Community Development Strand
Agriculture

Unit 1: Agriculture Resource Science

Module 1.2 Crops

Student Support Material

Acknowledgements

Materials compiled and edited by Michael Riach.

In consultation with:

Mr. Steven Potek, Lecturer in Agriculture Studies, at Madang Teachers' College, who has contributed much of the material used in writing this module.

Incorporating suggestions from Agriculture Curriculum Development Team:

Jack Hawap – Balob Teachers College
David Taudiveve – KabaleoTeachers College
John Ambelo – Gaulim Teachers College
Steven Tapi – St Benedict's Teachers College
Jimmy N'Draras – Kabaleo Teachers College
Nick Luba – St Benedict's Teachers College

Layout and diagrams supported by Nick Lauer.

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Unit outline

Unit	#	Modules
Unit 1 **Agriculture Resource Science**	1.1	Soil (Core)
	1.2	**Crops** **(Core)**
	1.3	Livestock (Core)
	1.4	Sustainable Agricultural Systems (Core)

Icons

 Read or research

 Write or summarise

 Activity or discussion

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Module 1.2 Crops

Rationale

Agricultural gardening is practiced by the vast majority of Papua New Guineans. Many of these gardeners use traditional techniques that are suited to the local environment. This module will explore traditional techniques alongside new methods that build on and improve traditional practices.

The purpose of this module is to increase your understanding and knowledge of growing crops by emphasising how this can be done in the context of the primary school. It is envisaged that this module will equip you with the skills and knowledge to teach and practice gardening in the primary school using improved methods learnt and practiced in the college gardens.

Objectives

By the end of this module you will be able to:

- Describe the significant crops, both traditional and introduced grown in Papua New Guinea
- Describe and practice the different methods used in propagating the significant crops of Papua New Guinea
- Describe different plant management practices used in Papua New Guinea and be able to blend the traditional practices with appropriate modern techniques
- Demonstrate various techniques used in a plant nursery
- Demonstrate appropriate pest management practices
- Design, establish and maintain a school garden
- Produce teaching resources suited to teaching students in Grades 6-8

Topics

1. Introduction to crops
2. Significant crops of Papua New Guinea
3. Plant Reproduction and Function
4. Plant propagation and nurseries
5. Cropping systems
6. Pest management

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Topic 1: Introduction to Crops

Objectives

Through this topic you will be able to:

- Understand the scope of the module
- Have an appreciation of the importance of agriculture and cropping in particular to Papua New Guinea
- Begin planing a school garden and appropriate teaching resources

Scope

This is the introductory section of this module. Through it you will be informed about the content of the module and major assignments. The lecturer will provide an overview of the importance of crops to the economy and well-being of Papua New Guineans. You will also be introduced to and begin planning a resource for a model school garden. Teaching and learning materials to support the teaching of agriculture in the Primary school will also be discussed.

Introduction to cropping

There is more to agriculture than information and skills learnt through this course. In Papua New Guinea, agriculture is a way of life. For well over 30 000 years people in this country have practiced some form of farming and gardening. Today over 70 percent of the population live in rural areas and depend on farming.

A few of the farmers own tree crops such as rubber, coffee, cocoa, coconut and oil palms and spice crops. A few farmers raise vegetables, tuber crops and sugarcane for cash. However, most farmers in Papua New Guinea are subsistence farmers.

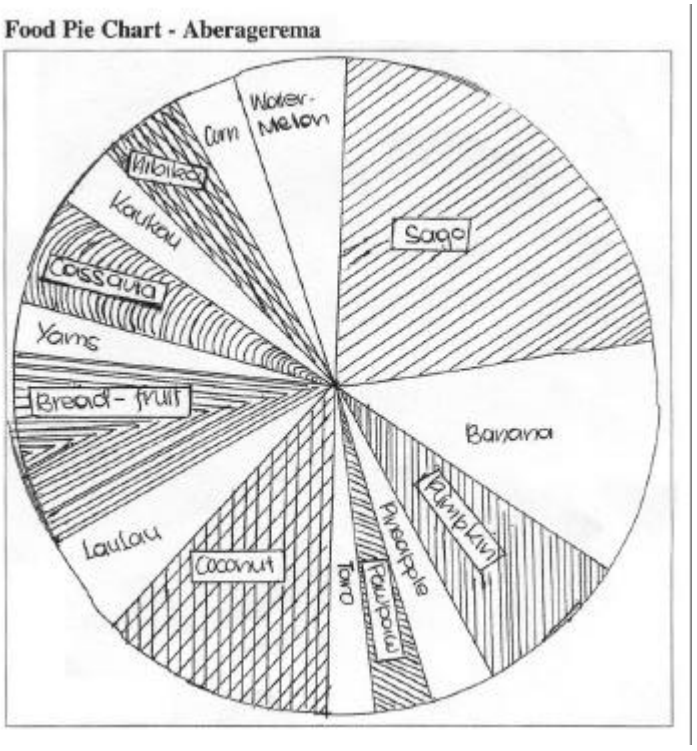


Figure 1 Food Pie Chart – Aberagerama, Western Province Source: ***Papua New Guinea Human Development Report****, 1998*

☞ 1.2 Activity 1

Look at the Food Pie Chart at Figure 1 –What can you tell about the way of life of the people of Aberagerama?

Sort the crops grown into types of plants, for example:

Tubers
Fruits
Vegetables
Cereals
Grain legumes
Tree crops

Make a comment about the types of farming and diet of these people.

Use the glossary or another reference to find definitions of these terms. Provide examples of each from your area.

intensive gardening *staple*

subsistence

Traditionally, gardening in Papua New Guinea needs large amounts of land and quite small amounts of labour. This is called **extensive gardening**. Intensive gardening is the opposite.

Many gardening systems in Papua New Guinea have traditionally been able to meet the nutritional needs of the community. People have grown staple foods in their gardens, collected vegetables, fruits and nuts in the forest, and hunted birds and animals. All these activities provided a good diet. Now, in many parts of Papua New Guinea people are being forced to change these ways of getting food. This is because the bush, an important source of food, is getting farther from the village or town. In many places, land is becoming short, and people do not have enough land to garden in the traditional way.

Gardening in Papua New Guinea is changing and so are the types of food people now eat.

☞ 1.2 Activity 2

Here are some of the factors that affect the amount of time available for gardening. Do you agree with them? Can you think of others?

Beside each factor, write an example to explain what might be happening.

Factors affecting time spent in gardens	***Example***
Social relationships between community members change.	
Time is spent working in other gardens to fulfil traditional social obligations, especially food production for ceremonies and public distribution	
Participation in the cash economy / wage labour	
Adult population leaving the community to work in towns	
Cash cropping	

Leading by example

As you can see, there are many pressures on traditional agricultural practices. The purpose of this Module is to open your eyes to new methods, which can support the traditional approaches. As a teacher coming into a community, you will be expected to have new knowledge on many things including agriculture. It would be **pointless** to tell people what they already know so it is important to begin to think in new ways about gardening. New ways, which you can share with your community through the school garden. We want you to be able to develop a model school garden. The local Department of Primary Industries (Officer) (DPI), if there is one, should become a valuable resource for you.

☞ 1.2 Activity 3

Model School Garden Project – getting started

Refer to the texts Agriculture in Melanesia. Book1 and Organising School Agriculture, Robertson, B and Toben, H. K., 1998.

In this module we are only concerned with Crops which should be the first priority in your school garden later livestock may be introduced.

Getting started

Look at the following diagram at Figure 2, which comes from ' Organising School Agriculture'. It is the beginning of a strategic plan for your school garden.

Establishing and Maintaining School Agricultural Gardens

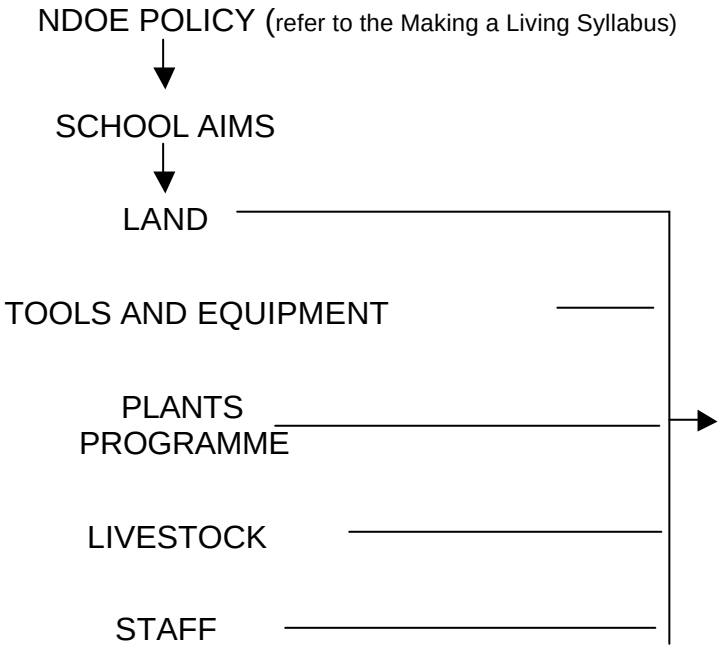


Figure 2 A Planning Framework

Using the available references develop a plan for a 'model school garden'. Make notes under each of these main headings: –

***NDOE** – use the Making a Living Syllabus and other NDOE agricultural publications. Note down the NDOE position on school gardens and the official position on school agriculture. A paragraph should be sufficient.*

***School aims** – you don't know the school so at this stage, think of some questions you can ask the staff and principal to assist them to develop specific 'school aims' that will build a school garden appropriate to the needs and environment of the school and community.*

***Land** – develop some guidelines about: where the garden should be, the amount of land needed and alternatives if there is insufficient land.*

***Tools and equipment** – develop an inventory of minimum tools needed if the school has few resources. A class set of tools so that there is at least one tool between two or three students will keep students motivated and involved. Look at alternatives such as children borrowing a tool from home.*

***Plants programme** – this will be specific to your environment. If you are clear about where you plan to teach then you can identify*

crops for crop rotation, legumes and trees for alley cropping and so on. Start small and build.

***Livestock** – leave this now. It will be dealt with in the module Livestock. It is probably wise not to start livestock until the garden area is well established.*

***Staff** – you won't know the staff and there could be a teacher already in charge of the school garden. It would probably be a useful exercise to prepare a short staff presentation on what you have to offer the school and (if there is already an agriculture programme and garden) ways you can support the existing staff and programme.*

*Keep all planning, teaching resources and activities in a **'Teaching Portfolio'.** This portfolio should be used to keep all CDS materials that are relevant to teaching and working in a Primary School.*

Topic 2: Significant Crops of Papua New Guinea

Objectives

Through this topic you will be able to:

- Identify the main food crops grown in Papua New Guinea and describe and practice techniques for optimal growing and care
- Select the best site on which to establish a garden based on a careful analysis of environmental conditions
- Develop plans for the development of a model school garden

Scope

This topic looks at the varieties of food crops both traditional and commercial, which are grown widely in the four regions of Papua New Guinea. (Highlands, Momase, New Guinea Islands and the Southern region.).Traditional and modern techniques will be examined. We will study growing and caring for a number of these crops all of which you will be expected to demonstrate in the college gardens. As well, you will continue to develop your model school garden plans and teaching resources.

Traditional and commercial crops

Most food crops grown in Papua New Guinea are not native to this country. Coconuts were introduced by Queen Emma* while early European settlers helped introduce several crops including sweet potato, yams, cabbage, cocoa and taro. The most important crops believed to have originated from Papua New Guinea are the winged bean and sugar cane while two important native tree crops are the Hoop pine and Klinki pine.

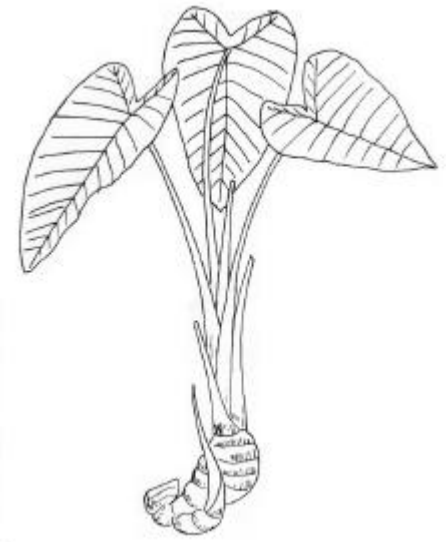
Figure 3 Winged bean

Current trends in Papua New Guinea are to increase production through different cropping and farming systems, by using high yielding disease-resistant crop varieties.

Significant crops

The significant crops grown in Papua New Guinea can be categorised into the following family groups:

- Tubers
- Fruits and nuts
- Vegetables
- Grain legumes
- Spices
- Tree crops



** Queen Emma was an early pioneer in East New Britain.*

Tubers

Tubers are a root crop and provide the most important source of carbohydrates for many Papua New Guineans.

The main tubers grown are:

- Sweet potato
- Yam
- Taro
- Potato
- Tapioca

Sweet potato / kaukau

Sweet Potato or Kaukau is the most important sustenance food in Papua New Guinea. Kaukau is often planted as part of a mixed cropping system.

More than 200 varieties of sweet potato are found here and they grow well in both highland and lowland areas. The largest tubers are grown in the Highlands.

Where is the erosion control in this type of kaukau planting?

How could it be improved?

Figure 4 Kaukau planting, Western Highlands

What are the advantages in planting kaukau in this way?

Discuss to find out what is under the mound.

Make a drawing to show a technique for growing kaukau on a slope so that topsoil is not exposed and erosion is minimised

Figure 5 Kaukau mounds, Enga Province

Yam

Yams are very important in Papua New Guinea, in places like the Trobriand Islands where yams are the most significant crop, and a 'yam cult' has developed over the years. Milne Bay Province is the leading producer of yams in Papua New Guinea. Other provinces which grow yams are; East Sepik, Sandaun, Central and Morobe Provinces.

