Year 12

Agricultural Science

AGRICULTURAL SCIENCE

Year 12

GOVERNMENT OF SĀMOA
MINISTRY OF EDUCATION, SPORTS AND CULTURE

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Introduction

This is the student book for Year 12 students studying Agricultural Science. The book is divided into six parts and covers six strands. These strands are: agriculture; soils; farm management, economics and marketing; crop production; animal production; and tools, equipment and facilities. A glossary of terms is also included.

Agriculture

Part 1

Unit 1

Natural And Managed Ecosystems

The word ecosystem is made up of two parts: **1**. 'eco' which refers to the biological environment, and **2**. 'system' which means a collection of interdependent parts or events that make up a whole. A natural ecosystem is an environment that has not been disturbed by people, for example, a rainforest. A managed ecosystem is an environment that has been disturbed or changed, for example, a garden or farm. Communities of plants and animals in a natural ecosystem like the rain forest, are often affected by human activity on managed ecosystems. For example, when a farmer sprays chemicals on the farm, wind can carry small droplets of chemicals to the natural environment that will effect plants and animals in that community. The most obvious part of the ecosystem is the 'biotic community'. The 'biotic community' is defined as a naturally occurring community of plants and animals that live in the same environment, that sustain each other and are interdependent, and are constantly fixing, using, and giving off energy. The different organisms that make up the biotic community form populations of plants and animals. Although populations make up the community, individual organisms reflect the morphological and physiological characteristics of the species.

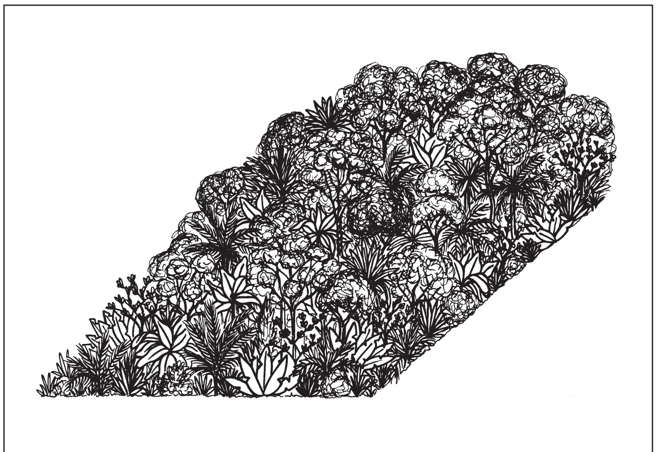

Figure 1.1 Natural ecosystem (forest)

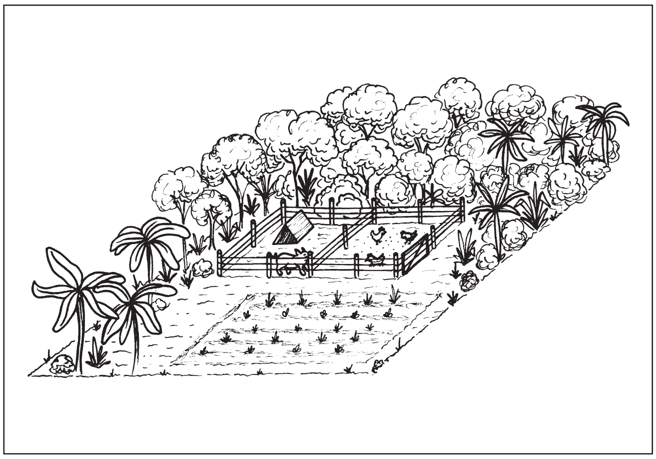

Figure 1.2 Managed ecosystem (farm)

Materials:

cardboard
pencil
coloured pens (optional).

Activity 1 Features of managed and unmanaged ecosystems

1 In pairs, observe and record features of the managed and unmanaged ecosystems your teacher has selected. Look at features such as types of plants and animals, population, food webs, nutrient cycle and soil erosion in each ecosystem.

2 Draw and label a flow chart of the two ecosystems side by side, showing organisms and how they interact.

3 Compare and discuss the major differences in features of the two ecosystems. In your exercise book make a chart like this:

Features of ecosystems	Major differences
Nutrient cycle	Continuous in a natural ecosystem and broken in a managed ecosystem by use of artificial fertilisers.

4 Write down some of the ways farming has changed the managed ecosystem you observed. (These are known as environmental impacts.)

Activity 2 Investigation

1 In pairs, investigate a regional or global problem with managed ecosystems. You can use information from the Internet, University of the South Pacific (USP) and public library, Ministry of Agriculture, Forestry, Fisheries and Meteorology (MAFFM), Food and Agricultural Organisation (FAO), United Nations Educational, Scientific and Cultural Organisation (UNESCO) and publications in books, magazines and newspapers. Use the following guideline to write a 1500-word report (about three typed pages):

- ❑ problem
- ❑ location
- ❑ introduction
- ❑ body (discussion)
- ❑ conclusion
- ❑ recommendations.

Review

1 What is the difference between a managed and unmanaged ecosystem?

2 Give example of unmanaged ecosystems in Sāmoa.

3 Which category does a reserve area come under? Give reasons for your answer.

4 How do activities in a managed ecosystem, for example, a farm, effect unmanaged ecosystems?

Unit 2

Genetics

Breeding And Genetic Improvement In Dairy Cattle

In most tropical countries there is a great potential for increasing milk yield by a combination of improved husbandry and improved breeding.

Improved genetic merit can be achieved in one of three ways:

1. selection for increased production within local stock
2. by crossing local stock with other breeds of indigenous or exotic cattle
3. by replacing local cows with other breeds.

The second method is most common because better cows are not always available and can be expensive. Farmers starting a new milk-production enterprise will want to begin with the most suitable breed. They will usually begin with local cattle and then improve their herd by one of the above methods.

Culling And Selection

In larger herds, when the level of management and husbandry are good, it might be possible to improve milk yield by increasing the genetic merit of the herd through culling and selection. Slow genetic improvement can be brought about by removing poor milkers from the herd and replacing them with better milk-producing cows. The degree to which improvement by this method can be achieved depends on the heritability of the traits for which selection is made. The heritability of milk-producing traits is relatively low.

Heritability is defined as:

- that part of the total variability (difference in a group of animals) that is carried on to the offspring
- a measure of how much a cow or bull can pass on its characteristics to its offspring.

However, a farmer with only two or three cows has little opportunity to influence the genetic merit of future cows by culling or selection. Such a farmer may have only one female calf born each year and will need to keep all female calves born to either replace the older cows or to allow the herd to grow. If the chance arises to replace a poor-producer cow with the daughter calf of a better producer, this option should be taken. If cows are poor producers only because they have suffered from a disease such as mastitis, then their daughters might also be worth keeping.

Records and experience will help the farmer to make such a decision. Without good records, improvement is difficult to achieve. **Selection indices** should be based on production traits and aspects of economic value, i.e. poor milk producers should be culled and their daughters should not be used for future milk production. The larger the herd, the greater the potential for overall improvement by culling and replacing with better stock. Genetic improvement by selection is slow even when numbers are high.

Having good records can assist the farmer to identify good milk producers and to improve the quality and total milk production of stock.

Crossbreeding And Grading-up

The quickest way to achieve increased milk yield by genetic improvement is by crossbreeding stock with a breed that has a higher genetic potential to produce milk. Such a breed is often called an 'improved breed' or, if it comes from somewhere else, an 'exotic breed'. These terms are misleading, because breeds which do well in some environments may do less well in other environments. Hence, exotic breeds do not necessarily perform better in local conditions than local breeds and are, therefore, not necessarily an 'improvement'.

Increased production by crossbreeding is most easily achieved through the male line by using an 'improved bull' or by AI. With the development of the technique of multiple ovulation and embryo transfer (MOET), rapid improvement through the female line is now possible.

An important benefit from crossbreeding is **hybrid vigour** – the half-breed is more vigorous and able to survive better than the parents.

If crossbreeding is to be undertaken, the farmer must have a high skill level for stock management and animal husbandry.

A bull, such as a Sahiwal, Jersey or Friesian, may be crossed (bred) with a local cow. The first cross (generation) will be a 50/50 grade animal. If the first generation offspring are crossed with one of the parent breeds, the next generation will be genetically closer to the parent breed.

Because the second cross (generation) will be a back-cross to one of the parent breeds and will produce a 75/25 cross, it is difficult to maintain a 50/50 crossbred population. This is a problem in crossbreeding, and the farmer must choose the method of crossbreeding that achieves the best grade animal for the environment. Crossbred bulls can also be used.

Criss-crossing breeding uses an exotic bull in one generation and a local in the next. **Three-way crossbreeding** alternates between three (or more) breeds of bull.

Local cow x Improved bull

⇩

First cross (50/50 Local/Improved)
Better first cross cows x Local bull

⇩

Backcross (75/25 Local/Improved)
Better backcross cows x Improved bull

⇩

Upcross (37.5/62.5 Local/Improved)
And so on . . .

Figure 2.1 An example of criss-cross breeding showing percentages

If a homozygous dominant (HH) polled bull is crossed with a homozygous recessive (hh) horned cow the first generation (F1) will both be heterozygous (polled). When crossing the two heterozygous polled cattle the second generation will give one homozygous dominant (HH) polled, two heterozygous (Hh) polled and one homozygous recessive (hh) horned.

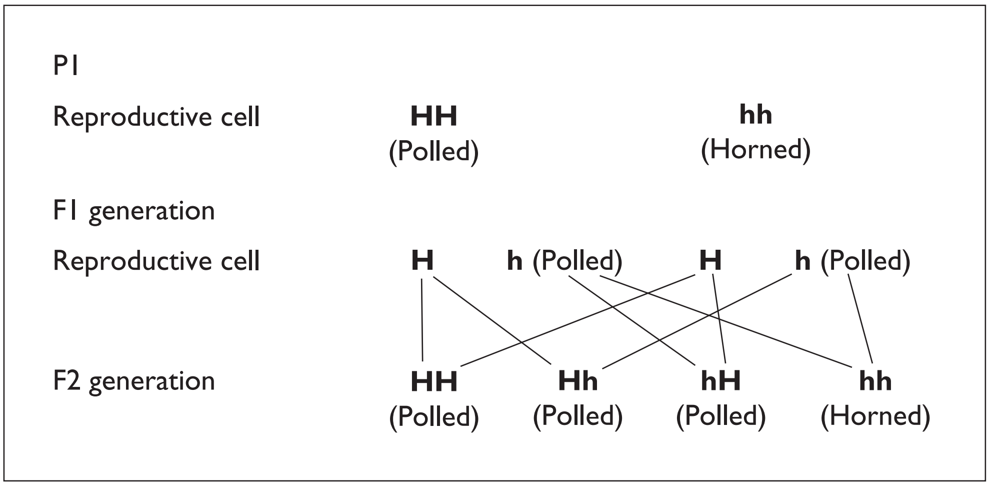

Figure 2.2 Genetic chart showing heritability

Progeny Testing

Older bulls can be assessed by the performance of their daughters. Bulls used for AI are often selected by this method, but it takes six or seven years from a bull's birth until lactation results of its daughters are available.

It must be remembered that most exotic bulls are tested in an environment very different from the tropics. They may not perform as well in the tropics as in their original environment.

Activity 1 Selection of breeds

MAFFM is encouraging interested people to go into dairy farming.

1. If you were to go into dairy farming what breeds would you use?
2. Explain why you selected these breeds.
3. Describe the options you have for obtaining your desired breeds. Which option would you select?
4. Explain why you selected that option.

Activity 2 Using genetic charts

1. Use a genetic chart to find the genotype (genetic make-up, for example, hh) and phenotype (physical characteristic, e.g. red coat) of the first and second generation when a red coat (RR) bull is crossed with a white coat (rr) cow.
2. Find the percentage of the genotypes.
3. Repeat steps 1 and 2 using Punnet squares (Agricultural Science Year 11 Book 1, Page 11.)

Review

1. What is the difference between a breed and a variety or cultivar?
2. List the reasons why selective breeding is used by farmers?
3. List some disadvantages of breeding.
4. Normal breeding programmes take a long time to develop the desired breed or variety. How can this period be shortened?
5. Explain why breeds of pig and cattle in temperate countries like New Zealand are not suitable for Sāmoa.

Soils

Part 2

Unit 3

Soil Fertility Management

Evaluation Of Crop And Soil Management System

Soil management is the science of tillage, cropping practices and the treatment of soil for crop production. The main objective is sustained profitable production. Soil conservation is the prevention of soil erosion and good soil management. Soil erosion is a symptom of poor soil management. Many factors that the evaluation of a crop and soil management system. These factors include organic matter, cultivation practices, plant nutrient supply, presence of weeds, insects and disease, water intake and soil erosion. Different soils have different management requirements. Any management system must be evaluated in relation to these requirements.

Soil fertility evaluation

Soil fertility evaluation is the process by which nutrient problems are diagnosed and fertiliser recommendations are made. The approaches that are used for soil fertility evaluation include observation of deficiency symptoms in plants, soil testing, plant analysis, and biological techniques like missing element and field trials.

