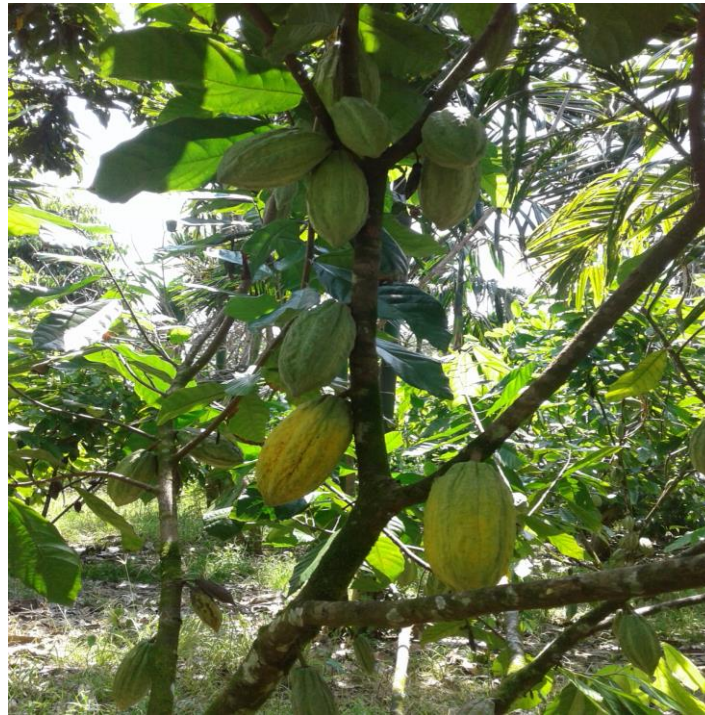


Cocoa and Goat Integration

Module 20



Developed by:
PNG University of Natural Resources & Environment and Australian Centre
for International Agricultural Research

Cocoa and Goat Integration

Module 20

Trainee Workbook

Integrated Agriculture Training Program

Developed by:

PNG University of Natural Resources & Environment
and
Australian Centre for International Agricultural Research
under two funded projects,
HORT2014/094 and HORT2014/096

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Cover photos:

A high yielding cocoa clone (left) and a goat feeding on dry cocoa leaves at Joseph Tauro farm in Buin, South Bougainville

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Contents

Page

Acknowledgement	5
Introduction	5
Aim.	5
Learning Outcomes	5
UNIT 1: Integrated Farming System (IFS)	6
Learning Objectives.....	6
1.1 Scope of Integrated Farming System	6
1.2 Choice of Enterprise in IFS	6
1.3 Integration of Enterprises	7
1.4 Components in Cocoa-Goat IFS	7
✎Activity 1.1	9
✎Activity 1.2	9
Summary	9
UNIT 2: Goat as an Enterprise in Cocoa Farming System	10
Learning Objectives.....	10
2.1 What makes an entrepreneur?.....	10
2.2 A simple Cocoa/Goat IFS Model for an entrepreneur	10
2.3 Characteristics of entrepreneurship	10
2.3.1. Identifying a business opportunity	10
✎Activity 2.1	11
2.3.2. Calculated Risks Taking	11
✎Activity 2.2	11
2.3.3. Objective Setting.....	11
✎Activity 2.3.....	12
2.3.4. Information Seeking.....	12
2.3.5. Commitment to the business plan	12
2.4. Goat as small ruminants	12
2.5 Record Keeping	14

2.5.1. Which records to keep?	14	4.3.3. Seed Sowing Methods and Procedures	26
2.5.2. Marketing	14	4.4. Vegetable Nursery Husbandry Practices.....	27
✎ Activity 2.4.	14	4.5 Vegetable Field Planting	27
Summary.....	15	4.6. Vegetable Garden Plan & Bed Construction.....	28
UNIT 3: Goat and Cocoa Management Practices in IFS	15	4.6.1 Garden Plan	28
Learning Objectives	15	4.6.2 Bed Construction	28
3.1 Housing Management	15	4.7 Practices for Vegetable Field Management.....	29
3.2 Breeding and Selection.....	18	4.8. Harvest and Post-Harvest Management.....	29
✎ Activity 3.1.....	18	4.9. Factors affecting quality at harvest	30
3.3 Waste Management	18	4.10. Post-Harvest Practices	30
3.4. Goat Nutrition and Feeding Management	19	4.11. Marketing.....	30
3.4.1 Energy sources in Integrated Farming System.....	19	✎ Activity 4.1.....	31
3.5 Protein Sources.....	20	Summary	31
3.5.1 Moringa	20	UNIT 5: Integrated Pest and Disease Management in IFS	31
✎ Activity 3.2.....	21	Learning Objectives.....	31
3.5.2 Leguminous trees	21	5.1 Purpose of integrated management.....	31
3.5.3. Supplementary Feeding	21	5.2 Common pests and diseases.....	32
✎ Activity 3.3	22	5.3 What is IPDM	32
Summary.....	22	5.3.1 Managing health condition of goat	32
Unit 4: Vegetables and Supplementary Crops as Enterprises in		5.3.2. Managing conditions for cocoa production	33
IFS	22	5.4 Application of IPDM	34
Learning Objectives	22	5.5 Approach of IPDM Technology	36
4.1 What is vegetable gardening in an IFS?.....	23	5.5.1 Type of pests and diseases	36
4.2. Site Selection and Nursery Establishment.....	23	5.5.2 Level of infestation (damage) or medical condition.....	36
4.2.1. Criteria for Site Selection.....	24	5.5.3 Climatic and environmental conditions.....	36
4.2.2. Importance of Crop Nurseries.....	25	5.5.4 Availability of resources.....	36
4.2.3. Types of Vegetable Nurseries.....	25	✎ Activity 5.1.	37
4.3. Vegetable Nursery and Media Preparation.....	26	Summary	37
4.3.1 Media collection, mixing, straining and sterilization	26	Unit 6: Utilization of wastes from cocoa and goat integrated	
4.3.2 Vegetable Nursery Practices & Procedures	26	farming system	37

Learning Objectives	37
6.1 Utilizing Cocoa and Goat wastes	37
6.1.1 Utilizing the waste from cocoa trees.....	37
6.1.2 Managing and confining goats to reduce damage.....	38
6.1.3 Collecting and storage of goat manure	38
6.1.4 Making compost and manure application	38
✎ Activity 6.1.....	39
Summary.....	39
Conclusion	39
Refernces	39

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Introduction

Integrated farming system (IFS) is a type of farming adopted using combination of different crops and livestock are farmed at the same time in one area. Many cocoa farmers in Papua New Guinea (PNG) practice multiple cropping or integrated farming, where cocoa is either grown under coconut, betel nut, galip (*canarium* sp), banana or a combination of all depending on farmer's choice of farming.

Livestock, especially goat, has never been part of or integrated with cocoa due to damages that are caused by the animal. However, records indicate that goats have been introduced to cocoa farming communities as pet and source of meat.

The importance of goat as a source of nutrition for cocoa and farmer was never realized until recently when cocoa and goat

integration concept was introduced under two ACIAR funded projects, Hort2014/094 and Hort2014/096 in 2016.

The IFS concept is aimed at enhancing nutrition for a farmer, cocoa and goat (or other livestock or fish) and diversity income. This module emphasizes the need for improvement in the health and wealth condition of a smallholder cocoa farmer through the introduction of livestock into existing cocoa farming system.

IFS emphasises that “waste” from one component of cocoa farming system becomes an input for another component within the system, which reduces cost and improves production and/or income. IFS ensures that waste of one form of agriculture becomes a resource for another. For example, goat waste is essential for cocoa and vegetable crops whilst wastes from cocoa and vegetable harvests are used to feed goats.

The concept does not only utilize wastes and promotes organic farming but also improves soil conservation, addresses nutrition and promotes organic farming.

Aim

The aim of this module is to provide relevant information necessary for cocoa farmers to add value and maximize the use of their land through integration of livestock (goat) into existing cocoa farming system.

Learning Outcomes

In this unit we will be able to;

1. To develop and manage an integrated goat –cocoa farming system

2. To utilise cocoa waste products as livestock inputs (livestock feeds) as a waste management exercise and likewise livestock output (manure) as a cocoa input (organic fertilizer) for the cocoa plants and other crops in the IFS.

UNIT 1: Integrated Farming System (IFS)

Learning Objectives

By the end of this unit participant should be able to;

1. Clearly explain the concept of IFS: goats - cocoa integrated system
2. Identify the components of Goat and Cocoa Integration.
3. Illustrate an IFS Goat – Cocoa model

1.1 Scope of Integrated Farming System

Farming enterprises may include food crop, livestock, poultry, fish, tree crops, plantation crops, etc.

A combination of one or more enterprises with cropping, carefully chosen, planned and executed, which can give a greater dividend than a single enterprise, especially for smallholder farmers.

A farm must be considered and planned for effective integration of enterprises to be combined with crop production activity. Integration of farm enterprises combined can be based on many factors,

- Soil and climatic features of the area in question.
- Availability of resources such as land, labour and capital.
- Present level of utilization of available resources.
- Economics of proposed integrated farming system.
- Managerial skill of the farmer

The following situations are ideal for the introduction of IFS:

- The farmer wishes to improve the soil quality
- The farm household is struggling to buy food or below the poverty line
- Fertilizers are expensive or unavailable
- The farmer is seeking to maximize profits on existing farming system
- The farmer wants to reduce pollution or waste disposal problems.

Hence, the farmer can use IFS to;

- Improve productivity and sustain livelihood
- Regulate nutrient and material flows
- Minimize pest and disease incidences
- Reduce the smell and waste management issues of some livestock & crop operations

1.2 Choice of Enterprise in IFS

Livestock is the best complimentary enterprise with cropping. The livestock activities in IFS consist of poultry, piggery, cattle and small ruminants (goats, sheep). The selection of livestock is dependent on preference based on family consumption, potential market, and availability of resources.

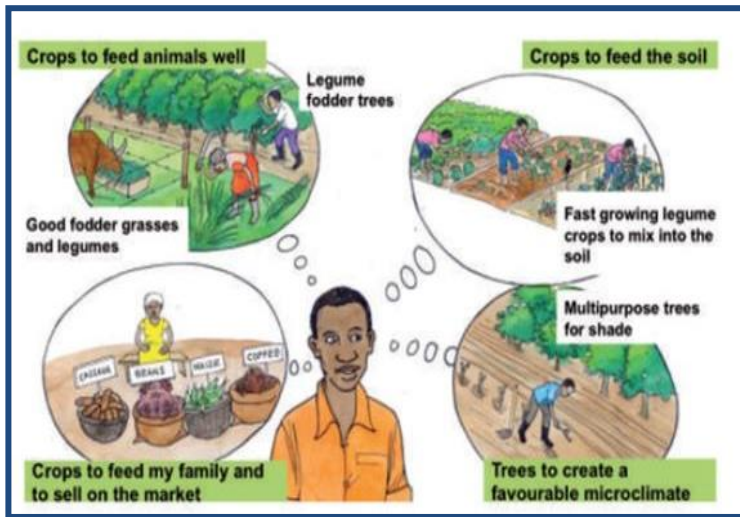


Figure 1. Making decision over alternative crops and livestock based on potential benefit from mixed farming. Source: Goggle web

1.3 Integration of Enterprises

Crop production is the main activity in PNG Agriculture. The income obtained from crop alone may not be sufficient to sustain the farmer's family throughout the year. Assured regular cash flow is possible only when the crop is combined with other enterprises within a cropping system and integrating existing farming with other enterprises such as livestock. Wise combination of enterprises, keeping in view of the environmental conditions of a locality will pay greater dividends as well as market options available. At the same time, it will also promote effective recycling of residue/waste matter.