There are three common species of yams in Papua New Guinea, which provide a staple food.

Figure 6 Yams. Source: ***Food crop cultivation****, Vol 2, NDOE, 1986*

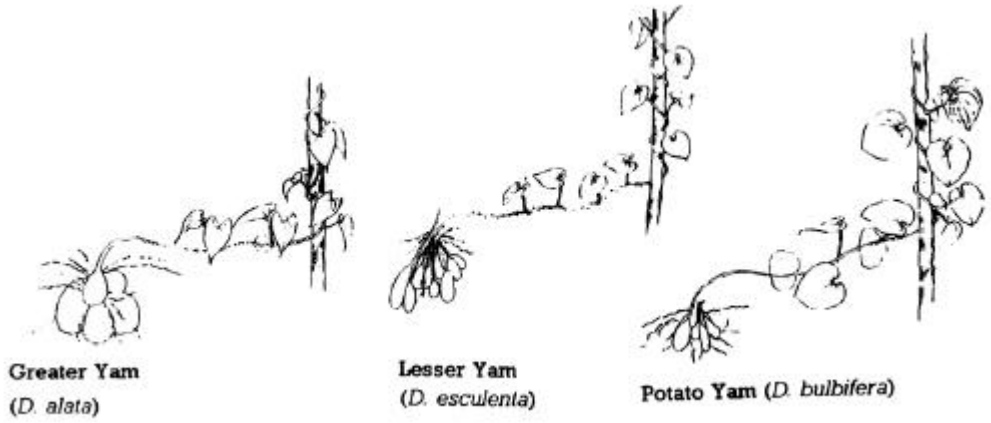
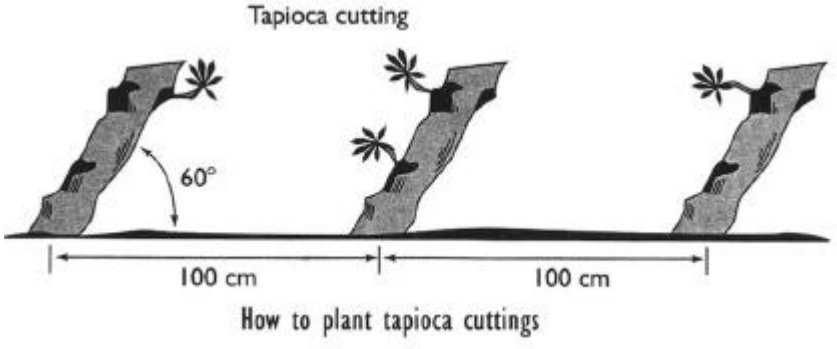


Figure 7 Three types of yams. Source: ***Food crop cultivation****, Vol 2, NDOE, 1986*

Tapioca

Tapioca has many common names including cassava, manioc and tapiok. It is a small tree-like plant, which has erect leaves and stems. Although frost kills the plant it can grow in most conditions in Papua New Guinea.

Tapioca is an insect pollinated plant, similar to pawpaw, with male and female flowers.



Taro

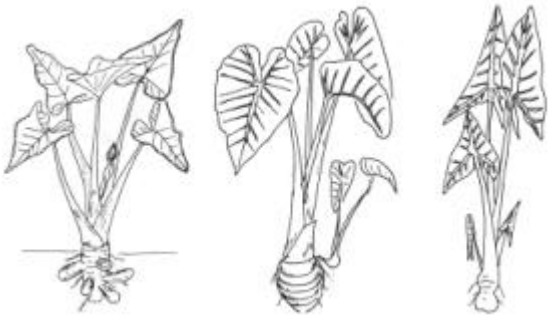
Taro is the second most important root crop staple after sweet potato in Papua New Guinea. The estimated annual production is about 436,000 tonnes from an area of 77,000ha.

Taro can be propagated through seeds (sexual reproduction) and vegetative parts of the plant (asexual reproduction). Growing taro from seeds is not ideal for rural farmers as it involves a lengthy process of screening and selecting desired progenies.

Three varieties of taro are grown.

- Taro tru
- Taro Hong Kong or Chinese taro
- Swamp taro

Unlike kaukau, taro is planted on the flat and not in mounds of soil. A spade or digging stick is used to dig a hole in the soil. In the North Solomon's Province, a special digging stick called an 'ariok' is used for digging holes.



Can you tell which taro is which?

Cereals

Cereal crops are those grass-like crops, the grains which are used for human or livestock consumption.

The two major cereals grown in Papua New Guinea are: corn and rice

Figure 8 Experimental rice grown at OISCA in East New Britain Province

Fruits

Among the fruits that are most important and common in Papua New Guinea are; banana, pineapple, pawpaw, passion fruit, citrus, guava, avocado, mango and breadfruit.

Vegetables

Among the most common vegetables grown in Papua New Guinea are: cabbage, eggplant, lettuce, tomato, onion,

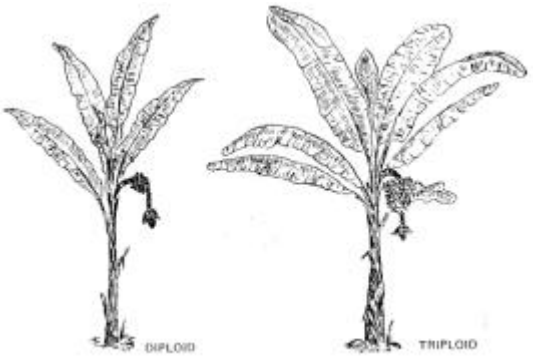


Figure 9 Banana varieties originating from Eumusa

cucumber, cauliflower, broccoli, carrot, oenanthe, pumpkin, and silver beet.

Pigeon pea

Grain legumes

Among the major legumes are peanuts, various beans including the winged bean, black eye bean (cowpea), soy beans, and peas. Grain legumes are also called pulses. Of all the legumes, peanuts and winged bean are the most important to Papua New Guinea.

Spices

Spices refer to the parts of various plants, which are used mainly for seasoning food to give it flavour and aroma. Examples of spices common to Papua New Guinea are: cardamom, ginger, turmeric, peppers and chillies.

Two young farmers drying ginger near Goroka

Tree Crops

Tree crops are called permanent crops, cash crops or perennial crops. They are those crops, which grow and produce for many years and include: coffee, coconut, cocoa, rubber, oil palm, kola and citrus.

☞ 1.2 Activity 4

Into what forms can you process sweet potato and English potato?

How would you prepare land for planting corn?

What are the different planting materials for banana?

Use the glossary to find the meaning of these words and terms.

pulses, perennial, annual

Give examples of how legumes can be grown as companion crops?

Try to grow these in your college garden:

- *A spice, 2-3 tubers, 2-3 legumes/pulses*

Keep production records for each crop.

Sago tree

Significant crops grown in the regions

What is meant by the term significant crops? A significant crop could be one that many Papua New Guineans depend on for their sustenance and income. A significant crop could also be termed a staple crop. The following are dominant/significant staple crops: banana, cassava, Chinese taro, sago, sweet potato, taro, yam and coconut.

☞ 1.2 Activity 5

Copy the following chart into your book. Use the available references to identify significant traditional and commercial crops for each region.

Highlands	Momase	New Guinea Islands	Southern
Traditional crops are:	**Traditional crops are:**	**Traditional crops are:**	**Traditional crops are:**
Commercial crops are:	**Commercial crops are:**	**Commercial crops are:**	**Commercial crops are:**

Figure 10:Significant crops grown by region.

☞ 1.2 Activity 6

Model School Garden Project – site selection, planning, clearing and composting

This is the second stage in our plan to create a model school garden. Use it for your own school/class preparation, and as a teaching and learning resource.

For this section, begin by reading this introduction to site selection, which encourages you to look at three key aspects: reading the land, climate and plants.

1. **Reading your land**
   - Become familiar with what is already at your school. For example; the buildings, shade trees, fruit trees, old existing gardens, water sources fences and neighbours
   - Draw a map of the school and include all the features and resources

2. **Plants**
    - Which plants will grow well in your school environment? Taking into consideration all of the above factors and including the geography, altitude and size of the school grounds.
3. **Climate**
    - When you understand the types of climate that effect your school environment, you can design ecosystems that:
        - Modify climatic extremes. For example, plant wind breaks and shade from the sun
        - Reduce crop and animal failures caused by climatic extremes

Check

Sun and wind exposed areas

- Which areas are hot and dry?
- Which direction do the winds come from?
- What plants are growing in these areas?

Water

- What areas get flooded?
- What areas are always dry?
- What types of plants are in these wet and dry areas?

Soil

- What types of soil do you have? (This will determine what you can plant initially).

Once you have read this section, look at the diagram at Figure 11 ***Micro climate study*** *and complete it for a possible Teachers College Garden. Choose two sites and make a comparison study.*

s

MICROCLIMATE STUDY		
MICROCLIMATE FACTORS	SITE A	SITE B
TOPOGRAPHY • Aspect (sun) • Slope (wind)		
SOIL • Cover • Colour • Texture • Moisture		

VEGETATION • Bare • Grass • Bushes • Trees		
WATER • Run-off • Ponding		
STRUCTURES • Windbreak • Wind funnel		*Figure 11 Microclimate study*

Other questions to answer about the climate in your local area:

*Is it seasonal or not seasonal?*_____

*What is the usual length of the dry season?*_____

*Which months are usually dry?*_____

*Which months are usually wet?*_____

Site planning

After examining all the factors in the microclimate study, you can map your school garden site. Try to envisage it planted and developed. Here are two perspectives of possible school gardens. To help you develop the necessary skills, map out a site on the college.

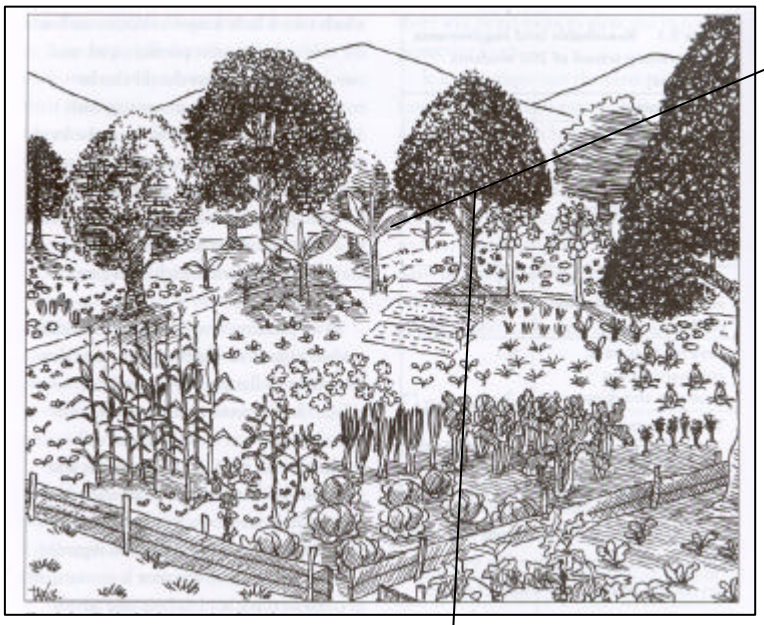
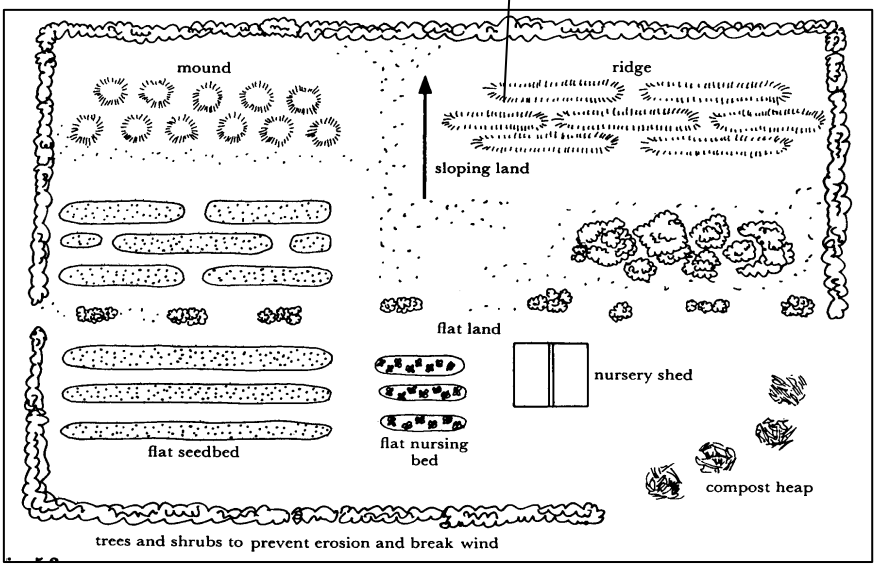


Figure 12 Layout of a typical primary school garden

*Source: **Organising School Agriculture**. Robertson, B. and Toben, H. K., 1998.*



What trees would you plant for;

- *erosion control?*
- *wind breaks and shade?*
- *alley cropping?*
- *firewood?*
- *food crops?*

Begin making a list of all the resources you might need to get your garden established.

For example, seeds, timber, food scraps, bamboo, old tires.

Fencing materials, money for buying seed and a few tools

Fertiliser or manure

Seed or plants

Food waste

Garden waste from your land, neighbours land, the local dump

Scraps, either on your own land, or lying around the community; old scrap iron (good for making fences), old tins and bottles (good for growing seedlings),

Tools, such as a pick, grass and bush knife, spade or hoe

Figure 13 A bird's –eye view of seedbeds on partly flat and sloping land.
Source: Agriculture for Melanesia.

