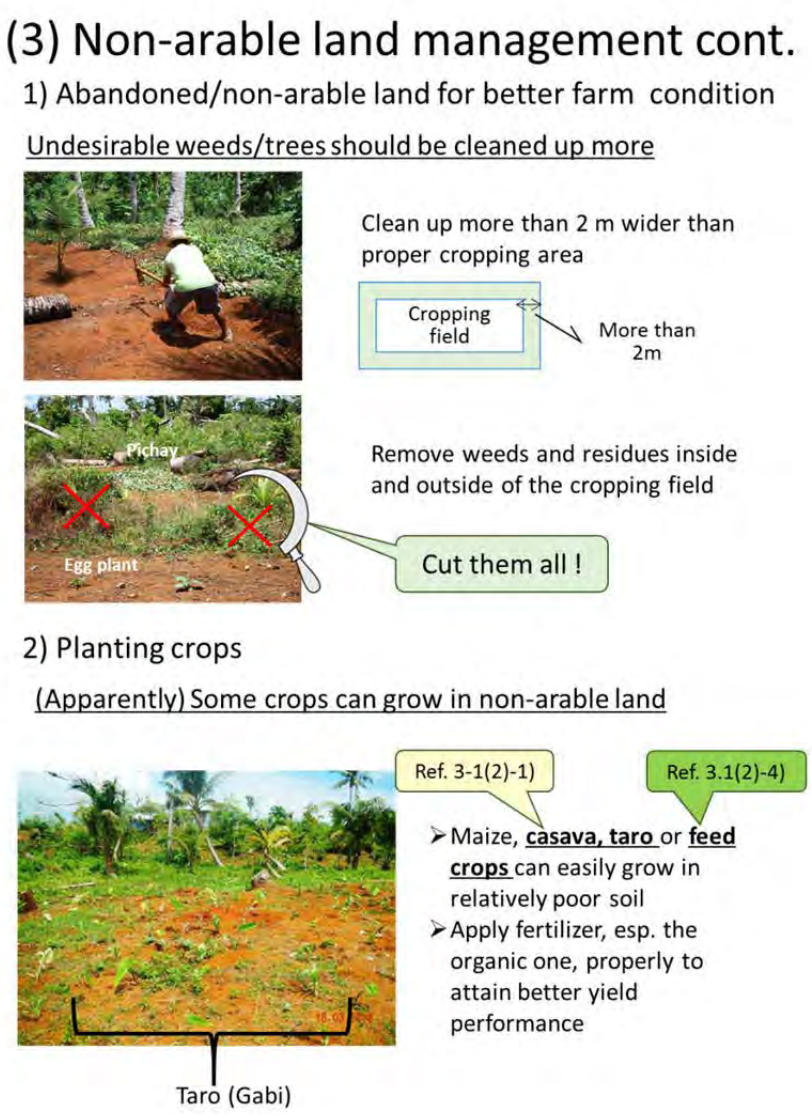
Plastic mulch can be reused 4-5 times if you use and remove them properly. By contrary organic materials such as compost or straw seem to be reasonable at once but they should be renewed every cropping season. In the end, the silver mulch can be reasonable with the best effectiveness for crop production.

<Further information>

Leaving the land barren and covered by weeds deteriorate the agricultural environment nearby. It is important to maintain appropriate environment of farm by utilizing the land for agricultural production even if there are non-arable land.

Non-arable land management should be done because of the weeds and useless trees that damage the whole intercropping field. Weeds and useless trees can:

- Provide an ideal nest for pests and devastate cropping land.
- Absorb fertilizer applied to the plants
- Disturb sunlight and aeration for good plant growth



<Further information>

Just like furrow management, abandoned/non-arable land near the intercropping farm need to be cleaned up. The method has two steps: removing thoroughly of weeds and useless trees and recovering the land to make it suitable for cropping. But the latter is not recommended to those who cannot afford to effectively use the recovering land for cropping. In that case, the recovering land needs to be cleaned up regularly.

1) Cleaning up abandoned/non-arable land
- Ideally more than 2 m wider than proper cropping area should be cleaned up to minimize negative influence.
- Remove weeds and residues inside and outside of the cropping field.

2) Planting crops
- At the early several years, the yield may not be good but it may increase gradually in fertilized soil.
- If the land recovered, root crops such as cassava or feed crops which are easy growing crops as a first step. And then, you will be able to grow other crops as the soil becomes richer.

When you need much further information, please refer to the following documents and web sites;

Referenced Document:

i. Coconut Intercropping No.1'Coconut-cereal', No.3 'Coconut-Papaye-Pineapple-Peanut Multi-story Cropping Model',Department of Agriculture, Philippine Coconut Authority(PCA) ,
ii. Kenneth R S Proud, A guide to intercropping coconuts,, April 2005
iii. PASTURE-CATTLE-COCONUT SYSTEMSCattle Under Coconuts, Stephen G. Reynolds, FAO, 1995
iv. Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO(ACCU)
v. Country Pasture/Forage Resource Profiles, Francisco A. Moog, FAO, 2006
vi. Livelihood Change in a Philippine Coconut Farming village,Fuji, Miho, Journal of Asian and Africa Studies, No.65,2003
vii. ATLANTIC CANADA PESTICIDE APPLICATOR TRAINING MANUAL SERIES , Agriculture Training Manual,2005
viii. ON-FARM COMPOSTING METHODS R.V. MistraandR.N.Roy, FAO

Web site:

ix. Aichi prefecture Homepage; http://www.pref.aichi.jp/nogyo-keiei/nogyo-aichi/tukuchaou/middy-tomato/
x. Takii Vegetable Growing Manual; http://www.takii.co.jp/tsk/manual/
xi. Basic idea of compost making; http://www.chikusan-kankyo.jp/taihiss/taihi/taihi.htm#s02_6
xii. Cattle under coconuts: a practical Pacific tradition, Agroforestry for the Pacific Technologies; http://collections.infocollections.org/ukedu/en/d/Jwi06ae/2.2.html

Appendix-9: Promotion Manual for Coconut Intercropping (for Farmers)

JICA

DEPARTMENT OF AGRICULTURE 1898

Philippine Coconut Authority

Preface

This Coconut Intercropping Manual was established for farmers in typhoon-stricken coconut areas based on the experience of the trial project in Mercedes, Eastern Samar. It should be noted that the manual can only be used as a reference and the crops and techniques recommended can necessarily adapt to all coconut farms. It is because the suitable farming style and agricultural practices are different depending on the natural and social environment. The field is always the primary source of learning agriculture. Field practice is the best training ground for a good and successful farming. Thus, the manual was developed through several studies, interviews, practices, and documents that served as a reference to be utilized in a large range of farmers.

Accordingly, field surveys and farmer interviews were conducted before starting the trial project in Mercedes to figure out the environmental condition and traditional farming style in the area. The details of the trial project that will be introduced to the farmers, such as planting crops, crop combination, and modernized techniques were formulated through the survey result. Additionally, all items and techniques were well-examined by referring several documents and good practices in the Philippines, Japan and other countries for designing the trial. Right after the implementation, farmers' reactions and remarks about the agricultural practices were noted and will be reviewed to identify whether the modern techniques are suitable or not. Some of them, regardless positive or negative, are noted in the manual as learned lessons.

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Chapter 1
Formulation of Coconut Intercropping Plan

1.1 Why practice intercropping in coconut farms?

(1) Rational

Coconut Intercropping Brings Advantages !

✓ Income addition and stabilization

Income is generated only from Coconut and is no stable.

85,000 PHP additional income a year can be expected from intercropping in 100m^2 (Photo: CNZ farm)

✓ Risk resilience

No other source of income after typhoon and/or epidemic damages (Photo : philstar.com)

If coconuts are damaged by natural disasters such as typhoon, it is still possible to harvest from other crops.

✓ Keeping good farm environment

Mo
distortion and erosion, and pest & diseases spread (Photo: PlantVillage)

Intercropping helps prevent soil problems as well as pest and diseases (Photo: PCA)

(2) Characteristics of Coconuts

Coconuts Are Suitable for Intercropping

Coconut (*Cocos nucifera* L.) is mainly classified into 2 types:

Tall palms

20-30 m

- Slow maturing and flowers from 6-10 years after planting
- Longer life span with an economic life of about 60-70 years

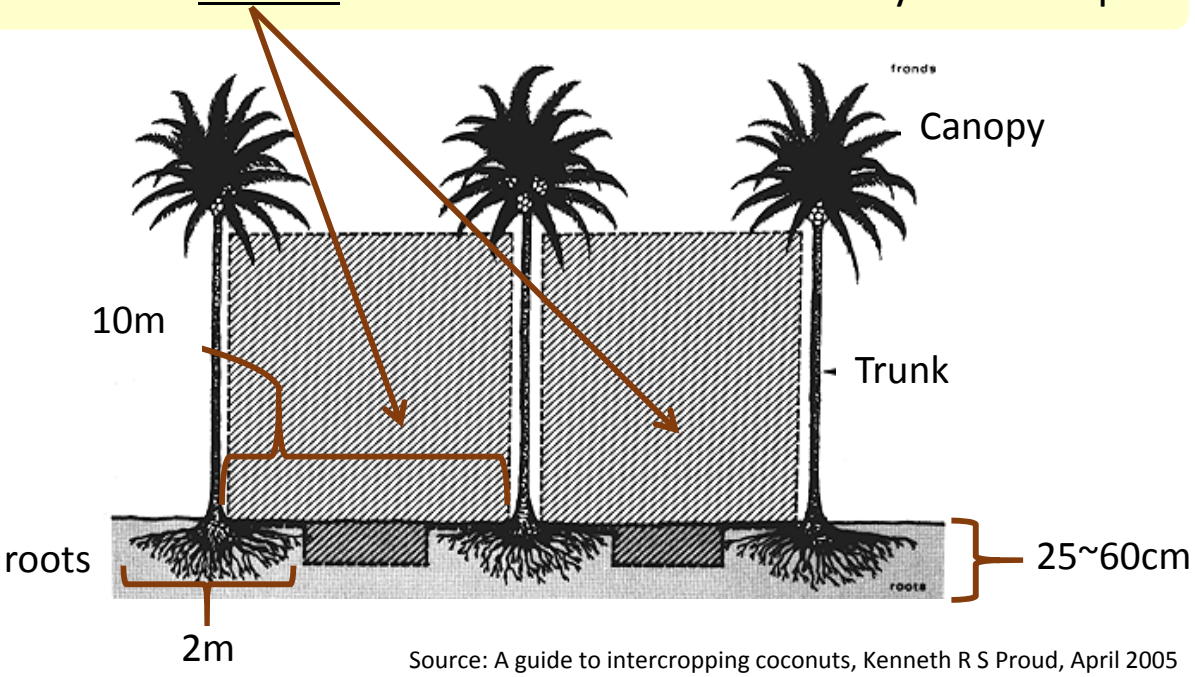
Dwarf palms

- Starts bearing fruits on its third year at less than 1 meter high
- Short productive life of 30-40 years.

8-10 m

Tall palms is common in Mercedes

Roots leave 70-75% of the soil available for use by other crops!



Source: A guide to intercropping coconuts, Kenneth R S Proud, April 2005

1.2 Environmental Factors to be Considered for Intercropping

- Environmental Factors Influencing Crop Growth -

(1) Rainfall condition

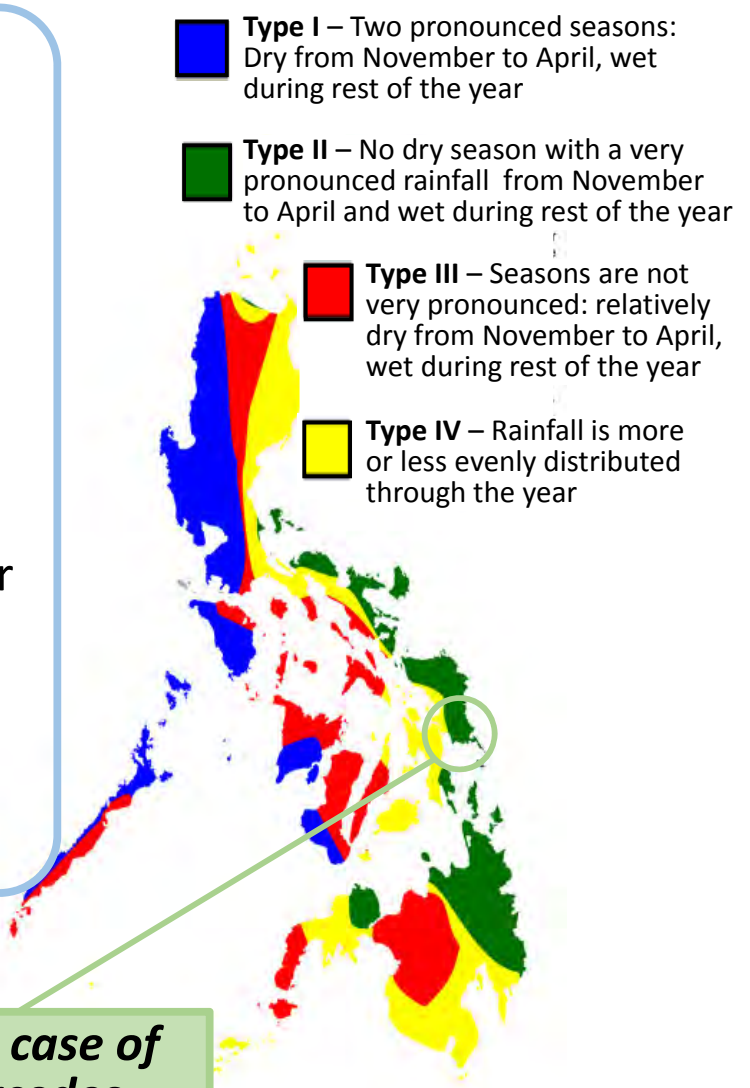
Utilize rainfall efficiently in your farming!

<Check Points>

i. Is there a period when no rain (dry season)?

ii. Which month is it rainy and relatively dry?

iii. Are there any water resources to supplement when the rainfall is not enough for crops?