Figure 2. A combination of enterprises in an IFS.

1.4 Components in Cocoa-Goat IFS

Let us have a look at the potential components of a Cocoa IFS;

1. Cocoa - main farming system
2. Goat – complimentary component introduced into the cocoa farming system
3. Supplementary Food crops/vegetables,
4. Fodder Production (mulberry, gliricidia, leucaena etc)
5. Composting and Vermiculture/organic fertilizer

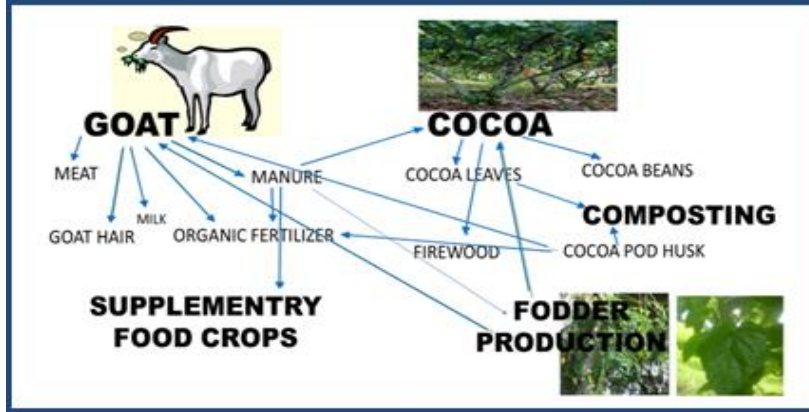


Figure 3. Integrated cocoa-goat farming system model.

The feeds derived from “alternative” crops (roots/tubers and leaves of cassava etc., leaves of mulberry, moringa, gliricidia, grasses) will require “alternative” farming systems. These are on small scale and are highly productive.

These are diversified and integrated and the role of goats in this system is synergistic rather than as primary producers. External inputs can be minimized through waste recycling and growing of nitrogen-fixing and pest-resistant plants in this farming system. For example, using goat manure as organic fertilizer and moringa for nitrogen fixing and, at the same time the leaves can be used as goat feed. The model provided in Figure 3 shows the goat – cocoa integrated farming system with its component e.g. Goats on fodder trees such as gliricidia/leucaena/mulberry/moringa, pasture and other supplementary sources of food.

Once the farmer has identified the components of a farming system, which in our case, cocoa is the main farming system while the components of the cocoa farming system are the shade trees and food crops.

Goat is the complimentary enterprise to complement the existing farming system and its sub systems. Again, the selection of livestock is dependent on preference based on family consumption, potential market, and availability of resources. The selected livestock must also compliment the other existing farming systems and sub systems.

As an entrepreneur, these existing farming systems of the Goat – Cocoa Integration can be seen as enterprises as shown in Figure 4 and 5 Cocoa, Supplementary Food Crops, Goat Production, Composting/vermicomposting.

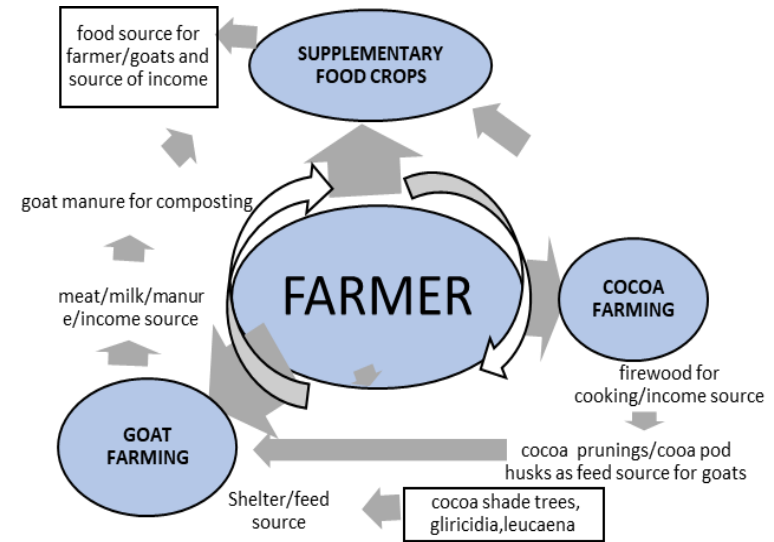


Figure 4. Potential enterprises from goat-cocoa integrated farming system. With livestock being introduced to cocoa farming, tree fodder can be viewed as potential enterprise.

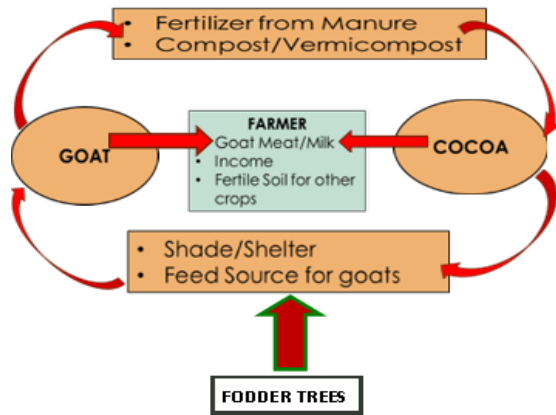


Figure 5. The benefits the farmer obtains from the different components in the cocoa goat IFS once he views the components and treats them as enterprises.

Activity 1.1

Let us have a look at 1 hectare of a cocoa farming system in your area.

- What are some of the shade trees that are commonly used in the cocoa farming system? Identify and list some of the shade trees used in cocoa farm.
- Identify some food crops grown within the cocoa farming system in your area.
- If there are any livestock raised by the cocoa farmer, identify and list them.
- Using the information obtained, develop schematic diagram representing an ideal integrated farming system for the cocoa and livestock.

Activity 1.2

Let us have a look at an existing one (1) hectare cocoa farming system in your area. Having identified your systems and viewing them as your potential enterprises.

- How will you integrate supplementary crops and goat into existing cocoa farming system?
- Where will you plant the crops? Justify your answer.
- Where will you raise the goats? Justify your answer
- Would you raise the goats in an area other than 1 hectare but input (feed) will be supplied from the 1 ha farming system?

Summary

- In this unit, we have explained the concept of an ‘Integrated Farming System’ and further discussed the cocoa – goat integration concept.
- We have also identified the components that make up the goat – cocoa integrated farming system. Remember that the components or subsystems should complement each other.
- We have also learnt that ‘Farm is a unit and it must be considered and planned for effective integration of the enterprises to be combined with crop production activity.
- Livestock is the best complimentary enterprise with cropping in an integrated farming system.
- In an IFS, external input can be minimized through waste recycling and growing of nitrogen-fixing and pest-resistant plants in this farming system.

UNIT 2: Goat as an Enterprise in Cocoa Farming System

Learning Objectives

By the end of this unit, you will be able to;

1. Exhibit entrepreneurial competencies needed to run a successful Goat Enterprise in a Cocoa IFS
2. Know and understand what goats are
3. Discuss the economic importance of raising goats.
4. Identify and discuss market options for goats.

2.1 What makes an entrepreneur?

Let us first of all have a look what or who an entrepreneur is?

An entrepreneur is a person who continuously identifies opportunities in the market for products or services and then develops new products and services to satisfy the identified needs. In IFS Cocoa/Goat and from the model below, as an entrepreneur what would be your products and services?

2.2 A simple Cocoa/Goat IFS Model for an entrepreneur

In Cocoa/Goat IFS as an entrepreneur, you as an entrepreneur need to visualize a successful goat business and then commit resources to achieving these set goals. Most producers have the “*The goats should look after themselves*’ mentality. They do not realize the value of goats, their total worth and how much more they could contribute to their livelihoods if well managed as a

business enterprise rather than as just pets or free roaming animals.

For the smallholder goat producers to run successful commercial goat enterprises they need:

- To understand that starting a business has some risks;
- To have Access to adequate knowledge and information;
- To identify opportunities;
- To commit time and resources; and
- To be ambitious and set goals that are realistic and achievable.

2.3 Characteristics of entrepreneurship

The entrepreneurial abilities that one needs to develop in order to be a successful commercial goat producer are;

- identifying business opportunities,
- calculate risk taking,
- goal setting,
- information seeking,
- commitment to a business plan,
- persuasion and networking, and
- systematic planning and monitoring.

2.3.1. Identifying a business opportunity

The key is the ability to see opportunities in business or personal life where others do not. An opportunity is therefore a chance, an opening or prospect, which avails itself. Thus, an entrepreneur is anyone who identifies problems, resources and unmet needs in society and develops these into business ideas. Thus, generating business ideas is the first step in business creation.

Examples of entrepreneurs are:

- A farmer who identifies the need for supplementary feeding and goes on to store the feed and sell it to other farmers during the dry season.
- A group of farmers who realize that the shortage of beef or pork is an opportunity for them to sell more slaughter goats. They organize themselves, hire a truck and transport 50 goats per month for sale.
- A trader who buys goats from the small-holder farmers and sells them to an abattoir in the province.

- They might lose their savings;
- They are not sure whether the goat enterprise will give them a return;
- They do not have information on available opportunities.

A good illustration of risk taking would be that of a goat trader.

- ❖ *Traders undertake tasks that most smallholder goat producers do not want to undertake on their own. The traders incur costs that include buying, transportation, pre-financing, personnel costs (for buyers/ herders) and slaughtering fees.*

Activity 2.1

What goal business opportunities available in your area? Use the tool below to identify your business opportunities in the goat sub-sector.

Problem/unmet needs	Resources	Business idea
1. Shortage of meat	Goat	Buy and sell
2. Shortage of fertilizer	Goat Manure	Buy and sell goat manure
3.		
3.		
4.		

Activity 2.2

Get into groups and discuss the activity below

- a. What calculated business risk have you ever undertaken in your life? Write down the event.
- b. What happened and how did it happen?

2.3.2. Calculated Risks Taking

Once an opportunity is identified, match with your capabilities, and then assess the risks involved. When one is taking a risk, it is a matter of striking a balance between success and failure. Risk can be minimized by seeking information and making informed decisions.