If the children have their own garden plots, encourage them to draw a scale map.

Prepare a lesson which could be integrated with mathematics to teach the students howto draw a scale diagram of their garden plot.

Include: dimensions and area

Compost making

Once you have selected your garden site start making your compost system. Refer to Module 1.1 Soil for specific information on compost systems.

Clear the land and compost the weeds. Take care not to burn or leave the land exposed to the elements.

☞ 1.2 Activity 7

Look at the example of the game 'Corn and Bean Garden Game' . It's played between 2-6 people and the only equipment needed is a game board and a dice. The purpose of this game is to teach and reinforce some of the main ideas in this topic 'Significant Crops'. Play the game with some friends and then make your own version on any aspect of this module. The completed game should be included in your teaching portfolio.

Procedure

- *Take turns to throw the dice and follow the instructions on the board.*
- *If you land on a bean read the statement and climb down.*
- *If you land on a corn, read the statement and climb back up.*

Corn and Bean Garden Game

1 Throw a six to start.	2	3	4 Name three types of yam and climb down to13	5	6	7 Drought. Sorry miss a turn.	8	9 You add humus to improve your soil.	10
11	12 Explain why gardeners plant cassarinia trees? Go to 17	13	14	15 Frost kills your cassava. Miss a turn	16 Model garden encourages one person to mulch and not burn.	17	18	19	20Your kaukau suffers black rot. Yield down 40% Return to 14.
21	22	23	24 Mung beans and corn as companion plants.	25 You grow the largest organic pumpkin. Move ahead 12 places.	26	27 Too much NPK kills the earthworms in your garden.	28	29	30 You make gardening certificates for your class.
31	32 Name 2 cereals grown in PNG and slide down.	33	34	35	36	37 Unable to plant because of heavy rain. Go back 7 places.	38	39	40
41	42	43 Name the type of coffee grown in Momase and move 5 places.	44	45 Principal falls in the compost pit.	46	47	48	49	50 Corn borer killed by garlic spray.
51	52	53	54	55 Name 2 types of taro & move to the peanut garden.	56	57	58 You teach only agriculture theory.	59	60
61 Pigs dig up your garden. Go back 4 squares.	62 Green manure crop increases production.	63	64 Heavy rain washes away top soil	65	66 Use of alley cropping with legume trees.	67	68	69	70 You forget to mulch and the ground dries up.
71	72	73 Snails and slugs eat your lettuce crop	74	75 Use of chicken manure for seedbed. Move ahead 3.	76	77 You grow lemon grass as a mulch.	78	79	80 Weeds take over the seed bed.
81	82	83 Your Grade 8 students complete a successful garden project.	84	85	86	87 You teach students compost making. Go ahead 6 places.	88	89 No garden tools so you give up teaching gardening.	90
91	92	93	94	95 Name 1 means of erosion control. Move to 97	96 Burning dry grass. Miss a turn.	97	98 Rascals steal your crop. Move back to 94	99	100 Congratulations champion gardener!

Topic 3: Plant Reproduction and Function

Objectives

By the end of this topic you will be able to:

- Describe the importance of collecting and saving your own seeds
- Prepare and grow seeds, cuttings and seedlings for planting
- Survey the local parents and community to discover the range of significant crops grown and sold locally and which crops parents would buy from the school

Resources

- Natural materials such as leaves and examples of seeds

Scope

This topic examines the asexual and sexual reproductive functions of plants. This is not an in depth study of plant reproduction, that will be covered in science. Asexual reproduction is studied with the latest reference to taro reproduction. Sexual reproduction centres on collecting and growing local seed stocks.

Reproduction systems

Plants have two ways of reproducing themselves:

- Asexual reproduction - a new plant grows from a part of a single parent
- Sexual reproduction – a new plant grows from seeds produced from two parents

Asexual reproduction: means without any kind of sexual process. Another name of it is **vegetative propagation**. Sweet potato and yam (two of the crops you will be growing) can easily be made to reproduce asexually. One of them is grown from tubers and the other from stem cuttings. In each case, there is just one plant and no seeds are sown. These crops grow into a new, complete plant, because they have the ability to regenerate completely from small parts of themselves. The offspring have all the characteristics of the original parent (shape, height, colour, scent and taste). They cannot be different as they are really the same plant. Variations between generations are not possible.

To illustrate this type of plant reproduction we will examine the taro – the second most important staple root crop in Papua New Guinea.

Efficient Propagation techniques for Taro – vegetative (asexual) reproduction

Traditionally, taro is propagated vegetatively through setts (top portion of the corm and 30-40 cm of petioles) and/or suckers. Depending on the variety, a mother plant may produce 2-10 daughter plants during one life-cycle (6-8 months). This practice often does not provide enough daughter plants if there is a shortfall in planting materials supply.

Rapid propagation using mini-setts

A taro mini-sett is a cut piece of taro corm or cormel bearing one or more axillary buds (growing points arising from the axil). An average size corm may have 10-12 axillary buds, and thus should provide 10-12 mini-setts. The setts should be germinated in a nursery bed before transplanting to the field.

Preparation of nursery bed

The nursery bed can be prepared in the open. Shading is preferable but not essential. The seed bed should be prepared with a medium made of a 1:1 mixture of topsoil and chicken manure. Other organic manure such as compost, coffee pulp, animal manure, etc may alternatively be used. The size of the bed is the same for mini-setts and stolon pieces. An area of 1 square meter can fit 100 or more mini-setts or stolon pieces. Small furrows (5-7cm deep) should be made to plant the mini-setts or stolons.

Procedure

1. Clean the corm or cormel without damaging the axillary buds.
2. Cut the corm or cormel into mini-setts, each weighing 20-50 grams and possessing at least one axillary bud. The mini-setts may be pre-treated with wood ash to reduce rotting.
3. Place the mini-setts with the cut sides facing upwards on a dry surface under a shed and leave them to dry overnight. This step should allow wounds to heal.
4. Place mini-setts 2-4 cm apart in the furrows made in the nursery bed. Make sure the axillary buds on the mini-setts are in their natural upright position.
5. Cover the furrows with soil/chicken manure mix until just visible. Place a thin (1-2cm) layer of mulch over the top to preserve moisture.
6. Thinning is not necessary. The sprouted plants will be ready for field planting when the petiole base diameter is greater than 4cm, and fully fledged leaves have developed. This may take 2-3 months.

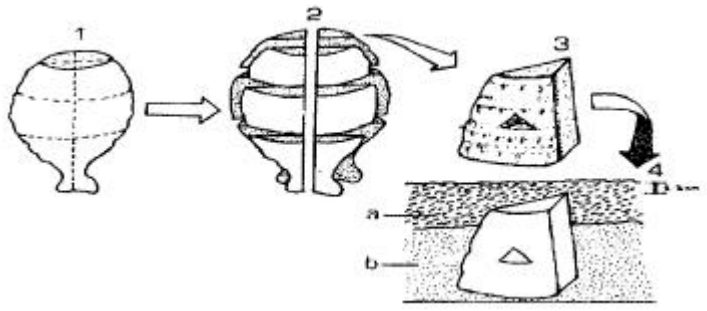


Figure 14 Steps involved in rapid propagation using mini-setts.

Rapid propagation using stolons

Some taro produce stolons or runners. These are modified stems, which develop from axillary buds on corms and extend on the ground surface up to a meter in length. A plant may produce up to ten or more stolons. Each stolon develops between 5-10 nodes. Individual nodes have single buds, which potentially can develop into a plant identical to the mother plant.

Procedure

1. Remove stolon from mother plant
2. Cut stolon at the internodes, to produce segments with one node each. Plant in the same way as mini-setts except –place each piece in an inclined position. It may take longer if pieces are placed horizontally in the furrows.

The techniques described for the propagation of taro are cost effective, practical and result in a high multiplication rate. Demand for taro for domestic markets and export is high in Papua New Guinea.

Unfortunately, many taro growers are ignorant about methods for rapid propagation. As a teacher with you may be in a position to demonstrate these techniques in a model school garden.

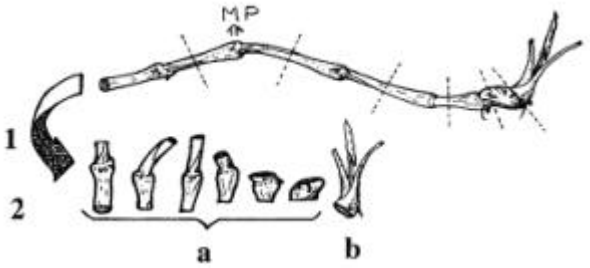


Figure 15 Propagation of taro using stolons.

Source: Adapted from Efficient Propagation Techniques for Taro Multiplication. NARI Extension Series Bk No 3. 2001.

Sexual reproduction: means a male cell and a female cell (gametes) join together and grows to become a new organism. These cells may come from two different parents. This means the offspring share the characteristics of both parents. Variation is possible from one generation to the next. The sexual organs of plants (male and female) are usually contained in the same flowers. Seeds are the product of sexual reproduction.

☞ 1.2 Activity 8

Prepare a short lesson to teach Grade 6,7 or 8 students on the propagation of taro. In the lesson include activities which teach the students:

- *The differences between sexual and asexual reproduction using specific examples.*
- *Vegetative propagation techniques for mini-setts or stolons.*
- *Preparation of nursery beds.*

This resource should be included in your teaching portfolio.

Complete the table Advantages and disadvantages of sexual and asexual reproduction shown at Table 1. Some basic research will be necessary.

Asexual Reproduction	Sexual Reproduction
Advantages	**Disadvantages**

Table 1 Advantages and Disadvantages

Why producing your own vegetable seeds is important

1. High quality seeds can easily be produced and at a low cost, thus reducing the costs of gardening
2. When the seeds you want are not available in the market, you can produce your own.
3. You can sell them for income and / or share them with neighbours and friends.
4. You can select seeds suited to your environment. If you want fruits that are big and are not attacked by pests in your garden, you can choose seeds of the plants that are grown in your garden with these specific traits.
5. Seed self-reliance can be achieved by producing your own seeds.
6. Valuable traditional or indigenous seed varieties' of vegetables can be preserved for future generations.

Disadvantages of a gardener growing their own seeds

- The grower must spend more time to locate those few best parent plants
- The grower must have more knowledge of his selected plants than just producing an ordinary crop
- More care must be taken so that plants selected do not become crossed with others of poor quality.

Traditional or indigenous seeds

Traditional or indigenous seeds are those produced, growing or living naturally in a particular country or climate. They are seeds that have been selected and managed by local people in the local growing environment.

Can you give five examples of indigenous seeds that originate from your area of Papua New Guinea? Share with your partner.

Characteristics of traditional seeds

1. Adapted to the conditions of the area where they are grown.
2. Multiple uses (examples: food, medicine, fuel, fibre, fertiliser, craft materials, feed for animals, religious artefacts).
3. Most are resistant to pests, diseases and environmental extremes, such as drought.
4. High nutritional value

5. They do not have a peak season harvest. The fruits do not mature at the same time, so harvesting is staggered. Hence, they can provide a daily source of food for the family.
6. They provide plant breeders with valuable traits needed for crop improvement.

Choosing good plants for seeds (plant selection)

The selection criteria for seeds depends on the selector's needs or use (example food, fodder). Below is a list of characteristics which can help the selector find good plants for seeds:

1. Vigour and health of the plant
2. Resistance to pests and diseases
3. Resistance to adverse environmental conditions, like drought, heat, flood
4. Time of fruit bearing
5. Yield
6. Characteristics of fruit and seed like colour, size, shape, texture, etc.
7. Cooking and eating quality (if the fruit or seed is meant for eating)
8. Storage life of fruit
9. Other characteristics depending on the use (example: medicine, crafts, religious artefacts)

Based on the above criteria, select the plant to be used for seeds. Put a tag or mark the plant so that it is not harvested by accident and so that special care can be given to it.

Site selection and timing of seed production

Seed comes from the flower. The flowering and seeding are affected by the health of the plant and its surroundings or environment. Seed quality is also affected by the parent plant.

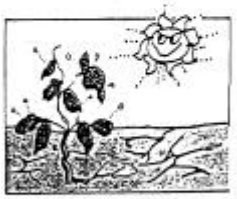
Environmental factors that affect seed production

A. Temperature

Temperature has a direct effect on flowering and seed production.

Tropical plants - these are plants that flower and produce seeds in hot or tropical areas. Most of these plants flower and produce seeds in Papua New Guinea. Example: tomato, pepper, cowpea, ladyfinger

Temperate plants - these are plants that flower and produce seeds in cold or temperate areas. Most of these plants flower and produce seeds in cold areas in Papua New Guinea, like the Highlands area. For example, pea, cabbage, radish, onion, carrot and cauliflower.

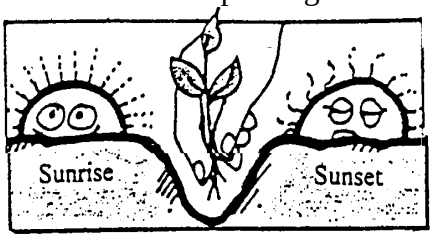


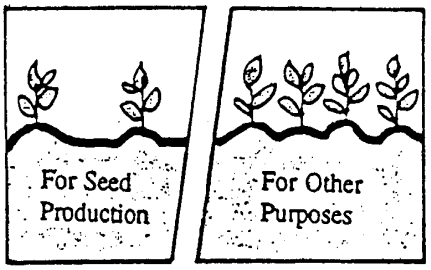
In areas where the temperature is not cold, temperate plants can be induced to flower and produce seeds if they are placed in cool conditions before planting. This method is called **vernalisation.** Vernalisation is done by soaking the seeds in water and placing them (after the radicle or rudiment" root has protruded) or their plant parts (example: onion bulb. tuber of carrot) in a cold place like a refrigerator.