Philippine Climate Map
Source: Philippine meteorological institute

in the case of Mercedes

i. No, always more and less → Possible to plant throughout the year

ii. Rainy: Nov.-Apr.
Relatively dry: June-Oct. → Favorable to grow any crops on Nov.-Apr., but only dry resistant crops for Jun-Oct.

iii. Partially Yes, but very limited → Any crops can grow throughout the year if the water is available

(2) Temperature

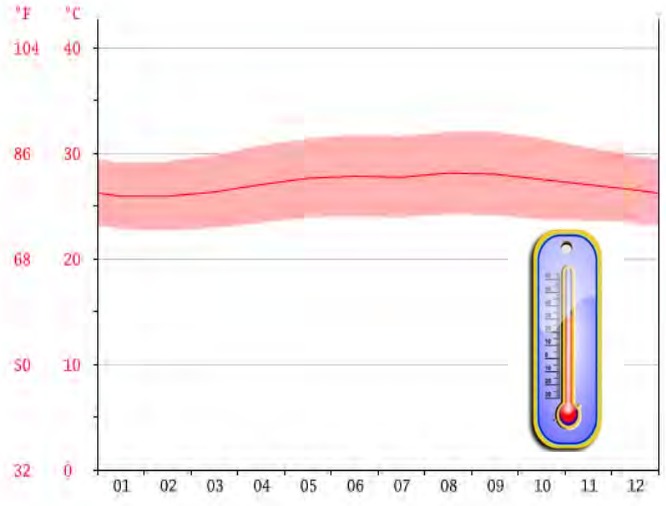
Select crops by temperature!

Optimum temperature for perennial crops is 15~25°C

<Check Points>

i. Which month is the hottest or coolest?

ii. What is the average temperature for each?



Temperature graph in Mercedes
Source: CLIMATE-DATA.ORG
(http://en.climate-data.org/location/985533/)

in the case of Mercedes

i. Hottest: Aug.-Sep.
Coolest: Dec.-Mar.

Easy to grow leafy vegetables such as pechay during the coolest period.

ii. Hottest: avg. 28.1°C
Cooler: avg. 25.9°C

Choose heat resistant crops such as camote during the hottest period.

(3) Sunlight and Day Length

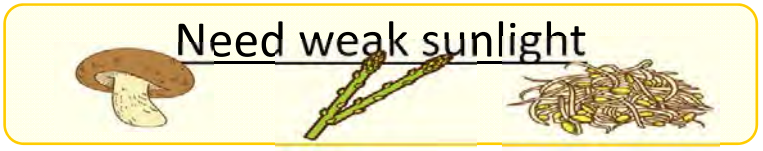
Crops have preferences for light & day!

PINAKBET vegetables needs strong sunlight!

<Check Points>

i. Does the sunlight get a lot in your farm?

ii. How many hours do you have a day?



Source: JICA Study team using illustration 'Free Illustrations (https://www.野菜素材.net/)

In the case of Mercedes

i. Yes, the strongest period is Aug.-Oct. → Fruit-bearing crops can grow well all year round but 'pechay 'and ginger grow better during the months of Dec.-Jan.

ii. Almost same hours throughout the year: avg. 11h'28-12h'45 → There is no problem for most of the crops except Chinese radish

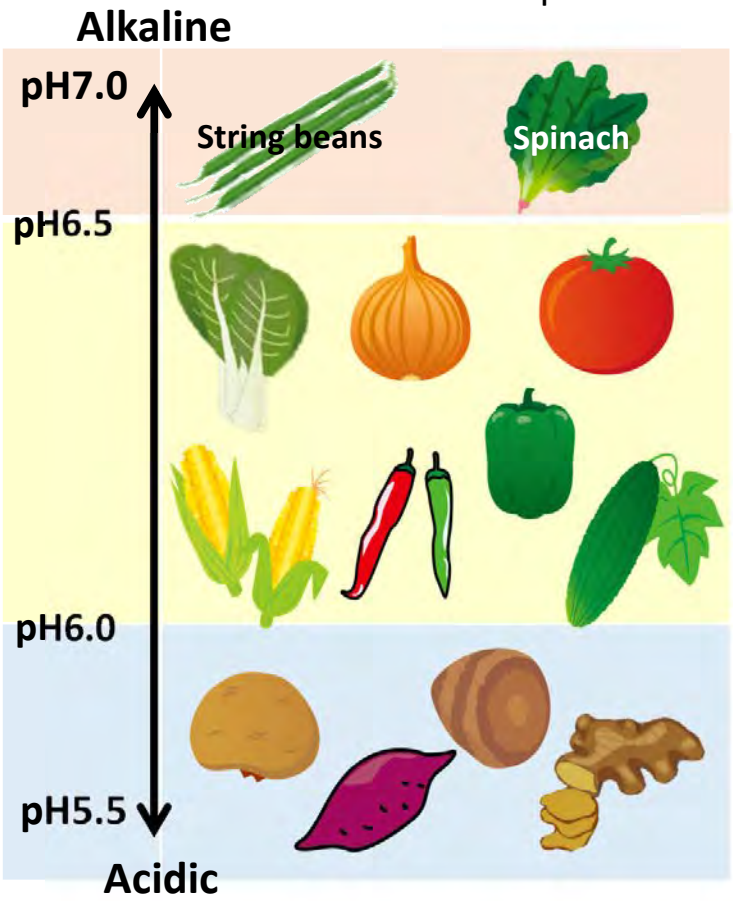
(4) Soil condition

Soil condition influences crop health

*__Acidity__ is estimated by the indicator "pH"

<Check Points>

i. What is **acidity***?
ii. What is the soil's physical type and humidity? Wet or dry?
iii. What kind of crops were grown before?



Source: JICA Study team using illustration 'Free Illustrations (https://www.野菜素材.net/)

In the case of Mercedes

i. pH5.5~6.7 depends on the planted crops	pH5.5~6.0: Roots crops are good pH6.0~6.7: PINAKBET is good
ii. Sandy and dry and sandy-loam and wet	Sandy and dry: string bean, maize, tomato Sandy-loam and wet: Soya, camote
iii. Coconuts, camote, and Cassava	Any crops can grow except the previous perennial ones.

1.3 Crop Rotation and Combination

- Crop characteristic and suitable combination -

(1) Crop rotation

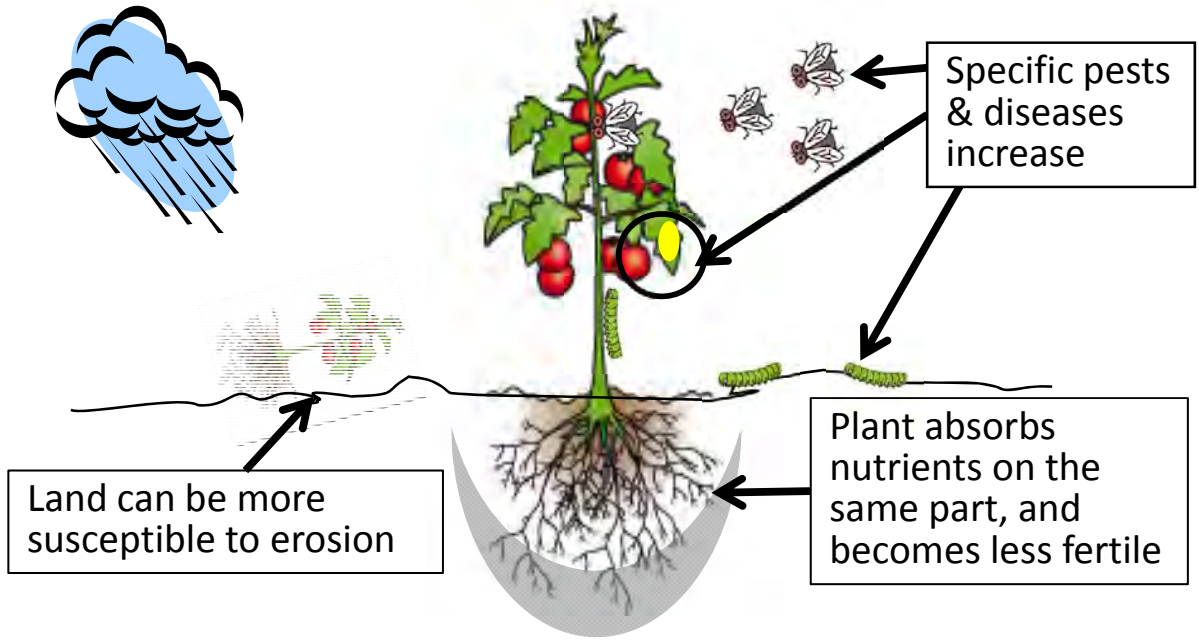
Crop rotation is a 'MUST' in the intercropping !

Crop rotation refers…
to the practice of growing different types of crops (or none at all) in the same area over a sequence of seasons.

Source: JICA study team using illustrations of 'Our Veggie Garden(http://www.ourveggiegarden.com/AnPlanRotation.html)

Why is it a MUST?

Because it is efficient to alleviate many problems caused by the monoculture



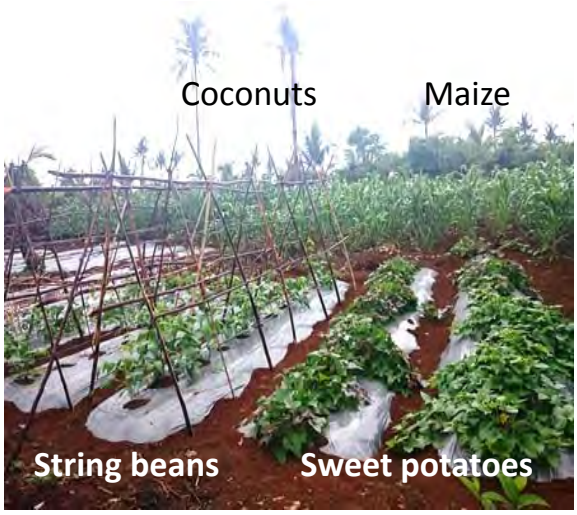
Source: JICA study team based on images of 'Grow Mate' (thehttp://growmate.co.uk/shop/custom.asp?cpid=custom30)

(2) How to practice crop rotation?

Formulate cropping pattern according to the features of the crops

1) Principles of crop rotation:

- ✓ Do not grow same crops and same family crops consequently (ref. Table-1)
- ✓ Plan growing crops in accordance to the necessary interval (ref. Table-2)
- ✓ Select and combine 'compatible' crops and avoid 'incompatible' ones (ref. table-3)



Intercropping in Mercedes

Table-1 Classification of Crop Family

	Classification (Family) and Crops	Characteristics
	Legume: String/Wing beans, Peanuts, Soy beans, Cow pea	Turns nitrogen in the air into nutrients the plant uses
	Solanum Fruits: Tomatoes, Egg plant, Belle/Hot peppers	Disease prone, advisable to move together
	Cucumber Fruits: Bitter gourd (Ampalaya), Gourd (Pemo), Pumpkin	Do not require much additional fertilizer
	Brassica leaf : Pechay, Cabbage, Radishes	Require high level of nutrients
	Root / Tuber: Cassava, Sweet potatoes, Taro, Carrot, Ginger, Onion, Leeks, Leaf onion	Do not require much additional fertilizer
	Others: Maize, Sudan grass, Okura	Depend on the crop

Source: JICA Study team based on 'Getting Down and Dirty in Your Allotment' (https://allotmentadvice.wordpress.com/)

(2) How to practice crop rotation?

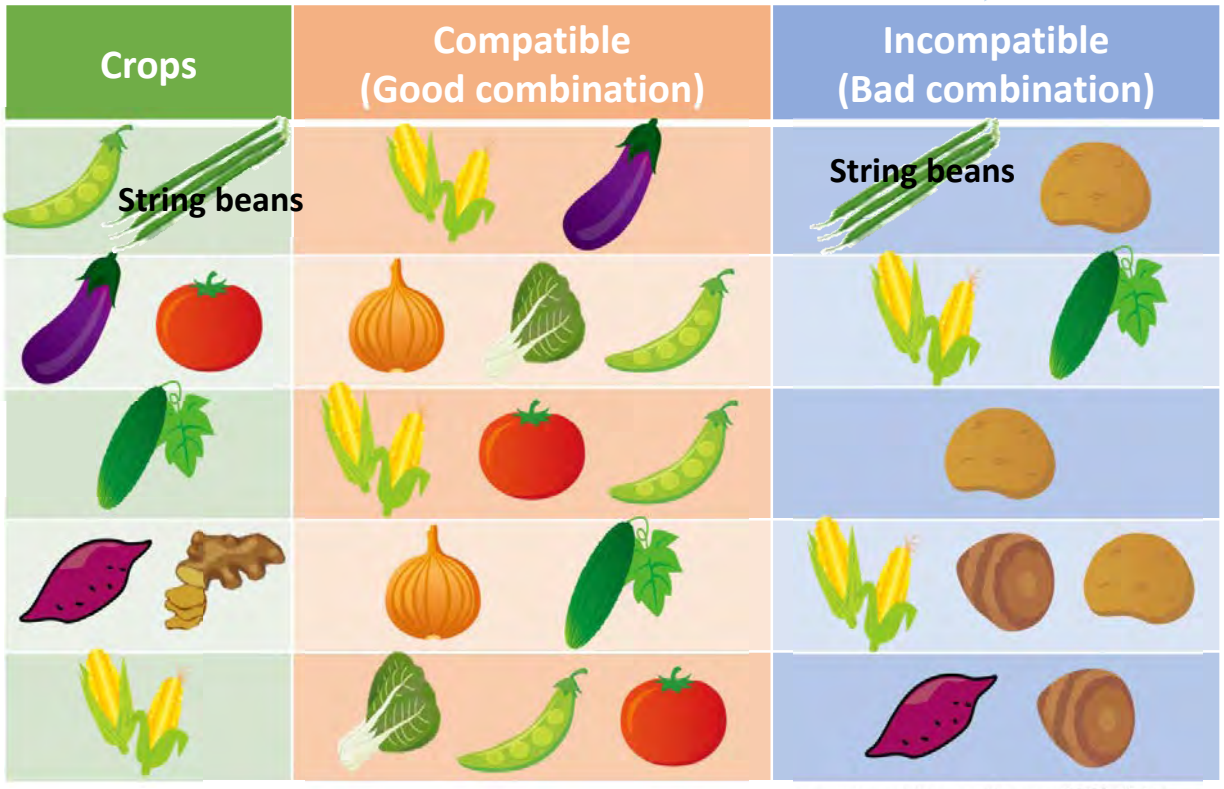
Table-2 Necessary interval by crop family

Necessary Interval	Classification (Family) and Crops
0 (possible to grow continuously)	Pumpkin , Sweet potatoes, Onion, Carrot
More than 1 year	Maize, Pechay, Okra, Cabbage, Radishes
More than 2 years	Taro, Ginger, Leeks, Leaf onion
3-4 years	Bell/Hot peppers, Bitter gourd (Ampalaya), Gourd (Pemo)
5-6 years	Tomatoes, Egg plant, String/Wing beans, Soy beans, Cow pea, Cassava

Source: Vegetable Growing Environment (in Japanese)
(https://www.pref.kagoshima.jp/ap11/chiiki/kumage/sangyo/nougyou/gijutsu/documents/02yasaidukurigaiyou.pdf)

All crops that belong to the same family are incompatible

Table-3 Crop combination



Source: JICA Study team using illustration 'Free Illustrations '(https://www.野菜素材.net/)

(3) How to combine other crops?