Most goat producers are afraid of taking risks because of the following reasons:

2.3.3. Objective Setting

An objective is defined as a specific and measurable achievement to be attained within a specific period of time and cost constraint. A well-defined objective statement is the foundation for goal achievement. Objectives are set to give direction, motivate one to work hard, assist one to be well organized and as monitoring tools. An objective should state the following:

- What is to be achieved?
- By who?
- By when?
- Where?

A good set of Objectives should be specific, measurable, achievable, realistic and time-bound (SMART)

 Activity 2.3.

1. Write a SMART objective for goat enterprise.

 1 Taking your objective as it is, if achieved what would it bring to you?

2.3.4. Information Seeking

An entrepreneur should access new technologies and other factors that affect their goat business. The information gathered should assist greatly to:

- Shape the business plan;
- Help reduce risk; and
- Enable the entrepreneur to make better/ informed decisions.

There are a number of information gathering methods that can be used. These are:

- Desk research;
- Interviews;
- Questionnaire; and
- Observation.

The sources of information include books, government records, electronic media (radio and television), Internet services,

competitions (fairs and shows), buyers, suppliers, other farmers and newspapers.

2.3.5. Commitment to the business plan

Once one has a business plan in place there is a need:

- To stay focused;
- To be committed to the tasks ahead;
- To adhere to a set work plan
- Motivate and provide leadership to the people you are working with on the goat business.

2.4. Goat as small ruminants

Example of an objective that is not SMART	Example of a SMART objective
“I want to have more money”.	“I will sell 5 goats directly to Vudal Farm by September, leading to an increase in my income by 100 %.

Goats belong to a group of animals called ruminants. They are further classified as *small ruminants* being for their body size being small compared to other ruminants such as cattle and buffalo. Animals can be divided into three groups when referring to their feeding mechanism/behaviour. Goats belong to group three. They eat mostly leaves and pastures.

1. Carnivores which eat meat
2. Omnivores which eat both meat and plants
3. Herbivores which eat plants

Let us have a look at the digestive system (Figure 6) of a goat and digestion process.

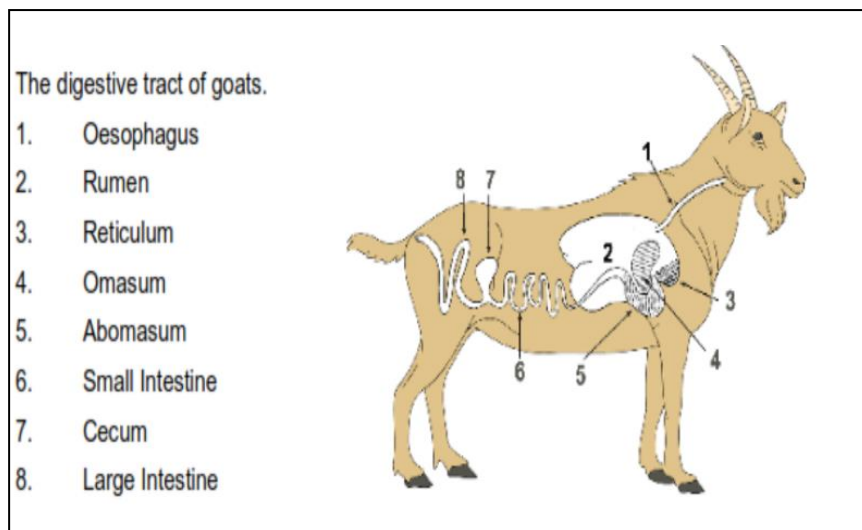


Figure 6. Digestive track of goat.

Ruminants are animals with a complex stomach and are classified as intermediate feeders (browsers). They eat and digest forages or plant-based feed by swallowing it first and allowing it to get moistened in the rumen, the first compartment of the complex stomach. The swallowed food is later regurgitated by the animal and re-chewed to break down the plant materials for digestion. This process is called rumination or chewing the cud. The cud is a semi-solid and semi-degraded digesta usually in a bolus form which is regurgitated from the reticulorumen of the animal. Examples of ruminant animals are cattle, sheep, goats, camel, water buffalo, giraffes, and antelopes to mention but a few.

In the IFS Goat – Cocoa Integrated System, a farmer will not only depend on his economic returns from the cocoa beans alone but he will also have an alternative source of income being earned from raising goats. Apart from that, goat meat will also serve as a

source of protein for the family. Goat meat is very popular in most parts of the world, although it is not common a meat eaten in PNG, most people would love to have a taste of goat meat.

Going back to Unit 1, the choice of enterprise: Goat has been chosen over other animals due to its feeding behaviour. Based on the diets they prefer, ruminants can be classified into distinct feeding types: grazers, browsers and intermediate types. Goats are classified as intermediate types, In this IFS of Goat – Cocoa Integration, it would mean that they can eat just about anything from browsing woody and shrubby type plants such as cocoa leaves and fodder from shade trees provided within the farming system. Dietary preference of goat compared to goat is indicated by Figure 7.

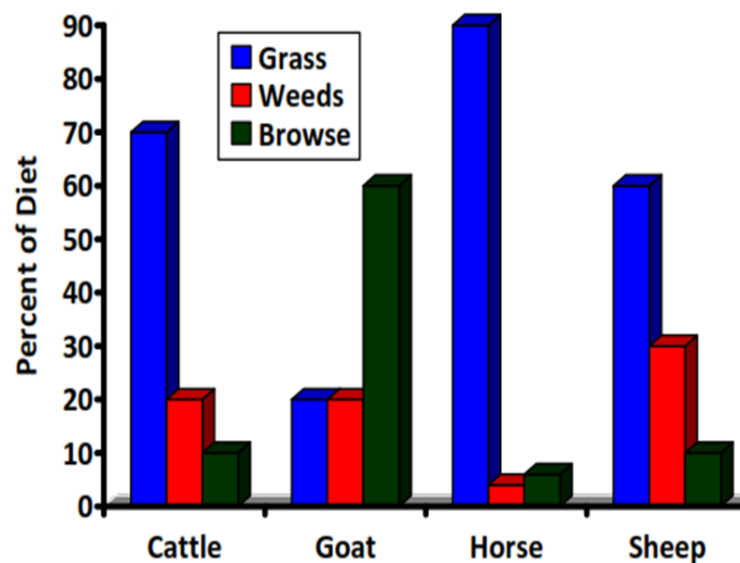


Figure 7. Dietary preference of different livestock species.
Source: An Peischel, 2005.

2.5 Record Keeping

To facilitate management of goats, a proper and well-kept record system must be in place as necessary. The records will reflect the goat farmers to make wise decisions on how to properly manage essential data on individual animals and likewise make right decisions on how to properly manage the whole farming system.

❖ Why keep records

- Helps you to know your goats
- Increases animal values and therefore, sales income
- Promotes improved genetic merit
- Helps you manage your animals well

2.5.1. Which records to keep?

Simple records should be kept by a farmer.

- Birth dates
- Birth weights
- Sire and Dam Weights
- Treatment Records
- Service Dates

Good record on service dates will help you calculate the expected date of birth after breeding. You can know the expected date by counting 5 months from the date of service.

2.5.2. Marketing

Who could resist the unique flavour and palatability of goat meat? Goat meat is leaner than most red meat and less tender. Goats can be marketed after five months based on their body weight. Market weight may vary depending on their growth performance for both males and females.

A roasted goat meat ‘cabrito’ is goat meat obtained once goat kids reach 4 – 8 weeks. It is mainly used as barbeque meat. Chevon is another goat meat obtained from goat kids at 6 – 9 months old. As an entrepreneur, you decide as to what age you can sell your goats.

1) Using live sales method of marketing

This method of marketing is common in rural farming systems where live animals are sold for instant cash from the buyer. On a commercial basis, the live animal is weighed and then sold to the buyer on a weight /kilo basis.

For example;

If the price per kilogram of a young goat is K15.00/kg. If the goat weighs 25kg then the farmer will charge the buyer as follows;
 $25\text{kg} * \text{K}15.00 = \text{K}375.00.$

In rural settings where there is no scale, the farmer simply charges the buyer by simply looking at the size of the animal etc. For example, in the Autonomous Region of Bougainville, a goat farmer sells his goats between K800.00 – K1000.00 regardless of the mass of the animal.



Activity 2.4.

1. Explain what we mean when we say goat is a ruminant animal? Why is it important to learn about the digestive tract of the goat?
2. What would be some food sources for the goats? List down 5 food sources.
3. Referring to Figure 5: Explain dietary preference of a cattle, goat and sheep. Are their dietary preference the same? Why is that?

Summary

In this unit, we have learnt that;

- ❑ A person who continuously identifies opportunities in the market for products or services and then develops new products and services to satisfy the identified needs is an *entrepreneur*. Thus an entrepreneur is anyone who identifies problems, resources and unmet needs in society and develops these into business ideas.
- ❑ the characteristics of an entrepreneur.
- ❑ Goats are small ruminant animals with a four – compartment stomach. They eat and digest forages or plant based feed.
- ❑ The importance of keeping good records as well as the type of records to keep.
- ❑ In the IFS Goat – Cocoa Integrated System, a farmer will not only depend on his economic returns from the cocoa beans but he will also have an alternative source of income being earned from raising goats.
- ❑ Goat can eat just about anything from browsing woody and shrubby type plants such as cocoa leaves, food crops (staples) and fodder from shade trees provided within the cocoa farming system.

UNIT 3: Goat and Cocoa Management Practices in IFS

Learning Objectives

By the end of this unit, we will be able to;

1. Clearly describe a basic goat house,
2. Clearly explain the necessary requirement of good animal housing
3. Discuss the goat breeding and reproductive cycle
4. Discuss the cocoa crop cycle and IPDM in IFS

3.1 Housing Management

Housing is of paramount importance when raising goats. A good goat house must be adequately ventilated, well drained and easy to clean.

The basic requirement of good animal housing is that it should alter or modify the environment for the benefit of the animals and also protect them from predation and theft. There is no one, single blueprint for housing; choose the form that best suits your situation. Build the structure so that goats can easily live, eat and rest. Make sure that you can also work there comfortably.

Goat house Specifications:

Floor:

Floor slatt spacing 1 – 1.5cm apart

Floor space for an animal

- Doe - 0.8m²/Animal

- Buck -2.5m²/Animal
- Kid – 0. 5m²/Animal

Walling:

- 1m height from floor and up with
- 1 -2 cm spaces in between the wall

Posts:

- 0.5m – 2m high depending on the climate be it wet or dry, cold or warm, and the location of the house, near the coast or up in the higher lands.

In PNG bamboo and other available bush materials can be used to build a house with thatched roof. House should be open on one side. Walls up to 1 - 1.2 m high, with a gap of 0.5 m to 0.8 m between the walls and roof, to provide sufficient ventilation.