Deficiency symptoms in plants

Mobile nutrients (Nitrogen [N], Phosphorus [P], Potassium [K] and Magnesium [Mg]) show symptoms in old leaves. Immobile elements (Sulfur [S], Calcium [Ca], and micro nutrients except Chloride [Cl]) first show symptoms in young leaves.

Looking for symptoms in leaves is a cheap and quick way to diagnose deficiencies, and no equipment is required. The disadvantages are that by the time the leaves show symptoms of stress it is too late to apply fertiliser. Also, different deficiencies can produce similar symptoms. For example, yellowing of old leaves may be caused by nutrient deficiency, or moisture loss. Wilting may be caused by pest damage, or abnormal weather conditions such as drought.

Soil testing

Soil testing is the chemical method of estimating the nutrient supply power of a soil by measuring the available nutrients in a soil sample. Soil tests are carried out in a laboratory using special equipment. The main advantage is that deficiencies can be identified from a small soil sample before planting. Disadvantages include problems in obtaining a representative sample. Tests need to be done for each soil type and sometimes it is difficult to select a correct soil extractant. Soil test results for micro nutrients are of little value unless pH levels are taken into consideration. Results need to be analysed carefully before making a fertiliser application. However, many factors effect responses to a nutrient, for example, climate, tillage and crop.

Plant tissue testing

Nutrients in plants relate to the nutrients in the soil. The two general types of plant analysis used are: testing fresh plant tissue in the field, and total analysis in laboratories. One problem is that a shortage of a particular element will limit plant growth. Therefore other nutrients may accumulate in the plant and show high test results even if the soil nutrient supply is not high. It is essential to test the part of the plant that will give the best indication of nutritional status.

Nutrient concentration varies with the age of a plant, between species, and in different weather conditions. It may be too late to save some plants by the time a deficiency is identified. However, plant tissue testing is a good technique to use to determine soil nutrient supply if other interactions are minimal.

Testing techniques

Plant growth performance, based on fertiliser applications, is used to measure the fertility status of soils.

In field testing a series of treatments are applied. Observations are made of plant growth, and soil and plant tissue are tested to answer experimental questions. The process is repeated to ensure reliability of results and to account for soil and management variations. The results are used to make general recommendations that can be used for similar soil types.

Laboratory and greenhouse tests are similar to field tests. They obtain results faster than field tests.

Effects of lime, manure, and fertilisers on soil properties

Lime is added to soil to increase pH levels. The soil pH increases because some hydrogen ions are removed. Commonly used liming materials include:

- calcitic limestone ([$CaCO_3$], commonly known as limestone)
- dolomitic limestone (CaMgCO3) is good for Mg deficient soil
- burnt lime (CaO) reacts quickly in soil and has the ability to neutralise a lot of hydrogen due to its low atomic weight
- hydroxide of lime (Ca[$OH]_2$), which is burnt lime with water added, is caustic and unpleasant to handle. It also has a high reaction speed.

Factors that affect the action of lime include:

- particle size – fine limestone particles will dissolve faster in the soil and raise the pH faster

- degree of mixing with soil – it is best to apply lime before tillage so that during tillage, lime and soil particles become well mixed
- neutralising value – when deciding which type of limestone to use consider the neutralising value of the types of lime available, e.g. Mg content.

Table 3.1 Neutralising value of selected liming material

Liming material	Neutralising value
Calcium carbonate	100
Dolomitic lime	100
Calcitic limestone	95
Hydrated lime	125
Burnt lime	160
Marl	70
Basic slag	60
Wood ash	45

The amount of lime to apply needs to be determined by soil tests and observations. When applying lime consider the soil pH, the cation exchange capacity (CEC) of the soil, and the crop to be grown. Some general guidelines are set out below:

Table 3.2 Guidelines for the application of lime

Soil type	Lime application rate	Frequency of application
sandy soils	1000–1500 kg/ha dolomitic limestone	2–3 years
clay loam	4000–5000 kg/ha	3–4 years
2:1 clay soils	6000–8000 kg/ha	4–6 years
organic soils	soil test needed to determine how much lime to apply	

Organic matter management

The cation exchange capacity of soil is its ability to attract and exchange cations. The source of negative charges in the soil that make this possible are organic matter and clay minerals.

Organic matter is any living or dead plant or animal material in the soil. Soils with high levels of organic matter are fertile and black in colour. The level of organic matter in soils can be raised by adding mulch, green manure and organic fertiliser.

Organic matter is often confused with humus. Humus is the substance which remains after soil organisms have modified organic materials and caused them to decay. Humus is the colloidal remains of organic matter.

Fertiliser management

Good root development helps the up take of fertiliser, but fertiliser placement is also important. Movement of fertilisers in soil must also be considered, e.g. nitrates move most freely, but ammonia moves very little until converted to nitrate. K moves little except in sandy soils and movement of P is limited. Band application provides a rapid start in the physiological process of fertiliser absorption. In cool conditions N, P, K and Zinc (Zn) are generally less available to young plants. Band placement improves their absorption. Broadcasting is the best means of applying large quantities of nutrients. P has limited mobility and must therefore be placed in the root development zone. Application of small amounts of N at planting improves the absorption of P.

The Nutrient Cycle

Before a natural area is cleared for development the soil and forest have a closed nutrient cycle. Most nutrients are stored in the biomass and topsoil and is transferred from one to another via rain water, litter fall, timber fall, root decomposition and plant uptake. The nutrient cycle is broken due to clearing and burning and physical and chemical changes takes place.

Nutrients in the soil come from minerals broken down from rocks, decomposition of plant and animal materials, and from the atmosphere. Nutrients are lost from the soil mainly by plants absorbing them, soil erosion and leaching. Many animals use plants as food and also take up nutrients from the soil. These nutrients are cycled back into the soil as animal waste and where animals decompose. When soils have been overused for growing crops they will have a low nutrient level. Crops do not grow well at low nutrient levels. Therefore, farmers have to add organic and inorganic fertilisers to improve soil condition. In a natural ecosystem there is a balanced continuous cycle of nutrients. In a farm situation or managed ecosystem, however, the nutrient cycle is broken. This means soils tend to lose nutrients after a few years of intensive farming. Nutrients are then added through the application of fertilisers. It is important to maintain a balanced nutrient cycle that allows a continuous flow of energy in ecosystems.

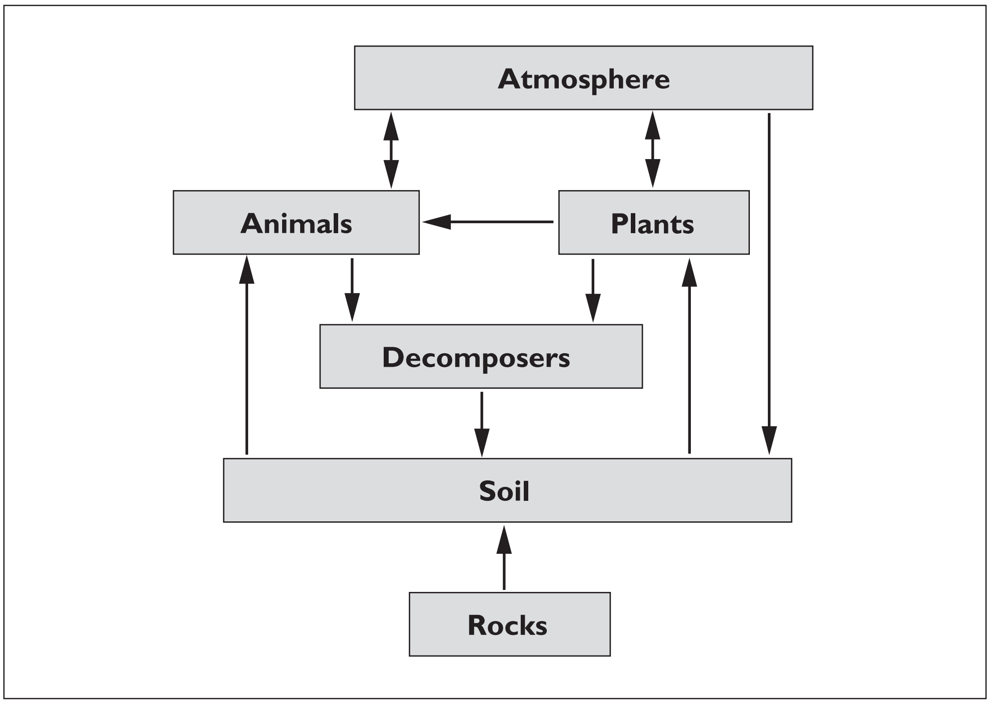

Figure 3.1 The nutrient cycle

Activity 1 Determining soil fertility

Materials

spade
soil auger
plastic bags
bucket
pH meter or litmus paper
cylinders

1 Divide into groups of three.

2 Select one method of determining soil fertility: soil colour, soil pH, soil structure, soil texture or plant growth appearance.

3 Go out into the school garden as a class and collect 1 kg samples of soil from nine different places using a Z pattern. Collect nine different 1 kg samples.

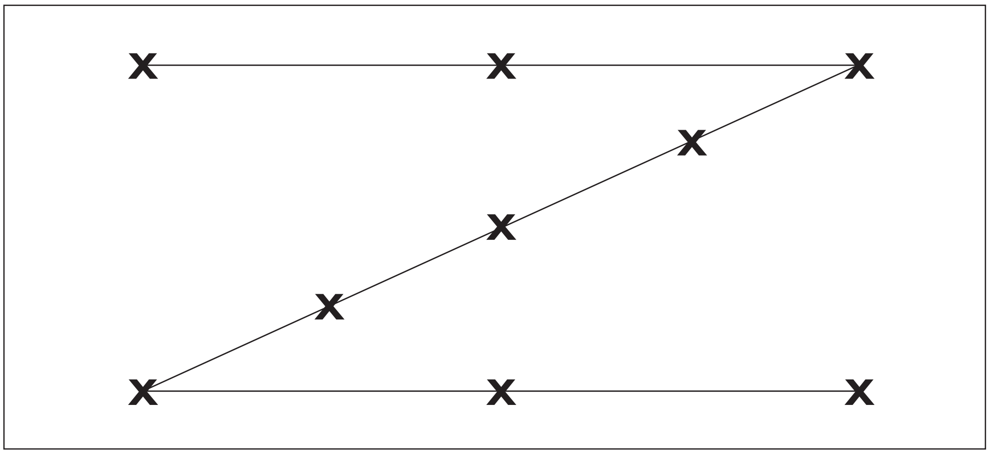

Figure 3.2 Sample collection

4 Mix all the soil samples together.

5 Take a soil sample for your group and determine its properties.

6 Record your class results on a chart similar to the one below.

Table 3.3 Soil fertility indicators

Groups	Soil Fertility Indicators of School Garden Soil				
	Soil colour	**Soil pH**	**Soil structure**	**Soil Texture**	**Plant appearance**
Group 1					
Group 2					
Group 3					

7 Use the table below as a standard to determine if the school garden soil is fertile or not.

Table 3.4 Indicators of fertile soil

Indicators of fertile soil				
Soil colour	**Soil pH**	**Soil structure**	**Soil Texture**	**Plant appearance**
Brownish black to Black	6–7	Granular	Loam soil	Healthy and dark green leaves

8 If your indicator shows that the soil is not fertile, discuss and list methods you can use to improve the soil fertility in your school garden.

Activity 2 Nutrient cycle

1 In your groups, discuss the nutrient cycle on page 14 then draw and label the nutrient cycle of your school garden.

2 Present your diagram to the class explaining the importance of micro-organisms in the nutrient cycle.

Review

1 Where do nutrients in the soil come from?

2 List methods we can use to maintain or improve the fertility of soils.

3 How can you reliably determine the fertility of a soil? List the steps.

4 Describe the role of micro-organisms in changing soil fertility?

Unit 4

Soil Conservation

Soil conservation mainly concerns the protection of soil from being eroded.

Soil Erosion

Soil erosion is defined as the removal of materials from the surface of the land by weathering, running water, wind and mass movement. Soil formation and soil erosion are two natural and opposing processes. Many natural undisturbed soils have a rate of formation that is balanced by a rate of erosion. Under these conditions, the soil appears to remain in a constant state as the landscape evolves. Erosion problems occur when the natural plant cover is removed and the rate of soil erosion is much greater than the rate of soil formation. Under these conditions, there is a need for erosion control practices that will reduce the erosion rate and maintain soil productivity. Erosion is a three-step process beginning with detachment, followed by transport and deposition. The energy of erosion comes from falling rain and then the movement of runoff water, or from the wind. Most soil erosion is caused by runoff.