B. Water / rain

The right amount of water is needed for the growth of the plant. Hard and continuous rain is not good for seed production since:

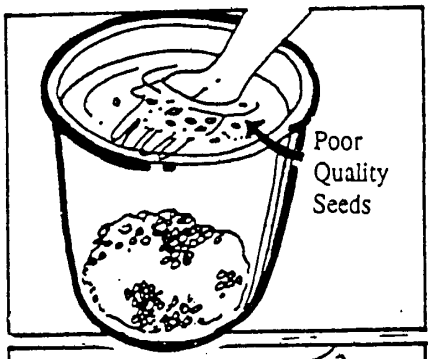
1. Pollen is not transferred
2. Seeds do not develop from flowers
3. The vegetative stage of the plant or the maturity of the fruit/seed is prolonged
4. Seeds germinate even if it is still not harvested from the plant
5. Harvesting becomes more laborious
6. Pests attack or infest the plants
7. Seed yield decreases





To prevent seed production during the rainy periods, plants can be spaced at wider or longer distances so that all the plants can have enough sunlight.

On the other hand, lack of rain or water is not good for the plant since it will prevent the normal growth of the plant and the plant may not produce flowers and seeds. Even if flowering occurs the quality of the seeds is not good and the seed yield is low.



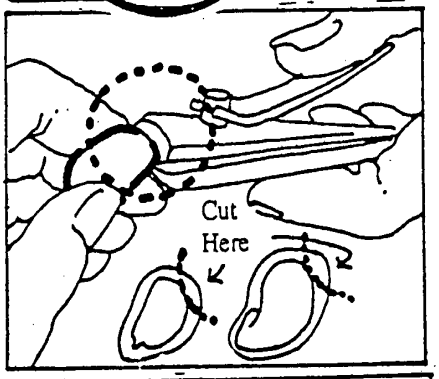
C. Wind

The strength and direction of the wind affects the pollination of flowers.

How? Try to explain to a friend.

D. Soil

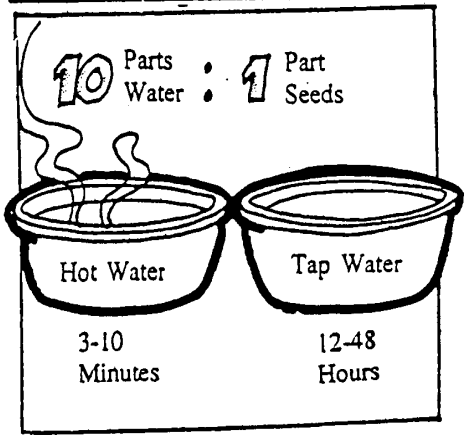
To produce good seeds, the soil must be healthy and fertile. The right pH (acidity of the soil) for a specific plant should also be obtained.



Cultural practice

A. Timing of planting

Plant seeds when the weather is good. Usually, seeds are planted during the rainy season in order to have continuous amounts of water. It is good to transplant early in the morning or late in the afternoon.



B. Planting distance and rate of planting

The distance between plants used for seed production is wider compared to that of plants used for other purposes (example: vegetable production, fodder production). More seeds need to be planted if the broadcast or sowing method is done. The distance of planting is also wider if the soil is not fertile and in the rainy season. Widening the distance will enable plants to receive enough sunlight.

C. Hastening seed germination

Seed cleaning or seed washing -- Soak the seeds in a container of water and remove the seeds that float. Seeds which float have poor quality.

Use of inoculants -- some micro-organisms help in good growth of seeds. Rhizobiwn (a kind of bacteria) gets nitrogen from air and gives the nitrogen to the plant and soil. This is usually used for legumes. Mychorrhiza (a kind of fungus) helps the root absorb elements like phosphorus from parts of the soil that cannot be reached by the root. This has been found effective in corn and different vegetables. The two inoculants can be used to minimise the use of fertiliser.

Seed scarification -- This method is appropriate to seeds (example: winged bean, bitter gourd. sponge gourd) that are hard and difficult for water and air to penetrate. This is done by (1) nicking off the seed coat with a knife or nail cutter. (2) Puncturing the seed coat with a needle; and, (3) rubbing the seeds in sandpaper, file or any rough material. Care should be done so as not to injure the internal portion of the seeds, especially the radicle.

Hot water treatment -- Pour hot water (boiled and then cooled for about 10 - 15 minutes) into a container with seed (10 parts water to 1 part seed). Let stand for 3 -10 minutes or until water cools off. Seeds may be left soaking overnight. Old seeds are soaked for a shorter time than new seeds.

Soaking seeds in ordinary water overnight -- Soak seeds in tap water for 12- 48 hours (depending on the species). This method is not recommended for all seeds especially seeds that quickly absorb water like most legumes.

☞ 1.2 Activity 9

Using the information above on 'Producing your own vegetable seeds', 'Cultural practices' and 'Site selection and Timing of seed production' produce a resource, which could be used by Grade 6-8 students or their parents.

The type of resource you choose to make will depend on how you might use it.

For example: a chart for your classroom, a small pamphlet, which can be copied and used, a set of activity cards or lessons.

You must make it really interesting and practical.

You can change the information around. You can write it in another language.

Use illustrations and provide examples.

Discussion questions:

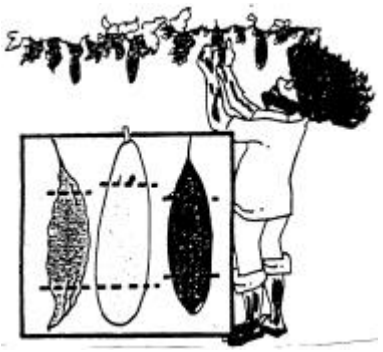
What are some of the best conditions for germinating seed? List four of them.

List down three advantages and three disadvantages of a farmer importing his seeds from New Zealand.

Refer to the glossary to help explain these terms and what use they are, use illustrations to help

- windbreak, bund,

Seed harvesting and seed extraction

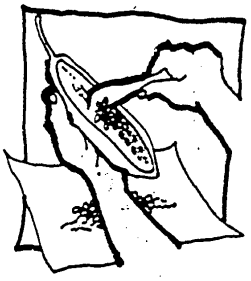


Seeds should be carefully harvested to ensure high quality. The seeds should possess the qualities of the variety that was planted. For example, if a long purple eggplant was planted, the harvested fruit should possess these qualities. Seeds from more plants should be harvested when the plant is cross-pollinated.

Seeds should also be harvested when they are already mature. Seeds that are over mature are not recommended since they might have already been infected with pests and diseases. Secondly, they are already weak because they are old.

How do you determine if the seeds are already mature?

Discuss and list your ideas.



After-ripening

Some seeds improve their germination if they are allowed to stay inside the fruit for several weeks. For example, squash, bottle gourd and pumpkin.

Seed Extraction/Cleaning

The extraction of seeds from the fruit depends on the condition of the fruit and seeds that will be harvested:

1. **Wet seeds from fleshy fruits** - the fruit and the seeds are both wet. Usually, the flesh is attached firmly to the seeds. Seeds are extracted using the hands or a knife. The fermentation process is sometimes done to remove the seeds. Soak the fruit in water for one to two days. After soaking, separate the seeds from the flesh, and throw away the flesh together with the seeds that float (except when the seeds naturally float). Sunken seeds are then washed and dried. For example, eggplant, cucumber, tomato, bitter gourd, pawpaw and squash.

2. Dry seeds -- these are obtained or extracted from a dried fruit or pod. They are extracted by hand or pounded collectively while inside a sack or net bag. Pounding the seeds inside the bag is necessary to prevent them from scattering. For example, cabbage, cauliflower, mustard, pechay, lettuce, pea, lima bean, mung bean, cowpea and onion.

If possible, do not harvest these seeds when it is raining or in early morning when there is still dew. Also, do not harvest at midday since the pods will break or shatter, allowing the seeds to come in contact with the soil and with micro-organisms that lower seed quality.

3. Dry seeds from fleshy fruits - The ripe fruit is dried before extracting the seeds. For example: chilli and ladyfinger.

For all kinds of seeds, winnowing or removal of contaminants after drying and before storage is recommended to maintain good quality. Contaminants include weed seeds, seeds of other crops or of different variety of the crop, chaff, dust and other inert materials like rocks, dim twigs and leaves.

Explain what these terms mean: winnowing, fermentation.

Market survey

This is an activity, which the teacher can use with her/his students when setting up a model garden. Remember the process of establishing a school garden should be as participatory as possible. A survey will involve the children and their parents, which could be a useful means of raising community interest.

☞ 1.2 Activity 10

Model School Garden Project – market survey

Here is a model survey which we want you to adapt to reflect the agricultural environment of your community. It could easily be written on the black board and copied by the children or better still, the children could design a survey with you.

If you ask the children to survey their family then this could be a good way of interesting people in your project and hopefully getting some of them involved. Decide whether a survey would better be read out for people to reply to or a written questionnaire.

What factors would determine this?

Sample survey

Excuse me: I am from_____Primary School and we are conducting a survey about the vegetables people in our community eat and grow. This will help us plan our school garden. Would you mind answering some questions?

1. Your name?
2. Sex: Male ☐ Female ☐
3. Your occupation? Wage earner ☐
   Subsistence farmer ☐
   Housekeeper ☐
   Other _____

"In this survey we are enquiring about vegetables such as:

tomatoes ☐ cucumbers ☐ corn ☐
beans ☐ cabbage ☐ taro ☐
peanuts ☐

4. Which of these vegetables do your grow in your own garden?

5. Which of these vegetables do you buy when they are available?

tomatoes ☐ cucumbers ☐ corn ☐
beans ☐ cabbage ☐ taro ☐
peanuts ☐

5. About how much money would you spend each week on these vegetables?

Less than K2 ☐
K2 to K5 ☐
K5 to K10 ☐
More than K10 ☐

6. Which of these vegetables do you spend most of this money on?

tomatoes ☐ cucumbers ☐ corn ☐
beans ☐ cabbage ☐ taro ☐
peanuts ☐ English cabbage ☐ ☐
shallots
Chinese cabbage ☐ greens ☐ ☐
kaukau

7. Which of these vegetables would you buy from the school if they were available?

tomatoes ☐ cucumbers ☐ corn ☐
beans ☐ cabbage ☐ taro ☐
peanuts ☐ English cabbage ☐ ☐
shallots
Chinese cabbage ☐ greens ☐ ☐
kaukau

Are there any other vegetables you would like to buy if they were available?

"Thankyou for your assistance."

Figure 16 Sample survey

After the survey has been conducted, work with the results and encourage your students to produce a report.

Some possible report headings:

- **Aim:** Why the survey was carried out
- **Method**: How was the survey carried out
- **Results:** Process the data collected in the form of graphs or tables
- **Conclusion**: What the survey results tell us
- **Recommendations:** What we should do after making these conclusions

You should now have a model survey ready to use in your new school. You should also have a plan of how to use the survey data. Include this information in your teaching portfolio.

Topic 4: Plant Propagation and Nurseries

Objectives

At the end of this topic you will be able to:

- Describe, illustrate and practice at least two methods of plant propagation
- Assist with the establishment and maintenance a college plant nursery
- Plan for the establishment of a school plant nursery

Resources

- Material for budding
- Sharp knives
- Copies of the *Liklik Buk* and *Good Gardens Good Food Good Development*

Scope

This topic looks at the area of plant propagation with an emphasis on:

- growing seeds and
- nursery techniques for seedlings

Other propagation techniques such as budding, grafting, layering, tissue culture and mounding will be covered briefly with references to encourage further research. Finally, you will be encouraged to construct or maintain a college nursery in preparation for establishing a school nursery in your model gardens.

Propagation

Propagation involves growing new young plants from old ones. When left alone most plants reproduce themselves perfectly well. Others require techniques such as growing cuttings, budding or grafting special varieties onto hardy root stock.

When plants grow from seed they contain half the genes of each parent to make one new individual, so each plant is slightly different. Most annual and some perennials are grown from seed.

☞ 1.2 Activity 11

What is an annual and what is a perennial? Provide examples to illustrate your answer.

Make lists of common perennials and annuals found in and around the vegetable garden.

Cuttings taken from trees and shrubs, are a type of cloning and each new plant is almost identical to its parent. Small shrubs like herbs, e.g. lavender and rosemary, are grown from softwood cuttings. These are taken from the young fast-growing tips after the plant has finished flowering. Many deciduous plants like roses, figs, grapes and mulberries are grown from hardwood cuttings. Stem cuttings, about 30cm long and about as thick as your thumb are taken. The cuttings can be put in a pot or planted directly into the ground.

Fruit trees are often budded or **grafted**. If you want to improve the vigour, hardiness or pest-resistance of a particularly special fruit tree, you can take a growing point (a bud or stem section) after fruiting and splice it into a vigorous, hardy rootstock.

For more information on plant propagation refer to the Liklik Buk and Agriculture for Melanesia Book 1.

☞ 1.2 Activity 12

Model School Garden Project – establishing a school plant nursery.

This is the fourth stage in the establishment of a model school garden. The work and activities here are to assist you in your school and with your teaching of agriculture.

All activities and resources should be kept in your Teaching Portfolio.

Examine the two models of plant nursery houses shown at figure 17 and 18, select the model which suits your needs (or design another).

Draft an action plan for the planning and construction of a nursery, which you will be able to use with your class.

Include in your action plan:

- *General Planning Form and*
- *Resource Planning Form.*

(Refer to CDS Module 2.2 Integrated Projects for guidance)

Plan a lesson that is suitable for Grade 6-8, which involves making a nursery using these action plans.