Housing could be on raised floor made of bamboo or betel nut trunk with a thatched roof covering mid-way into the pens on both sides. Space could be as above.

In fencing, leguminous fodder trees like *Gliricidia sepium* and *Leucaena leucocephala* can be planted around the edges of the paddock to form a solid fencing and at the same time used as browse plants for the animals.

A quarantine period of 14 days should be observed in bringing freshly purchased animals into a flock. This gives ample time for observation of the new flock.

Below is an example of a goat house constructed based on the availability of the housing materials and the climatic conditions experienced in that locality.

Remember! *There is no one, single blueprint for housing. Choose the form that best suits your situation. Build the structure so that*

goats can easily live, eat and rest. Make sure that you can also work there comfortably.

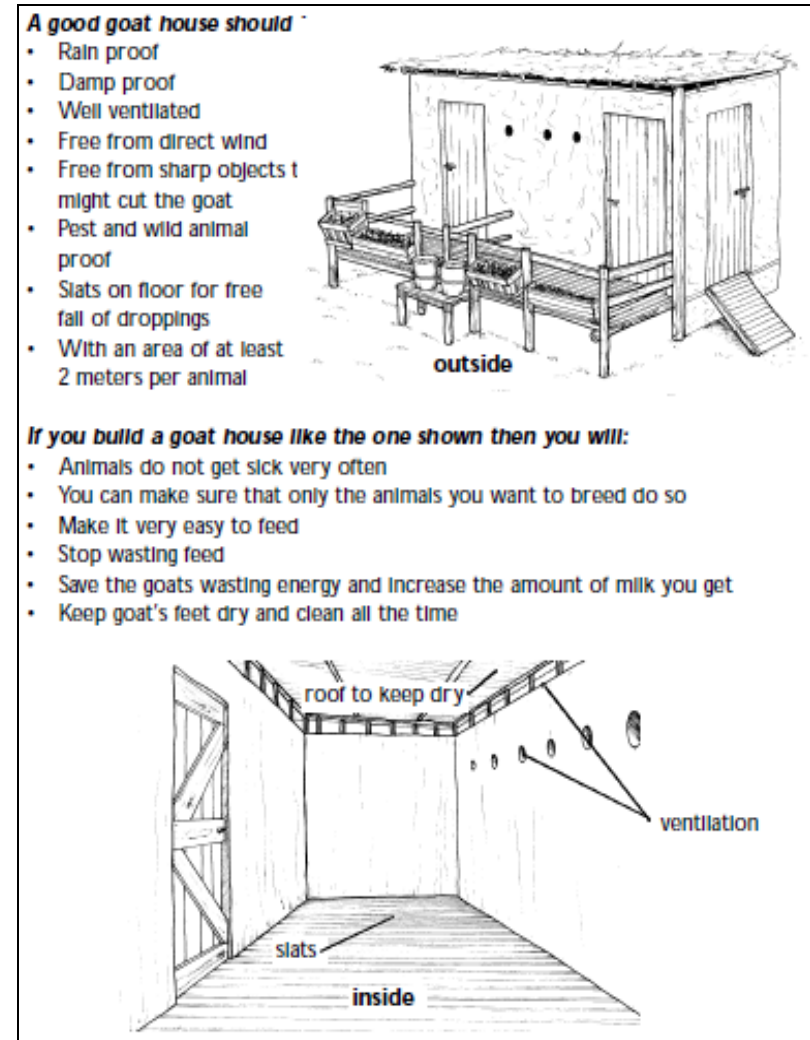
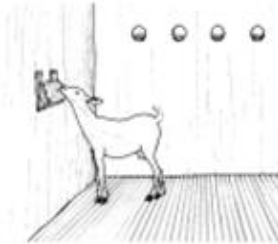


Figure 8. Details of inside and outside plan of a goat house.

There are two main areas of the house, the sleeping area and feeding area.

Sleeping area

- Wall right around - with a door
- It must be roofed
- Lots of air allowed in (well ventilated)



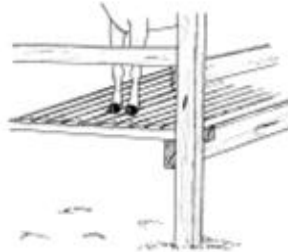
Feeding area

- Open not roofed, goats need some sun
- Fence right around with a door/gate
- Feed trough/water area
- Place for hanging fodder [feed racks]
- Floor with slats to let manure fall through - keeps feet and animals clean and dry
- Place to hang mineral block (placed where it cannot be rained on)

2.4. The house parts

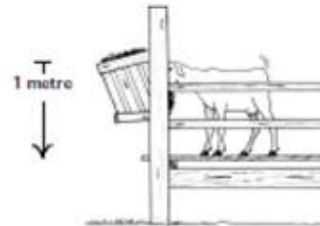
Floor

- House should be raised 1.5 feet (or just below knee height) from the ground.
- A slatted wooden floor is very important. This has small gaps - about half an inch wide (or the width of a side of a match box) between the planks or rafters
- Use of local materials means you can use off cut planks, etc.
- The floor racks made of rafters should be put where the goats feed and sleep, this stops foot rot when it is wet, keeps the house clean and dry



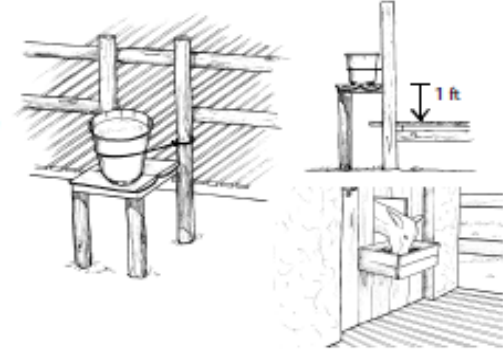
Feed Trough

- In the feeding area, built 1 metre (3 feet) above the platform
- Make with rafters, must be easy to clean troughs
- Floor of trough can be made of off cuts
- Must be able to hold hay



Water Trough

- Be placed 1 foot above the floor in the feeding area
- Hang a 5 litre can on the door to the sleeping room
- The door should have a small window so that goats can have access to water - day and night



Kid Pen

- Toggenburgs often give birth to twin kids so don't make the pen small!
- Kid pen should be for at least 6 kids
- Be half the area for the 4 does. i.e 4 square metres

Hay Barn/Store

- To store fodder, for use during the dry season, build a store adjacent to the goat house that is roofed to avoid hay being rained on

Mineral Trough

- Should be made where the goats sleep
- A one [1] foot square box is ideal for the purpose. A halved long ways plastic container nailed to a board, at least 1 foot wide can be useful
- Or just as good - hang the salt so the goat has to reach for it



Figure 8. Details of inside and outside plan of a goat house. (Continue...)

3.2 Breeding and Selection

Goats reach puberty from 5 to 8 months. They can be mated at 9 - 10 months depending on their body condition. Poor breeding performance or infertility may result if breeding takes place too early. The mating ratio for young bucks to female per breeding cycle is 1:5 likewise for older bucks would be 1:15- 20.per breeding season. Below is a diagram showing the reproductive cycle of a female which farmers can take advantage of in their breeding program.

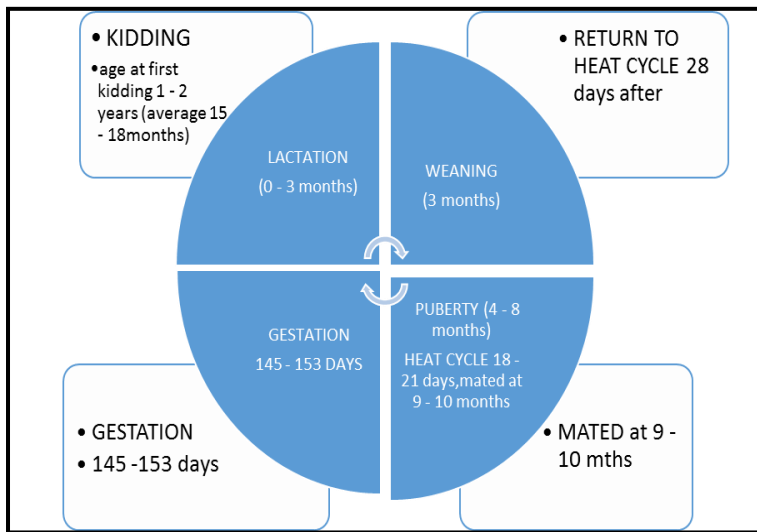


Figure 9. Reproductive cycle of a female goat.

Basic information we should know about goats.

- Length of gestation period (pregnancy) 145 – 153 days
- Birth weight 2.5kg
- Weaning weight 12 – 15kg
- Mature mass of female 35 – 40kg

- Mature mass of bucks 45 – 50kg
- Breeding age for young does 9 months
- Main kidding seasons (April to June) and (September to January)
- Buck to Doe ratio 1 buck to 15 - 20 does (5 bucks for every 100 does)
- Lifespan 10 -12 years

Activity 3.1.

Write your plans for your goat business for the coming 12 months.

.....

.....

.....

.....

3.3 Waste Management

Goat wastes can be a source of parasite and disease if not properly disposed or managed. However, goat wastes can be a useful source of fertilizer for improving crop production. The potential use of the manure and other wastes will need to be assessed.

In the cocoa farm, there are quite a lot of wastes that can be used to maximize the nutrients utilization. The most important are cocoa pods, pruning outcomes, as well as litter. A large amount of farm waste and litter should be returned to the farm, and only a bit of waste and litter may be taken out of it. Wastes can be turned into compost by placing them into holes/trenches made in the farm.

3.4. Goat Nutrition and Feeding Management

All animals need the nutrients called carbohydrates, proteins, fats, vitamins and minerals in order to stay healthy, have energy, grow and reproduce. These nutrients are obtained by the animals through their feed.

Goats require adequate amount and quality of feeds. They are efficient browsers and prefer eating brushy plants along with some other woody and weedy plants. Goat nutrient requirements in this IFS Goat – Cocoa Integration are met through the diversified crops or subsystems. That is, their feed sources.

- ❑ Cocoa pruning outcomes - leaves and pod husks,
- ❑ Fodder from shade trees –leucaena, gliricidia, and introduced mulberry leaves and moringa leaves
- ❑ Established grass – guinea, rats tail, paragrass, setaria, signal
- ❑ Cut & Carry & locally formulated feeds.
- ❑ Supplementary food crops

3.4.1 Energy sources in Integrated Farming System

A. Cocoa pruning outcomes

Cocoa pod or husk is the part which contains the bean in the raw cocoa fruit. It forms about 75% of the weight of the whole fruit and constitutes an undesirable waste product in the cocoa industry. The amount of protein and fibre in the pod is comparable to those of grass hay and so could be used as ruminant feed.



Plate 1. Goat feeding on a cocoa leaf.

Cocoa leaves on the other hand will need more research to be tested out. However, goats have been observed feeding on both fresh and dried leaves.