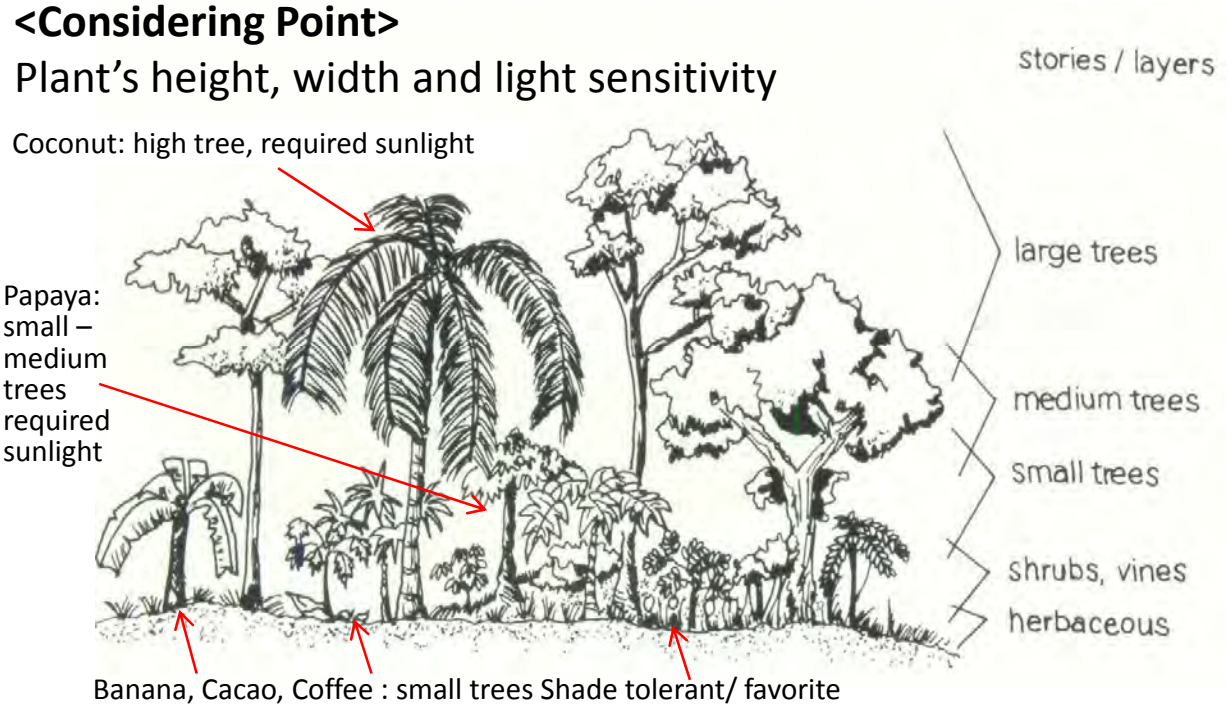
Select crops by your farming style

Refer to the chapter 3 for further information

1) Fruit-bearing crops

<Considering Point>

Plant's height, width and light sensitivity



Source: World Agroforestry Center (http://www.worldagroforestry.org/)

2) Fodder crops

<Considering Point>

Type of raising animal: grazing, domestic, etc.

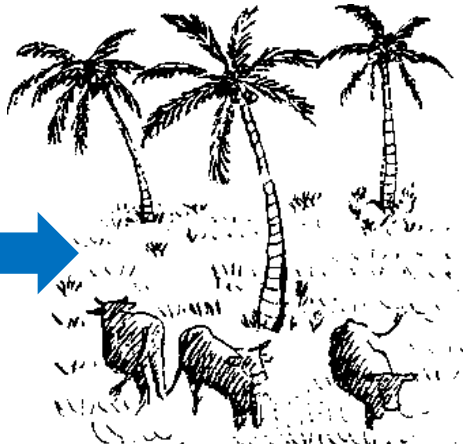
House raising

Source: Country Pasture/Forage Resource Profiles, FAO

Annual (e.g. sorghum)

Perennial (e.g. clover)

Pasturage



Source: World Agroforestry Center (http://www.worldagroforestry.org/)

1.4 Model of Coconuts Intercropping

(1) Replanting of coconut

Model based on PCA recommendation for damaged coconut farm and replantation

Present situation

Trees are randomly grown from naturally germinated seedlings

Trees are damaged by typhoons

Benefits of the PCA model

✓ Improves land utilization

✓ Improves typhoon resistance

✓ Improves environment natural condition for coconut growth

✓ More efficient intercropping can be adopted

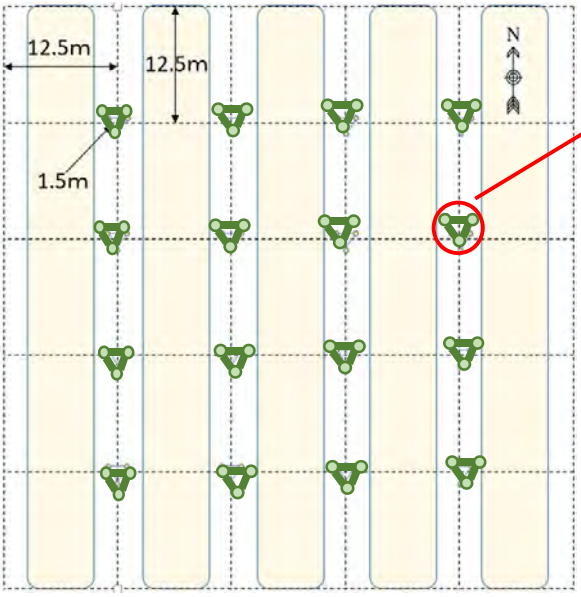
Source: PCA web site & teca.FAO.org

(1) Replanting of coconut cont.

Make straight rows to improve land utilization for efficient intercropping!

- Within 2 km from coast line

PCA developed a more resilient coconut planting model combined with intercropping against super typhoon like Typhoon Yolanda.

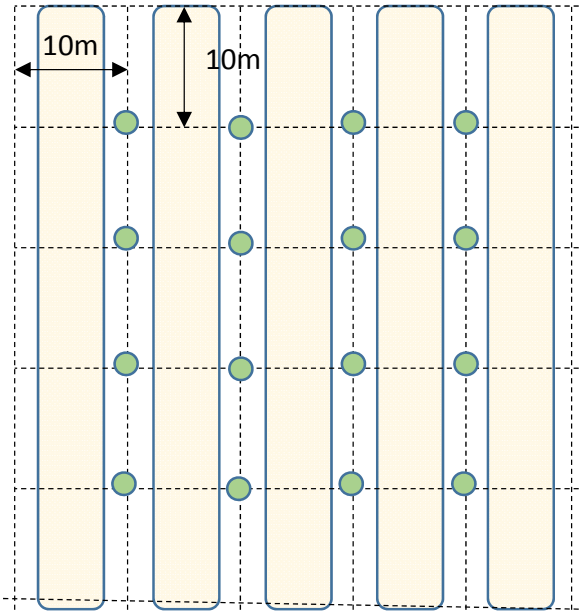


- 12.5 m interval
- 3 trees at one place with 1.5 m interval
- 192 trees /ha

➢ Plant **3 trees** at a single place in triangular location to improve tolerance

Trees can stand by supporting each other!

- Farther than 2 km from coast line



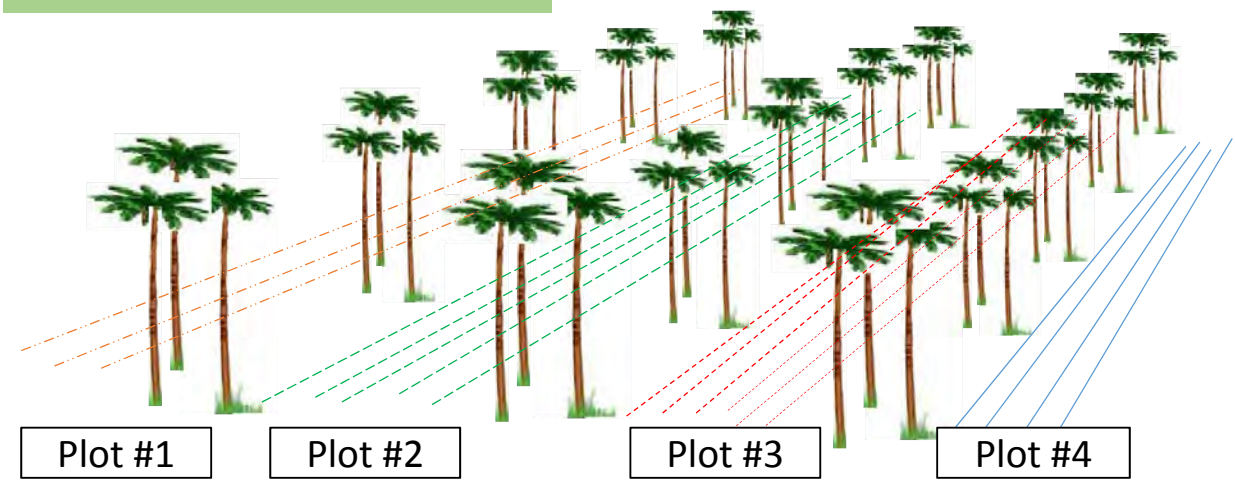
- **1 tree** for 10m x 10m interval
- 100 trees / ha

Source: PCA

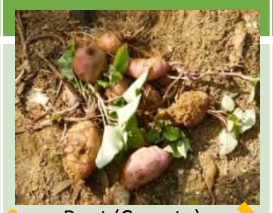
(2) Intercropping Model

Combine PCA model with intercropping to improve your income and resilience against natural disasters!

PCA planting model



Example-1: Vegetable intercropping in Mercedes

Season	Plot #1	Plot #2	Plot #3	Plot #4
Wet and cool season (Nov.-Mar.)	 Pulse (String bean)		 Root (Camote)	 Cucumber (Ampalaya)
Plan A Hot dry season (Mar.-Oct)	 Cucumber fruits (Ampalaya)	 Pulse (String bean)	 Brassica (Pechay)	 Root (Camote)
Plan B	 Cucumber (Ampalaya)	 Malvaceae (Okra)	 Cereals (Maize)	 Solanaum (Tomato)

Possible to organize the crops and follow crop rotation by season (Plan-A) or to plant different crops (Plan-B)

(2) Intercropping Model cont.

Combine PCA model with intercropping to improve your income and resilience against disasters!

Example-2: Root crops and forage intercropping for less fertile land

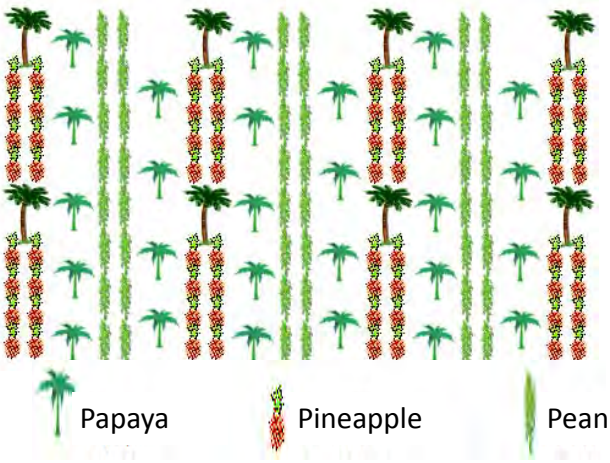
Year	Plot #1	Plot #2	Plot #3	Plot #4
1st year	 Root (Cassava)	 Legume forage (Centro)	 Root (Sweet Potatoes)	 Cereal forage (Napier Grass)
2nd year	Napier grass	Cassava	Centro	Sweet potatoes
3rd year	Sweet potatoes	Napier grass	Cassava	Centro
4th year	Centro	Sweet potatoes	Napier grass	Cassava

Source: http://www.feedipedia.org/node/321

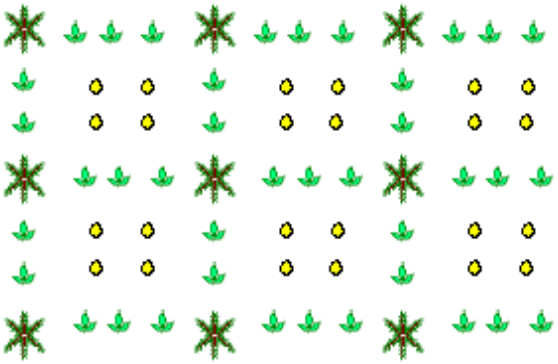
Back to the 1st year's order

Example-3: Mix cropping models

Model-1 fruits & legume



Model-2 Mix fruit trees



Papaya Pineapple Peanut Coconut Banana Fruits tree /Coffee

Source: PCA, Severino S. Magat,

Refer to Chapter 3 for further information

Chapter 2
Agricultural Practice Recommended for Coconut Intercropping

2.1 Field preparation

(1) Steps of field preparation

1) Select land for intercropping

Chose appropriate land according to crop type

2) Cut and dry the weeds

Leave the weeds on the site so the ground could evenly burn

3) Clean the field

Clean and recondition the soil

4) Cultivate the ground

Loosen up the soil and cultivate certain depth for root growth

5) Apply fertilizers

Apply fertilizers and mix evenly

6) Make ridges

Getting ready for crop production

(2) Main point-1: Cleaning the field

Why should we clean up the field before cropping?

Because it is easier to extend the land area for intercropping and to practice it easily!

1) Weeding

- Pests and weed seeds should be cleaned thoroughly not to disturb intercropping
- Insects are also media for many viral diseases

2) Removing rocks and root stocks

- Rocks and root stocks should be removed as much as possible to secure large farm area
- Stones disturb cultivation of land and plant growth especially root crops like sweet potatoes and cassava

3) Being ready for cultivation and fertilization

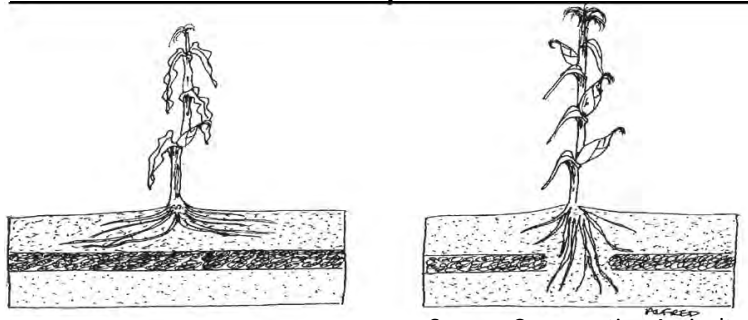
- Fine soil condition leads to good practice

(3) Main point-2: Cultivation

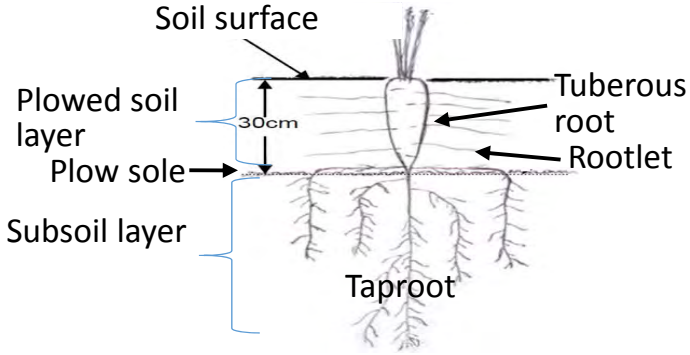
Why is cultivation important to intercropping?