Preparing a seedling and plant nursery

A nursery is a small house where delicate young seedlings are grown to protect them from too much sun and rain. Vegetables like lettuce, cabbage, tomato, Chinese cabbage and eggplant are very weak when they are young. After a few weeks growing in a nursery they are strong enough for transplanting on their own in the garden.

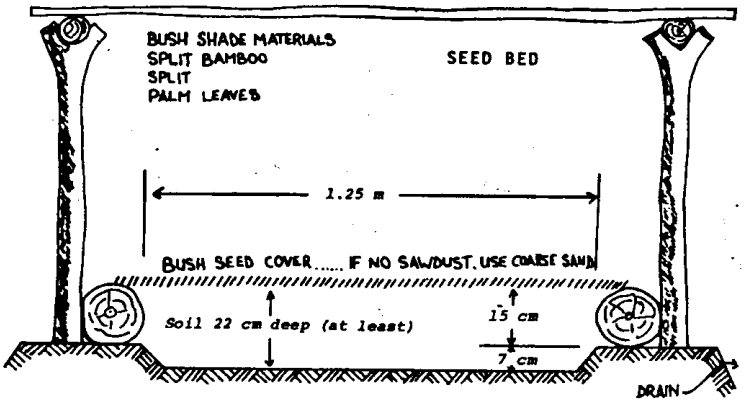


Figure 17 Plan for a bush material nursery

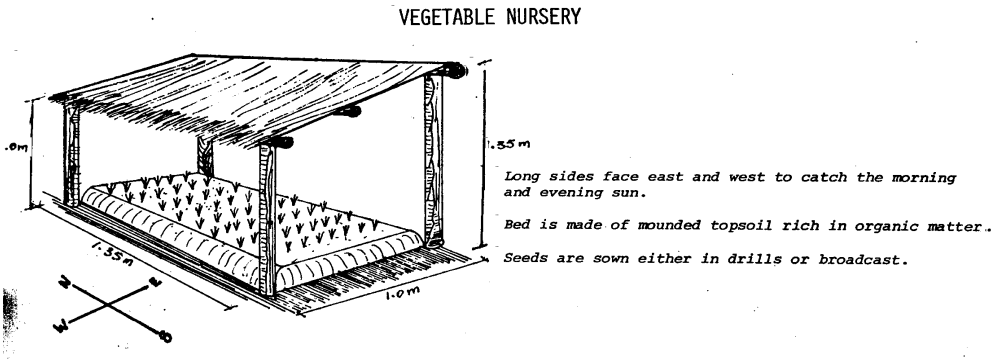
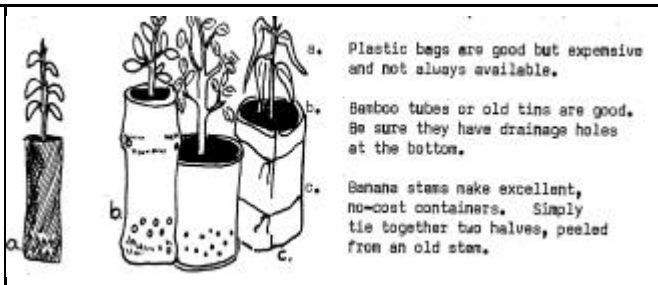


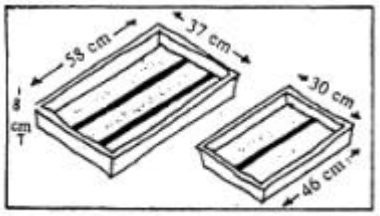
Figure 18 Design for a vegetable nursery

Nursery techniques for seedlings

Direct seeding is the most common method of sowing vegetable seeds. However, some vegetable seeds perform better if they are sown in containers or seedbeds initially and are later transplanted. Here are some basic steps in starting plants by this method.

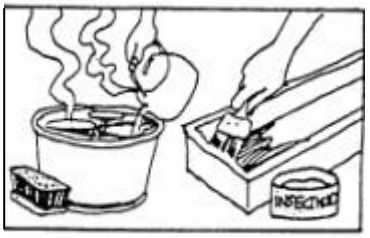
1. Select a suitable container. Planting in a seedbed is cheaper that using a container. However, using a container allows the gardener to choose the right medium for growing the seedlings. Any container deep enough to allow seedlings to root and wide enough to prevent their becoming cramped will do.	

2. Prepare containers for planting. Containers should be cleaned properly to ensure they harbour no fungus spores or insects pests. Adequate drainage should also be provided to avoid damping-off (soil-borne disease that destroys seedlings)

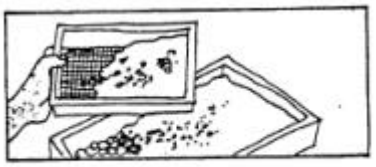


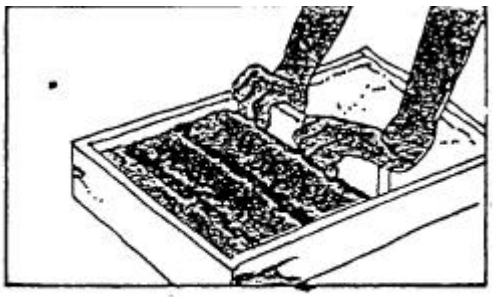
Seed flats

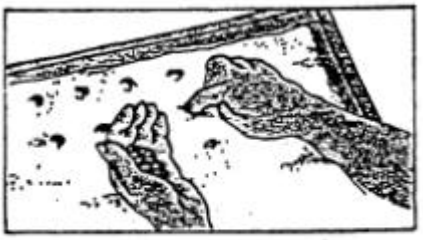
3. Prepare the soil medium. The soil medium should be free of weed seeds, fungus spores and garden pests. It should be sufficiently porous to allow the delicate rootlets to penetrate and to admit air and moisture. Usually a mixture of equal parts of sand, soil and compost is recommended, though a modified mixture can be made to produce a soil mixture that is more favourable for the growth of seedlings.


Cleaning containers

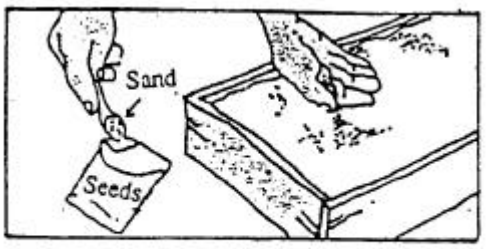
4. Sow the seeds. The manner in which seeds are placed in the soil depends largely on their size. Fine seeds can be mixed with sand and sown with the sand.


Filling flat or pan


Medium-sized seeds are often sown in drills.

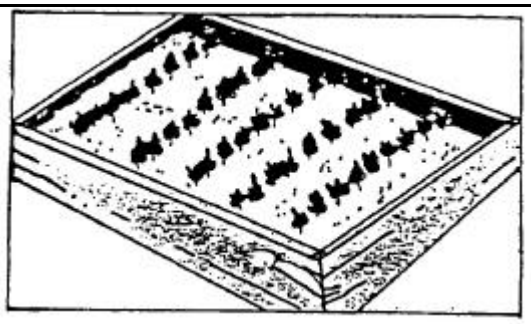

Large seeds can be poked in slightly with a finger.

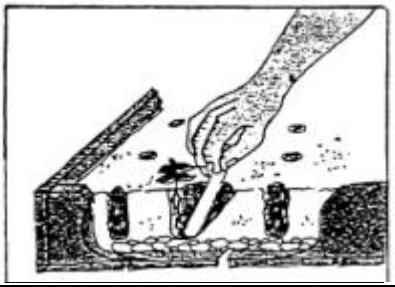
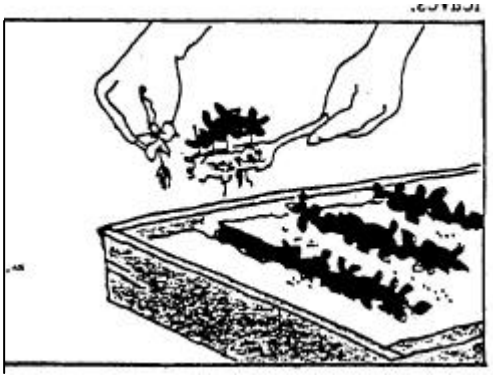
5. Cover the seeds. Cover the seeds by sifting the soil medium through a fine sieve held above the seedbed. Large seeds are covered to a depth equal to twice their width.



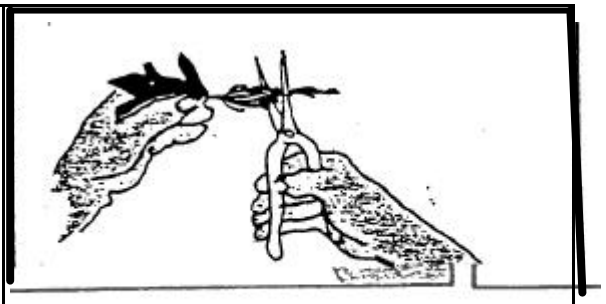
Fine seeds are usually broadcast together with sand.

6. Care for Germinating Seeds. Seedlings should be protected from temperature fluctuations. Enough moisture and air circulation must be provided. Dry soil can stop germination, but over-watering can encourage damping off. When watering is necessary, soak by immersion if possible. It is advisable to set the seed box in the open. If it is covered or is indoors, the seedlings may suffer from lack of moving air. The seedlings should continue to get some protection until the first true leaves emerge. When one or two sets of true leaves become visible, the seedlings are ready for transplanting.	

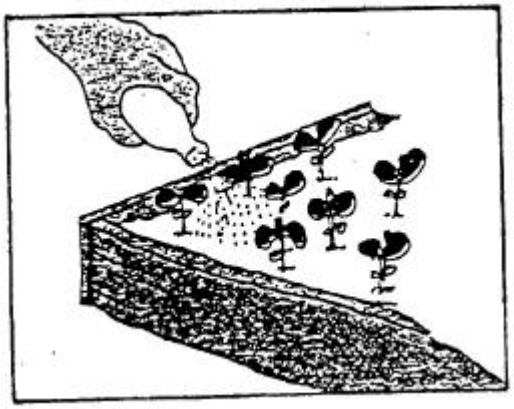
7(a). Pricking/thinning is the process of transplanting seedlings from the seed box to another seed box. This step gives the seedlings a chance to start development of root and leaf systems before the plants are left to fend for themselves in the garden. Seedlings should be pricked out as soon as they have two sets of leaves.	

(b). Use a sharp tool to help remove the plants so as not to injure them. If seedlings come up with their roots entangled, they can be separated by soaking the root ball in water.	
	

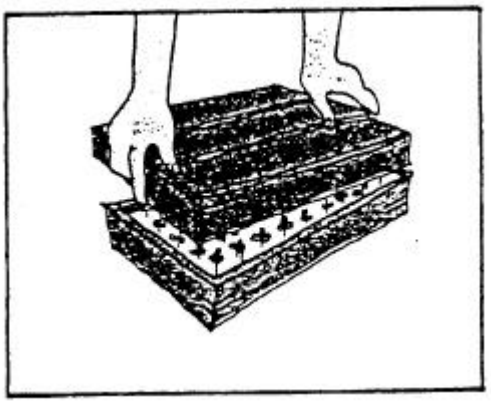
(c). Transplant the Seedlings. Punch holes in the seedbed with a dibble/stick at four cm apart. Working quickly, insert the roots of the individual seedlings in the holes and firm them in with either the dibble or with fore finger and middle finger.
If roots of a seedling are lengthy, they should be cut with shears or sharp knife



(d). When the seed box is filled, it should be watered with a fine spray from a hand container to settle the soil around the roots and to freshen wilted stems and leaves
If plants are particularly soft and subject to wilting, cover the box with a sheet of newspaper or another box turned upside down.



(e) In about four or five weeks, the young plants will be ready to go out into the open ground. A week before transplanting, the plants should be hardened by gradually increasing exposure to sun and air. Before finally setting in the garden, the plants should be given several days of full sunlight if they are going into a sunny position. Watering is also held back gradually before transplanting



Topic 5: Cropping Systems

Objectives

At the end of this topic you will be able to:

- Explain the significance of different environmental influences on plants and cropping
- Examine the growing requirements of different crops and put into practice this knowledge in the college garden
- Describe and implement at least two types of cropping systems
- Prepare soil preparation resources for model gardens

Scope

This topic examines the environmental influences which effect crops and the techniques used to minimise any harmful influences. It explores the growing requirements of a number of plants and asks you to research others. You will be given the opportunity to apply this knowledge in college gardens where different cropping systems will be practiced. This topic will also continue the development of the model school garden – looking at soil preparation and planting.

Crop planning

We should encourage the practice of cultivating a food garden at or near our home or school to grow food crops for the family or ourselves, for the children to eat, to learn from and to sell at market. Our main aim in cultivating a food garden is to produce food in the shortest possible time, with minimum input and maximum output, in the smallest space possible. A well thought out garden system will always provide you with food, for the least amount of work.

Figure20: A coastal home garden scene

What are some of the ways we can achieve this? Make a list

Look at the coastal home garden at Figure 19.

Make a drawing of a typical home garden from your place.

Choosing the right cropping system depends on what you want to grow and how much of a particular crop you wish to grow. Crop planning considers what, when, where and which plants to grow in relation to their requirements for space, sunshine, water, maturation, season of planting and tolerance for each other.

For a garden to give the maximum yield for the family, it should be kept planted all the time.

The National Agriculture Research Institute in East New Britain Province is experimenting with a ground cover crop – **'makuna bean'** which forms excellent mulch and plenty of rich organic matter to enrich the soil. It can be grown during periods when there is no one to look after the garden such as school holidays. For more information on this bean and other current research information in cropping, refer to Appendix 2 Research and support organisations.