B. Pasture grasses

Pasture is a combination of edible grasses and legumes, which supply nearly all the food requirements of ruminant animals, cattle buffalo, sheep, goats' etc. Grasses like para grass, star grass, napier grass, setaria and guinea grass as well as legumes such as centrosema are commonly planted forages good for goats. Others can be given as cut forages.



Plate 2. Goats feeding on pasture grass.

3.5 Protein Sources

Mulberry (*Morus* spp.): The nutritive value of mulberry is one of the highest found in products of plant origin. It has high levels of crude protein (14 – 35%) and high levels of digestible energy. It has also good mineral content and has low fiber content. Mulberry has a cutting interval of three months, there is a surplus in the rainy season. If this additional forage is not harvested, there is an imbalance in the nutritional quality of the shoot through ageing, a decrease in edible biomass and a waste of productive potential.



Plate 3. A mulberry plant.

3.5.1 Moringa

All parts of the moringa tree are used for food, oil, fiber, and/or medicine; the most important products are pods and leaves. Leaves are readily eaten by cattle, small ruminants, pigs and poultry and can also be used as food for fish. Protein content of leaves is 20-30% on a dry weight basis. Most important is that the protein is of high quality having significant quantities of all the essential amino acids.



Plate 4. Moringa leaves with pods.

 Activity 3.2

Let us look at your cocoa farming system. Identify and list down some of the feed sources for the goats and within your farming system.

	Protein source	Energy source
1		
2		
3		
4		

a. Explain how you will prepare the foods to feed the goats.

.....

3.5.2 Leguminous trees

Legume trees such as gliricidia and leucaena are established trees used as shade trees for cocoa. In the IFS the leaves of these trees will be used as feed for goats in cut and carry feeding system. Gliricidia and leucaena has been used as protein sources of livestock in PNG and other parts of the world. In these IFS of goats and cocoa, leaves of gliricidia and leucaena can be fed fresh through the cut and carry system.



Plate 5. Goat feeding on Leucaena leaves.

3.5.3. Supplementary Feeding

Supplementary feeding to goats can be done during ‘Peak Flower and Fruit Set’ period. These periods fall on the months, April, May, June, July, November, December, January and February. Cocoa pod husk (CPH) feeding to goats can be done during the ‘Peak Harvest Period’. This period falls in the months of October,

November, December, January, April, May, June and July. Table 1 below shows the periods where supplementary feeding of goats should occur.

Table 1. The cocoa cropping cycle in PNG and IPDM inputs in relation to crop cycle.

Input Application Months	Peak Flower & Fruit Set	Peak Harvest
Jan, Feb & March (Major peak)	April, May, June & July Supplementary Feeding	Oct, Nov, Dec & Jan CPH feed to goats
Aug, Sept & Oct (Minor peak)	Nov, Dec, Jan & Feb Supplementary feeding	Apr, May, June & July CPH feed to goats

Activity 3.3

Imagine you have five (5) goats (1 buck: 4 Does). Describe the type and size of the goat house you would construct for the current and future stock. Use the goat house specification, breeding/reproductive cycle and cocoa crop cycle as a guide to help you with designing your model goat house. Explain your goat house design and necessary requirements.

What would be the expected stock on hand for the 5 goats after two (2) years. Use the breeding/reproductive cycle to explain your answer.

Using the cocoa crop cycle and IPDM in IFS, develop a goat feeding program for the 5 goats for a year.

Summary

In this Unit we have learnt that;

- ❑ In raising goats, housing is of paramount importance. The basic requirement of a good animal housing is that it should alter or modify the environment for the benefit of the animals and also protect them from predation and theft.
- ❑ The house built must best suit the environmental condition and your situation. The structure should be build so that goats can easily live, eat and rest.
- ❑ Farmers can take advantage of the reproductive cycle of a doe to develop their breeding program and also use the cocoa crop cycle to their advantage to develop their feeding program for the goats in the cocoa/goat IFS.

Unit 4: Vegetables and Supplementary Crops as Enterprises in IFS

Learning Objectives

By the end of this unit, we should be able to;

1. Apply the principles and techniques involved in a successful vegetable production for good nutrition, income generation and food security to support a ‘healthy, smart and happy community’.
2. Confidently apply vegetable farming as an important component in IFS.
3. Know the criteria in selecting a better site for vegetable production, establishing a vegetable nursery and planning a garden and bed construction.

4.1 What is vegetable gardening in an IFS?

PNG has a long history of gardening to grow food to sustain their families through subsistence farming. However, due to high population density, high mortality rates and impacts of climate change, food insecurity and nutrition has become an issue.

An important task for farmers is to grow good nutritious crops integrated with livestock in a fair space of land to feed their families well and at the same time earn an income to meet necessary family needs (Figure 10). IFS is an opportunity and a way forward to sustain rural livelihoods, supports food and nutrition, and ensures climate resilient population.



Figure 10. Illustration of typical backyard vegetable gardening integrated with goat and poultry.

Vegetable gardening in IFS is simply a system where vegetables are grown together with other crops and livestock on the same land area or space in which each sub - system is dependent on each other for better output. Vegetables, crops and livestock

farming integrated in the backyard is a way forward for many rural farmers to embrace for better returns.

Below are some examples of vegetables (Table 2) which can be found grown in a typical cocoa farming system, we may find staples and some local leafy vegetables being grown in the midst of cocoa trees. For instance, in East New Britain Province, banana and cassava are amongst the food crops common in the cocoa farming system. Here, we want to encourage cocoa farmers to view these food crops (sub – systems) /components) within the cocoa farming as enterprises rather as just crops for family consumption. Vegetable production can also be introduced into cocoa farming to utilize spaces in between or within the rows of the cocoa plants.

Table 2. Example of various leafy vegetables, fruits and root crops.

Leafy vegetables	Fruit vegetables	Root vegetables
Cabbages	Tomatoes	Sweet Potatoes
Lettuces	Cucumber	Yams
Broccoli	Egg Plants	Taro
Cauliflower	Beans	Cassava
Chinese cabbages	Pumpkins	Carrots
Celery	Water Melos	Ginger
Various Herbs	Peppers	Irish Potatoes

4.2. Site Selection and Nursery Establishment

Crop nursery phase is an important part of the planting operation in the cultivation of vegetable crop species. The major aspects of a nursery are the operational practices. The most important determining factors to be considered are *site selection, soil preparation and seed sowing techniques* and their procedures.

A farmer must consider these factors for a successful crop production enterprise and in order to stay in business.

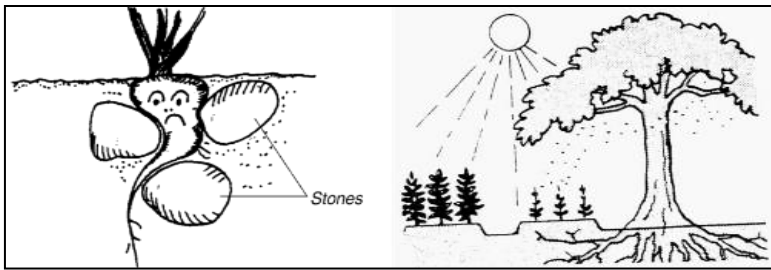


Figure 11. Diagram demonstrates the importance of site selection.

Nursery can be described as a place / building. Provided with modified ecological conditions / environment for raising young plants (vegetables) up to the stage when they are ready for field establishment / planting.

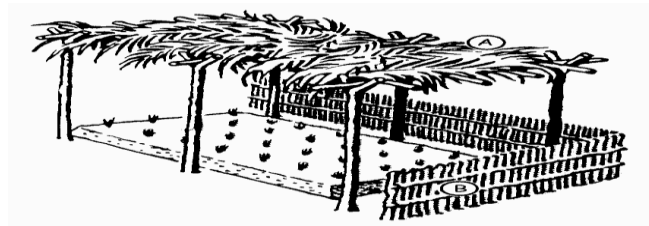


Figure 12. The diagram below shows a simple set up of a crop nursery.

4.2.1. Criteria for Site Selection

Deciding on the most suitable site for a nursery to be built is important. A number of factors must be thoroughly examined before it can be determined that a potential nursery site is suitable for the intended use. Principle question is whether the site is suitable for the production of a specific range of plants you intended to grow. The most important thing is the site must be ideally suitable for the crop. Criteria in selecting site include;

- Close to permanent site* – good investment, cost saving in the long run.
- Access to water source* – quantity & quality, available all year round to meet demand and future expansion of nursery.
- Away from infestation area* (pests & diseases – cropping field)
- Close to farmers house* - for care and security
- Availability of roads* – Access to Nursery site for effective and efficient nursery productivity and easy transportation
- Local Climatic Conditions* (Rainfall, temperature, wind, floods, pests, etc)
- Size and Shape of Nursery* – Is site large enough for current use and for future planned expansion; thus small site with little room for expansion, may be a bad investment. Shape of block determines nursery design.
- Local Soil Conditions* – detail soil type examination is needed, Friable (sandy or clay) loam soils are more suitable than heavier clay soils.
- Electricity Supply* – Is it really necessary for nursery and is it available to cater for nursery demands (needed for planning stage and cost involvement)
- Labor Availability* – for execution of all nursery operations, need to be well supervised to ensure operations are well performed to maintain productivity.

4.2.2. Importance of Crop Nurseries

Nurseries play a vital role in any crop production. Sowing of seeds can be direct or in-direct. In-direct sowing seeds are pre-germinated in nurseries prior to field planting. Seedlings are well protected from pests and allow best selection of superior plants for field establishment.

The prime reasons of having or building a nursery is to;

- Allow effective use of resources and vigorous (healthy/strong) in growth of young crop plants.
- Allows better selection for field planting
- Uniformity in growth and maturity in the field
- Avoid wastage of seeds or planting materials and
- Ease and more attention for effective nursery husbandry / management practices.

4.2.3. Types of Vegetable Nurseries

Nurseries can be categorized in any of the following;

- Permanent
- Semi-permanent
- Temporary (Bush materials)
- Ground bed nursery
- Above ground nursery
- Poly bags, boxes, ice block cups, etc.



Plate 6. Above are different types of vegetable nurseries which farmers can adopt based on their situation or convenience.



Plate 7. Picture shows a dibble board being used to do holing (left) and seed sowing (right).

4.3. Vegetable Nursery and Media Preparation

4.3.1 Media collection, mixing, straining and sterilization

Important part of a crop nursery is preparation of the media. Media is any material used as growing medium for germination and seedlings. Media can be water, agar or soil depending on type of plant and objective of the project. As we deal with soil in many crop nurseries, this training will cover how to prepare soil as a source of media for sowing seeds and growing seedlings.

Prior to sowing, soil must be premixed with compost or manure. Loam soil may not necessarily need fertilizer or manure. Pre-mixed /loam soil must be heated at 100°C to destroy microorganisms, seeds and spores of soil borne diseases, fungus and viruses. Materials required for nursery and pre-heating soil media is shown in Figure 13.