Because cultivation can improve soil condition and fertilizer efficiency, and maintain root growth properly!

◆Recommended depth of cultivation: more than 10cm



Source: Conservation Agriculture, FAO
www.fao.org/ag/ca/.../pdf%20files/03fiel1.pdf



- Without cultivation, the roots cannot penetrate the soil making it difficult to absorb enough water and nutrients in the soil. Then the crop is stunted, and wilts easily
- Especially tuberous root and rootlet will grow in plowed soil layer more than 1m

◆How to cultivate (plow)?

- Breaking the hardpan with pickaxe or shovel

- Plowing with tools until soil softens and reach certain depth

(3) Main point-3: Fertilization

What kinds of fertilizers should be applied for crops?

It depends on the soil condition and growing crops, but it should be combined with the chemical ones and compost!

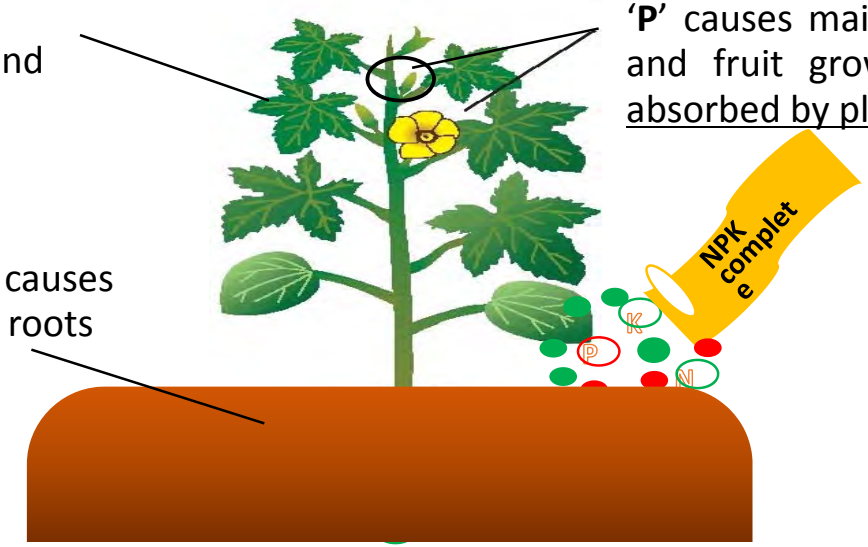
- Chemical fertilizer – helps crops become more productive

Chemical fertilizer is compounded 'NPK' which stands for nitrogen(N), phosphorus(P), and potassium (K: *Karium* in German) which are main elements for plant growth.

'**N**' causes main effects on plant and leaf growth

'**P**' causes main effects on flower and fruit growth, <u>but is barely absorbed by plants.</u>

'**K**'(pottassium) causes main effects on roots



Chemical fertilizer available in Mercedes

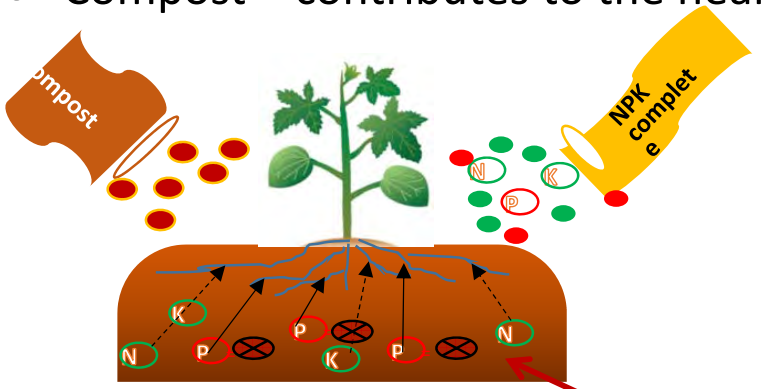
Urea (46% of N)
-Efficient
-Especially good for cereals

NPK complete (14-14-14)
-Possible to use in all plants
-A bit expensive

Photo: ROMGO International Corporation (http://www.ramgoseeds.com/products.do?item_id=435)

(3) Main point-3: Fertilization cont.

- Compost – contributes to the healthy plant growth



◆ <u>Compost can improve:</u>

- ➢ Soil structure and drainage
- ➢ Contribute plant growth providing some nutrients
- ➢ <u>Efficiency of chemical fertilizer, especially 'P'</u>

by holding elements which hinder plant absorption of fertilizer

See the details on Chapter 3

- Other materials – e.g. <u>Coco ash</u>

Coco ash is useful in adjusting the acidity level and acts as a source of potassium

e.g. Mercedes case: utilized the by-product of charcoal production

Charcoal production

Coco ash from charcoal

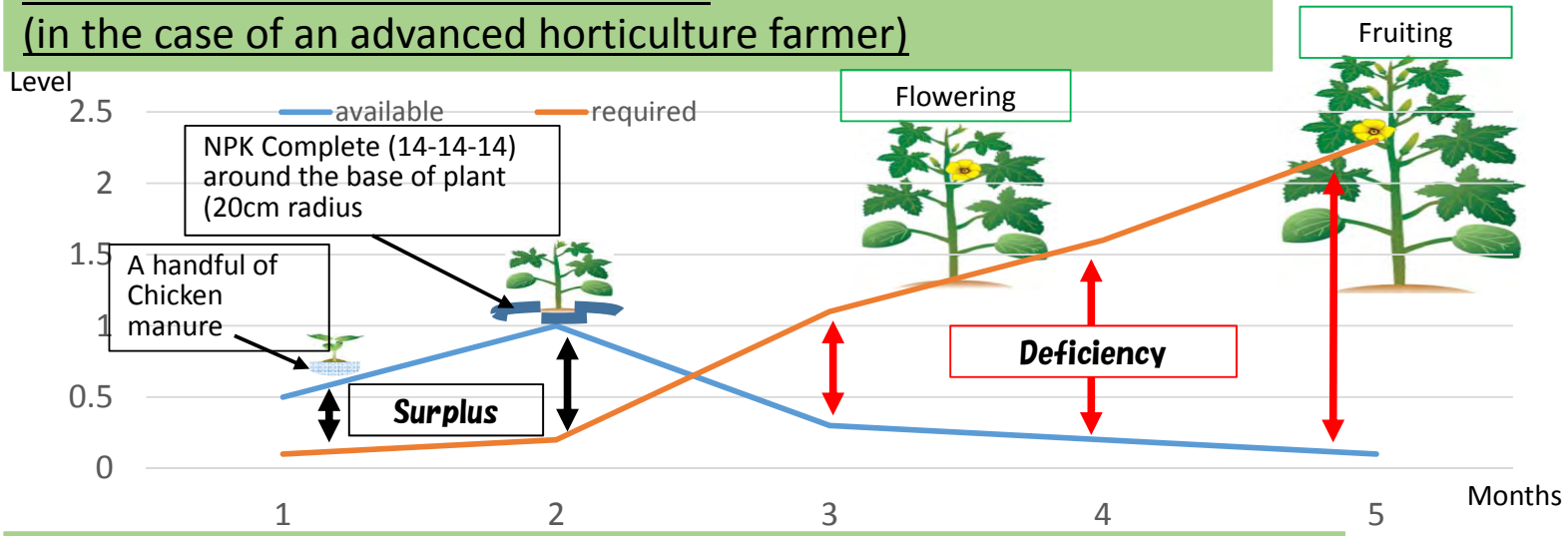
- ➢ Ash in the kitchen or residues are also efficient like the coco ash.
- ➢ Coconut and sweet potatoes, the main crops in Mercedes, require high potassium.

(3) Main point-3: Fertilization cont.

- Appropriate fertilization

Most of coconut farmers do not apply such for veggies!

A traditional fertilization in Mercedes (in the case of an advanced horticulture farmer)

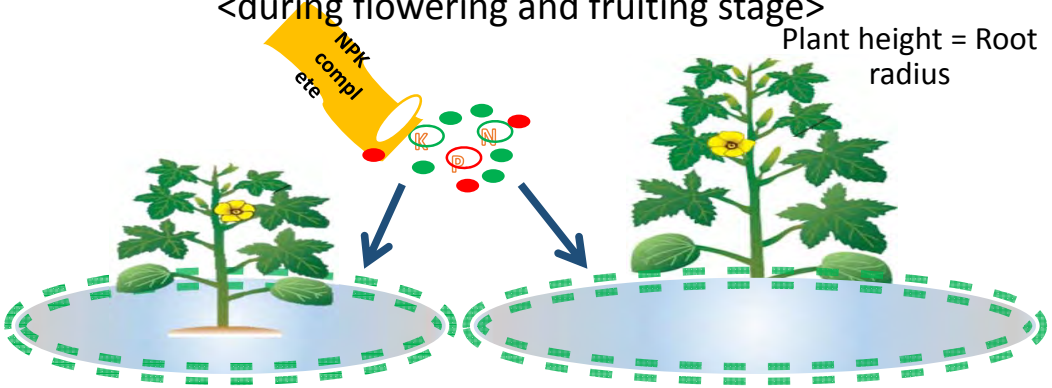


So, apply fertilizers according to plant requirement!

Basal fertilization
<before planting >

Apply all basal fertilizers (compost, plant ash, NPK) evenly, and then mix the fertilizer evenly within the plowed layer.

Topdressing
<during flowering and fruiting stage>



Apply fertilizers in active root area
= root radius! (See more detail in 2-3 for topdressing)

2.2 Crop Production in the Early Stage

- Nursery raising is highly recommended for intercropping -

(1) Flow of crop production

1) Sowing & Planting

Nursery raising

All crops, except root crops, can be grown

Direct sowing

Practiced especially in root and leaf crops

Planting cutting

Common way for tuber crops: Camote, Cassava

Source: Sweet Potato Growing Manual, Takii Shubyo Kabushiki Kaisha

Nursery raising is highly recommended to get good seedling and production
(see for the details in the next page)

2) Nursery raising and production *in the case of Japan*

Germination

Pot up

Rearing

Nursery raising method provides an opportunity to select the ideal seedlings to be transplanted (possible to be eliminated during the process)

Transplanting

Uniform growth

Higher yield with higher quality

Good seedlings improve the survival ratio after transplanting and maintain uniform growth.

As a result, yield and quality is stabilized at a higher level.

(2) Nursery raising - advantages

In which case is the application of nursery effective?

It is effective in the case of 1) limited time, 2) heat and drought, and 3) low seed quality

1) Limited time

Nursery bed

1m²

:

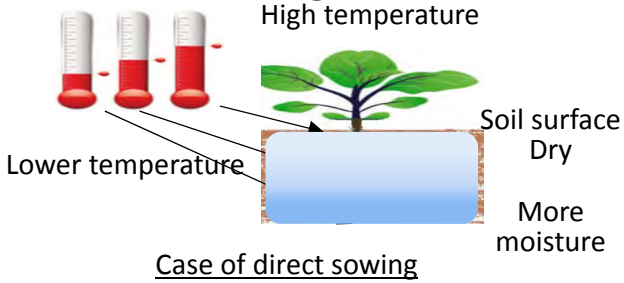
Direct sowing on farm

100m²

➢ Seedling for 100m can be grown in a 1m² of nursery in the early stage.

<u>Easier early stage growth control</u>

2) Heat & Drought



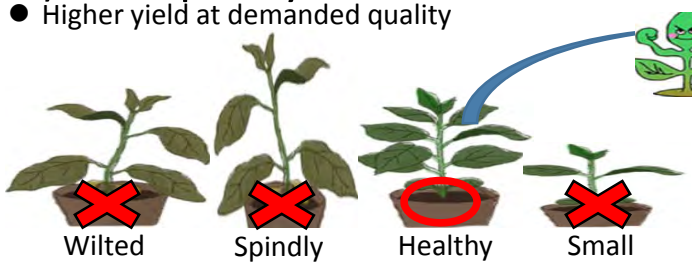
Case of direct sowing

➢ Possible to control temperature and moisture and keep it more stable

<u>Improves heat and drought resistance</u>

3) Low quality of seeds

● Higher yield at demanded quality



Transplant strong seedling only

Selected seedlings at good condition will stabilize the plant growth until harvest

● Equal quality crop without missing plant

<u>Less missing plant and stable production</u>

Source: JICA Study Team based on Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

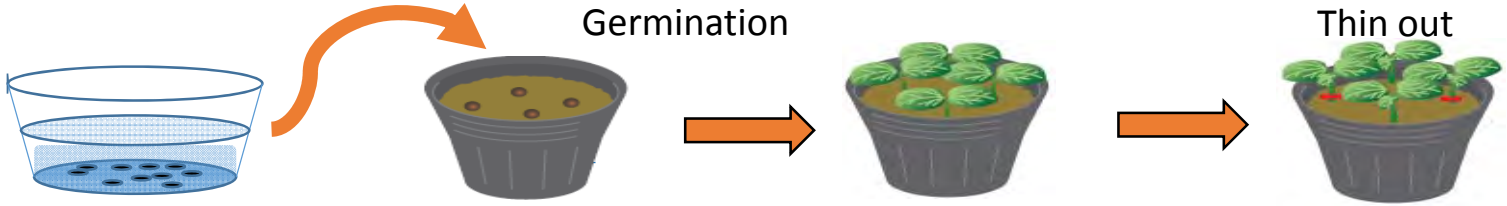
(2) Nursery raising - methods

How to make a nursery ?

Germination process with crop type but same rearing method can be done after all!

1) Germination and pot-up : 2 ways of germination process

(a) Germinate seeds in a pot, then thin out



Soaking is necessary <u>for hard shell seed</u>:
Okra, Legume crop like peanuts, Cucumber crops like Ampalaya

(b) Germinate in a pan, then pot-up

It is recommended to take the second process when the seed germination is not guaranteed since selecting a good germinated sprout from the germination pan is much easier .

Make sure to follow appropriate process for each crop!