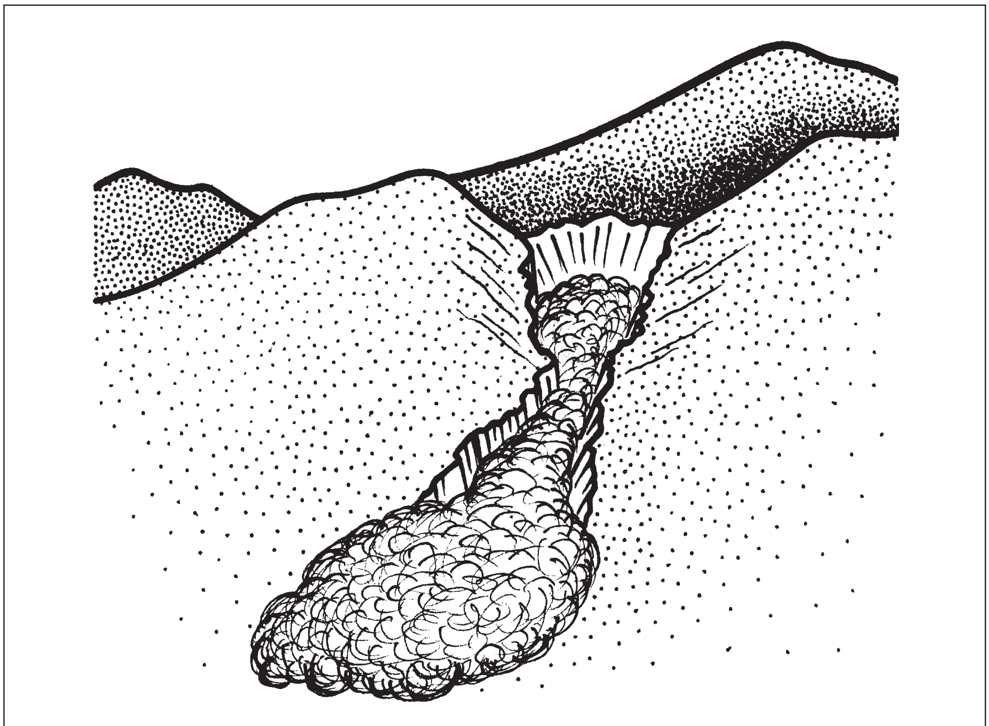

Figure 4.1 Soil erosion

Water erosion

Water erosion takes place whenever flowing water passes over loose soil and carries some of it away. There are four basic types of water erosion: splash erosion, sheet erosion, rill erosion and gully erosion. Splash erosion occurs when raindrops hit the soil surface and break soil aggregates into fine particles that can be carried away. Sheet erosion occurs when water moves across the soil surface and removes thin sheets of soil. Rill erosion is when water moves across the soil surface and cuts many small ditches several centimetres across. Gully erosion happens when water flows across one place long enough to cut large gullies. Factors influencing water erosion are rainfall, slope and vegetation. Water erosion can be controlled by agronomic practices (crop and vegetation, cropping pattern – mixed, contour and strip cropping, mulching, reforestation, manure and fertiliser application) and engineering practices, e.g. terracing.

Wind erosion

Wind erosion is greatest in dry areas and it is directly related to water conservation because lack of water leaves land barren and exposed to the wind.

Erosion as a result of human activity

Human activities like deforestation, poor farming systems and overgrazing have increased soil erosion.

Damage caused by erosion

Damage caused by erosion includes the removal of fertile top soil, the loss of nutrients and water, a decrease in productivity of the remaining soil, deposition of infertile subsoil over an area of productive soil, cutting up of fields into irregular pieces, irrigation problems, reduced water storage capacity, and leaching of nutrients and pesticides into water courses.

Cropping Systems

Shifting cultivation

Shifting cultivation is the planting of crops in one area for 3–4 years before moving to another area.

It is a commonly used form of soil management. The physical changes that occur as a result of shifting cultivation include soil and air temperature increases, changes in soil moisture level, and soil structure deterioration, which leads to runoff and erosion.

The chemical changes that take place include increased soil pH. (This is beneficial for acidic soils due to an increase in Ca and Mg). In high base status soils burn-off ash may raise the pH up to 7–8 and may cause iron (Fe) deficiency. Phosphorus and K increase due to ash. Organic matter and N content increase due to partially burned material.

Continuous cultivation without fertilisers leads to a decrease in yields. To increase crop production, use improved varieties and recommended plant spacing, increase the length of fallow and use organic fertilisers.

The fertility decline as a result of continuous cultivation can be corrected by fertilising or manuring However, in many areas it is uneconomic to use large amounts of fertiliser because of the cost of fertiliser and transportation.

A combination of minimum tillage, mulching, and multiple cropping, with small applications of fertiliser has been successful in maintaining good yields on a continuous basis in certain areas previously under shifting cultivation.

Multiple cropping

Multiple cropping is growing of different crops at the same time (intercropping) or the same crop planted at different times (phase planting) in the same field, and harvested in a single year. Intercropping is where crop intensification happens in both time and space. This is also called simultaneous cropping. There are four main types of intercropping: mixed, row, relay and strip intercropping. Intercropping is more efficient than monocropping (growing only one crop) because it makes better use of sunlight. Intercropping has higher efficiency in using soil and fertiliser; has fewer problems with weeds and pest and disease control; and makes better use of available manual labour and low energy technology.

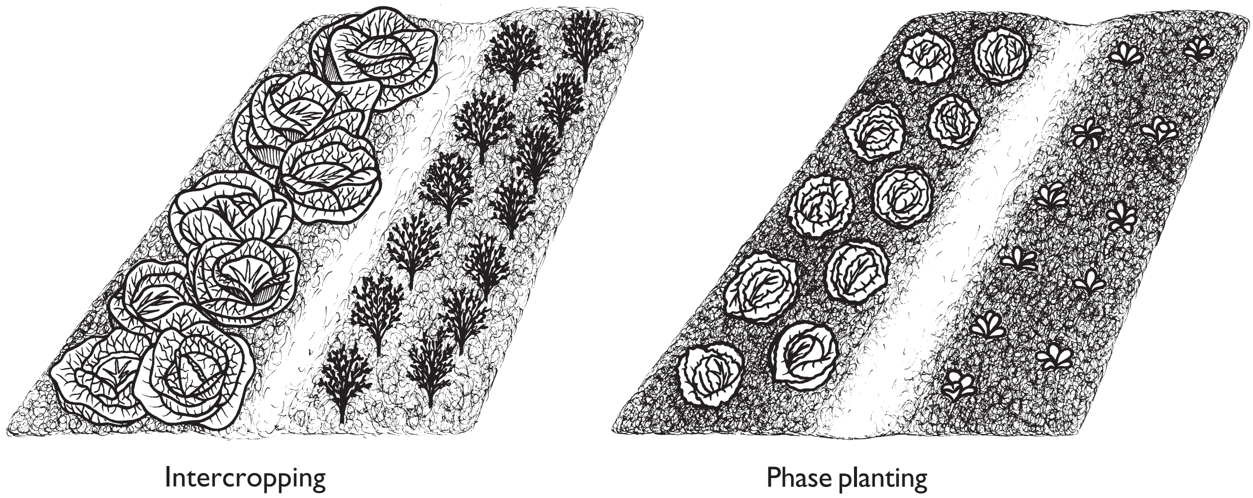

Figure 4.2 Intercropping and phase planting

Sequential cropping is a system that involves intensification in time only such as, double, triple, quadruple, or ratoon cropping. It makes better use of available sunlight, heat and available moisture.

Activity 1 Understanding the text on soil conservation

1. Divide into groups of five.
2. Select a leader for your group.
3. Each group member is to read one paragraph of the text about soil conservation. Write down the main points of the paragraph you read. Allow five minutes for this.
4. Discuss what you have read and written with your group.
5. The teacher will brainstorm, discuss and write on the board the main points of soil conservation with the class.
6. Do the same (steps 1–5) for the text on cropping systems.

Activity 2 Comparing land use systems

In groups of three or four study the table below which shows the soil properties for three types of land use.

Table 4.1 Soil properties for different types of land use

Soil Property	Natural ecosystem	Beef farm	Vegetable farm
Soil colour	Dark	Dark brown	Brown
Structure	Granular	Platy	Crumb
Soil pH	6.7	6.0	5.7
Soil organisms	Very high	High	Low
Pore spaces	High	Low	High
Organic matter	Very high	Low	Low
Soil erosion risk	Low	High	High

1 Beef and vegetable farming are two different land use systems. Discuss and write down which of the two systems is better for maintaining soil properties? Give reasons to support your answer.

2 Discuss and suggest agricultural practices that can help improve and maintain good soil properties for beef and vegetable farming.

3 Have a class discussion, comparing answers from each group.

4 Write a paragraph in your exercise book making improvements to your answers based on the class discussion.

Review

1 Why is soil conservation important?

2 Why should farmers work to reduce soil erosion?

3 List the agents of soil erosion.

4 What are some farming practices we can use to reduce soil erosion?

Unit 5

Determining What Enterprise To Operate

Gross Margins

Farm management advisors use the concept of marginal costing and it is now accepted as the most useful method of management accounting for agriculture. Agriculturalists usually call it gross margin but, sometimes, gross profit.

Gross margin is the difference between the value of production and the marginal cost of that production, i.e. it is the surplus (or deficit) remaining after deducting variable costs from the value of production or gross income.

The basis of gross margin analysis is to think of a farm as a group of independent, productive enterprises, centered on the farm unit, which provides common services and co-ordination. The table on page 22 gives some examples of enterprise gross margins taken from surveys of large-scale, mechanised, commercial farms in Zimbabwe. Enterprise gross margins organise a shapeless mass of costs and returns into recognisable pieces. Any increase in whole-farm gross margin will raise profit by exactly the same amount, provided common costs stay constant. Thus, provided an enterprise has a positive gross margin, it may be worth keeping even if its total costs, including overheads, exceeds the value of production. However, it would be even better to replace it with an enterprise with a higher gross margin.

The gross margin of a farm activity is the difference between its gross income and the variable costs. This is the most common measure in farm analysis and planning. Enterprise gross income is the total value of production, which may differ from sales income. It also includes produce consumed by the farm family, given as gifts or transferred to other farm enterprises. Changes in the value of stock in hand also need consideration. This is important especially with livestock and perennial crops. Annual gross income, therefore, is the sum of sales income and the value of produce used by the farm household or farm labour, after various adjustments. Adjustments include deducting livestock purchases, and adjusting for the changes in the value of growing crops, livestock and stocks in hand. With annual crops, like tobacco and cotton, gross income usually equals total cash income as stock are rarely kept from one year to the next. In other cases, however, such as a beef herd that is changing in size, gross income and cash income may vary widely.

For example,

	$	$
Closing value of cattle	9000	
Cattle sales	1000	10 000
Opening value of cattle	10 000	
Cattle purchases	500	10 500
Cattle gross income (deficit)		(500)

Here, the cattle gross output consists of $1000 from sales, less $500 purchases and less $1000 drop in value. Therefore, it is negative.

Gross margins from livestock enterprises must allow for inventory changes during the year in addition to the sales of animal, animal products and by-products. The following example shows typical adjustments to variable cost items for changes in the value of stocks in hand:

	$	$
Purchases of poultry concentrates	1200	
Plus opening value of stocks	50	1250
Less closing value of stocks	100	
Poultry concentrate variable cost	1150	

The concentrate cost relating to this year's gross output is $50 less than the cost of purchases because $50 worth of purchases remains for next year's production.

It is important to account for product transfers between enterprises on the farm. If you do this, you can accurately compare the relative profitability of the enterprises. Valuations are necessary for all saleable products. These include, for example, an incalf heifer moved from a rearing to a milk production unit, or a weaner pig moved from a breeding to a fattening enterprise. Each product valuation should be at market price less what it would have cost to market it. This is its opportunity cost. The opportunity cost should form part of the gross output of the giving enterprise, and it should be one of the variable costs of the receiving enterprise. This is most important for making decisions such as whether to buy replacement stock or to rear them on the farm, and whether to have a fattening enterprise or to sell weaners.

Grazing and fodder crops, such as silage, are not usually saleable so they have no gross income or gross margin, only variable costs. These are allowed for by adding to the variable costs of the livestock enterprises. If more than one livestock enterprise consumes these products, we split their variable costs in proportion to the quantity used by each enterprise. Good gross margin costings need full and accurate physical records and financial accounts because any errors multiply quickly with changes in activity level.

There is a constant relationship, within any enterprise, between gross income, variable costs and gross margin, because of the nature of variable costs. This is true whatever the size of enterprise, provided technical efficiency, costs and prices stay constant.

Gross margins are used by farm managers to breakdown and evaluate the efficiency of each enterprise on a farm and decide which activities are most profitable. They form the basis of most analysis and planning processes that enable farmers to understand their businesses better. Calculating gross margins is a simple and direct process. It is a useful first stage of any form of farm budgeting and planning. A farm adviser needs only to identify production and planning constraints and to budget incomes and variable costs for each activity.

Gross margin planning helps to answer questions such as, 'What would be the likely financial effect of:

a 'changing the scale of production of an enterprise or dropping it?'

b 'buying in stock feeds instead of growing them?'

c 'a change in prices or costs?'

d 'a change in a contract?'