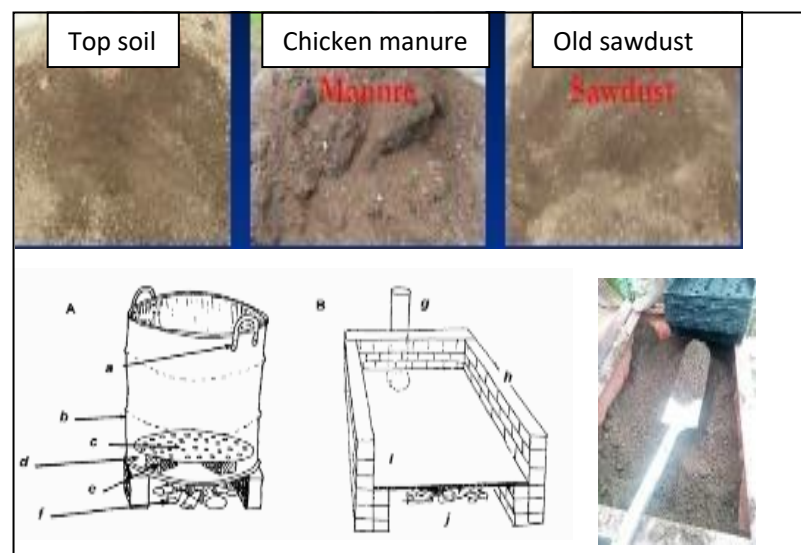


Figure 13. Materials used in sterilizing soil.

4.3.2 Vegetable Nursery Practices & Procedures

There are four (4) steps involved in producing a seedling;

Step 1. Tray Filling – filling of seedling trays with prepared soil media

Step 2. Tray alignment on nursery benches and watering

Step 3. Holing (Dibble board / drill) –creating of 1cm holes in the seedling trays or nursery for seed sowing.

Step 4. Dropping/planting of seeds into the holed trays or broadcasting on prepared nursery beds.

4.3.3. Seed Sowing Methods and Procedures

There are three ways of sowing;

1. Broadcasting – spreading openly on soil surface or seedling trays/boxes

2. Drill sowing – creating drain –like holes on soil surface or trays
3. Dibbling Board – an improvised standard board with 5cm spacing that fits well in a seedling tray. Good for commercial vegetable production and seed saving method.



Plate 8. Picture showing some examples of alternative seedling trays used to sow seeds in nurseries.

4.4. Vegetable Nursery Husbandry Practices

The main husbandry practices in a vegetable nursery for healthy seedlings are;

- | | |
|--------------------------|-----------------|
| - Thinning | - watering |
| - Pest & disease control | - Media tillage |
| - Tray spacing | - Hardening |
| - Transplanting | - Fencing |
| - Security | |



Plate 9. Seedling trays placed on nursery bench tops kept under shade.

4.5 Vegetable Field Planting

Correct nursery practices are important in producing healthy seedlings for field planting for better results. Prior to field planting, a farmer must consider the following;

- i. Make sure that the seedlings are properly hardened off.
- ii. Seed beds must be properly cultivated to a fine tilt and well-watered seedling before planting out.
- iii. Transplant the seedlings at the two-leaf stage. This is about two to three weeks in the nursery
- iv. Use only vigorous healthy seedlings to ensure uniformity in growth to maturity.
- v. Transplanting must be done in early morning or late afternoon.

- vi. Seedlings must be kept well-watered during the first few weeks after transplanting.

4.6. Vegetable Garden Plan & Bed Construction Procedures

The diagram below shows a sample garden layout. A farmer can design his/her garden according to what crops he/she has or is planning to plant and what animals he / she wants to raise in an IFS model.

4.6.1 Garden Plan

For an effective integrated farming use of a garden plan helps establish a balanced gardening while aiming to produce quality crop and livestock. A simple garden plan is illustrated in Figure 14.

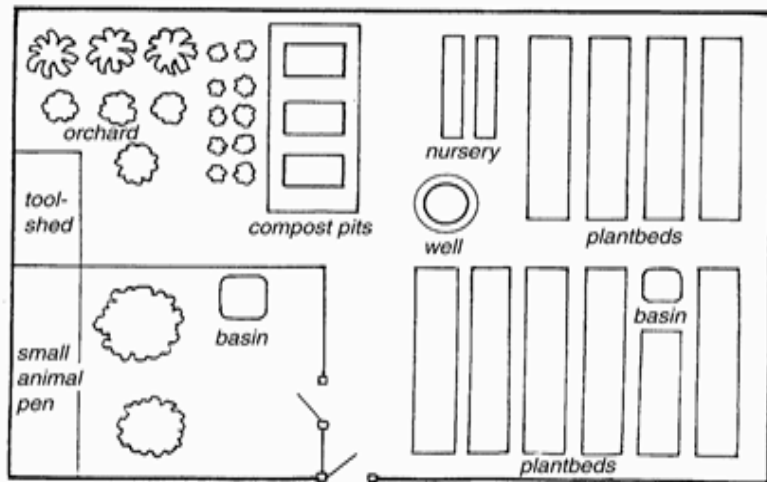


Figure 14. Simple design of a garden plan.

Some points to consider when planning a garden;

- Decide on what crops to grow and for what purpose. Mark out the desired garden area – based on plot dimensions.
- Having got the garden size and the type of crop to grow, workout the number of beds to fit the garden.
- Knowing the spacing of the crop you are to grow, workout the number of plants per bed / plot.
- The number of seeds to germinate & number of trays to sow.

Below is the formula used to calculate the number of plants / seedlings a farmer needs to plant his / her given land area.

Formula:

$$\text{Plant Density} = \text{Total Area} / \text{PS} \times \text{RS}$$

Where;

Total Area = 5sq. meters (length = 10m x width =5m)

Spacing: 40cm x 50cm

PS – Plant Spacing, RS – Row spacing

Recommended capacity per tray = 35 seedlings (5cm x 7cm)

4.6.2 Bed Construction

Bed nursery is a nursery consists of seed/seedling bed prepared at ground level or on soil surface. Temporary shade is sometimes provided to protect seeds/seedlings from rain and direct sunlight. Shade is provided depending on weather condition and type of seed used. An example of ‘bed nursery’ is shown in Plate 10.



Plate 10. An example lay out of established plots on a 10.0m x 5.0m area

It is up to the farmer to decide on the type of bed and size and depending on the type of crop to plant. However, it is important to consider the following:

- Seed beds must be properly cultivated to a fine tilt and well-watered before planting out.
- Transplant the seedlings at the two-leaf stage and about two to three weeks in the nursery.
- Garden beds must be raised at least 25 - 30cm high.
- Use only vigorous healthy seedlings to ensure uniformity in growth to maturity.
- The planting density (the number of plants that can be planted in that area)
- Transplanting must be done in early morning or late afternoon
- The optimum growing conditions.
- Ease of management (bed size).
- Seedlings must be kept well-watered during the first few weeks after transplanting.

4.7 Practices for Vegetable Field Management

Once seedlings are hardened off and transplanted onto plots, they have to be managed daily applying field management practices. Below are important management practices to keep your vegetables growing healthy.

- i. *Watering* – must be carried out early in the morning or late afternoon
- ii. *Shading* - temporary shades must be provided during sunny days
- iii. *Mulching* – grass clippings or any biodegradable materials to keep moisture, suppress weeds and add organic matter into soil.
- iv. *Weeding* – manual using cultural techniques better than chemical use.
- v. *Earthing – up* - mounding at around base to cover exposed roots and tubers.
- vi. *Staking* – allow crawling vines to crawl up stakes for better aeration, exposure to full sunlight, makes garden neat.
- vii. *Pest and Disease Control* – use of cultural method of control, e.g., chilies, Neem, etc.
- viii. *Pruning* – removal of unwanted and drying parts of vegetables, to boost growth and for sanitation.
- ix. *Fertilizer Application* – organic manures, legumes are used to increase soil fertility.

4.8. Harvest and Post-Harvest Management

Harvest and Post-Harvest Technology is a process involved with proper and better management in handling of fresh produce starting from harvest to time it reaches the market or consumer. It is very critical in vegetable production as we are dealing with perishable produce. A farmer's effort, sweat and resources may

go to waste if this area is overlooked and produce poorly handled due to lack of knowledge in postharvest technology.

4.9. Factors affecting quality at harvest

Quality of the produce is what we expect to achieve during harvest of vegetables. Some of the factors to be considered are;

- Time of the day
- Early morning or late afternoon
- Manual method of harvesting
- Stage of maturity
- Right stage for quality

4.10. Post-Harvest Practices

Quality after harvest is critical for crops. Therefore, care must be provided to maintain freshness, especially during transportation and storage. Some tips to take note are;

- Care after harvest
- Cooling and Storage
- Cooling minimizes loss of quality
- Cooling reduces rate of respiration
- Respiration is greatly influenced by temperature
- Respiration uses stored food – speeds up deterioration.

A. Respiration and storage

Leafy vegetables continue to respire even after harvest. The process can affect freshness of the vegetable. Therefore, respiration process can be minimized by;

- Harvesting at cool times of the day
- Keep produce shaded
- Avoid staking of produce in big heaps – produce gets hot.
- Remove diseased, damaged and bad samples

- Use good containers / baskets in the field to avoid damage of produce immediately.

B. Post-harvest Handling

If the harvested produce is not handled well, damages can occur which leads to deterioration and loss.

Types of damages;

1. Impact – caused by diseased or damaged vegetables
2. Pressure – caused by weight from other vegetables
3. Vibration – cause by movement during transportation/ friction
4. Over Packing – too much weight applied / vegetables falling off from packing boxes
5. Temperature Shock – vegetables not covered from direct sunlight or exposed quickly to sunlight.

4.11. Marketing

Marketing is an important part of production and business. It is not only the selling of your produce but also knowing and understanding who **customers are, what are their needs and wants** and knowing also who **your competitors** are. This gives you the direction to plan your marketing.

With vegetables production in an IFS, marketing can be one component of the whole idea of growing vegetables at your backyard. Most important, there is nutritious and available food supply for the family and if there is surplus, then consider marketing options.

Some marketing options for fresh produce;

- Local markets
- Agents at major markets
- Retailers – supermarkets

- Exporting overseas

In PNG, most vegetables are sold in open markets and direct selling to smaller retail outlets. It is good to deal with specialist fresh produce wholesalers, but requirements must be met, in terms of price and quantity to be supplied.

Marketing your fresh produce in a higher level of quality will have direct impact on profit and viability of your fresh produce business to also greatly support the other sub-systems within the IFS model.