Source: JICA Study Team based on Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

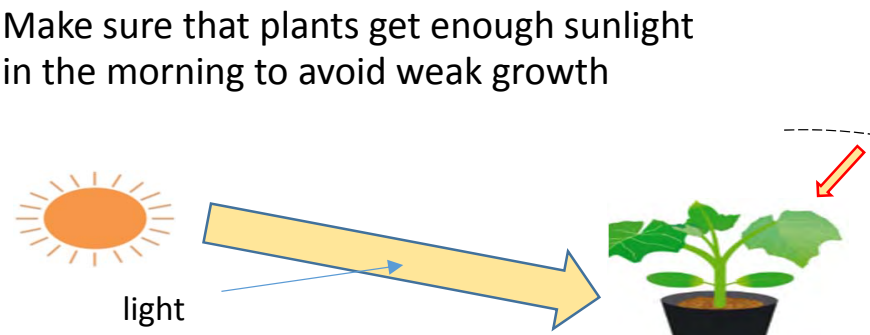
(2) Nursery raising - methods cont.

Important points to consider when producing strong seedling!

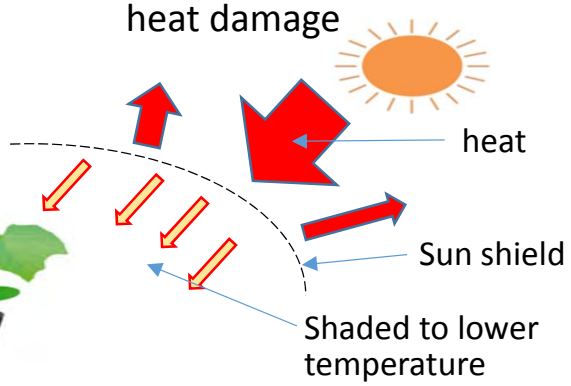
2) Plants Rearing

Sunlight and temperature control

Make sure that plants get enough sunlight in the morning to avoid weak growth



Shield sunlight during midday to reduce heat damage



Watering

Too much water rather inhibit appropriate root growth

- Too much irrigation may cause roots to rot
- Too frequent irrigation inhibit appropriate root growth

Target condition of seedling

- Sturdy stem that can support the plant
- Sustain itself even under dry condition

- White and healthy root
- Enough root development

Source: JICA Study Team based on Takii Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

(3) Transplanting

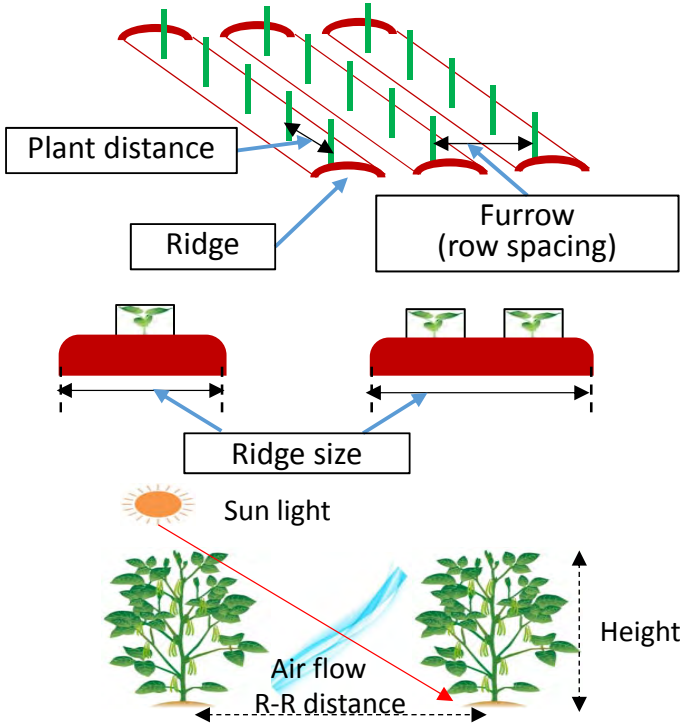
What is the most important thing to consider in transplanting ?

To follow appropriate plant and furrow distances per crop!

<Basic Points >

1) Follow appropriate distances of furrow and between plants
2) Prepare straight ridge row according to the required distances
3) Prepare seedlings at the right condition

1) Appropriate distance by crop : Plants need a certain space!



Appropriate distance (Example)

crop	Furrow (cm)	Plant distance (cm)
Sweet potato (Camote)	90	25-35
Better gourd (Ampalaya)	150-270	80-90
String bean	120-200	30-40
Okura	100-150	25-35
Tomato	180	25-50

- Furrow distance should be equal to the plant's height to improve growing environment; sunlight and air

Plant height ≒ Furrow distance

Source: JICA Study Team based on Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

(3) Transplanting cont.

2) Ridge preparation

Prepare straight ridge rows following appropriate distance per crop

Cord or string is very useful in making straight ridges

Well done!

3) Seedling preparation transplanting

Choose a cloudy day or cooler time of the day like evening for transplanting

Soak seedlings in the water before transplanting in order to absorb adequate water for rooting

Un-pot the seedling carefully without breaking pot soil

Dig a deep planting hole and put the plant and make sure that the upper part of the plant is visible. Cover planting hole with soil firmly.

Source: How to Grow (Lots of) Tomatoes Organically (http://commonsensehome.com/grow-tomatoes-organically/)

Appropriate preparation of ridges can improve the plant's growth and rooting system!

2.3 Plant Management

- Plant management requires more proper management than coconut farming -

Various plant management

What is plant management?

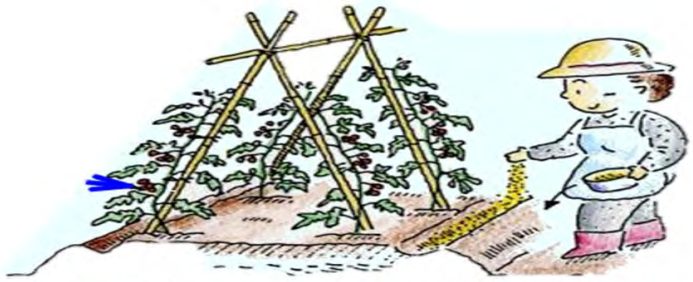
It is a series of tasks indispensable during plant growth to have a good harvest

1) Mulching

2) Weeding

3) Training

4) Top-dressing



Source: Method of jam and midi tomato (http://www.pref.aichi.jp/nogyo-keiei/nogyo-aichi/tukuchaou/middy-tomato/)

5) Pest & Disease control

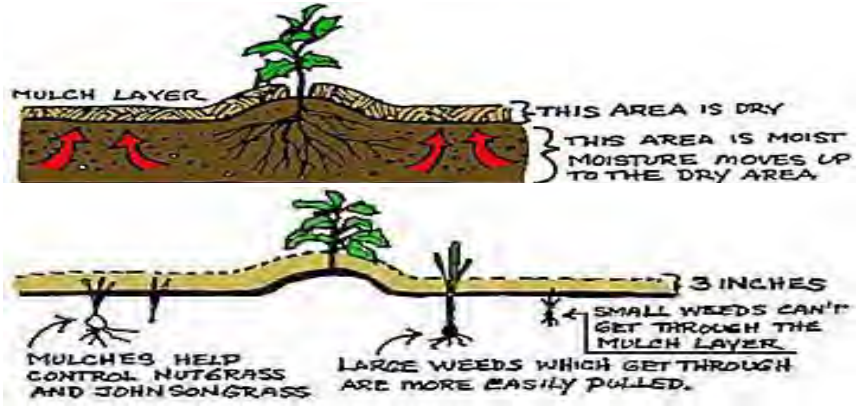
Plant management influences enormously on the crop growth and production

(1) Mulching

What is mulch and what is it for?

Any substance spread on the ground to protect plant roots from heat, cold, and drought

◆ Benefits of mulching



- ✓ Retains moisture /Reduces water loss from the soil
- ✓ Control weed
- ✓ Fertilizer conservation
- ✓ Prevent soil erosion
- ✓ Keep the soil cooler or warmer depending on the type of mulch used.

◆ Selection of Mulches

Consider the following factors when selecting materials:

- ✓ **Cost of the material:** Do not spend money on mulching material when suitable materials are available at little or no cost.

- ✓ **Used crop:** Never use material from the crop that is to be protected. E.g. do not use potato vines to mulch.

- ✓ **When the mulch is to be used:** Select light-colored mulch during the hot season to reflect heat. Use dark-colored mulch in early rainy season to help warm the soil and to hasten early growth.

Source: Resource Manual on Integrated Production and Pest Management (IPPM9 in Vegetables, World Education (INGO), Philippines, Inc.

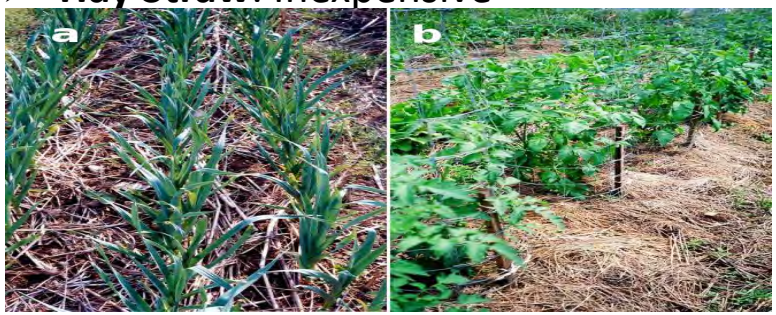
(1) Mulching cont.

◆ Mulcting materials

➢ **Compost**: Useful If available

- More effective and economical
- Commonly leads to excessive levels of P, K, and some micronutrients in the soil

➢ **Hay Straw**: Inexpensive



- Allow air and rain to reach the soil
- Moderate soil temperature during hot weather

➢ **Sawdust/husk**: Improve soil condition

- Tends to mat down and keep soil wet and airless
- Good germination medium for wind-borne weed seed

Source: Organic Mulching Materials for Weed Management(http://articles.extension.org/pages/65025/organic-mulching-materials-for-weed-management#top)

➢ **Plastic** : more effective if used properly

Silver mulch　　Black mulch

- Inhibit weed germination
- Control soil temperature
- Retains nutrients in the soil

Source: Vegetable Growing Manual oriented to Direct Markets

As for the plastic mulch, see the detail on Chapter 3

(2) Weeding

What are the benefits of weed control and how it affects the production?

It reduces pest infection, avoids completion of fertilizer, and easier field management!

■ Pest control

- Weeds around the farm become ideal nest for insects
- Insects are also a media for many viral diseases

■ Improving efficiency of fertilizer

- Absorption ability of fertilizer is higher for weeds than vegetables
- Weeds growing around the crops suck up fertilizer intended for vegetables

■ Improving work environment

- Working environment influences the performance of crop production
- Weeds can be a major obstacle in observing the plants and proper management.

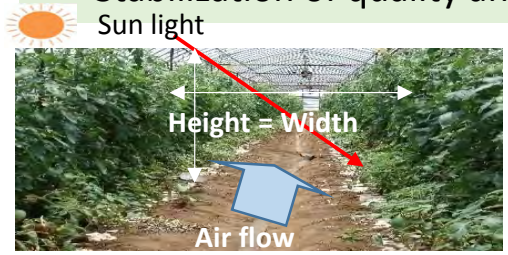
(3) Training

What is training?

It is a series of methods in maintaining the plant healthier and more productive

<Benefits>

- Improves utilization of space and husbandry efficiency
- Improves condition against pest and disease infection
- Stabilization of quality and quantity



- Fruits of trained plants can grow freely on the whole surface
- Appropriate space between plants for efficient husbandry work
- Adequate aeration maintains appropriate temperature and humidity for healthy growth condition

Bitter gourd (Ampalaya)

Trail on ground

Train on stakes

Fruits can be protected

- Fruits of vertically trained plants can grow healthier than ground grown
- Damage on fruits also decreases

String bean

Plants are trained on sticks

Plants are trained properly to utilize whole surface

- Yield of crop increases significantly when the plant is trained properly
- Appropriate method can improve work efficiency

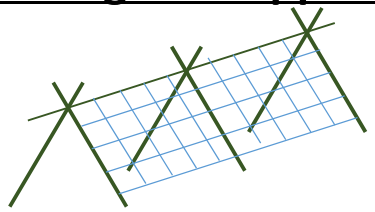
<Basic Points>

1) Set up of stakes and place the shoots on stakes
2) Topping, pruning and thinning

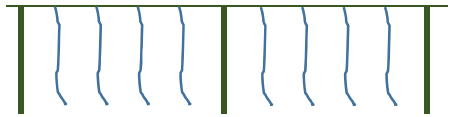
(3) Training cont.

1) Set up stakes

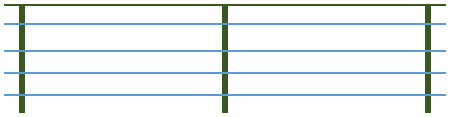
Stakes must be strong enough to support grown plants



- Place net or strings on both sides
- Able to maintain more weight with thinner stake
- Plant can be trained to 2 dimensions



- Hang each plant by each string
- Easier to adjust plants to maintain same height
- Stakes should be stronger than above set up



- Stretch strings horizontally to tack plant as it grows
- Easier to train side shoots to utilize space

Make sure to install stakes at an appropriate interval and strength to be able to support the plant:

- ✓ Height and ridge size need to be determined by crop type
- ✓ Weight of Plant - they are heavier than what they seem to be like, especially when fruiting

If not…

- Plants may collapse if strings cannot hold the weight of plants
- Stakes may break and strings may be cut off
- Collapsed plants become more susceptible to diseases

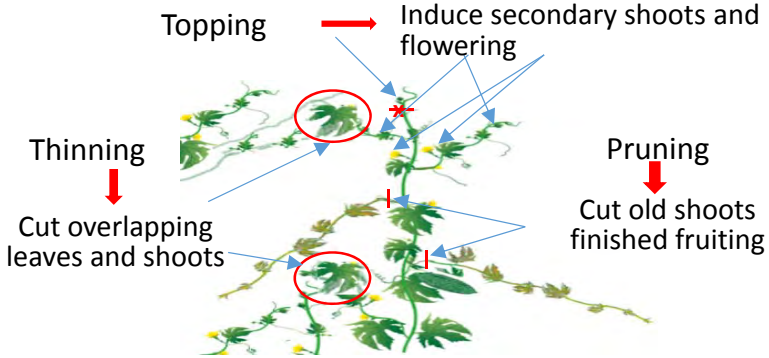
This will cause a big loss of harvest

(3) Training cont.