Growing Requirements for plants

Plants require at least four basic requirements to grow well: water, spacing, shade and nutrients. In the natural environment plants compete with each other with only the strongest surviving. 1.2 Activity 13 examines how we can get this balance right.

☞ 1.2 Activity 13

Copy this table into your book and complete.

Requirement	Too much	Too little	Balance
WATER	- plant rots - drowns	- stress, plant may produce flowers, seed and die.	The right amount of water when the plant needs it. Mulch keeps soil moisture available to the plants
SPACING			
SHADE			
NUTRIENTS			

Environmental influences

Climate is the main environmental determinate of vegetation. Throughout Papua New Guinea, different climates are affected by rain (precipitation), radiation (sunlight) and wind. When we understand and appreciate the workings of these 'wild energies' we can design garden ecosystems which:

- Modify climatic extremes
- Reduce failures of crops caused by climatic extremes
- Provide greater energy efficiency

Precipitation

Precipitation is generally seasonal with a wet and a dry season throughout most of the country. Country people understand the rainfall patterns for their area although climatic changes caused by El Nino and La Nino are changing these well-understood patterns.

The affects of too much rain or too little can be minimised through various techniques.

Research to find techniques for minimising the effects of too much or too little rain.

Wind

Like precipitation, Papua New Guinea has fairly predictable wind patterns. An understanding of these patterns can assist us to:

Plant wind breaks in the right place to provide protection for plants and animals.

What are the regular wind patterns for this country and your area?

Sun (radiation)

Dark bodies absorb the greatest amount of light and later radiate it back as heat. Light-coloured objects tend to reflect light which can be then used or absorbed by other plants, materials or water. Vegetation absorbs heat and light. Without vegetation, soil radiation and reflection is very intense; the soil becomes vulnerable to loss of soil nutrients, to drying out and to the forces of erosion. Vegetation regulates soil temperature.

Explain why burning is so detrimental to soil health and why mulch is a good gardening technique.

Go back and examine the 'Microclimatic Study at Activity 7. On your site, plan mark in the different climatic conditions that exist on the college garden area.

How will these affect the cropping system used?

1. Mixed cropping

Mixed cropping is to grow different kinds of vegetables trees and other plants in one area. Each plot must contain at least one of each of the following crop categories: leafy legume, tuberous and fruit-bearing vegetables. In this way, the nutritional needs of the family are being met by growing a diversity of vegetables of different durations. The family is assured of the availability of vegetables throughout the year. This practice is also one way of checking pest outbreaks and certain intercrops serve the additional purpose of being insect repellents.

2. Crop rotation

Different plants have varying rooting depths and so extract nutrients and moisture from different points of the soil profile. The cultivation of different plants in the same part of the bed from season to season does not overburden the soil also; each kind of plant takes away something from the soil but also gives something back.

Bed Subdivision	Planting Season			
	First	Second	Third	Fourth
1	Leaf	Fruit	Root	Legume
2	Fruit	Leaf	Legume	Root
3	Root	Legume	Leaf	Fruit
4	Legume	Root	Fruit	leaf

Figure 21 A simple crop rotation guide

By rotating the plants from one part of the bed to another, the land is allowed to rest from one kind of plant and the soil gets richer from the other plant that was put in its place. Crop rotation enables the land to rest without keeping it idle. Follow heavy feeders with heavy givers and then light feeders.

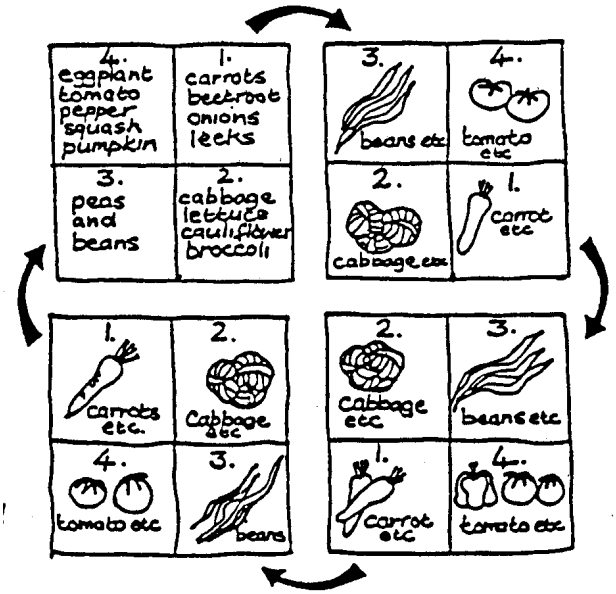


Figure 22 Crop rotation of crops and beds

3. Intensive Planting

Use every bit of the garden area for as many months of the year as possible. Close spacing is recommended to prevent the growth of weeds and reduce the direct exposure of the soil to sunlight thereby reducing moisture evaporation as the plant canopy serves as "living mulch".

Space plants closely, seeing to it that each plant has enough sunshine and space to grow. Plants are correctly spaced when the leaves of the fully-grown plants barely overlap with, the adjacent ones.

Not all crops are planted at the same spacing. When too close a spacing is used in planting, the number of plants per unit space (plant population) becomes too high. Plants in such a situation will compete for nutrients, light and water. Since these may not be enough for all the plants, some of them will look sickly, very tall or very short, depending on which nutrient is insufficient in the environment. If light is lacking, the plants will be very tall; if nutrients like nitrogen or phosphorus are lacking, the plants will be short, and have typical nutrient deficiency symptoms.

Plant in a triangular fashion. The seeds or seedlings are planted at each end of an imaginary triangle, with the sides of the triangle being equal to the recommended spacing. This portion allows more plants to be grown within a small area than the usual method of square or row planting.

Two methods of planting

Figure 23 Row planting has more soil exposed to the sunlight which leads to rapid evaporation of soil moisture

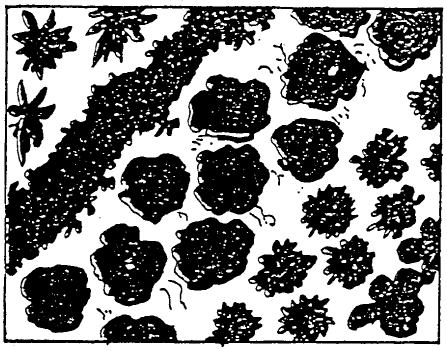


Figure 24 A thick canopy of plants reduces moisture evaporation and reduces weed growth.

Alley cropping

Alley cropping is a form of intercropping vegetable plots between rows of fast-growing trees or bushes. It is especially useful in areas where animal manure is not available. Its main purpose is to provide a steady and reliable source of organic matter to crops. Since these hedgerows are legumes which fix atmospheric nitrogen, they are doubly valuable .

Important considerations

1. Select fast- growing and nitrogen-fixing trees that can withstand frequent pruning.

For example: Leucaenia, Calliandra Calothyrsus, Cassia siamea, Flemingia macrophylla

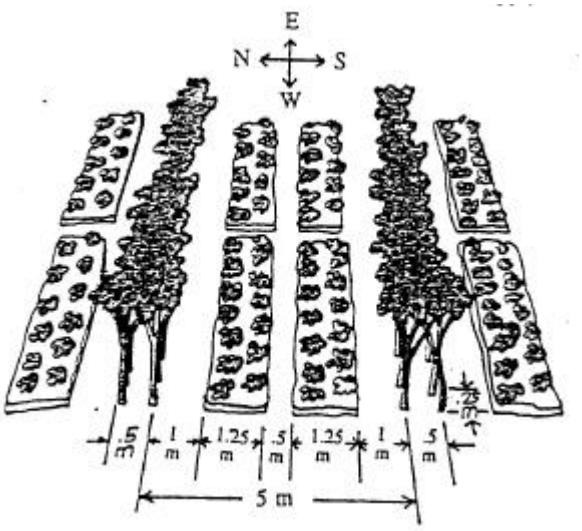
2. Orient the rows in an east-west direction to avoid shading the crops.

3. Tree rows should have a minimum space of 5m to allow more space for vegetable crops.

4. Soil should be dug and loosened to a minimum depth of 30 cm.

5. Pruning is first done after the trees are 9-12 months old. Trees are cut 0.5 m above the ground.

Figure25 Established alley cropping system



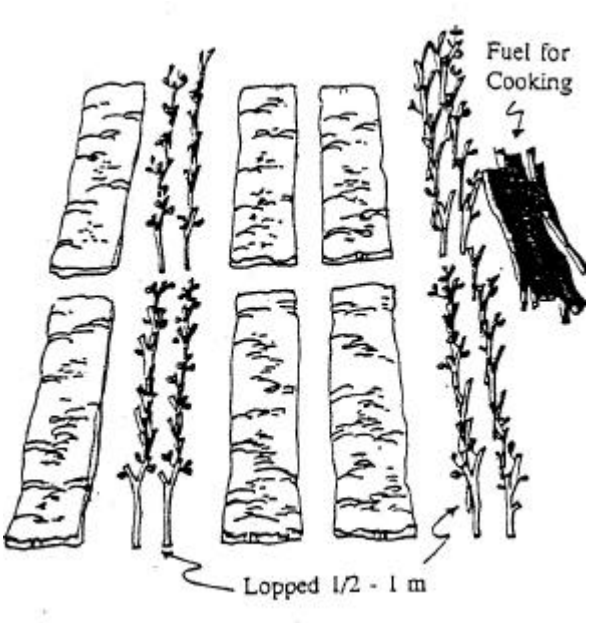


Figure26 Coppiced Alley crop for green manure

Hedgerows looped and incorporated into the beds

Procedure

1. Cut the trees when they are about three meters in height. Leave one branch/tree longer to ensure regrowth in the event of very dry weather.

2. Place cut branches over the whole bed and leave for two days. This will allow leaves to wilt and speed up defoliation.

3. Remove all leaves from the branches there should be an 8cm layer of leaves over the bed.(The branches can be used for firewood)

4. Dig the leaves into the soil to a depth of 15cm.

5. Allow the leaves to decompose for 10-14 days.

6. After another 10-14 days apply any necessary soil supplements like wood ash or crushed eggshells.

7. Shape the bed and plant.

☞ 1.2 Activity 14

Prepare a short presentation on one of these cropping methods:

- *Mixed cropping, crop rotation, intensive planting, alley cropping.*

You may work in groups and should use models, drawings and or activities to involve and educate the class.

Some maths should also be involved.

Using the Fence line for Planting Annual and Perennial Crops

Trees, shrubs and other crops must be planted in such a way that a multi-storied cropping pattern is achieved. This way, various crops can be grown in a limited space without competing with each other. Weed growth is also controlled through shading by the upper canopy level and by crawling vines.

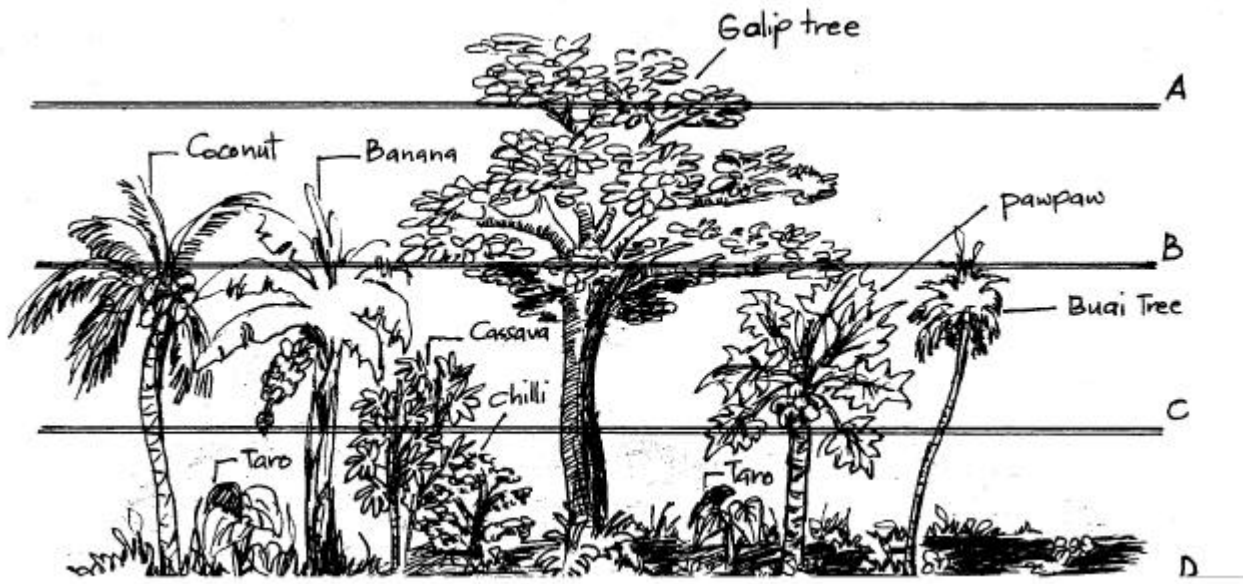


Figure 27 An example of a living fence line

Upper canopy species (A) – form a protective canopy against tropical sun and torrential rains.

Middle canopy species (B) – feature staple and fruit production including trailing plants which can be allowed to climb the trees.

Lower canopy species (C) – bush-level growth which can be grown to form a double layer of protection against stray animals.

Under story crops and creepers (D) – shade tolerant crops and crawling vines can be planted to further cover the soil.

Purpose of live fence	**How to make a fence line**
1. Protection against stray animals 2. Windbreak 3. Green manure 4. Food 5. Fuel wood 6. Fodder	1. Dig a trench 40-50cm wide and 30-40cm deep along the fence 2. Mix the dug out soil with wood ash and compost and return the mixture into the trench 3. Plant the seeds or cuttings

Examples of plants that can be used in a fence.