Table 5.1 Examples of Gross Margins for Mechanised Commercial Farming

Enterprise	Flue-cured Tobacco	Maize	Rain fed cotton	Rain fed groundnuts
Yield [kg/ha]	1580 ($/ha)	5820 ($/ha)	1894 ($/ha)	1180 ($/ha)
Gross income	1915	400	617	433
Fertilisers	141	100	57	27
Chemicals	110	11	107	12
Fuel	49	21	18	15
Tractors and Implements	46	21	18	15
Machinery contract	1	2	22	–
Labour	301	49	128	93
Building repairs	11	–	–	–
Coal	73	–	–	–
Seed	–	16	8	40
Insurance	56	–	3	–
Packing	22	15	7	–
Transport	17	12	10	–
Levies/selling costs	78	2	9	–
Other	26	5	19	18
Total variable costs	931	254	406	220
'Work'-days	385	55	141	170
Gross Margin/ha	$984	$146	$211	$213
Gross Margin/ 'Work'-day	$2.56	$2.65	$1.50	$1.25
Gross margin/ $ Variable cost	$1.06	$0.57	$0.52	$0.97
(Whole-farm common costs = $27 000)				

It is often possible to plan with gross margins alone and to ignore common costs. Most local farmers have few common costs – they do not pay rent, or wages to family labour, have hardly any buildings or equipment and borrow little capital. Most of their costs are variable so most of the total gross margin is family income. Increasing the size of enterprises with high gross margins and reducing those with low ones will usually raise profit.

Marginal analysis techniques are useful especially when the production cycle is a year or less. Use the actual period for, say, fattening a pen of cattle, if it is less than a year. Costs and returns are then directly related to a specific crop or batch of livestock.

Accurate comparisons require the use of a common resource unit measure for all the activities being compared. This unit can be any of the following:

- land area, if each activity uses the same class of land
- per hour of labour during a critical period, such as planting, weeding or harvesting
- per $100 of annual working funds or capital invested
- per head of livestock.

If the available family labour, or village labour in the case of co-operative enterprise, is fixed, labour may be the most suitable basis for comparison. If land is the scarcest resource, including enterprises with the highest gross margins per hectare will maximise whole-farm gross margin. However, labour or capital is often the most limiting resource and the farmer should then try to maximise gross margin per man-day or per dollar spent. Table 5.1 shows that if land is most limiting, the best enterprises to include are tobacco, groundnuts, cotton and maize; in that order. If labour is most limiting, the best order becomes maize, tobacco, cotton and groundnuts. Planning for the highest gross margin per unit of the scarcest resource is a useful shortcut. However, any changes in common costs, capital, or labour demand need to be considered.

On farms with several different activities, the total or whole-farm gross margin is the sum of the gross margins of each activity. The farm business will be unviable unless it earns a sufficient whole-farm gross margin to cover its common costs and earn an acceptable profit. It is necessary to decide the target whole-farm gross margin needed when planning begins. This means listing all expenses to be met other than enterprise variable production costs. The whole-farm gross margin target must cover:

- general farm overheads. These are based on financial statements from the previous year. They include rent, rates, accounting fees, office expenses, interest, bank charges and unallocated labour and machinery costs
- tax liability for either income or company tax
- repayments on long- and medium-term loans. It is vital to allow for these annual cash expenses
- capital costs for buying new capital assets that will be depreciated slowly over the years
- development costs. Farmers have to meet the cost of present development plans
- basic living expenses. These will vary between farmers according to their personal situations. Typical items include insurance premiums and school fees.

The sum of all these shows the whole-farm gross margin needed to meet all commitments. Any farm plan that does not meet this target, with a surplus for unavoidable bad seasons, will be unviable.

The gross margins per hectare of crops and per head of livestock are in widespread use for comparing different activities on one farm; also between farms in similar environments. This sometimes highlights technical weaknesses. It cannot, however, answer technical questions like 'How profitable is my farming compared to Lafi's over the river?' Lafi may have a high total gross margin that is offset by high common costs whereas your total gross margin may be lower but be offset by even lower common costs. It is often misleading to compare enterprises on different farms with different types of management.

Gross margin planning can be dangerous unless used carefully as common costs also need attention. This becomes more important in commercial farming as the size and complexity of any proposed change rise. You need to be careful when you use gross margins for planning. For example, cash crops often have the highest gross margin per hectare. However, before increasing the crop area, a manager needs to know:

- the maximum area that is feasible with existing soil type, land, labour working capital supply and available machinery
- any technical limits to expansion, e.g. under a fallow or other rotation system designed to maintain soil productivity, cash cropping may need to be limited on a particular field to only three years out of six.

Gross margins can be very useful for farm managers but their simplicity can mislead. It is important to understand that there may be a variation in gross margin of individual activities between years. It is also necessary to ensure that all the cost items have been calculated in the same way, before making any comparison with previous results or standards.

In planning the food supply on subsistence farms, where the cash input is fairly small, the main aim is to produce an adequate diet for the household. Thus, the contributions that the main activities make to total food supply are often more important than the size of the gross margin. Although food supply has thus replaced the gross margin of the commercial farm as an objective, exactly the same principles in choosing activities and activity mixes apply. Subsistence farmers should identify the activity with the safest, highest expected food supply and expand that first until it meets the limit of a resource. They should then expand the next best activity until it, in turn, meets a limiting resource, and so on.

There can be many limiting resources beside land availability and subsistence needs on small farms. These include labour limits, both in numbers and skills, at critical times of the year and money limits for essential cash inputs. They also include rotational limits if, say, the land must be fallowed to regenerate after a period of cropping. If one of these is the main limiting factor, then that should be the starting point for gross margin analysis.

Gross margin analysis

For each enterprise

GROSS INCOME Sum of all income adjusted for valuation changes minus livestock purchase.	−	VARIABLE COSTS Easily allocated. Vary with size of enterprise. Directly controlled by farmer, e.g. fertiliser, feed, seed, etc.	=	GROSS MARGIN Calculated for each enterprise.

For the whole farm

FARM GROSS MARGIN The sum of all enterprises.	−	COMMON COSTS Not easily allocated. Do not vary directly with size of enterprise, e.g. mortgage, rent, etc.	=	NET FARM INCOME
NET FARM INCOME	−	VALUE OF FAMILY LABOUR	=	MANAGEMENT AND INVESTMENT INCOME
MANAGEMENT AND INVESTMENT INCOME	−	INTEREST ON OPERATORS' CAPITAL	=	PROFIT (RETURN ON MANAGEMENT AND RISK)

Figure 5.1 Gross margin analysis

Net farm income

Net farm income is sometimes called net income or net profit. This is whole-farm gross margin less common costs. It is the income from the business that pays for a farm family's physical and managerial effort and interest on their own capital invested in the business. Net farm income is available to the owner of the business to pay taxes or to provide living expenses. However, as it includes the value of farm products consumed by them, it is not necessarily cash income.

Net farm income will disappear if whole-farm gross margin cannot cover common costs. In that case, a net loss will occur. This loss reduces the capital available to the business unless it is replaced from outside sources. Alternative ways of raising net farm income, or reducing losses are:

- reducing common costs
- reducing enterprise variable costs
- increasing level of activity – provided this raises whole-farm gross margin by more than any rise in common costs.

Activity 1 Deciding whether or not to use fertiliser

Mrs Paulo has never fertilised her maize. However, she has just seen a field trial on her friend's plot and intends to use fertiliser next year. The results on her friend's plot were as follows:

Table 5.2 Deciding whether or not to use fertiliser

Sulfate of ammonia (kg/ha)	Yield of shelled maize (bags/ha)
0	17
155	25
275	32
455	37
610	40

A pre-planting price of $35 per bag of maize has been set for the next season but, if she stores the crop and sells to neighbours five months after harvest, she expects to get $51.00 per bag. Storage would cost $1.21c per bag. Sulfate of ammonia costs $64 per 45 kg bag now but might rise to $85 next year.

Mrs Paulo wants to plant 1.5 ha maize next year and she could find up to $645 for fertilising it. What would you advise her to do? In your answer, be sure to consider the financial – and any other – advantages and disadvantages of each course of action.

Activity 2 Calculating enterprise gross margins and farm income

Mr Fruean planted 7.5 ha of crops in 1994–5. This consisted of 3.0 ha rice and 1.5 ha each of kava, beans and cotton.

During this season, he sold 64 bags of rice at $35 per bag and consumed nine bags. The stocks of rice in hand at the start and end of the year did not change.

During the year, Mr Fruean sold 1100 kg of kava at $4 per kg and 1450 kg beans at $2.20 per kg. He had 350 kg of beans in store on 1 September 1994, and 275 kg on 1 September 1995. He used 90 kg beans on the farm during the year.

Cotton sales amounted to $2400.

Planting material costs were as follows: rice – $90; beans – $150; cotton and kava – no cost. Each enterprise received the following fertiliser: rice – 700 kg sulphate of ammonia and 700 kg 20: 20: 0 compound fertiliser; kava – 550 kg 20: 20: 0; cotton – 350 kg 20: 20: 0. Sulfate of ammonia cost $40 per 50 kg bag and 20: 20: 0 cost $55 per 50 kg bag. Other costs were $28 for insecticides to control stem borer in rice and $350 for chemicals to spray cotton. The cotton sprayer cost $210 and had an expected life of four seasons. Implements purchased for ploughing cost $475 and should last for six years.

Calculate enterprise gross margins, the common costs of the farm as a whole, and Mr Fruean's net farm income for the year.

Activity 3 Calculating enterprise and whole-farm gross margins

The following information relates to a typical farm of 3 ha growing 2.0 ha maize, 0.4 ha groundnuts, 0.4 ha cotton and 0.2 ha vegetables for sale.

Table 5.3 Calculating enterprise and whole-farm gross margins

Crop	Seed (kg)	Fertiliser (kg)	Chemicals (litres)	Casual labour (day)	Mech Unit hire (hours)	Transport (tonne km)
Maize	25@42c	100	–	5	5	45
Groundnuts	90@63c	–	–	80	7.5	–
Cotton	12@55c	50	10	3.5	5	75
Vegetables	2.5@$4.20	150	30	–	10	–
Unit Price		$140/tonne	$1.40	$0.56	3.50	5c/tonne km

Gross incomes

Table 5.4 Gross incomes

Crop	Yield/ha	Price/unit yield $
Maize	10 bags	6.30
Groundnuts	10 bags	21.00
Cotton	1500 kg	0.42
Vegetables	2000 kg	0.28

Calculate the enterprise and whole-farm gross margins.

Partial Budgeting

Managers often need a quick way to assess the financial effect of a proposed change in policy or prices in an otherwise satisfactory farm business where the overall farm organisation is unchanged. Partial budgeting not only enables them to assess the effect of small changes, such as buying a sprayer instead of hiring one or adding a few more sows to the herd, but it is also useful for assessing the likely financial effect of fairly large changes, such as disposal of a dairy herd and substituting beef and cash crops on the freed land.

Partial budgeting is a marginal analysis technique as it looks at the changes in costs and receipts, and thus net farm income, which are likely to result from a marginal change in the farming system. There are, of course, many possible changes in a farm system that need only partial adjustment of the business.

When considering or suggesting a change, the first question is usually 'Would it pay?' The situation is often complicated because there are usually several ways of changing the farm business and the question becomes 'Which would pay best?' Partial budgeting helps to answer such questions by looking at the expected effects on net farm income. There are two main situations in which partial budgets help most.

Change in the combination of enterprises (product substitution)

This could mean complete substitution of a new enterprise. Farmers often face problems like whether to keep pigs or poultry in existing buildings, whether to intensify a business activity to increase profit by increasing turnover, or whether to dispose of some cattle and grow more crops. These are some of the most common questions facing farmers when they plan a year or two ahead.

Change in production method

A typical example is buying a new machine or building either to increase output or to reduce costs. This usually means finding the most profitable of two or more alternatives, for example, whether to invest capital in a machine and thereby reduce labour costs, whether to invest in a grain dryer or large tractor, or whether to feed cattle in pens instead of grazing them.

Partial budgets thus assess the likely effect of future policies or changes in part of the farm system on whole-farm results. They are quick and easy to make and are good for assessing fairly small changes. However, sometimes it is necessary to prepare a complete budget. For example, if a farmer is planning to buy a first tractor to replace most hand labour the decision will affect most existing inputs and outputs and modify the whole-farming system.

To achieve the same accuracy, you need the same detailed items and calculations for partial budgets as for complete budgets.

Partial Budget to Estimate the Effect of . . .

. . . .

	Losses		**Gains**
Income lost:	______	New income:	______
New costs:	______	Costs saved:	______
Net gain or	______	Net loss	______

Non-Quantifiable Intangibles

______	______
______	______
______	______
______	______

Figure 5.2 Standard Layout for Partial Budgets

Partial budgeting simplifies decision making for many problems by giving the most accurate estimate of the financial effect of a proposed change. This should prevent unprofitable changes being made, and the budget also serves as a target against which to compare later performance.