2) Topping, Pruning and Thinning

Necessary to practice for a continuous good harvest

◆ Kinds of training



Topping
- ➢ Induces secondary shoot growth
- ➢ Shifts vegetative growth to reproductive growth

Pruning
- ➢ Reduces overcrowded shoots
- ➢ Shifts nutrients for new shoots growth with flowers

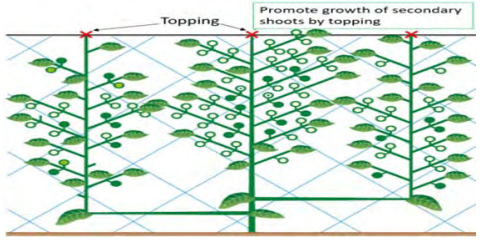
Thinning
- ➢ Improves aeration for better environment
- ➢ Improves sunlight efficiency for better photosynthesis

◆ Examples of training

- Bitter gourd (Ampalaya)

- ➢ Pinch top before transplanting after 5th true leaves developed
- ➢ Main shoot generates less female flower, so induce secondary shoot growth at the beginning
- ➢ Pinch top to generate tertiary shoots growth when the shoot reaches the top height of the stake

- String bean



- ➢ Maintain main and side shoots to grow at same strength
- ➢ Train side shoots to open space for efficient utilization of space
- ➢ Pinch top to generate tertiary shoots growth when the shoot reaches the top height of the stake

Source: Vegetable Growing Manual(lhttp://www.takii.co.jp/tsk/manual/)

(4) Top dressing

Where should be applied top dressing?

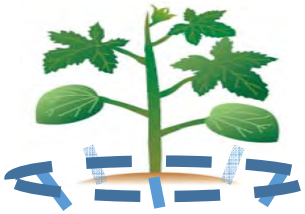
It is important to apply fertilizer around active root area!

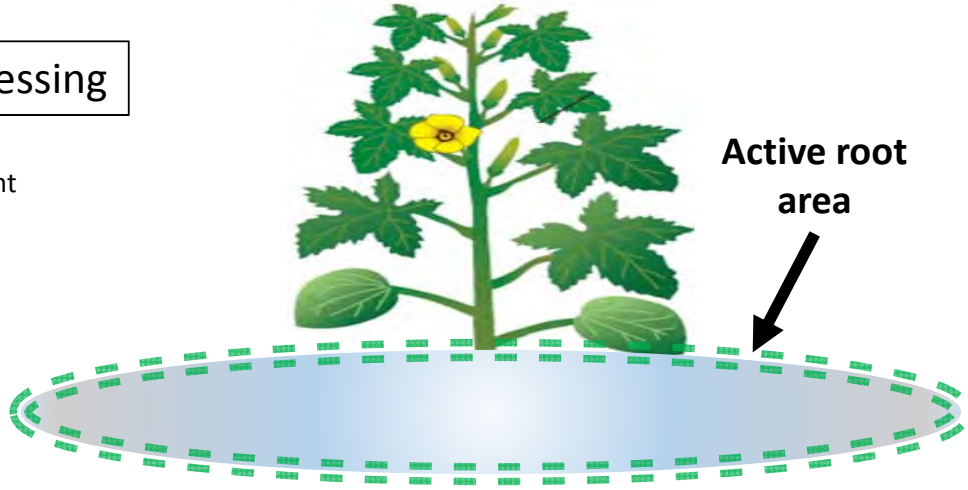
Basal

Apply a handful of chicken manure in the planting hole before transplanting

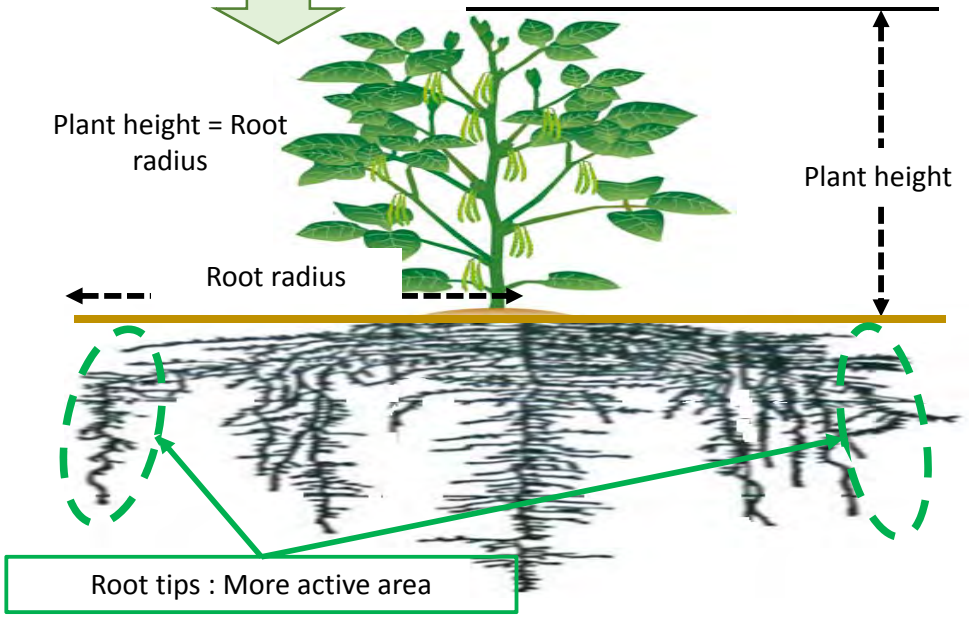
Topdressing

Apply complete (14-14-14) around the base of the plant (20cm radius)





- ✓ The root grows outside
- ✓ The requirement of fertilizer increases as plant grows
- ✓ More fertilizer is required during flowering and fruiting stage



(5) Pest & Disease Control

How to control a large number of pests and diseases?

Prevention is the most basic and important control!

- If pest and diseases are controlled…
  - ✓ The yield and quality of harvest will improve
  - ✓ The harvest period for fruit-bearing crops is prolonged
- If these kinds of symptoms appear…

Tomato fruit damaged by fungal disease.

String bean damaged by aphids.

String bean plant damaged by disease.

Insects eat the corn until the plant rots.

It is too difficult to recover plant

Follow the appropriate prevention practices to attain adequate harvest

- Two priorities to prevent pest and diseases:
  - ➢ 1st priority: Maintain a favorable and healthy environment for plants
  - ➢ 2nd priority: Practice appropriate application of chemicals (pesticide and fungicide)

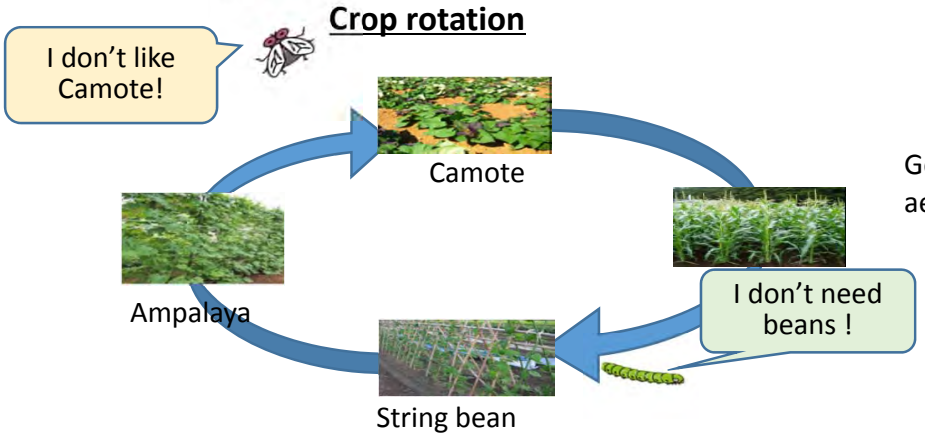
(5) Pest & Disease Control cont.

1) 1st priority: Maintain a favorable and healthy environment for plants

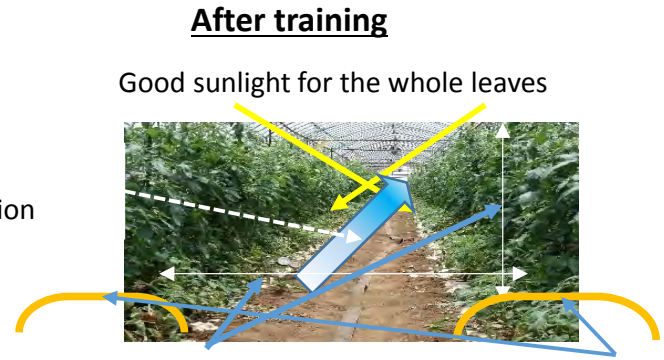
◆ Weed control: by eliminating nests of insects and diseases

- Minimizing nest /shelter of pest light
- Good aeration and sunlight
- Avoiding nutrition concurrence

◆ Maintain an environment by crop rotation and training



Good aeration



◆ Maintain healthy plant growth by appropriate fertilization

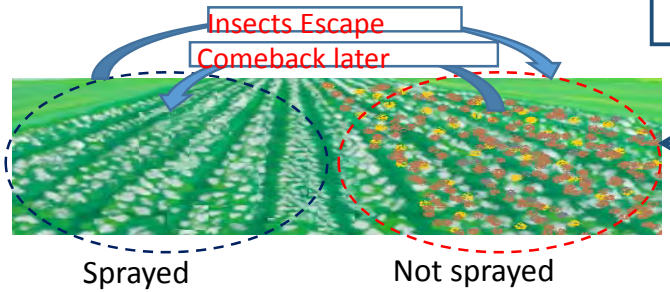
- Necessary nutrients must be supplied at the right timing of plant growth

(5) Pest & Disease Control cont.

2) 2nd priority: Practice appropriate application of chemicals (pesticide)

- Application of chemicals

More insects generally inhabit the back side of the leaves

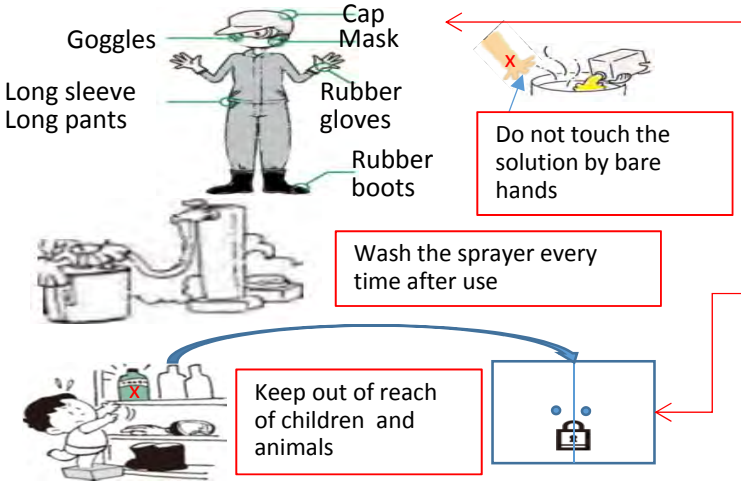


Use different types of chemicals if multiple application is required

<Notice!>

- Select the right type of chemicals contact or systemic by occasion
- Keep appropriate rotation to avoid developing tolerance
- Spray the plant thoroughly including the back side of the leaves
- Make sure to spray the whole field
- Use lower dilution which makes it easier to apply the solution evenly

- Reminders for safety use : it is **IMPORTANT!!**



Make sure the instructions on the label before using!

<Usage>

- Wear the appropriate attire when applying chemicals
- Always wash the equipment with running water
- Keep the equipment in a proper storage
- Maintain an appropriate interval for harvest (follow the instruction)

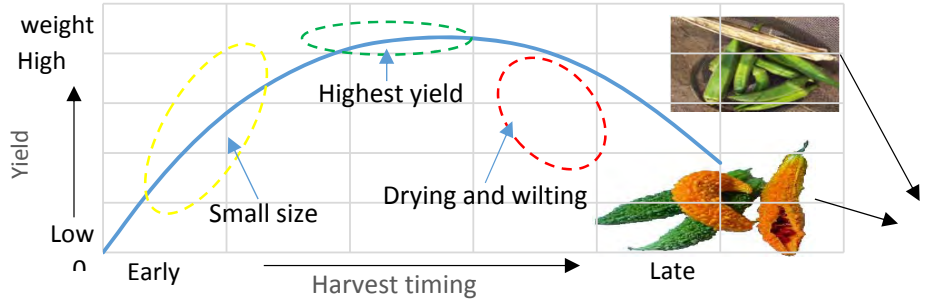
2.4 Harvest and Cleaning for the Next Cropping Season

(1) Harvest crops

What are the basic points to consider during harvest?

1) Timing, 2) Selection of fruits, and
3) Conservation method after harvest!

1) Appropriate timing of harvest



Lowers not only the quality but also the quantity

Use for seed production

2) Selection during harvest

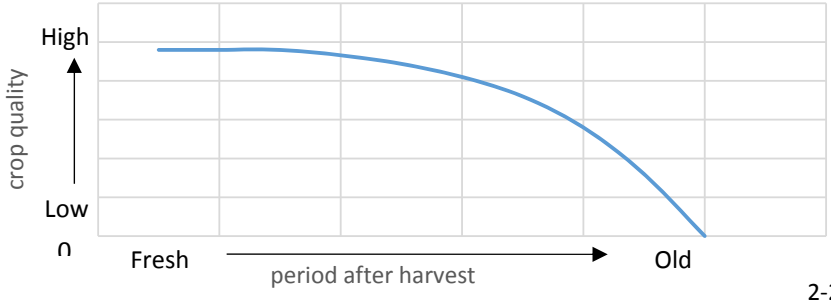
Armyworm inside the tomatoes and string bean

Weevil and beetle caused damage on sweet potato

Fungal and viral diseases caused damage on fruits

Fruits damaged by insects and diseases need to be eliminated

3) Appropriate handling of harvested crop



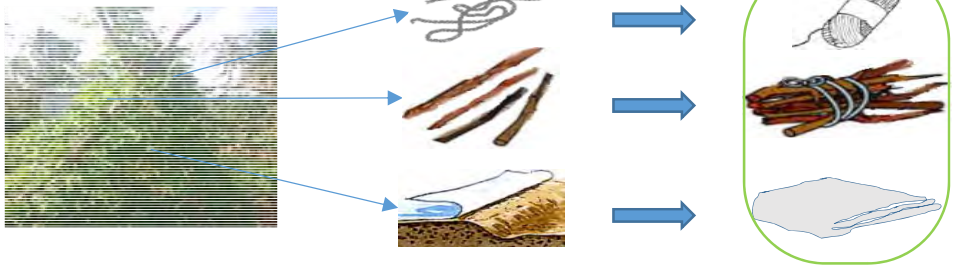
Crops will start degrading soon after harvest

(2)Cleaning for the next cropping

What should be done after harvest?

Recover of used materials and to aftercare should be done for next cropping!

1) Recovery of reusable materials



Cut the plants at root stock, then dry them up.

Remove the materials carefully to avoid damage.

Store these materials for the next cropping season.

- Many input materials are reusable, so do not dispose them immediately.
- Keep away from rain and direct sunlight.

2) Appropriate aftercare

Flowered weeds drop seeds on the farm

Cut the weeds on finished crop, then dry.