A. Upper canopy species	**B. Middle canopy species**
Moringa oleifera (horseradish tree) Sesbania grandiflora (katuray) Gitiricidia sepium (kakawate) Averrhoa bilimbi (karnyas) Psidium guajava (guava) Persia americana (avocado) Artocarpus altilis (breadfruit) Artocarpus heterophyllus (jackfruit) Annona muricata (soursop) Annona squamosa (sugar apple) Calliandra calothyrsus (calliandra)	Carica papaya (papaya) Musa spp. (banana) Citrus mitis (calamansi) Flemingia macrophylla (flemingia) Desmodiurn rensonii (rensonii)
C. Lower canopy species	**D. Understory crops and creepers**
Sauropus androgynus (Japanese milungay) Corchorus olitorius (jute) Capsicumfrutescens (chili) Manihot esculenta (cassava) Cajanus cajan (pigeon pea) Zea mays (corn) Pandanus odoratissimus (pandan) Maranta arundinacea (arrowroot)	Ananas comosus (pineapple) Zingiberofficinate (ginger) Colocasia esculenta (taro) Adropogon citraw (lemon grass) Sesamum orientale (sesame) Foeniculum vulgare (fennel) Ipomoea batatas (sweet potato) Ipomoea aquatica (swamp cabbage) Basella alba (basella)

Climbers

Psophocarpus tetragonolobus (winged bean)

Dioscorea alata (greater yam)

Dioscorea esculenta (lesser yam)

Pachyrrhizas erosus (yarn bean)

☞ 1.2 Activity 15

Model School Garden Project –Soil preparation and planting

This is the fifth stage in the preparation of a model school garden.

Task1:

Prepare lessons and teaching resources on at least one cropping system, which you will demonstrate in your model garden. Your lessons should have specific objectives for class and practical garden activities. You should be experimenting with different cropping systems in the college gardens.

Task 2:

Choose one of these activities:

Describe how you would prepare clay and poor soil for planting a mixed vegetable garden.

Or

*Make a chart, which explains how you would plant a living fence line at your school. In*clude names of plants, their uses for the school and drawings.

In the library, refer to "Good gardens good food good development" by Ellen Fitzpatrick and Elizabeth Cox, for further ideas on crop rotation and intercropping (pp 45-47) and "Good gardens for good food" by E. Cox (pp 29-32).

Topic 6: Pest Management

Objectives

At the end of this topic you will be able to:

- Identify the major pests to agricultural crops in Papua New Guinea
- Apply appropriate measures to manage pests

Resources

Liklik Buk

Good Gardens Good Food Good Development

Scope

This topic looks at pest control with an emphasis on organic control methods, which are environmentally friendly and economically sustainable for farmers and gardeners. It examines some of the major garden pests in Papua New Guinea and various methods for controlling them. There is a brief section looking at chemical sprays and pesticides. You will be encouraged to make and experiment with different organic insecticides. You will also continue to prepare resources for the establishment of a model school garden.

Pests and management

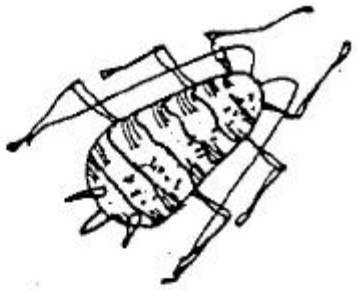
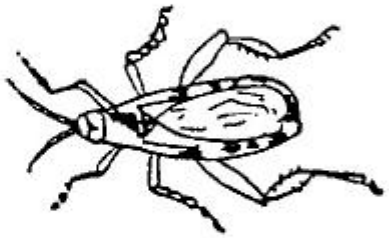
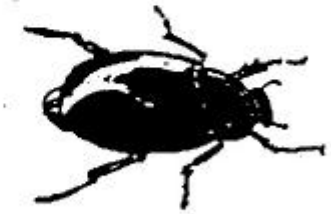
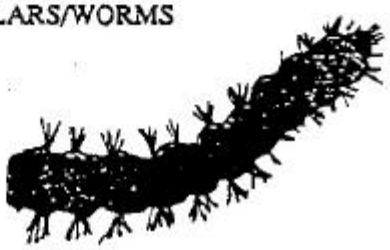
Insect pests cause a great deal of damage to crops. They can harm crops by biting, chewing or cutting them, by sucking plant juices and also by spreading diseases from their mouth parts or digestive juices

Pests can be controlled by pesticides, which are chemical substances used to kill pests. Many farmers use commercial inorganic pesticides which contain dangerous chemicals – these not only kill the pests but beneficial insects as well. Synthetic/inorganic pesticides can also poison the environment, kill the soil and harm the people who eat the sprayed food and live in the surrounding environment.

Chemical inorganic pesticides are expensive, often difficult to obtain and difficult to use safely. Many pest become resistant to pesticides in the same way malaria parasites become resistant to anti-malaria drugs

Alternative pest control is cheaper, simple to use and an effective alternative to commercial pesticides. They are also environmentally friendly in that they do not harm human health or beneficial pest predators.

Some common garden pests

Name of Pest		*Description*
1 APHIDS		Sucking insects attacking the leaves and stems. When attacked, the leaves and stems of the plants begin to look pale and spindly. Aphids can change colour to match plant parts and metamorphose from nymphs to adult, both with and without wings. When the aphids in one plant are overcrowded, they develop wings and fly to another plant host of the same plant family. Aphids mature in 12 days.
2. BORERS		Boring insects attacking the flowers, pods, stems and roots. Borers hatch, eat and grow inside plant part as caterpillars. The presence of borers is indicated by the sudden wilting of plant tops.
3. BUGS		Sucking insects that attach to plant parts and drain plant juices. In case of mealy bug, eggs are laid in white, cottony masses. Young are crawlers like scale insects. Bugs excrete large amounts of honeydew that attract ants and encourage black mould fungus.
4. BEETLES		Chewing insects which feed on leaves, flowers, stems and even roots. They feed on most vegetables. Severe infestation can defoliate plant.
5 CATERPILLARS/WORMS		Chewing insects usually developing from patches of eggs on the underside of leaves. The larval stage of moths and butterflies, caterpillars feed on foliage and tender stems.

☞ 1.2 Activity 16

Make a simple card game for children to play and learn about insect pests and predators. The type of game could be like 'snap' or any other adapted card game.

***Instructions for making and playing Snap**: Cards are playing card size. Pests and predators are drawn on one side of a card. One creature per card, two cards per creature. Cards are mixed, shuffled and dealt to players. In turn, each player plays a card face up. When two of a kind turn up the first person to call snap collects the pile of cards, but only if she/he can name the pest or predator. The winner is the player with the most cards.*

☞ 1.2 Activity 17

Model School Garden Project –Soil maintenance and pest control

In this section of your model school garden project, you will be required to undertake some individual research. All activities and information must support the establishment of a model garden and the teaching of new techniques to your class. Resources and plans should be added to your teaching portfolio.

1. ***Soil maintenance** (Refer to Module 1.1 Soil for useful techniques for maintaining healthy soil.)*

   What does soil maintenance have to do with pest control?

Choose one technique and prepare a lesson on maintaining healthy soil. Remember the lesson must involve the students in the school garden as well as in the classroom.

*2. **Pest control***

Gather knowledge from local gardeners about organic/natural pest control. Write these up in your portfolio book and include the pests for which these methods are designed.

Choose one organic insecticide recipe from Appendix 1. These insecticides will not harm pest predators or the environment. Write the recipe as an activity for teaching or for display in your class.

Gather the necessary ingredients and after making the chemical apply it to your crop and over several weeks take note of the results.

Natural pest management

This approach utilises different techniques other than the use of inorganic or synthetic pesticides to control pests. It involves natural pest population-control methods, including cultural, biological controls, and the use of botanical pesticides as needed.

1. Good soil preparation

This is the first important element in pest control strategy. A healthy soil means healthy plants, which are relatively more resistant to pests. A soil rich in humus hosts a wide variety of beneficial microflora that trap nematodes and destroy or keep in inactive disease organisms thereby encouraging beneficial insects.

2. Use of indigenous varieties

Traditional varieties are hardier and relatively more resistant to pests. They can withstand harsh environmental conditions better than modem hybrids.

3. Intercropping with aromatic herbs.

Several types of odorous plants can be grown together with the main crop to repel insects. The following are some examples:

Allium cepa (onion)

Allium odorum (leek)

Allium sativum (garlic)

Artemisia vulgaris (mugwort, worm wood)

Coleus amboinicus (oregano)

Hyptis suaveolens (bush-tea bush)

Mentha cordifolia (mint)

Ocimum basilicum (sweet basil)

Ocimum sanctum (sacred basil)

Tagetes spp. (marigold)

4. Pruning

Removal of diseased plants or plant parts prevents the spread of micro-organisms to uninfected areas.

5. Encouraging insect predators

Pests can be controlled by their natural enemies. By growing a variety of flowering plants, specifically those belonging to *Umbelliferae* family, such as, fennel (*Foeniculum vulgare*) and celery (Apium graveolens) insect predators will be attracted to stay in the garden. These beneficial insects feed on pests keeping the pest population low.

6. Multiple cropping

This provides genetic diversity to minimise pest increase. Variation in susceptibility among species or varieties to a particular disease is great given abundant hosts of a single species or variety; a pest could easily be spread from host to host. When the number of hosts declines, the pest numbers will also decrease.

7. Crop rotation

This is a practice of following a crop susceptible to a pest by a resistant crop. There is no build-up of the organism to a high level since the growth cycle of the organism has been broken.

☞ 1.2 Activity 18

Choose at least one of the above techniques to try on your garden plot and keep accurate records of any change.

Share and discuss the data gathered.

Make a chart for your classroom with the title ***Natural pest management.*** *Use creative ways to communicate the seven methods described.*

Encouraging predators

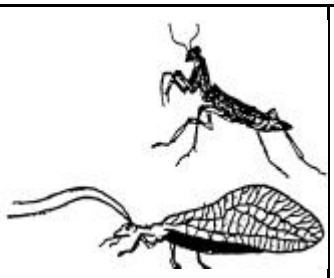
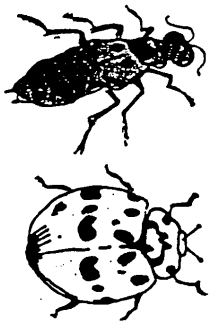
In nature, pests are usually controlled by the presence of insect predators and parasites which keep the populations of harmful insects in control. Most of the insects in nature are either beneficial or at least harmless. There are many ways to encourage insect predators in a garden.

1. **Create a Suitable Habitat for Insect Predators** : Flowering shrubs and trees throughout the garden will attract many beneficial insects, including parasitic wasps which require pollen and nectar for their growth and maturity. Plants belonging to *Umbelliferae* family are particularly effective in attracting natural enemies of pests.
2. **Provide Alternate Hosts for Pests**: To ensure availability of food for the beneficial organisms grow alternate host plants along fence lines or garden boundaries and in between cultivated crops. The natural enemy populations on these alternate host plants will control pests attacking the cultivated crop.
3. **Create Nesting Sites for Frogs, Reptiles and Birds** : Logs of dead trees, irregularly shaped rocks with crevices and cavities and plenty of mulch can be a good nesting sites for snakes, lizards, frogs rove beetles and carabid beetles, which feed on insects.
4. **Increase Humidity by Providing Water Holes**: Humidity is much needed for the survival of natural enemies. It serves as a source of drinking water for reptiles, birds and frogs. Many predatory insects live in on and near water. Well-vegetated small dams, little water pools and swales scattered throughout the garden will create conditions for the build-up of natural enemies.
5. **Practice Mixed Cultivation**: - Growing mixed crops and harvesting them in strips help maintain natural enemies and confuses pests. For fungal pathogens, the practice of mixed cropping is desirable as the chemicals given off by the root of another crop can be toxic to the pathogen. Mixed cropping also encourages soil microbes which in turn act as barriers to the fungal pathogen.
6. **Reduce Dust Build up in Crop Plants:** - Dust inhibits the functioning of natural enemies. Growing well-designed windbreaks and ground cover crops like centrosema and makuna bean will reduce dust.

7. **Avoid Spraying Chemical Pesticides**:- Chemical pesticides eliminate beneficial insects. If pest infestation reaches economic threshold levels and spraying cannot be avoided, use selective chemicals, such as:
    - Soil incorporated granular systemic insecticides for sucking insects
    - Stomach poisons; avoid broad-spectrum contact poisons
    - Insecticides with short-term residual action rather than persistent action

☞ 1.2 Activity 19

The following insects and animals are natural predators. What are some of the ways we can encourage them to live near our vegetable gardens?

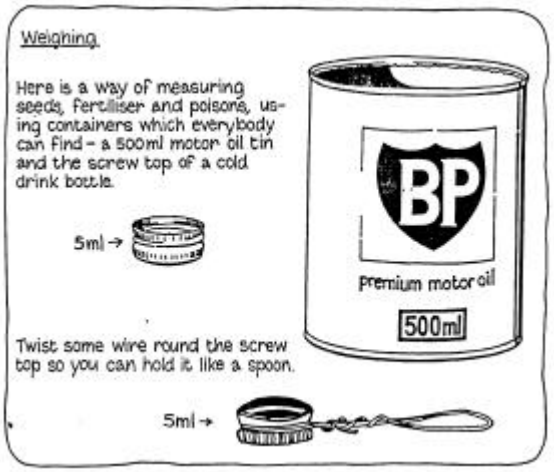
	*Praying mantis, Dragon fly, Assassin bugs* *Lacewings, Robber flies*		*Toads, spiders and snakes* *Birds*
	*Ground beetles, Rove beetles, Green carabid beetles and tiger beetles* *Ladybird beetles*		

Make a chart in your book and provide examples on the different ways these helpful animals can be encouraged to assist the gardener.