It is important in partial budgeting to be systematic, to head the budget clearly and to state clearly any assumptions made. Four basic questions must then be answered:

- What new costs will arise?
- What former costs will disappear?
- What new income will be gained?
- What existing income will be lost?

Provided each question is answered, there should be few errors in the budget. It helps to use the standard layout and headings.

The two sides of the budget must balance. If total gains on the right exceed total losses on the left, the balancing figure is an expected rise in net farm income (net gain). The net gain appears on the left side. On the other hand, if total losses exceed total gains, the balancing amount is a net loss on the right side.

Being systematic means more than having a standard layout for partial budgets. As with complete budgeting, it is also essential to clearly state the proposed change, stating what changes are likely and when they will happen. It then helps to go through the following stages:

- find out the present situation
- calculate the situation after the proposed change
- complete the partial budget.

To clarify the use of partial budgets, let us look at a few examples.

Example 1

Mrs Sia Tone is thinking of reducing her maize area by one hectare and substituting a hectare of tobacco. She would have to hire more casual labour to cope with the tobacco in the peak reaping and curing period and would need to build curing barns.

The table below shows the likely financial effect of this proposed substitution.

Partial Budget to Estimate the Effect of Substituting Tobacco for Maize (1ha)

Table 5.5 Effect of substitution

Losses		**Gains**	
Income lost	**$**	***New income***	**$**
36 bags maize at $5.20/bag	187.20	900 kg tobacco at 50c	450.00
New costs		**Costs saved**	
Fertiliser – 7 bags at $10.50	73.50	22.5 kg maize seed at 20c	4.50
Specific casual labour	54.00	Fertiliser – 5 bags at $7.50	37.50
Depreciation of 7 curing barns at $3.50 each	24.50	Fumigant for storage	3.30
Net gain	156.10		
	$495.30		$495.30

Example 2

Mr Sio Petelo is considering changing from hand-milking his dairy herd and produces the partial budget shown in the table below.

Partial Budget to Estimate the Effect of Introducing Machine Milking

Table 5.6 Effect of introducing milking machine

Losses		**Gains**	
Income lost	**$**	***New income***	**$**
New costs		**Costs saved**	
Electricity, $10 a week	520	Four less dairy labourers	1900
Replacement of liners, etc.	364		
More cleaning materials	180		
Annual machine depreciation	270		
Annual interest on capital	190		
Net gain	376		
	$1900		$1900

Whether or not to adopt this change may depend on the farmer's estimate of any likely change in milk yield or quality.

Activity 4 Deciding which equipment to buy

A banana producer is thinking of buying a knapsack sprayer and a mist blower to use on his 2.0 ha banana plantation to control leaf streak. His present banana yield is 20 tonnes per hectare per year. He wishes to assess the likely effect on profit of this partial change to his farm plan.

List the likely changes in input and output items that would result from this change.

A Technical Data

The producer obtains the following annual estimates of input requirements and yield changes from local agricultural extension officers.

Use of emulsifier	4 l/ha
Use of benlate	10 kg/ha
Use of misting oil	30 l/ha
Extra work-days needed	90 work-days/ha/year

B Financial Data

From the Agriculture Store Corporation, he obtains the following estimates of costs.

Price of emulsifier	$4 per l
Price of benlate	$45 per kg
Price of misting oil	$2 per l
Cost of knapsack sprayer	$175
Cost of mist blower	$825
Cost of protective clothing	$110
Annual fuel and oil costs	$175
Annual repairs and maintenance	$20

The Producer Market Board supplies the following information:

Price of banana	$0.35 per kg
Cost of 25 kg banana cases	$1.40 per case
Transport costs	$1.50 per 5 cases

Casual labour would be employed to carry out the spraying at a wage rate of $5.00 per day.

The knapsack and mist blower should remain usable for five years.
The protective clothing will need replacement every four years.

The Ministry of Agriculture, Forests, Fisheries and Meteorology estimates that farmers produce up to 35 tonnes per hectare if leaf streak was controlled. So the potential increase in yield is 15 tonnes per hectare per year.

Calculate the likely change in profit if he controls leaf streak in this way.

Activity 5 Changing crops

A root crop farmer is considering a change to her farm plan in which she would replace 1.0 ha of taro with yams. List the likely changes in input and outputs arising from this product substitution. The farmer uses the following information in preparing a partial budget:

Planting material	
Yams:	14000 cuttings per ha @ $10.00 per 100 cuttings
Taro:	12000 tops per ha @ $4.80 per 100 tops
Yield	
Yams:	13 tonnes/ha
Taro:	13 tonnes/ha
Prices	
Yams:	$1.35 per kg
Taro:	$2.20 per kg
Staking	
Yams:	$300 per ha
Taro:	Nil
Transport	$10/ha more for yams than taro
Labour	25 man days/ha/year more for yams than taro. Labour will receive a casual wage rate of $5.00 a day.
Sacks	$7.50/ha more for taro than for yams

Calculate the likely change in profit.

Review

1. List two methods or tools farmers can use to help them make decisions.
2. Explain the differences between the two methods.
3. Which method would you recommend farmers to use? Give reasons for your answer.

Unit 6

Records

Physical Records

Most farmers dislike any record keeping. However, well-kept records help you to see aspects of a business clearly and make it easier to plan improvements accurately. Up-to-date records, kept accurately and regularly throughout the year, are essential for good management. Improved management must come from inside a business – outsiders cannot impose it. If a farmer is aware of a financial problem, having good financial records will help to diagnose the cause. The remedy often becomes obvious, needing no outside advice.

We do not take all our aches to a doctor!

Physical records cover the source and disposal of materials and services and, therefore, complement financial records.

Financial accounts show income and expenditure, and physical records relate the income and expenditure to units of output and input. Together they measure the efficiency of use of both physical and financial resources. Without physical records, you cannot make full use of financial records. For example, financial accounts show the total cost of labour and machinery. The only way to split these costs accurately between enterprises is by having labour and machinery-use records.

The advice given on physical record-keeping applies not only to those farmers who keep the records themselves, but also to large farming companies with full-time office staff. Few of them now keep the best records for management use. Farming is a highly competitive and diverse business, needing frequent decisions. Records supply the facts upon which to base these decisions.

Record keeping may seem to be slow and hard work, but, as the aim is to make farmers aware of their input and output levels, the time spent is small compared to the benefits gained. Any records kept should enable farmers, potentially, to raise profit enough to offset the time and effort. The benefits gained will depend on the quality and accuracy of the records.

Most farmers keep few records and are too involved in the daily problems of broken-down tractors, bad weather and labour problems to study their records closely. They may achieve some beautiful 'trees in the forest', such as high yields, reliable tractors, a stable and efficient labour force and perfect farm roads, but the forest as a whole may be in bad shape. The business may not pay well despite some perfect aspects. An hour or so regularly spent compiling and analysing records can be far more profitable than staying awake to supervise night ploughing – which may have been unnecessary if tractor use had been planned properly.

The benefits of keeping good physical (and financial) records are as follows:

1 Those farmers who use records to produce budgets are best able to compete for credit.
2 Properly analysed records provide facts on which to base decisions. Never take decisions in isolation as they are all related.
3 Farmers with records can plan to help ensure the best use of their available resources.
4 Records enable comparison of yields and inputs between seasons, land (fields) and livestock. On most farms, some areas need different treatment. Managers seldom realise the size of these differences unless they have kept records of their husbandry methods and results for several seasons. This information should lead to a definite policy for soil management and animal-feeding practice and thus remove much of the guesswork farmers often use for base fertiliser and feed levels.
5 Records provide data so that farmers can compare their enterprises with published 'standards' for similar enterprises in a similar physical and economic environment.

Farmers need to keep physical records to provide some of the necessary information from which they can:

1 produce detailed financial information regularly
2 check and control physical performance
3 guide future decisions and
4 provide the basic data needed for planning.

Without adequate records, there is no basis for planning except memory, guessing, instinct or opinion. These are all unreliable and plans derived from unreliable information cannot reasonably predict the future. It is best to use information collected to predict what is likely to occur in the future. This is more reliable than guessing or luck.

It takes skill to collect and organise physical information and even more skill and experience to interpret the facts and draw right conclusions about their relevance to a given problem.

What records to keep

Recording systems usually fall into two extremes:

- ❑ those that provide a lot of information about the business, often collected at great effort and cost, which is little used
- ❑ those that provide a minimum of rather imprecise information used to produce financial statements for tax purposes.

The best systems lie between these extremes.

Information has a cost, and the more information collected, the higher the cost will be. Record keeping takes time, usually the farmer's time, and this is one of his/her scarcest resources. Unless managers use the information, it is a waste of money and time to collect it. For example, it is possible to spend time collecting and breaking down data on tractor running costs and allocating it to individual enterprises. However, unless farmers or managers use the information profitably, they will have wasted both cash and time. Record keeping is not itself productive, so it is pointless to record anything unless you can use the records profitably to make informed decisions.

There is a vast range of possible physical records. Most managers are quite good at keeping records of output, e.g. yield per hectare or milk per cow. However, they are often poor at recording inputs, such as feed used by various types of livestock. It is important to keep all records that can help in running the business efficiently.

The most suitable planning data for a specific farm are those obtained from that farm's records because they reflect the specific conditions of that farm and the quality of its management and staff. Sadly, such data are never perfect. Besides possible recording errors, situations and staff change. For example:

- changes occur in techniques and the prices of both inputs and products
- the make-up of the labour force may change
- the farmer's or manager's experience will grow
- the farmer's or manager's aims and motivation may change.

Nevertheless, data from the farm itself still provides the best available guide to the future. However, such information may need 'normalising', that is, adjusting to expectations for a 'normal' future year. This is because of unusual past or changing conditions, and in any case, expected future prices need to be added to the physical data collected.

We keep records to help us farm; we do not farm to keep records!

Unlike financial accounts, which are fairly standardised, the physical records needed on farms vary widely with the enterprise and production methods used. For example, no reasonable farmer would expect to develop a successful pig breeding unit without having detailed records of each of his/her sows and boars. The choice of type and layout of records depends not only on the farming enterprises but also on their intensity, the preferences of those who will use the records and the accounting system used.

Physical records should include the following:

- tractor and fuel-use records by enterprise
- stock control records, for example, fuel, fertiliser, feed and spares held in store, received and issued
- labour records classifying the type of labour, time of the year and enterprise
- crop records including areas, yields, planting and harvesting dates
- inputs used, including irrigation water and rotations
- livestock records, including a monthly record of numbers, births, deaths, sales, farm slaughtering and purchases and breeding records.

It is impossible to gauge the need for information exactly, but remember the reason for keeping records is to help make good decisions. Good farm records should serve a definite purpose and use, be easy for recorders to complete accurately and be up-to-date to facilitate quick remedial action and yield maximum useful information for farmers, farm managers and accountants.

Farmers and managers should decide which physical records are worth keeping by asking themselves the following three questions:

- What decisions do I have to make?
- What information do I need to make those decisions as rational as possible?
- What records will give me this information most easily and reliably?

Each business needs to design forms for keeping records that best suit their need for information. Farm records that are suitable for tax purposes are not always suitable for management purposes. Farmers, their spouses or managers keep most physical records as only they have access to the data needed. However, in many countries, computer-based, electronic data processing and farm-recording services are used to produce regular management accounts. Computer systems can reduce the hard, repetitive work needed to analyse records and, therefore, are more than a quick way to obtain tax records.

To have information available when needed and to ensure that as many daily and yearly decisions as possible are good, we must collect and store information so that we can find it again.

There is only one way of collecting information and that is by measurement. There is only one way of storing it and that is by recording.

Activity 1 Designing records for an agricultural enterprise

1. In pairs select an agricultural enterprise.
2. What records does your enterprise keep?
3. What information do they provide to help in management decision making?
4. Would it be to the manager's advantage to keep any other records?
5. Design a suitable system for keeping records, remembering that most people do not enjoy keeping records.
6. Discuss your recording system with the manager of the enterprise and record his comments.

Review

1. Why are records important?
2. What are the key points you should keep in mind when designing record sheets?
3. List the types of record a cattle farmer will keep.

Unit 7

Optimum Combination Of Inputs

Optimum Usage Of Input

How do you work out the optimum (profit-maximising) use of an input in a riskless situation?

Table 7.1 contains information about the effect of an incremental increase in the rate of fertiliser application (the input) on a crop of beans (the output).

The graph of this information (Figure 7.1) makes it easy to see that there is a benefit (increased production of beans per hectare) from increasing fertiliser levels up to 120 kg/ha. However, the production increases by a varying amount. The economic term for the change in output as the result of an incremental change in input is the marginal physical product (MPP). The value of the MPP is called the marginal value product (MVP).

The decision-making rule for maximising profit from an input is that as long as the MVP is greater than the cost of the input it is worth using the input.