Burn the dried plants thoroughly to clean the field

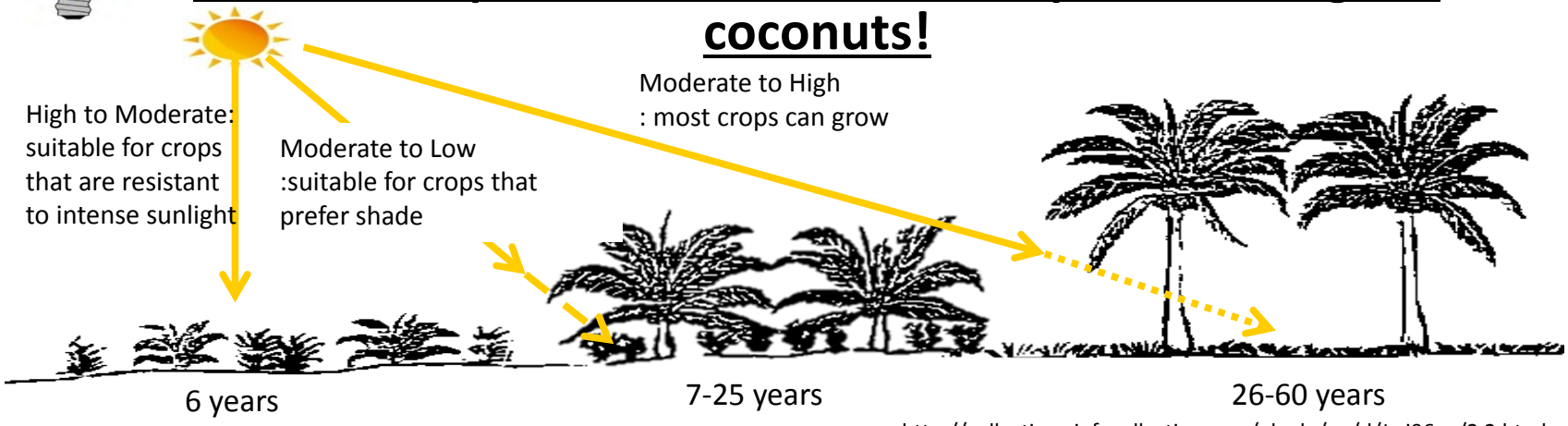
Repeat this cleaning process for several period to reduce the density of weeds and pests in the farm

Chapter 3
Advanced Farming and Agricultural Techniques

3.1 Various Cropping/Farming Type

(1) Suitable crops for advanced farming

Suitable crops varies with the developmental stage of coconuts!



http://collections.infocollections.org/ukedu/en/d/Jwi06ae/2.2.html

<Suitable crops by coconut age after plantation>

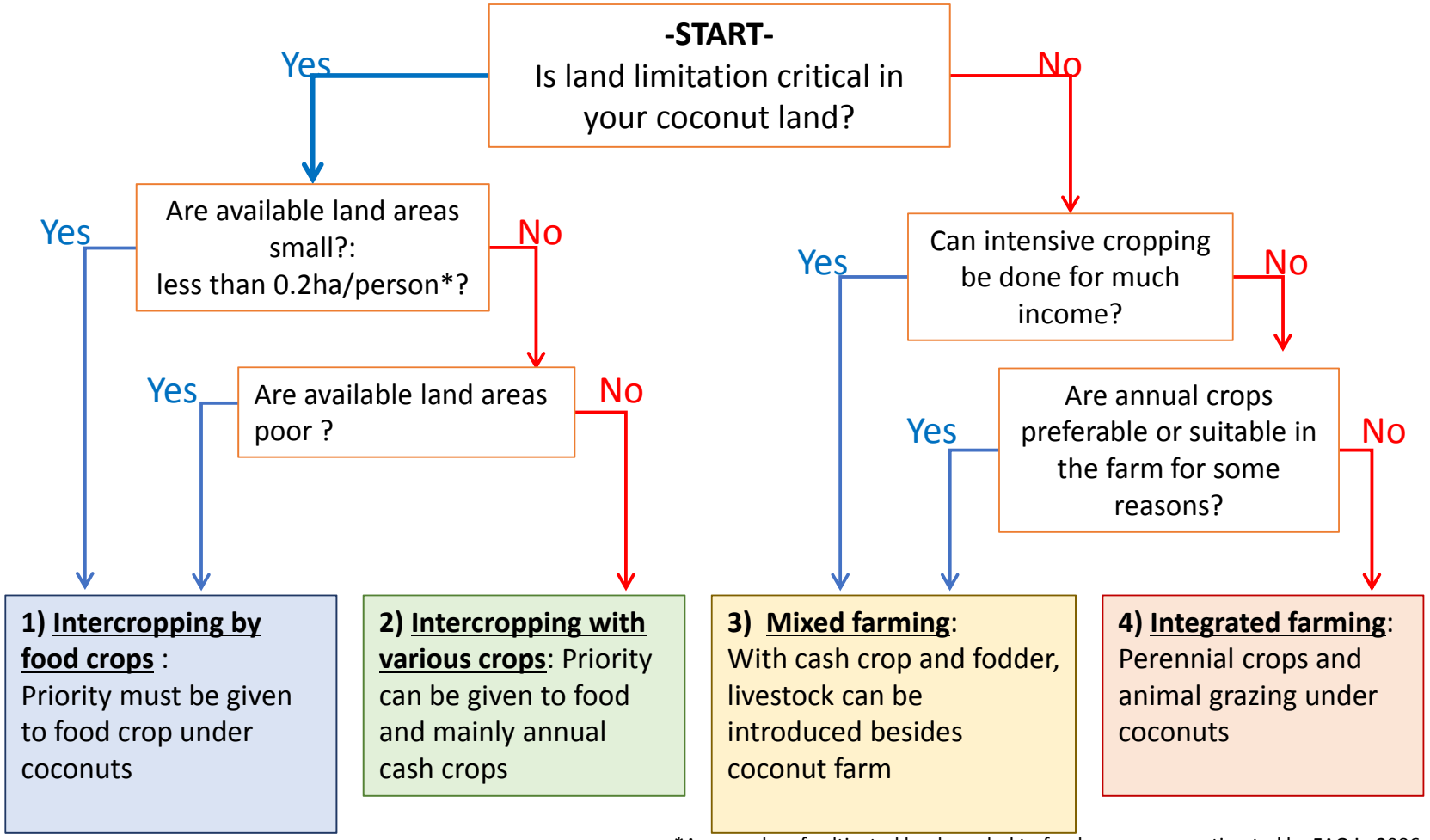
Duration	Sunlight	Highly suitable intercrops
Field-planting to 6years	High to Moderate	Cereals - corn, upland rice Legumes - cowpea, peanut, mungbean, sitao, beans Root crops - sweet potato, gabi (taro) Vegetables - tomato, cabbage, PINAKBET vegetables Fruit crops - pineapple, citrus, watermelon, papaya, banana Forage: any tropical grass
7-25 years	Moderate to Low	Root crops :ginger Vegetable: cabbage, pechay Fruit crops :black pepper, cacao, coffee, vanilla, lanzones, durian, rambutan, mangosteen, gemelina (for wood & lumber) Forage: Guinea grass, Para grass, Signal, humidicola
26-60 years	Moderate to High	Cereals - corn, upland rice Legumes - peanut, mungbean, cowpea, beans Root crops - sweet potato, gabi, cassava, ube, ginger Vegetables – PINAKBET vegetables , tomato Fruit crops -cacao, coffee, lanzones, rambutan, durian, mangosteen, citrus (pomelo, calamansi), gemelina (for wood & lumber) Fiber crops - ramie, abaca, Forage: any tropical grass

Source: JICA Study Team based on 'Coconut Intercropping Gide No.5 ' Department of Agriculture, PCA, 2006)

(2) Cropping/Farming Type Selection

What type of cropping/farming is recommended in your farm?

This flowchart uses simple "yes" or "no" questions to lead you to a logical solution !



*Average ha of cultivated land needed to feed one person estimated by FAO in 2006

The chart just shows recommended cropping/faming types. It can be changed according to natural and social condition and marketing.

(2) Cropping/farming type Selection cont.

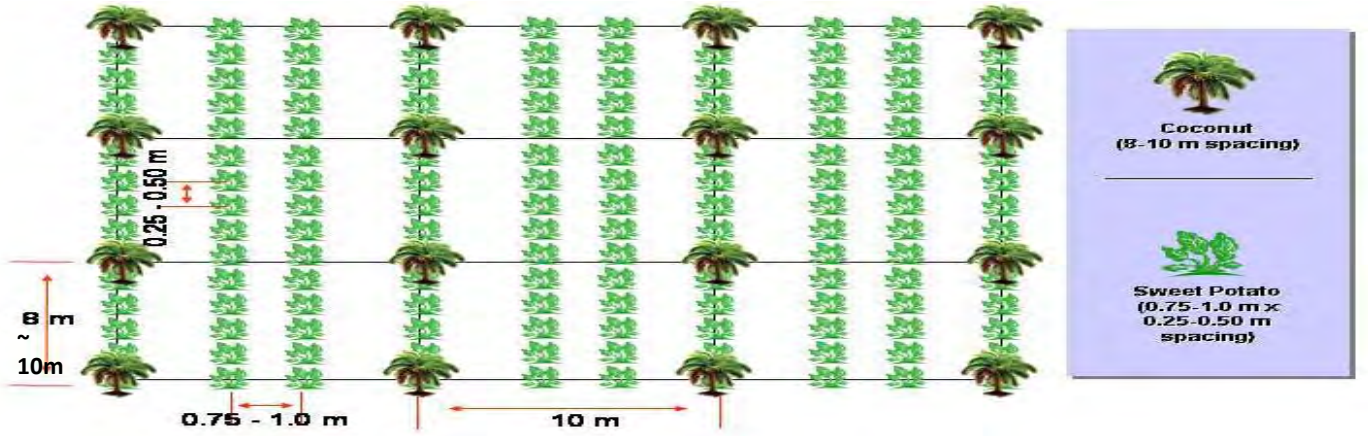
1) Intercropping with food crops

Focus on nutritious food and additional income

◆ Main points

- Generally, root and cereal crops consume much nutrients; hence, both crops should be supplied with the required fertilizers.
- Root and cereal crops must not be exposed to strong sunlight, except ginger which is tolerant to weak sunlight and cool weather.

◆ Example of a Farm Layout (root crop)



- Cassava can be replaced with different crops.
- Gabi and ube can be planted 3 rows at the space 50 X 60-75 cm.
- Ginger should be distanced 50 X 50 cm and 2m away from the base of the coconut trees.
- Maize should be distanced at 0.75 m apart and 2 m away from the base of coconut trees.

Source: Multi-story cropping with peanuts and pineapples , PCA

(2) Cropping/Farming Type Selection cont.

2) Intercropping with Various crops

This manual focuses on that!!

Aiming for a more resilient agricultural income

◆ Main points

- Vegetables should be supplied with the required fertilizers and plant management needed until harvest
- Heat intolerant crops like pechay and young fruits are well grown under coconuts that age 7-25 years after planting.
- Especially, PINAKBET same with other root crops, can grow healthier with strong sunlight

◆ Example of Farm layout

- All other crops can be replaced except for legumes which provide nutrients for the fruit-bearing crops.
- Peanuts should be replaced with other crop family and legumes can be grown after 3-4 cropping

Crop rotation is indispensable!

e.g. Maize->Cabbage->Okura->Tomato->
String beans

Source :Multi-story cropping with peanuts and pineapples , Coconut-vegetable cropping model , PCA

(2) Cropping/Farming Type Selection cont.

3) Mixed farming- livestock raising on nearby site

Introduce fodder in your crop rotation !

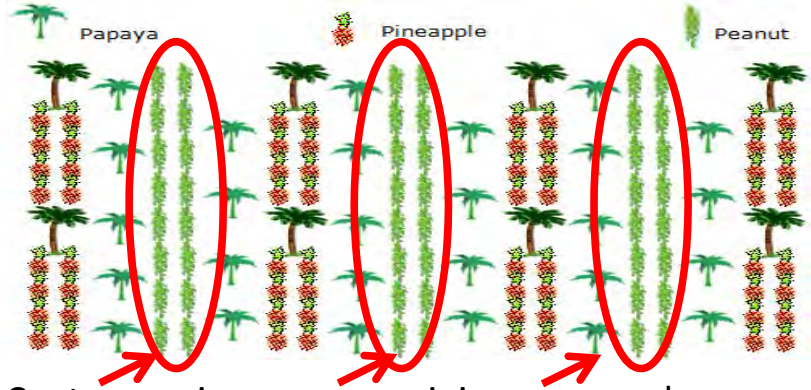
- Main points:

Source: Country Pasture/Forage Resource Profiles (source :FAO)

- Animal husbandry can generate additional income
- Possible used straw of cereals (e.g. rice) and forage (e.g. maize)
- Annual forage can be grown under hot and less fertilized land and can be introduced in the crop rotation
- Fruit trees and perennial fodder trees (e.g. *leucaena* and *gliricida)* can also be combined under coconuts as an alley crops

- Example of Farm layout

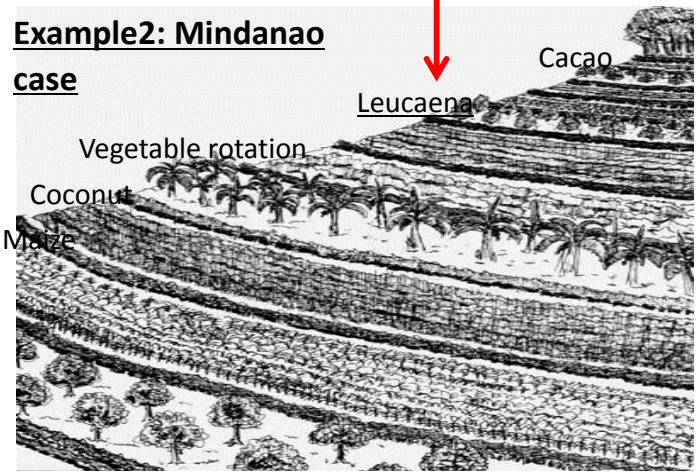
Example1: intercropping with fruit tree



Centro, napier grass or guinia grass can be replaced with peanuts

Source: World Agroforestry Center, Chapter4: Agroforestry and A Guide to Intercropping Coconuts, Project ALA-97/98

Example2: Mindanao case



Source: Technique agricole pour les terres en pente: technique agroforestière mise au point par une ONG aux philippineshttp://www.fao.org/docrep/u7760f/u7760f09.htm

(2) Cropping/farming Type Selection cont.

4) Integrated farming with animal grazing in coconut farm (esp. cattle and buffalo)

Taking synergy of integration farming!