Activity 4.1

1. Why is it important to have a vegetable nursery?
2. What are the criteria involved in site selection for a vegetable nursery and vegetable garden?
3. Imagine you have a 100m² area of land with a length of 20m and width of 5m. Design your vegetable garden within a cocoa IFS. How would you lay out your plots and what vegetables will you plant?
4. Calculate the number of vegetables needed to plant in the space between rows of your cocoa trees with 5m in length and 2m in width. The spacing to be used is 40cm x 50cm.

Summary

In this unit, we have learnt to;

Apply the principles and techniques involved in a successful vegetable production for Good Nutrition, Income Generation and Food Security to support a 'Healthy, Smart and Happy Community' concept. In addition it gives us the confidence to

apply vegetable farming as an important component of Integrated Farming system (IFS).

UNIT 5: Integrated Pest and Disease Management in IFS

Learning Objectives

By the end of this unit participants should be able to;

1. Familiarize with major pests and diseases affecting cocoa production
2. Familiarize with major parasites and diseases affecting goat production
3. Clearly illustrate the methods of controlling parasites, pests and diseases in goats and cocoa.
4. Familiarize with process of selecting different methods for managing specific pests, parasite and disease of concern

5.1 Purpose of integrated management

Pests, parasites and diseases in both cocoa and goat are here to stay. The goal is not to create free animal (e.g. goat) or crop (e.g. cocoa). It is normal for the goat to have parasites or cocoa to be exposed to pests. Both pests and diseases cannot be eradicated from the environment, we rather manage them at lower level while aiming to produce more.

The goal of integrated management is to prevent the spread of clinical or epidemiological diseases, pests/parasites while maintaining production losses low.

Other reasons include;

- Reduce cost in managing pests/parasites and diseases in the long term
- Reduce labour input or requirements
- Increase productivity

5.2 Common pests and diseases

Losses in production of cocoa and goat are accounted by some of the commonly known pests/parasites and diseases. The lists in Table 3 to Table 4 indicates some of the common pests, parasites and diseases of cocoa and goat.

Table 3. Common pests and diseases of cocoa and their control.

	Common name	Control	Method
Pests	Cocoa Pod Borer (CPB)	Insecticide Handpick Pruning Chop down cocoa tree Fire smoke/heat Red ants?	Chemical Cultural Cultural Cultural Cultural Biological
	Longicorn	Insecticide Handpick Heavy pruning	Chemical Cultural Cultural
Diseases	Black pod (Phytophthora)	Fungicide Pruning Hand pick	Chemical Cultural Cultural
	Pick disease	Fungicide (e.g. Furadine) Pruning	Chemical Cultural
	Vascular streak dieback (VSD)	Fungicide (e.g. Furadine) Pruning Provide drainage	Chemical Cultural Cultural

Table 4. Common parasites and diseases of goat and their control.

	Common name	Control	Method
Parasites	Biting lice	Animal residual spray Bath	Chemical Cultural
	Sucking lice	Animal residual spray Bath	Chemical Cultural
Diseases	Anthrax	Vaccination once in a year in affected areas	Chemical
		Disposal of carcass by burying/burning	Cultural
		Don't open carcass the germ spread through air.	Cultural
	Foot rot	Keep animal in the dry clean house	Cultural
	Pneumonia	Clean water well painted	Cultural

5.3 What is IPDM

IPDM is the acronym for Integrated Pest (parasite) and Disease Management. IPDM is a management concept which encourages the use of more than one method of addressing pest/parasite and disease problems affecting cocoa or goat production. The concept aims to collate and combine cultural, chemical, and biological methods to control threats, mainly pests and diseases, influenced directly or indirectly by climatic and environmental conditions.

5.3.1 Managing health condition of goat

Goat is a sensitive animal and unfavorable conditions can alter performance, breeding and productivity. Some of the unfavorable conditions are;

- Poor housing

- Poor pasteurization
- High level of internal/external parasites
- Poor nutrition
- Dirty/unhygienic water
- Stress
- Poor breeding cycle

A sick animal (e.g. goat or sheep) can be checked using “Five-point check”. The Five-Point Check (FPC) is a quick and easy method to diagnose, examine and categorize level of infection before a treatment is recommended.

The areas where FPC conducted in goat are shown in Figure 4.1. Firstly, check the nose for any discharge, followed by eye for anaemia, jaw for swelling, back condition for parasite and tail condition for type and level of parasite. Sick goat may indicate one or few symptoms and that specific treatment or combination of different treatments can be offered.

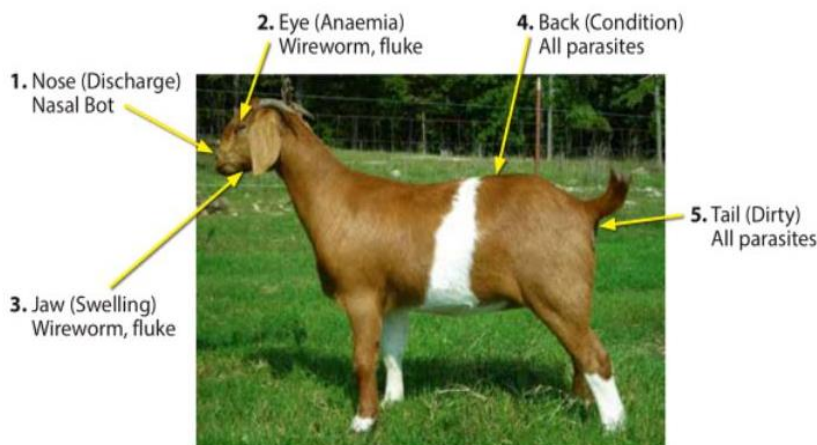


Plate 11. The components of ‘five-point check’ in goat.

Routine management would continue to sustain better condition of animal health. This can be achieved by adopt of integrated health management. An integrated parasite and disease management in goat is illustrated in Figure 15.

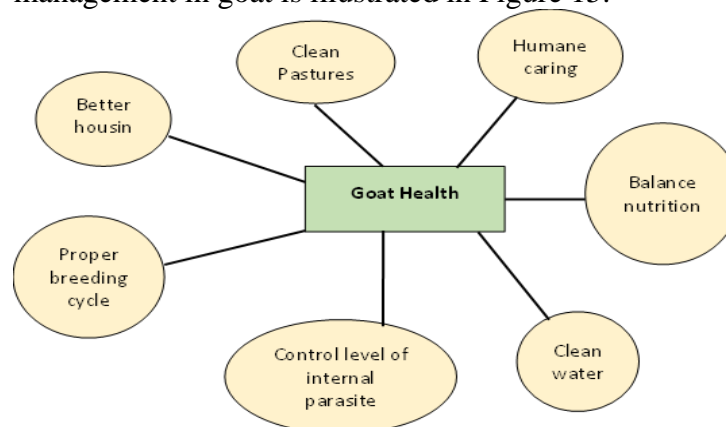


Figure 15. An illustration of integrated management required to maintain health of goat.

5.3.2. Managing conditions for cocoa production

Increased yield of cocoa relies on good management and type of variety used. Good management includes proper drainage, scheduled pruning, scheduled pest and disease sprays, scheduled fertilizer application and establishment of proper shade. Generally, combination of different inputs in management (either pests, disease or agronomic requirements) increases the chances of improving productivity. Application of different management inputs enhance conditions to promote protection against common pests and diseases (Figure 16).

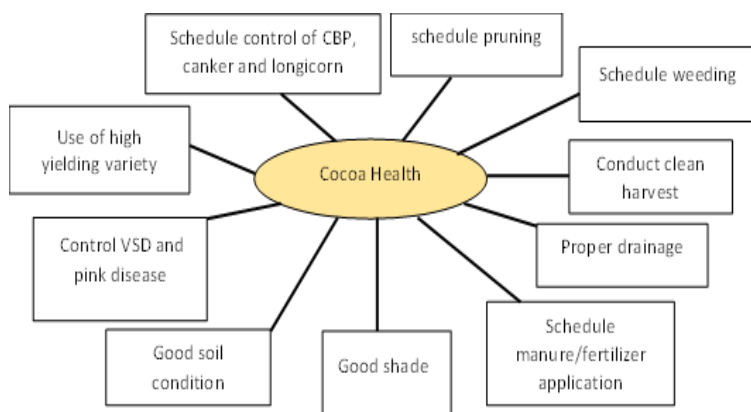


Figure 16. An illustration of integrated management required to maintain health of cocoa.

One for form of management input addresses other problems as indicated in Table 5.

Table 5. Application of one management input can address other pest and diseases problems.

Management Input	Example	Protection	
		Pest	Disease
Released tolerant variety	CPB tolerant clones	CPB*	Pink disease, VSD**
Schedule pruning	Formation pruning (3, 6 months)	CPB, longicorn	VSD, Pink disease, Black pod
Weeding	Slashing	CBP Birds	Black pod
Shade	Pruning Gliricidia	CPB	Black pod

* CPB - Cocoa Pod Borer, *VSD - Vascular streak dieback

5.4 Application of IPDM

Use of IPDM technology is by far considered a regular practice and follows personalized or adopted system for maximum outcome. For example, controlling a particular threat such as CPB must be controlled by adoption of different methods on weekly basis, fortnightly or monthly depending on the extent of population and level of infestation. Similarly, internal parasite builds up in goats may not be addressed by one method, but rather be effective through combination of cultural (e.g. feed quality), chemical, or biological. Use of one or more of the control methods depends on the nature and extent of the infestation level. Adoption of IPDM ensures stability in providing favourable conditions for optimal yield or productivity while maintaining low level of pest/parasite and disease infestation. Maintaining low level of infestation can be achieved by implementing scheduled management practices as indicated in Table 5. Routine practice of general management somewhat addresses some of the potential areas of infestation, breeding, sporulation and distribution of commonly known pests and diseases.

Table 6. Example of schedule activities performed as part of IPDM to improve production.

Enterprise	Management Practice	Practice	Purpose
Cocoa	Pruning	3-months light pruning 6-months heavy pruning	<ul style="list-style-type: none"> - Promote healthy growth - Increase pollination - Develop flower cushions - Reduce level of pest and disease infestation
	Shade	Provide shade all year around	<ul style="list-style-type: none"> - Promote healthy growth and improves protection against diseases (e.g, VSD) - Increase favorable conditions for pollinators
	Drainage	Provide good drainage system	<ul style="list-style-type: none"> - Prevents waterlog which can become breeding ground for soil borne diseases such as <i>phythoptera</i>.
	Fertilizer	Apply manure/fertilizer 6 monthly	<ul style="list-style-type: none"> - Healthy crop defends diseases such as VSD
Goat	Drenching/deworming	Monthly supply	<ul style="list-style-type: none"> - Reduce parasite population - Eradicate potential diseases
	Balanced nutrition	Daily supply	<ul style="list-style-type: none"> - Healthy growth improves general appetite and enhance protection against potential pests and diseases
	Clean house	Daily inspection	<ul style="list-style-type: none"> - Maintains low level of parasite - Protects goats from potential parasites and diseases.
	Bath	Fortnightly	<ul style="list-style-type: none"> - Control external parasites
	Hoof trimming	6 monthly	<ul style="list-style-type: none"> - Control foot rot - Control parasite

5.5 Approach of IPDM Technology

The query on when to apply, use or implement IPDM technology depends on type of pest/parasite, disease, level of infestation, climatic and environmental conditions, and availability of resources such as, tools, chemicals and funds. Controlling or eradicating a known pest or disease requires a systematic approach that defines the use of two or more methods. For example, a known internal parasite can be controlled using two of four available methods given necessary requirements are provided.