Table 7.1 Bean production per hectare

1 Fertiliser Application Rate (kg/ha)	2 Total Physical Product of (or output) beans in kg/ha (TTP)	3 Marginal Physical Product of beans (MPP) in kg/ha	4 Marginal Value Product (MVP)	5 Price per Unit of Fertiliser
0	200	–	–	–
20	250	2.50	25.00	5.00
40	290	2.00	20.00	5.00
60	320	1.50	15.00	5.00
80	340	1.00	10.00	5.00
100	350	0.50	5.00	5.00
120	355	0.25	2.50	5.00

Notes on Table 7.1

a Column 3 is calculated by dividing the change in Column 2 by the change in Column 1.

b Column 4 is calculated by multiplying Column 3 by the price of beans (10 tala).

c Price of beans is assumed to be 10T per kilogram.

d Price of fertiliser is assumed to be 5T per kilogram.

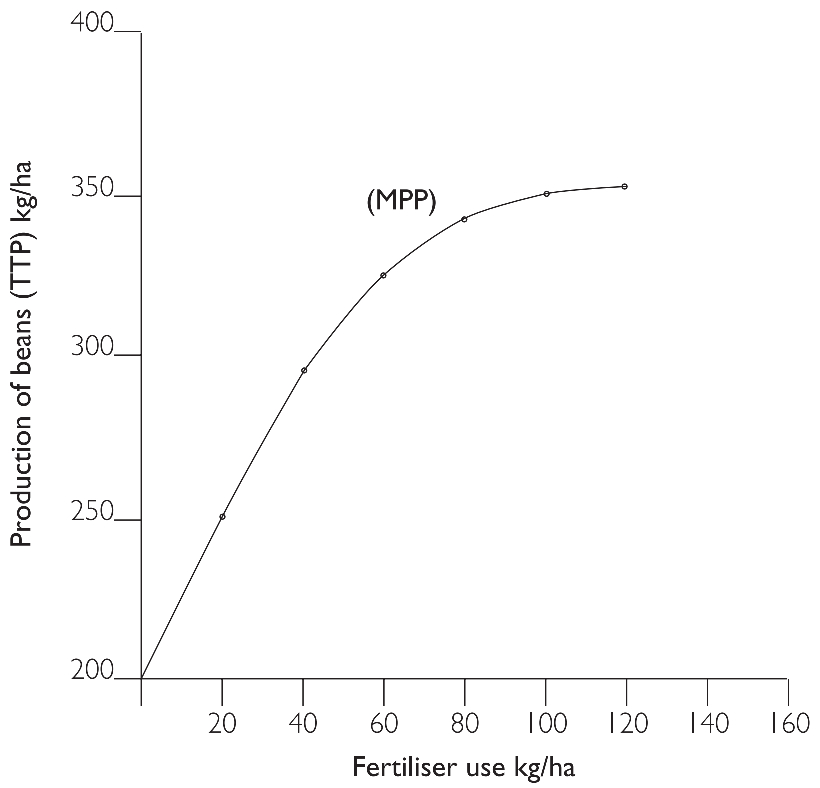

Figure 7.1 The effect of fertiliser on bean production per hectare

Optimum Output Level

How does a farmer decide how much to produce?

In setting production targets farmers must first establish the optimum output for each enterprise by comparing the marginal revenue (MR) to the marginal cost (MC) of each enterprise.

Marginal revenue is defined as the change in total revenue as a result of the sale of one additional unit of output. Marginal cost is the additional cost incurred to produce that unit.

Here is another way of expressing this relationship:

$$MR = \frac{\text{change in total revenue}}{\text{change in output}}$$

$$MC = \frac{\text{change in total input cost}}{\text{change in output}}$$

If the MR is greater than the MC then the increase in output will generate more revenue than costs, so, if possible, a farmer should aim to increase output until marginal revenue equals marginal cost. There is more information about this in Agricultural Science Year 11 Book 2 on pages 54 and 55.

The Input-Input Relationship

The input-input relationship involves the combination by the farmer of two or more inputs to produce a given farm commodity, e.g. land and labour combine on a farm to produce maize. The farmer is faced with the problem of how to combine these two inputs to produce a certain volume of maize (the output) in the least expensive way. If a farmer has decided on the target output level, the question is how should the inputs or resources be combined to produce that particular output at the least cost? The role of economic theory is to equip the farmer with a decision rule to make such a choice if the necessary information is available.

The example below illustrates the use of information about input-input combinations. A farmer rents land at a cost of $1000 per ha and purchases fertiliser at $160 per unit. Based on 200 kilograms (2 bags) per person per year use of maize grains, the farmer with the a family size of ten, estimated he needs 2,000 kilograms or 20 bags of maize grains for the year. He needs to produce an additional 30 bags of maize to be able to meet other needs such as purchases of other food and non-food items. Hence, the farmer wants to produce 50 bags of maize. After consulting with friends and the local agricultural extension office the farmer will decide on the best combination of land and fertiliser to obtain the target 50 bags of maize.

The information is presented in the following table.

Table 7.2 Options for optimum input-input combination for a semi-subsistence farmer to obtain 50 bags of maize in a production season under normal weather conditions

Farm plan	A Units of fertiliser	B Land area in ha	C Change in A	D Change in B	E D/C	F Inverse price ratio P1/P2 (160/1000)	G Total cost of land and fertliser ($) (160xA+1000xB)
1	0.00	5.00	–	–	–	–	5000
2	5.00	4.20	5.00	-0.80	0.16	0.16	5000
3	10.00	3.50	5.00	-0.70	0.14	0.16	5100
4	15.00	3.00	5.00	-0.50	0.10	0.16	5400

In real farming situations the farmer instead of equating the rate of technical substitution to the inverse price ratio, will probably look at the different levels of inputs combination and derive the total costs for each combination by the process of budgeting. He will then choose the combination of inputs that minimises the cost of production in achieving the desired output level. In this example, the farmer will choose either the farm plan 1 or farm plan 2, since these two plans minimise the total cost of land and fertiliser (at $5,000) in order to produce the 50 bags of maize.

Activity 1 Changes in input relationships

1. If the farmer increases fertiliser application rates by five units and land rent increases by $300 per unit which farm plan should the farmer choose?

Review

1 What is the difference between optimum and maximum production?

2 What are the benefits of using the optimum combination of inputs?

3 Where can farmers find information about the best input combinations to use for crops and livestock production?

Unit 8

Break Even

Break-even Analysis

For any venture to succeed it is important to work out the break-even point, i.e. where the cost of production equals the revenue from sales. The costs involved in running an operation are broken down into fixed costs (FC) and variable costs (VC). Break-even analysis weighs costs against income or revenue to project potential profits (or losses). You need to familiarise yourself with the following abbreviations before continuing:

FC	fixed costs	those costs that remain the same regardless of the volume of production of output, e.g. land, buildings, machinery
VC	variable costs	those costs that increase as output increases, e.g. electricity use Note that at zero output the variable cost is also zero.
TC	total cost	the sum of fixed and variable costs, i.e. TC = FC + VC. At 0 output, TC = FC because at 0 output, VC = 0.
V	volume	level of output
SP	selling price	selling price per unit of production
TR	total revenue	total income generated by a business/production enterprise
NP	net profit	revenue left over after all costs (TC) have been deducted from total income (TR).

Here is a graphic representation of the fixed, variable and total costs overlaid with the total revenue. This is known as a break-even chart. Note that at 0 output the enterprise has a zero VC and a set FC. This is because no enterprise can start without having some facilities and those involve fixed costs.

Figure 8.1 Break-even chart

Adding the revenue line completes the break-even chart. The break-even point is easily identified as the point at which the total revenue line crosses the total cost line.

Calculating net profit

Net Profit = Total Revenue – Total Cost

NP = TR – TC

Total Revenue = Volume x Selling Price

TR = v(SP) <u>equation 1</u>

Total Cost = Variable Cost + Fixed Cost

TC = VC + FC

But variable cost increases with volume, therefore, VC = V (VC)

Therefore, TC = v(VC) + FC <u>equation 2</u>

Net Profit = <u>equation 1</u> minus <u>equation 2</u>

NP = v(SP) – [v(VC) + FC]

here we need to remove the brackets

NP = v(SP) – v(VC) – FC

Volume can then be isolated in this equation to calculate break-even volume:

NP = v(SP–VC) – FC

NP + FC = v(SP – VC)

(NP + FC) / (SP – VC) = v

Thus v = (NP+FC) / (SP–VC)

The graph approach

The break-even point can also be calculated by using a graph approach. To do this you need to prepare a break-even chart like the one in Figure 8.1. This chart shows the relationship between profits and activity (volume).

How to draw a graph (break-even chart)

The following steps outline the stages in finding the break-even point by using a graph.

1. Take the two axes on the graph and take the sales or units of productions on the X-axis (horizontal line) and total sales ($) on the Y-axis (vertical line).
2. Draw a fixed cost (12 000) line parallel to horizontal line.
3. Calculate total cost at any level of activity. Take the VC for 1 unit as $90. Let us take the level of activity at 200 units. The total cost will be

Variable Cost ($90 × 200 units)	=	$18 000 (point 'a' on the graph)
Fixed Cost		$12 000 (point 'b' on the graph)
Total Cost		$30 000 (point 'c' on the graph)

4. Calculate the total revenue at any level of activity by multiplying the selling price ($160/unit) and the number of units sold. Using the level of 200 units sold,

   Total Revenue = Selling Price per unit × Units Sold

   = 160 × 200 units

   = $32 000

   Plot this point on the graph. This is shown as 'd' on the graph.
5. Label the graph as shown below:

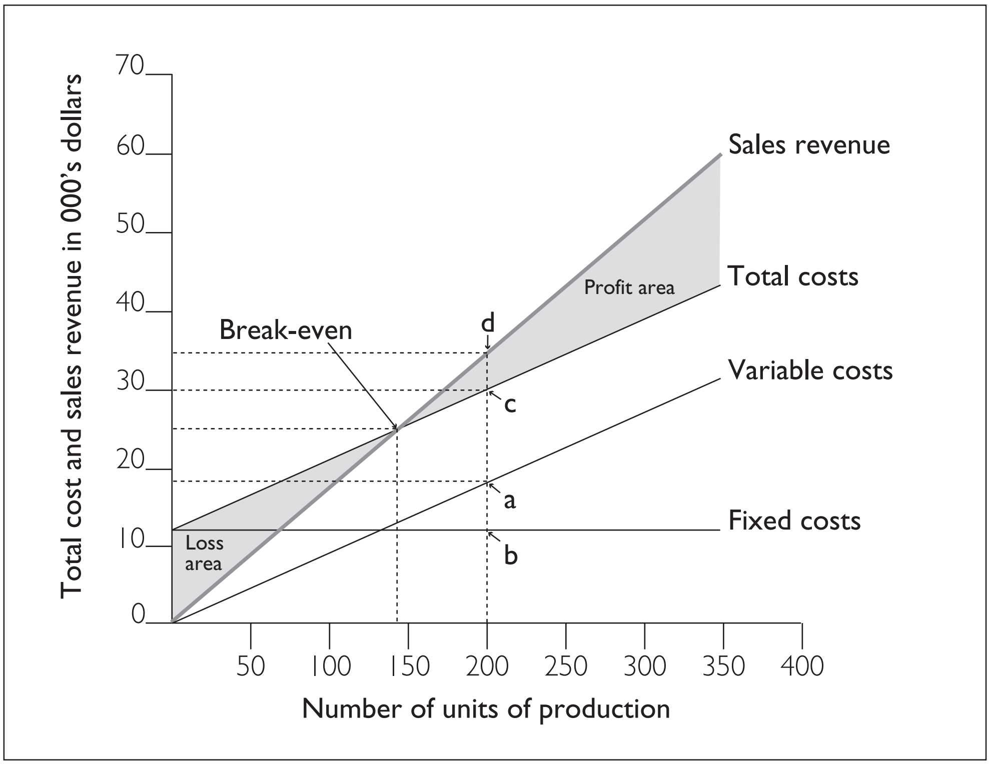

Figure 8.2 Break-even chart

The break-even point is shown as 'Break-even' on your chart.

Can you calculate the exact break-even volume in this case? Try it on your own before we go through it together.

Break-even volume (calculation)

SP = \$160/unit

VC = \$90/unit

FC = \$12 000

You will recall that our equation for the break-even volume (v) was:

$$v = \frac{(NP+FC)}{(SP-VC)}$$

At break-even, NP = 0 because there is no profit at that stage, therefore,

$$v = \frac{(0+FC)}{(SP-VC)}$$

$$v = \frac{\$12,000}{(\$160-\$90)} = \frac{\$12\,000}{70}$$

$$= 171.43 \text{ units}$$

Activity 1 Break-even analysis

1 In pairs read the information in the box and answer the questions that follow.

> Mitsubishi Motors, a leading Japanese tractor manufacturer, recently decided to produce a basic light tractor in either Indonesia or the Philippines with the hope of supplying the South Pacific region with a cheap and reliable multi-purpose machine. Both countries have cheap labour, electricity and other costs.
>
> For Indonesia, it has been projected that plant and equipment would incur a fixed cost of \$15 million. Mitsubishi hopes to sell the tractor for \$9000, and the variable cost of producing each unit is estimated at \$6500.
>
> For the Philippines, the cost structure is as follows: FC = \$14m; VC = \$6700 and Mitsubishi hopes to sell the tractor for \$9000.