◆ Main points

Source: Pasture-Cattle-coconut System, FAO, 1995

Pasturage and feed under coconut tree

Advantages

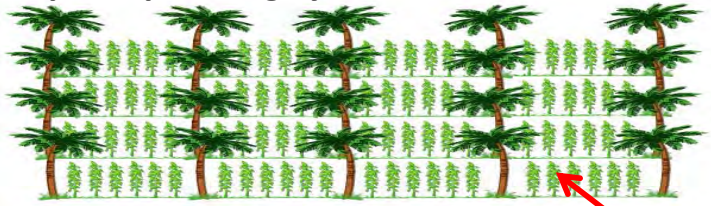
- ✓ Increase soil fertility while animals graze with manure and urine
- ✓ Using land resource efficiently can provide a better environment for cattles.

Disadvantages

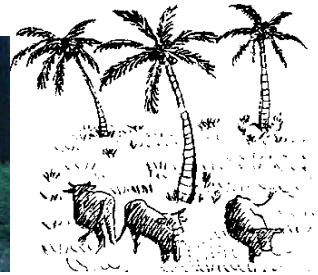
- ✓ Damaged palms can cause soil compaction
- ✓ May also cause insect pests from animal dung

◆ Example of Farm layout

Square planting system



Triangular planting system



- Planting distance should be 8-10m to make graze cattle
- Plant perennial fodder grass like Guinea grass and Centro between coconuts

Source: Coconut-cereal cropping model ,PCA and https://www.ilri.org/InfoServ/Webpub/fulldocs/SmHDairy/chap9.html

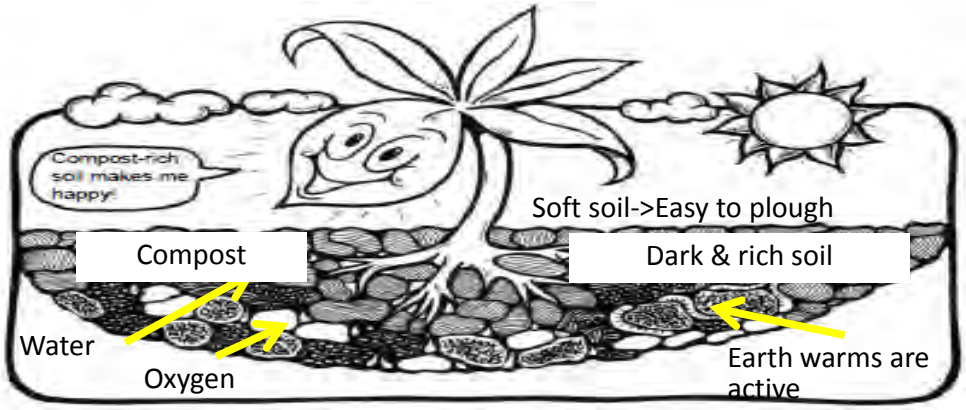
If you wish to raise animals, follow the instructions from DA because the required techniques are different per animal

3.2 Advanced techniques for intercropping

(1) Composting

Compost helps make the soil rich and healthy!

1) Benefits of composting



- ✓ Preserves a lot of air and water in the soil
- ✓ Destroys seeds of weeds and pests
- ✓ Enhances interaction of bacteria in the soil

2) What is compost?

Compost is a mixture of decayed organic materials decomposed by microorganisms, releasing nutrients into readily available forms for plant use

So the materials are:

Farm residues:
leaves, straw, dry stalks, legume plants, wide weed, etc.

Animal waste:
fresh animal manure (cow, chicken, pig, duck, rabbits, etc.)

Kitchen waste materials:
Bones of fish and meat, vegetable peels, leftovers, etc.

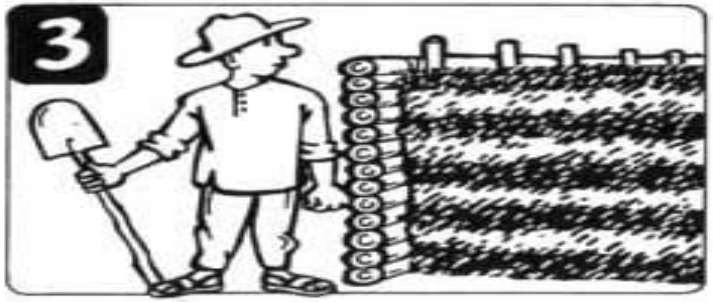
Source: Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO (ACCU)

(1) Composting cont.

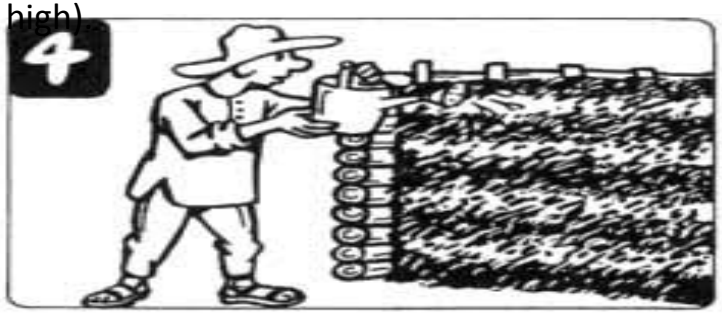
3) Steps of compost preparation:

Make a pile of dry farm residue about 1 m x 1m and 30-40 cm high.

Cover the pile with fresh animal waste to about 1/3 to 1/2 the height of number 1 (10-20 cm high)



Repeat numbers 1 and 2 until the pile is 1 to 1.4 m high (up to about your shoulder).



If the surface of the pile gets dry, water to keep it damp.

Spread soil (up to 2.5 cm thick) evenly on top of the pile to speed up the process of compost.

After about 2 weeks, the compost pile will become hot inside (60~70°C). Mix the compost well and if it is dry, water the pile to dampen it.

Source: Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO (ACCU)

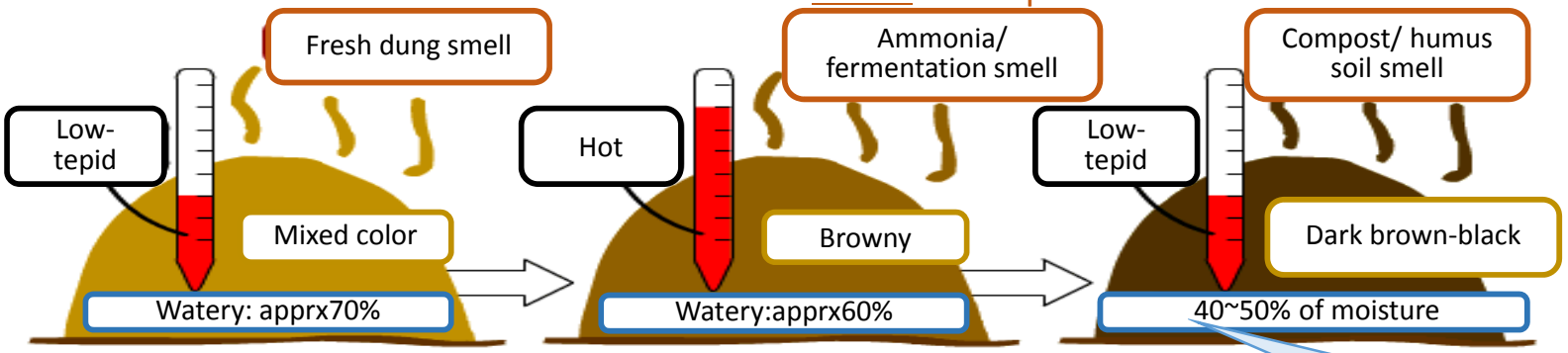
(1) Composting cont.

4) Well-matured compost

Compost can be applied after changing 4 features as follows:

1. Temperature inside the compost will be likely the same in the outside.

2. Smell of compost will be better.



3. Color will turn to dark brown or black.

4. Moisture will decrease due to the heat of fermentation

Source: Basic idea of compost makinghttp://www.chikusan-kankyo.jp/taihiss/taihi/taihi.htm#s02_6

5) Application of compost

- Before planting seeds or seedlings, spread well-matured compost on the field. Then, plough the soil.
- For 10 hectares of land, 1-2 tons of compost (about 1 to 2 piles of the compost made) will be sufficient.
- If you are not using chemical fertilizer, 3-4 tons of well-matured composts are needed.

Source: Better Crops from Healthy Soil with Compost, Asia/Pacific Cultural Center for UNESCO (ACCU)

(2) Plastic Mulch

Relatively expensive but it is worth using!

Plastic mulch is generally available in local market
but it is expensive….

◆ Which is better?

Without silver mulch in Mercedes:
Pechay is damaged by drought, erosion, weeds, and insects.

OR

With plastic (silver)mulch in Leyte:
Pechay grows healthier without damages.

◆ Advantages of using plastic mulch:

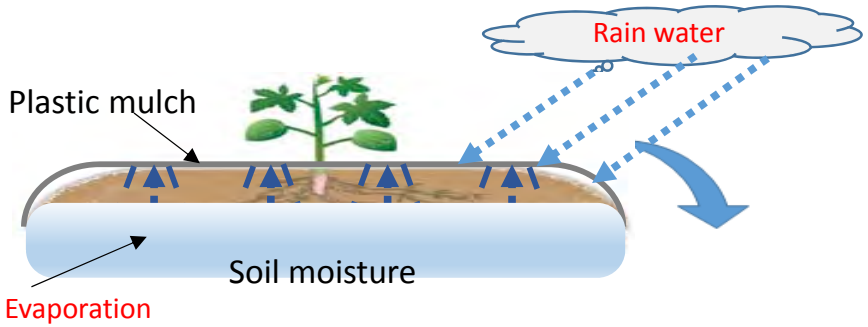
- ✓ Moisture control
- ✓ Prevents soil erosion=fertilizer conservation
- ✓ Weed control
- ✓ Insect repellency
- ✓ Possible to reuse several times

Cost of plastic mulch < Effects for vegetable production

(2) Plastic Mulch cont.

1) Retain moisture

Moisture underneath the mulching maintained stable

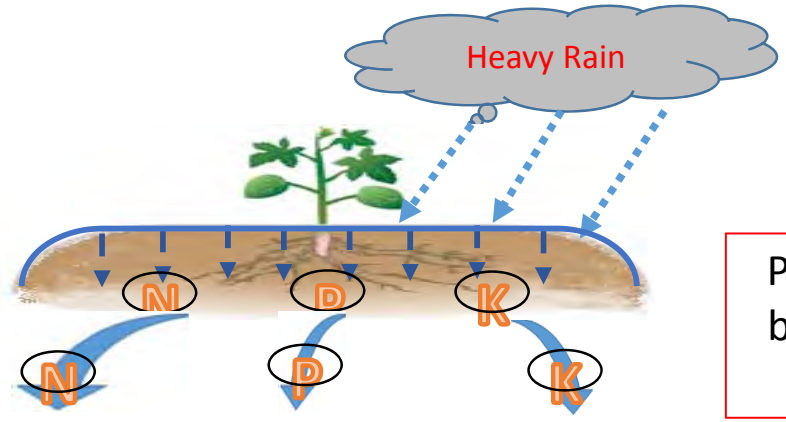


Mulching helps to maintain appropriate soil moisture underneath the plastic

Be careful to use plastic mulch when it is hot!
It can also maintain soil temperature
which may kill plants.

2) Prevention erosion=Fertilizer conservation

Heavy rain cause an erosion and drainage of fertilizer in the soil



Local soil is well drained by rain

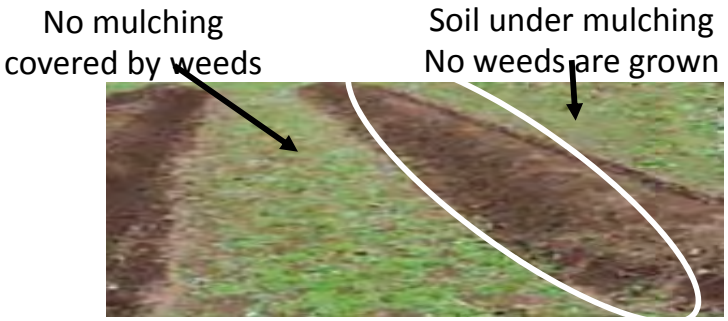
Fertilizer is also easily drained off from the soil

Plastic mulch inhibit direct hit of the rain to be penetrated into the soil bed and protect fertilized soil

(2) Plastic Mulch cont.

3) Weed control

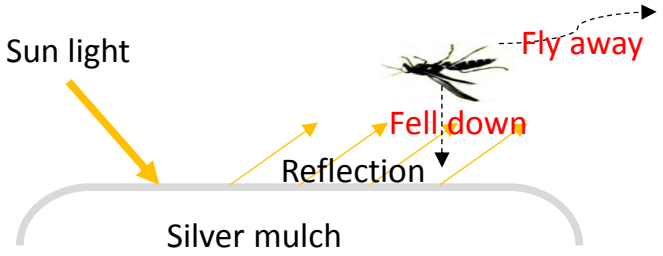
Shielding the sunlight inhibits weed growth underneath the mulch



No weeds on bed
=
Improve plant growth condition

4) Insect repellency by silver plastic mulch

Reflection of sunlight has effect on insect repellency



Insects may fell down or fly away because of reflection
=
Lowers pest damage

5) Possible to reuse

Plastic mulch can be reused 4-5 times

Reuse several times
=
Save money and labor with many effectiveness

(3) Non-arable land management

Keep the abandoned/non-arable land clean

Is there abandoned/non arable land?

In the case of Mercedes, it is said that most land is non-arable…

For example:

➢ Irremovable large rocks are scattered everywhere

➢ Abandoned old coconut farm after Yolanda

Generally, abandoned/non-arable lands are located near the coconut farms where intercropping can be practiced

If weeds and useless trees are grown actively there,

➢ Ideal nest for pests created

➢ Inhibit fertilizer absorption

➢ Disturb sunlight and aeration

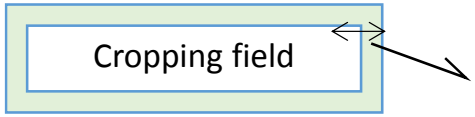
Managing the abandoned/non-arable land is important for cropping area and efficient land use!

(3) Non-arable land management cont.

1) Cleaning up abandoned/non-arable land

Undesirable weeds/trees should be cleaned up more

Clean up more than 2 m wider than proper cropping area



Remove weeds and residues inside and outside of the cropping field

Cut them all !

2) Planting crops

Some crops may grow in non-arable land

Taro (Gabi)

Ref. 3-1(2)-1)

Ref. 3.1(2)-4)

- Maize, **cassava, taro,** or **feed crops** can easily grow in relatively poor soil
- Apply fertilizer, esp. the organic one, properly to attain better yield performance

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