Often people's attitudes have to change before they can consider this type of organic pest control. How might you try to persuade a gardener of the advantages of organic pest control?

Chemical sprays and commercial pesticides

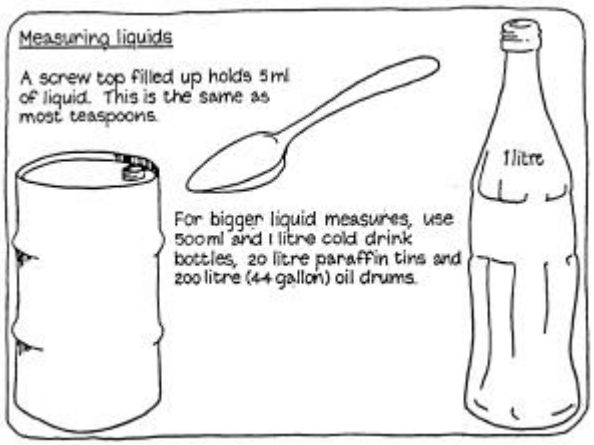
You can buy very strong chemical poisons for killing insects and other pests, but the problem is that they also kill useful insects and birds. Some chemical poisons stay in the soil and kill all insects and worms for many years. These poisons must always be handled carefully, because they are dangerous. If people eat or breathe some poisons or allow these poisons to touch their skin by mistake or through carelessness, they can get sick and even die. Many of these synthetic poisons are carcinogenic or cancer creating.
It is better and cheaper to grow crops without chemical poisons, but sometimes pests and diseases become so bad that you have to use chemicals.



Choosing a poison. There are many different chemical poisons. Find out which poisons are right for your particular crops. Ask someone who knows about poisons, such as an experienced farmer or farm adviser. Buy a poison, which you can get locally and which is easy to use. Ask for poisons, which do not stay in the environment for a long time.

How much poison to use. Poisons are very strong, so you usually have to mix them with water before you use them. In this module we don't tell you how much to use. We think it is better if you use the amount the poison makers say on their labels. Therefore, it is important to read the labels of poisons carefully, and to use exactly the right amount. You can measure poisons with a bottle cap. **Remember never allow poisons to touch your bare skin**.

When to use poisons. It is important to inspect fields often, to see when insects are starting to be a problem. Put on poisons as soon as you find lots of insects all over the field. Look carefully because some insects and insect eggs are very small. For example, aphids are hard to find. They are very small and live underneath leaves, so you must know where to look for them. Stalk borer worms hatch from eggs laid by white moths. When you see lots of white moths, wait for 10 days and then put on the poison. The eggs hatch after 10 days so the stalk borer worms are killed straight away. With fungus and bacterial diseases, you need to use poisons before damage, as a way of preventing damage.



Spraying. Most poisons must be sprayed onto the crops. There are many different sprayers to choose from. For spraying crops use one which you carry on your back and is easy to pump. Ask the shop or your agricultural extension officer what size sprayer is best for your crop and the poison you want to use. Make sure the sprayer does not leak, because the poison can get into your skin and make you sick.

Learn to read labels carefully. The label will tell you how dangerous a

poison is. Never smoke, drink or eat while mixing poisons. Wear overalls and gloves while mixing. Make sure you follow instructions. Afterwards wash your hands, gloves and face well. After applying poisons always wash your overalls with soap - do not wear them again until they have been washed. Bury empty poison tins. Don't leave them lying around or use them for anything else. Keep children away from poisons and from the fields where you are spraying.

☞ 1.2 Activity 20

What are the advantages and disadvantages of using inorganic/synthetic insecticides and pesticides?

What are some of the unintended consequences of inorganic pesticide use for soil health and human health?

Glossary

Agriculture	The cultivation of land, including raising crops and animals.
Agroforestry	Planting of food or forage crops in the same plots with young trees.
Alley cropping	Growing annual crops in spaces between rows of trees or shrubs, often leguminous ones that tolerate heavy and regular coppicing.
Annual	A plant that lasts for only one year. E.g. marigold, peanut, yam
Apiary	Place with a collection of beehives and where honey is separated from the comb.
Aquaculture	The deliberate production for human use of plant and animal organisms in water.
Biological control	The use of natural enemies to control pests.
Biomass	The weight of material produced by a living organism or collection of organisms, plant or animal.
Bund	A ridge of earth placed in a line with the contour of a slope to control water run-off and soil erosion.
Bush fallow cultivation	A system of farming which involves clearing a piece of land, cultivating it until the soil loses its nutrients, and then moving to another piece of land Usually such a piece of land is left fallow (unused) for at least ten years to regain its nutrients naturally, before it is used again.
Compost	A mixture of different kinds of organic matter, such as manure and plant remains, which is decaying. It is used to put nutrients back into the land and is the basis of organic farming.
Contour	An imaginary line on a field joining all places at the same height above sea level.
Contour ploughing	Ploughing or preparing the land along the contour lines of a hill; ploughing across the lines of a hill.
Cover crop	Annual crop sown to create a favourable soil microclimate, decrease evaporation, and protect soil from erosion.
Crop	Annual or perennial plants grown to yield products desired for human consumption or processing.
Deforestation	Destruction or removal of the forest cover from a piece of land.
Erosion	The process of wearing away the land surface through natural factors such as wind and rain. Erosion is encouraged by the clearing of bush and not replanting.
Evaporation	The process of water turning into vapour. Part of the water cycle
Extensive farming	Traditional slash and burn farming that relies on large areas of land under cultivation and fallow.
Fallow	Land left uncultivated for one or more growing seasons
Fertiliser	Any material which, when added to the soil, increases the supply of nutrients to encourage plant growth.
Fungicide	Chemical which can kill fungus.
Fungus	Plant lacking chlorophyll which lives on dead organic matter.

Green manure	Green plant biomass used as fertiliser.
Hardening	Putting young plants in the early morning sun or late afternoon sun for a period of time, before transplanting them.
Herbicide	Any chemical that is primarily designed to kill weeds.
Horticulture	The science or art of gardening
Humidity	The amount of water vapour in the air.
Humus	When compost is fully decomposed it is called humus. An important source of nutrients for plants.
Hybrid seed	Seed produced by crossing genetically dissimilar plants.
Inorganic fertiliser	Fertiliser made-up of chemicals, not organic.
Intensive farming	Making maximum use of the land through different cropping systems, composting – that allows the land to be farmed over long periods
Insecticides	Poisons which kill insects. They can be organic and inorganic.
Larva	The immature stage in the life of an insect.
Leaching	The process where water, filtered through the soil, removes material from topsoil and washes it away.
Legume	Plants belonging to the legume family, *Leguminosae*. They are able to fix nitrogen from the air. e.g. beans, peas and peanuts.
Loam soil	The best soil for plant growth. It is one part clay, two parts silt and two parts sand.
Microclimate	The temperature, humidity, sunlight and other climatic conditions in a small localised area.
Mixed cropping	Planting more than one type of crop without being constrained by the use of planting rows or lines.
Monocropping	Repeated growing of the same crop on the same land.
Mulch	Any material which when placed around plants serves to prevent water loss and inhibit weed growth. Mulch material can be dried grass, leaves, rocks or newspapers.
Multiple cropping	Growing two or more crops in the same field in a year, at the same time, or one after the other.
Mycorrhiza	Symbiotic relationship of a fungus with the roots of higher plants, which can increase the plants' capacity to absorb nutrients from the soil.
Nematodes	Roundworms/eelworms which cause disease in plants.
Nitrogen fixation	The process carried out by bacteria attached to the roots of some plants. It involves combining nitrogen from the air with other elements, making nitrogen compounds (nitrates) which plants can use directly. Legumes are nitrogen fixing plants.
Organic	Any chemical compound containing carbon or derived from living organisms.
Parasite	An organism that lives in or on another organism (the host) from which it obtains its food.
Parboiling	Partial boiling or steaming of rice grains.
Pathogen	Any micro-organism or virus that lives and feeds on or in a larger organism and thereby hurts it.
Perennial	A plant that lasts several years before dying. E.g. aibeka
Pest	An organism (insect, mite, weed, fungus, disease, animal etc,) that humans wish to control or get rid of.

Pesticide	Chemical that kills pests.
Progeny	The off-spring or young of an animal. Person or organism
Pruning	Cutting excess growth off plants, to encourage better fruiting.
Pulses	Grain legumes.
Root nodules	Swellings in the roots of legumes inside which bacteria live.
Shift cultivation	A system of farming that involves clearing a piece of land, farming it until it is worn out and moving to another piece of land. Farmers may or may not return to the original cleared plots. A major cause of deforestation.
Soil profile	A vertical cut showing topsoil, subsoil and bedrock.
Soil sterilisation	Heating soil to kill most soil organisms and most weeds.
Staking	Tying plants to stakes to encourage better growth and fruiting.
Staple	The main crop or produce grown and consumed. E.g. kaukau is a staple
Stomata	Tiny holes in leaves, which allow carbon dioxide to enter and moisture to leave.
Subsistence farming	Farming systems in which a larger part of the final yield are consumed by the farmer (producer)
Synthetic insecticide	Chemical and artificial usually made from oil. Not easily broken down in the food chain.
Topsoil	The surface layer of a soil, which is cultivated.
Transpiration	In plants, the process of breathing out waste matter, mainly water, through the stomata in the leaves, to keep cool.
Vegetation	A collective term for plants.
Weed	A plant growing where it is not wanted.
Wind break	The deliberate planting or building of a structure to reduce the direct force of the wind.

Appendix 1 Organic Insecticides

To make tomato plant solution

1. Chop up the stalks and leaves of one fully-grown tomato plant.
2. Pour 1 litre of boiling water over the leaves and leave them to soak for at least 5 hours.
3. Pour the solution through a sieve or filter to remove all the pieces of plant.
4. Add a cup of soapy water and spray on plants.

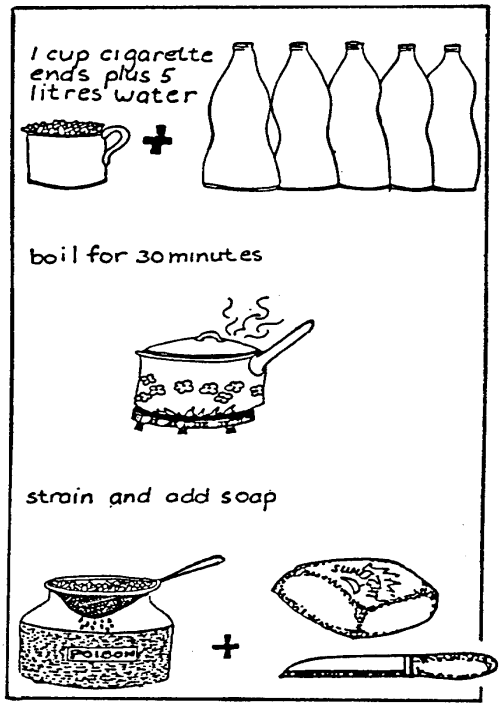
To make chilli solution

1. Take 100g (around 12 large fruits) of fresh, ripe chillies and cut them into pieces.
2. Add to 1 litre of water and soak for 24 hours.
3. Pour the solution through a filter or sieve to remove the pieces of chilli.
4. Add 5 litres of soapy water and spray on plants.

To make papaya solution

1. Take 1kg of fresh papaya leaves and tear them up.
2. Soak the leaves in 10 litres of water with 2 spoonfuls of kerosene and leave them to soak for 3 hours.
3. Pour the solution through a filter or sieve.
4. Add 10 litres of soapy water and spray on plants.

A chemical recipe for poisoning pests



The Neem tree (Azadirachta indica), an example of an organic insecticide.

1. Grind 200g of neem seeds (240 dried seeds) into a fine paste.
2. Soak over night in 10 litres of rainwater.
3. A little detergent, OMO or soap can be added to aid wetting the waxy surface of leaves.
4. Strain the solution, if a knapsack sprayer is to be used for the application.
5. Otherwise use twigs or leaves dipped into the solution for spreading the insecticide.
6. Do not spray when the sun is hot – apply early in the morning or late afternoon.

Target insects: **Lepidoptera** (moths and butterflies), **Diptera** (true flies, mosquitoes, midges), **Coleoptera** (beetles), **Othoptera** (locust, grasshoppers and crickets), **Hemiptera** (aphids, leafhoppers, cicadas)

For more information on the neem tree, refer to Module 1.6 School Nurseries and Tree Planting.

Appendix 2 Agricultural Research and Support Organisations

NARI – Bubia
PO Box 1639, Lae
Ph: 475 1198 Fax: 475 1034
Email: dsingh@datec.com.pg

NARI -LAES
Lowland Agricultural Experiment Station
PO Box Keravat, Rabaul, ESBP
Email: narilli@datec.com.pg

University of Vudal
PMB Service, Rabaul.
Library Ph: 983 9252
Administration . Ph: 983 9247

Fresh Produce Development Company (FPDC)
Head Office
FPDC
PO Box 1290
Mt Hagen .
Ph: 542 2242 Fax; 542 1462
Email: fpdc@datec.com.pg

Lae Office
FPDC
PO Box 3001
Lae.
Ph/Fax: 472 –2737

Food Processing and Preservation
PO Box 19
UNITEC Post Office, Lae.
Ph: 473 4562 Fax: 473 4579

Port Moresby Office
FPDC
PO Box 2788
Boroko, NCD.
Ph: 323 1882 Fax: 325 9067

Organisation of Industry Spiritual and Cultural Advancement (OISCA),
PO Box 426, Rabaul, ENBP.
Ph / Fax: 983 9290