1 Calculate the variable cost, fixed cost and total cost for producing 1500 tractors in each location.

2 Plot the information from your calculation on a break-even chart.

3 Calculate the total revenue in each case and complete the break-even chart.

4 At higher volumes of output the more expensive location might promise higher levels of profit, so determine maximum, optimum and break-even production for each option. Decide which location you would recommend to Mitsubishi Motors for their new plant.

Review

1 List and explain the differences between the main types of cost.

2 Why is it important to keep costs as low as possible?

3 List some of the risks involved in cutting costs.

4 Define the terms 'break-even', 'optimum production' and 'maximum production'.

5 Why is it useful for farm managers to know the break-even point?

6 Why is it difficult for an enterprise to break-even or make a profit during the first year of operation? Name or design a situation where a profit can be made in the first year of operation.

Unit 9

Market Channels And Promotion

Marketing Channels

When you visit a local market, you will get the impression that products go through many hands on their journey from the farmer to the consumer. Marketing does give jobs to many people, from large scale farms to the many small farms that are operated by just one person or family. This does not mean, however, that a single batch of produce passes through every marketing agency available. There are usually fixed channels from farmer to consumer. For example, assembling is when a marketing agent or enterprise buys product from the farmer and gathers it together in a marketplace, storage facility or processing plant. Processing is where a product is converted into a suitable form before distribution to consumers. Wholesalers buy products in bulk to distribute to retailers who sell the product to consumers.

The marketing channels for farm produce have adapted themselves over the years to the special needs of given products. Consequently, many different systems now exist and there are frequent new developments.

Marketing channels vary from individual farmers or companies acting alone, farmers contracting to supply produce to processors and other bodies, to farmers acting together in co-operative societies and statutory marketing bodies. There is no need to confine the marketing of a given product to only one of these channels. Several may exist side-by-side although, with some products, there may be good reasons for using only one channel.

Choosing suitable distribution outlets, both wholesale and retail, is highly important for successful selling. Wholesalers, retailers and consumers all buy some farm produce directly from farmers but the first buyer is increasingly either a co-operative, a food processor or a statutory marketing board.

In the simplest marketing channel, producers have direct contact with consumers and this is still important in farming. There is an unknown amount of local producer trade between individuals and villages and much of this occurs as barter.

Products sold privately, without help from formal marketing organisations often include poultry, eggs, fruit and vegetables and estate-grown coffee and cocoa. Merchants sometimes buy produce straight from farms by private treaty for selling on to processors or shippers. Much private selling of cattle occurs 'on the hoof' on farms.

Activity 1 Marketing channel of an export product

1 In groups of three investigate and draw a flow chart of the marketing channel of a product exported from Sāmoa. Collect information from a company or person exporting the product, MAFFM, Ministry of Foreign Affairs and Trade, company websites, University of the South Pacific (USP) or FAO.

2 Analyse the marketing channel and suggest ways of improving it. Present this to the class for discussion. Discuss your opinion with the exporter.

3 Collect and display the promotional material used by the company to market their product. For example, newspaper, radio, TV, website advertisements and packaging.

4 Describe the key features of the promotional material used. For example, colour, size and typeface of words, choice of words, target audience, arrangement, music and sound.

5 Develop a marketing channel and a promotional plan for a potential export product.

Review

1 Define the terms 'marketing', 'marketing channel' and 'promotion'.

2 Why is it important for farmers and exporters to be more market-oriented than production-oriented?

3 How does quality link to profit?

4 What are some promotional programmes Sāmoa is using to sell products and services overseas?

5 How can good marketing and promotion give an edge over competitors?

Unit 10

Agroforestry

Sāmoa has both natural and managed forests. The natural forest is gradually declining due to logging and clearing of land for farming. It is home to many wild plants and animals. Some areas of the natural forest and mangrove areas are put under reserve, for example, Togitogiga rainforest and Sanapu mangrove reserve. MAFFM has forestry projects in West and East Savaiʻi and South Upolu totaling 32 000 hectares. Some of the species planted are *Intsia bijuga* (banyan – ifilele), *Toona australis* (red cedar), *Eucalyptus pellita* (red mahogany – iukalipi), *Tectona grandis* (teak – kiki), *Switenia macrophylla* (royal mahogany – mahoki), *Flueggea flexuosa* (island cedar – poumuli), *Terminalia calamansanai* (jelawai mentalyn – talie solomona) and *Terminalia superba* (afara – talie).

Agroforestry is the planting of tree crops with agricultural crops either in areas side-by-side or together. Trees serve as shade and shelter plants or as a source of nitrogen. A good local example is the planting of cocoa. Cocoa needs shade during the early part of its growth and it is, therefore, often planted under coconut trees. These trees are then gradually thinned as the cocoa trees grow older.

When adequate shade is established for young cocoa seedlings, it is time to transplant them in the field.

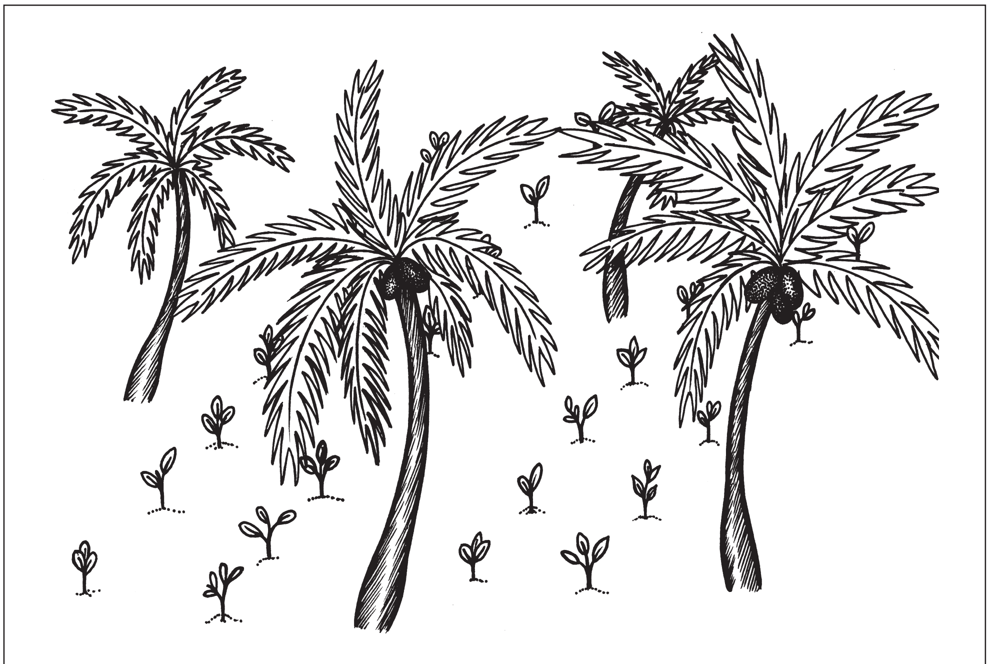

Figure 10.1 Block has enough shade to plant the cocoa seedlings

If the dadap shade trees were established when the block was marked out, it is easy to find the mid point between two dadap trees in the line. The seedling is planted here.

A hole is dug with a spade or oso. It should be as deep as the soil in the plastic planting bag, and slightly wider than the base of the bag. The bottom two centimetres of the bag is cut off. This removes the bent portion of the tap root.

The seedling in its bag, with the bottom of the bag cut off, is then placed in the hole, and a little soil is pushed in around it. The bag is then gently pulled up over the seedling and removed. The rest of the soil is then pushed in firmly. Water seedlings after planting.

Figure 10.2 Remove the plastic bag before filling the hole

It is important to remove the bag. If it is left around the plant the feeder roots will not be able to grow and the seedling will take a long time to establish. It will probably fall over in windy weather when it is three- or four-years old. All your work can be wasted if you leave the bag in the ground. Remember to water the seedling after planting.

Materials:

long blade spade
watering can
seedlings in plastic bags
oso
bush knife
labels
measuring tape (30 m)

Activity 1 Agroforestry research

1 In groups of three gather and compare information on the location and area covered by natural and managed forests in Sāmoa in 1987 and 1997. Information can be obtained from MAFFM, the Ministry of the Environment, websites, USP library, FAO and the book *Sāmoa: Mapping the Diversity*, R. Gerard Ward and Paul Aschcroft (1998).

2 Present the information you have gathered in a table.

3 Mark the areas on a map of Sāmoa.

4 Write conclusions on the trends and from your findings make recommendations about future development.

Activity 2 Planting trees

1 As a class, plan areas within the school compound to plant forest and fruit trees, e.g. paumuli, ifilele, pine, mahogany, mango, avocado, lime, vi, breadfruit and coconut.

2 Get approval from the principal to plant trees around the school compound.

3 Watch the teacher demonstrate planting one tree.

4 Plant or assist in planting a tree.

5 Attach labels to the trees your class has planted giving the scientific and local names and date of planting.

Review

1 Define the term agroforestry.

2 What are the advantages and disadvantages of agroforestry?

3 What conclusions can you make about the trends in the quantity of forest planted?

Part 4 Crop Production

Unit 11 Internal Structures Of Leaves, Stems And Roots

Leaves

The leaves of plants provide large flat surfaces for the absorption of light energy and carbon dioxide (CO_2) both of which are required for photosynthesis. However, water is lost from the surface of the leaf and this can lead to wilting and even plant death. So the external morphology (form) of leaves is determined by the need to have high light and CO_2 absorption and low water loss.

There are two types of plants – dicotyledon and monocotyledon – and they are distinctly different. When dicot seeds sprout there are two 'seed' leaves formed and monocot seeds sprout with a single leaf.

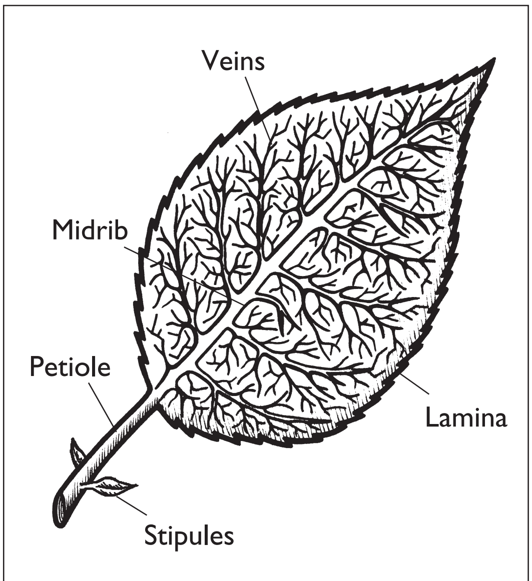

Figure 11.1 Dicot leaf

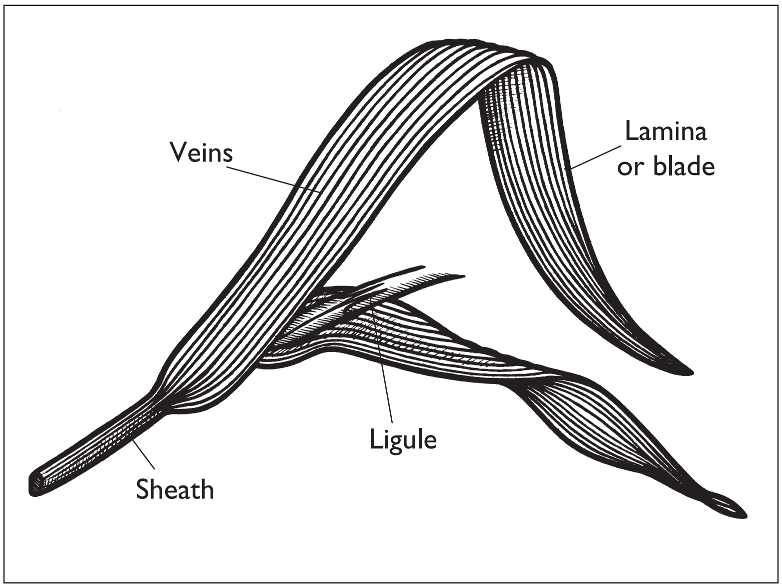

Figure 11.2 Monocot leaf

Dicotyledons or dicots have leaves with a central midrib and a network of veins that are usually attached to the plant by a stem called a petiole. However, some dicots do not have stems on their leaves and these are called sessile leaves. Dicots are the largest group of flowering plants. Some dicot plants have highly modified leaves called stipules at the base of the petiole.

Monocotyledons or monocots have narrow leaves with parallel veins. The leaves are in two parts – the blade, and the sheath which joins the blade to the stem. There is a small flap of tissue, the ligule, that extends up from the sheath and envelopes the stem. It keeps water and dirt away from the stem. Sometimes the base of the leaf blade wraps around the stem in two ear-like points called auricles. The ligule and auricles are useful in identifying members of the grass family (*Gramineae*). In both dicot and monocot plants leaves are either simple, (where the blade is continuous), or compound (where the blade is broken into leaflets).