5.5.1 Type of pests and diseases

Some pests and disease are devastating than others and so as their level of management and resources input. In this case assessment of the originality, localization and distribution of the pest or disease is crucial. Further, it is important to establish facts governing survival of the pest or disease whilst an appropriate method(s) of control is identified.

5.5.2 Level of infestation (damage) or medical condition

Some pests and diseases may cause severe damage within moments than others. Some may slowly develop or damage over time. Those that have increasingly more damages have higher chances of wiping out entire crop or kill the animal without much for treatment. Type and number of treatments (methods) required may depend on severity, stage and level of infestation.

5.5.3 Climatic and environmental conditions

Selection of suitable control method(s) under certain climatic and environmental condition is essential part of pests and disease management. When choosing a type of method, it is important to consider the following;

- Current status of the weather,

- type and amount of food and nutrition,
- housing condition,
- level of shade,
- soil condition,
- water quality
- level of management
- security, and etc.

Some pests and diseases may develop under favorable weather and environmental conditions. By manipulating these conditions can improve health status of crop and livestock. For example, in cocoa, exposing upper canopy, especially the branches by pruning reduces amount of shade thereby reducing the black pod inoculation process and spread of other diseases. Pruning can also break breeding cycle of pests such as CPB.

Besides pruning, it is also recommended to physically remove black pod by hand or spray fungicide. However, during bad weather we may opt to use other methods than fungicide spray or other chemicals. Similarly, in goat dry weather condition is required for controlling external parasites.

5.5.4 Availability of resources

For an effective control or eradication process, proper resources are required and must be available on time when needed. Resources include;

- funds
- tools
- fungicide
- pesticides
- medical drugs
- Sanitary items
- transport
- labour
- Stationary
- Computer software and hardware items
- Accessories

Absence of one or more of the above resources may determine type of control measure needed for specific pest, parasite or disease of concern. It is advisable to use more than one method to address pathogenic problems given necessary resources provided and weather and environmental conditions favorable.

Activity 5.1.

Get into groups of five and do the following exercises.

1. Choose one of the following enterprises. List three common problems (pest, parasite or disease) affecting the enterprise;
 - Cocoa,
 - livestock (either goat, pig or poultry)
2. Develop an Annual Management Schedule (AMS) for the enterprise, indicate in the schedule type of control (treatment) you think appropriate to address the three major problems you listed in question 1.
3. On the AMS, list additional routine management requirements appropriate for the enterprise.

Summary

- ❑ Managing a specific pest and disease may require use of one or combination of different control methods. However, they may rely on certain factors such as; availability of resources, climatic and environmental conditions, type of pests/disease and level of infestation.
- ❑ It is recommended to choose more than one method that could address other problems at the same time.
- ❑ With the help of Annual Management Schedule (AMS), level of pest and disease infestation can reach low level and stabilizes better conditions for productivity.

Unit 6: Utilization of wastes from cocoa and goat integrated farming system

Learning Objectives

By the end of this unit, you will be able to;

1. Understand how to utilize wastes from cocoa and goat integrated system
2. Learn how to manage goats and avoid damages to cocoa trees
3. Understand how to collect and store goat manure to make compost
4. Know how to make and apply the goat manure compost to cocoa trees

6.1 Utilizing Cocoa and Goat wastes

Raising goat as an integrated livestock with cocoa trees is an important farming system that utilizes the waste products from both the cocoa tree and the goat manure. Goats are not allowed to browse on cocoa trees and so it is important to learn how to properly manage them and avoid damages to crop trees while benefiting from goat manure as a cheaper organic source of fertilizer for cocoa.

6.1.1 Utilizing the waste from cocoa trees

The raw material or wastes from cocoa trees include the pruned leaves and harvested pods which have the cocoa beans removed from it. Both of these are good source of feedstuff for goats and farmers should know how to manage them and feed their animals. The cocoa leaves and pods become available for feeding during pruning and when pods are harvested by the farmer. The leaves and pods should be allowed sometime to wilt before feeding to goats. It is also important to consider feeding your

goats with other forages that are growing around the vicinity of your cocoa block. For example, sweet potato foliage, banana leaves and other leguminous tree and forage species such as *Leucaena leucocephala*, *mulberries* and *gliricidia sepum*. Some of these forages like sweet potato vines and banana leaves can be chopped up and offered fresh to goats.

6.1.2 Managing and confining goats to reduce damage

Goats are inquisitive feeders and can wander away from where they are housed if not properly confined. Goats kept in cages or pens should have feeding and water troughs constructed so that they have access to water and feedstuff when offered to them. The feed trough will reduce wastage and provide for efficient feeding of forage and other dietary supplements.

Cocoa farmers should not let their goats out into the cocoa block where the cocoa trees and pods are at risk of being damaged via debarking. Instead the animals should remain confined to their goat house and only allowed out to forage on nearby paddock areas if these are secured with appropriate fencing. Always ensure that goats are not free to browse and damage cocoa trees.

6.1.3 Collecting and storage of goat manure

In order to benefit more from the cocoa and goat integration technology it is necessary that goat manure are collected and stored in a separate storage shed near the cocoa farm. Goat manure is already pelletized before defecation. This fact is taken into consideration when constructing a goat house or cage in order to separate the faecal droppings from the animals as soon as they are expelled. It is important to design the floor spacing to 1-2cm so that the droppings pass through without getting trapped on the flooring where the goats are being confined. The faecal pellets will pile up at the bottom as they pass through the spacing to the ground. Sometime later these are collected and put in to bags to be moved to the storage shed. The manure is stored in the shed to keep it dry and away from rain and other sources of moisture. The manure stored this

way will not break down and will be used to make compost as and when the time is right.

6.1.4 Making compost and manure application

The following steps are taken in making compost using goat manure;

Step 1: Dig a small pit about 30-50cm deep in the cocoa growing area

Step 2: Put dried cocoa leaves, twigs, small branches and pod husks into the hole.

Step 3: Add 5-10 kg of goat manure to the heap.

Step 4: Cover the layer with top soil and sprinkle water over the heap

Step 5: Dig a trench 1 meter away from cocoa trees

Step 6: Wait for 6-12 months and apply the composted materials in trenches.



Plate 12. Composted materials are collected and applied in trenches.

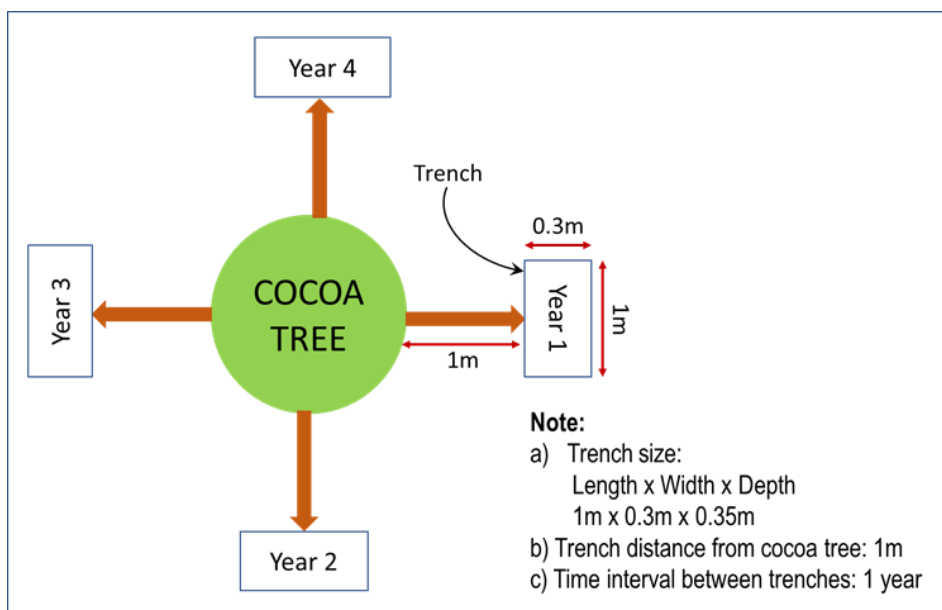


Figure 17. Diagram shows how to apply goat manure compost in trenches around cocoa trees.

Activity 6.1

You will involve in making a compost using goat manure. Use the steps outline in 17 above and prepare some waste from cocoa trees and goat manure from the storage shed. Using spades and other digging implements dig a compost pit. Measure out the depth of the pit and add your various raw materials to make a goat manure compost. Also dig a trench near a cocoa tree for applying the compost manure according the steps shown in Figure 17.

Answer the following question.

1. What is the purpose of applying composted manure to cocoa trees?
2. Draw a flow chart showing the steps involved in making a goat manure compost.

3. Discuss and list the advantages and disadvantages of integrating goats with cocoa.

Summary

In this unit, we have learnt that:

- In an integrated cocoa and goat farming system all the by-products of cocoa pruning and harvested pod husks are not wasted but utilized as feedstuff together with other available forage species to maintain growth, health and nutrition of goats.
- Goat manure is used to develop an organic cheaper fertilizer derived from the composted animal manure.
- Cocoa growers with declining soil fertility on their farms can improve yield of cocoa trees by using goat manure as a cheaper organic fertilizer.

Conclusion

This manual has been written to provide basic information to cocoa farmers who need knowledge to venture into starting a goat enterprise and vegetable/food crops integrated into an existing Cocoa Farming System. The information is not completely comprehensive but combines relevant experiences from the author(s) and cocoa farmers. We anticipate that by the end of this manual and through continuous practice, a goat/cocoa farmer should be able to establish and well manage a cocoa /goat integration system and also be able to view sub-systems and cocoa farming components as enterprises.

References

- Charray, J., Humbert, J.M and Levif J. 1989. Manual of sheep production in the humid tropics of Africa. Translated by Alan Leeson. Published by C.A.B International. Technical Centre for Agricultural and Rural Cooperation.

Devendra, C and McLeroy, G.B.1982. Goat and sheep production in the Tropics. Intermediate Tropical Agriculture series Sheep Producers Association. 1982. Sheep handbook.

Peischel A. 2005.Dietary preference of different livestock species. In Feeding small ruminants: Developing a grazing system for sheep and goats. Forage News. Mississippi State University. Web page: <https://extension.msstate.edu/sites/default/files/newsletter/forage-news/2008/7.pdf>