Compound leaves are of two types: pinnate – leaflets arising on opposite sides of a rachis (prolonged petiole) in dicot or modified middle part of the blade in monocot and palmate – leaflets arising from the same point of a petiole in dicots.

Internal anatomy of leaves

Leaves have many types of cells. The main types of cells are found in the epidermis, mesophyll and vascular bundles.

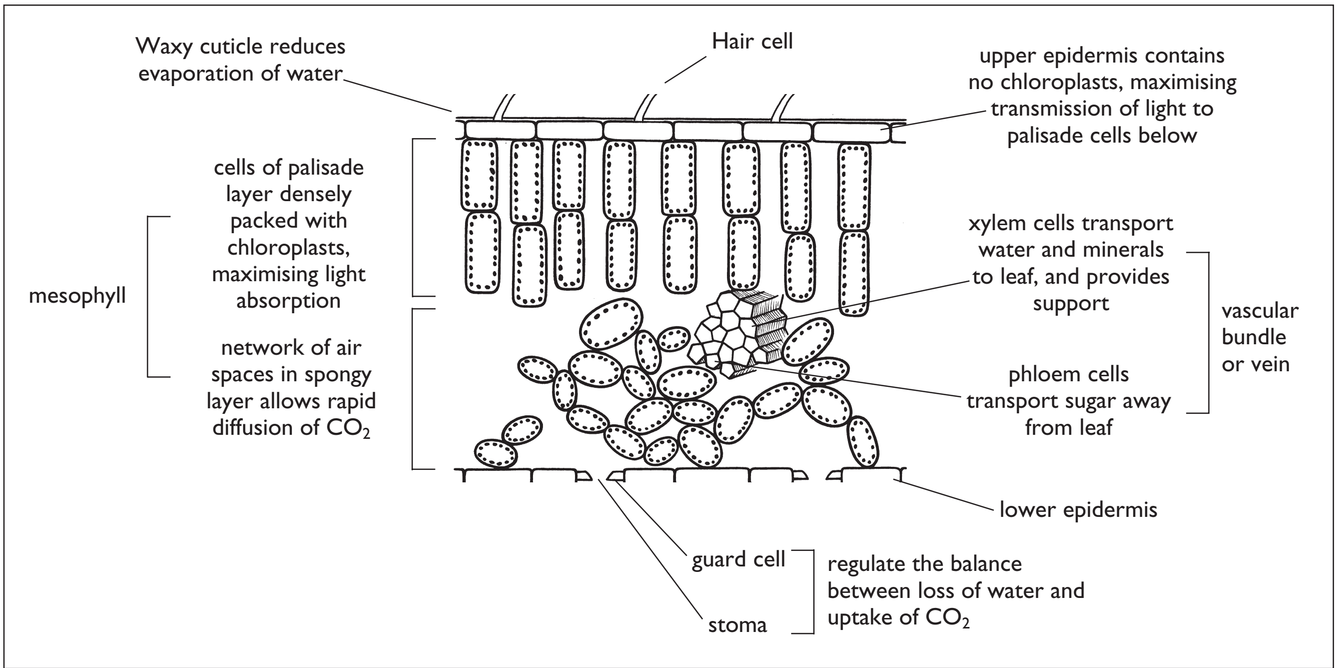

Figure 11.3 Cross section of a leaf

Epidermis

The epidermis is a single layer of cells, which covers the entire leaf surface to protect the leaf from damage and from drying out. There are ordinary epidermal cells, guard cells and hair cells (trichomes).

The ordinary epidermal cells have a thick outer wall and fit tightly together forming a tough layer. They also excrete a waxy cuticle, particularly on the upper surface of the leaf. The cuticle reduces water loss.

The guard cells surround openings called stomata which regulate water loss and CO_2 uptake.

Mesophyll

The mesophyll consists of many layers of cells between the upper and lower epidermis.

In dicot plants, there is an upper layer or layers of closely packed rectangular cells just underneath the upper epidermis called the palisade parenchyma (cellular tissue). Most photosynthetic activity occurs in these cells. There is also a lower layer of loosely packed cells (with spaces between most cells) between the palisade parenchyma and lower epidermis called the spongy parenchyma. This is the area for gas exchange – primarily oxygen (O_2) and carbon dioxide (CO_2) – in the leaf. The spaces immediately below a stoma is termed a sub-stomatal chamber.

In monocot plants, mesophyll cells have only one type of parenchyma cell. Most monocot leaves have an area of large thin walled cells (bulbiform cells) on either side of the main central vein near the upper epidermis. In dry conditions these bulbiform cells collapse, causing the leaf to roll up and lose less water.

Vascular bundles

The vascular bundles or veins of a leaf range from complex main veins to simple veinlets, which are surrounded by a thin layer of cells called bundle sheath parenchyma. These assist in transferring water, salts and foods from conducting cells to other mesophyll cells.

Activity 1 Monocot and dicot plants

1 What are the main differences between dicot and monocot leaves?

2 Select, observe and draw a common monocot and dicot leaf.

Activity 2 Anatomy of a leaf

Materials

microscope

scalpel

leaf

Observe a leaf under the microscope and draw a labelled cross-section of a leaf showing the following features:

1 epidermis (upper and lower)

2 palisade parenchyma

3 xylem

4 phloem

5 spongy parenchyma.

Stems

The stem of a plant is an organ that bears leaves. It may be herbaceous (having reasonably soft tissues) or woody (having hard tissues). The stem (or whole plant) may live for one year (annual), two years (biennial) or more than two years (perennial).

The stem is one of the three vegetative organs of a plant – the other two are roots and leaves. The development and nature of these vegetative organs is sufficiently different in dicot plants and monocot plants that each sub class needs to be discussed separately.

Each of these organs is made up of a number of what are termed ‘primary’ tissues. These tissues develop from meristems (growing points). Both the meristems and tissues are made up of a number of different types of cells.

Stems have the following functions:

- to support the leaves and expose them to light in order for the plant to be able to manufacture food (photosynthesis) for growth and development of the plants/crops
- to transport water and nutrients from the roots (where they are absorbed) to the leaves and other parts of the plant/crop (where they are used)
- to transport growth hormones from the site of production (plant cells) to the site of use (meristems).

Primary meristems

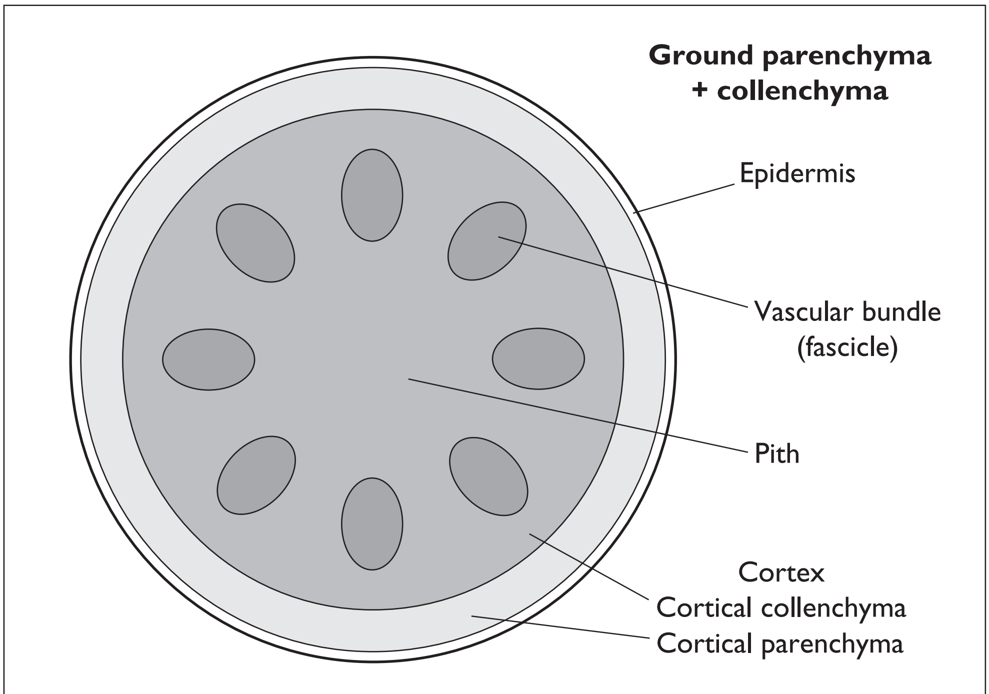

Figure 11.4 Cross section of dicot stem

The formation of new cells and the initiation of differentiation of the cells into tissues take place in stem (shoot) tips called apical meristems. The apical meristems form three primary meristems:

- protoderm — this is the outermost layer of cells. It ultimately develops into epidermis.
- ground meristem — this comprises the major portion of cells at the shoot apex, which are large, thin walled even-sized cells. The ground meristem develops into: pith – the very centre of a stem, and the cortex – a cylinder of cells just beneath the epidermis and surrounding the vascular tissue.
- procambium — these cells appear first as strands among ground meristem; and in cross-section appear as an incomplete or complete circle, depending on species. The procambium cells differentiate into two primary vascular tissues – phloem and xylem.

  The phloem conduct photosynthates (food) from leaves to all parts of the plants while the xylem conduct water and nutrients from roots to leaves.

Primary tissues

The primary tissues of the stem are differentiated from the three primary meristems just mentioned. This process occurs within a few weeks of the life of the plant in annual or biennial plants and by the end of the first growing season in perennial plants. In biennial and perennial dicot, secondary tissues are formed from secondary meristems – vascular cambium and cork cambium, which will be discussed later. The production of secondary tissues from secondary meristems leads to an increase in the diameter of stems.

Epidermis

Like leaves, the stem has a single layer of cells covering all other primary tissue to prevent damage. The outer walls of epidermal cells are often thicker than other cells and are covered with a waxy cuticle.

Cortex

The cortex is made up of three main tissues, each having a different cell type. The tissues are:

- ❑ parenchyma — this is the main tissue of the cortex and is made up of isodiametric cells with thin cellulose walls. This tissue is also found in the pith of a stem and is also found in other plant organs, e.g. leaf, root. The cells are living at maturity, and function in storage of water and food, photosynthesise, and secrete of waste.
- ❑ collenchyma — this is the outermost tissue of the cortex, arranged in either a complete cylinder or strands. The cells are elongated in shape and the walls contain cellulose and pectin. The cells function mainly in strengthening and protection.
- ❑ sclerenchyma — this tissue is found in areas throughout the cortex, as well as in other plant organs, e.g. fruit, seeds, leaves. The cell walls are very thick and contain lignin. The cells are dead at maturity and function in strengthening.

  There are two types of sclerenchyma cells, sclerids and fibres.

Pith

The pith makes up the central core of many stems. It is composed mainly of parenchyma cells which store starch. Some sclerenchyma cells, mainly sclereids, are also found in the pith.

Primary vascular tissues

The function of primary vascular tissues is to transport water and various water soluble salts from the soil and food substances.

In a young stem, vascular tissue occurs as discrete bundles, termed 'primary vascular bundles'. Each primary vascular bundle is differentiated from a procambium strand and contains primary phloem and primary xylem.

Primary growth in dicot stems

In a stem growth cycle, the apical meristem cells continually divide. The cells, which divide off from the meristem, differentiate into the cells and tissues we have just discussed. During a stem's primary growth phase it is only increasing in length.

Activity 3 Primary growth

Why is primary growth important?

Secondary growth in a dicot stem

A dicot stem increases considerably in diameter as well as length during its life. The increase of diameter involves the activity of a secondary meristem – the vascular cambium. The vascular cambium consist of two parts:

- fiscicular cambium — this is the continuation of the procambium of primary vascular bundles
- inter-fiscicular cambium — this forms from some of the parenchyma cells between primary vascular bundles.

The vascular cambium produces secondary phloem to the outside and secondary xylem to the inside during the secondary and subsequent cycles (flushes) of stem growth. A cycle of growth produces a ring of wood, only the xylem part of it being preserved in old stems. These rings of wood are annual in cool-temperate, dry-temperate and tropical regions but not in other regions of the world.

The epidermis of a stem is broken and loses its protective function soon after secondary growth begins. A cork cambium, which develops in the outer cortex, produces cork cells to provide protection in stems. The cork cambium produces cork cells on its outside and parenchyma cells called phelloderm on the inside.

Activity 4 Secondary growth

Why is secondary growth important?

External morphology of dicot stems

Arrangements of buds and leaves

The tip of a twig has a large terminal bud. At regular intervals along the stem there are lateral buds. These buds also occur in leaf axils (the angle between the petiole of a leaf and a stem), so they are also called axillary buds.

Lateral buds are always associated with a leaf. Scales of buds give bud scale scars when they are shed as a bud grows. Buds are always found at the nodes of stems, the portion of the stem between nodes is termed an internode.

Position of buds on a woody twig

In some species there is only one bud and one leaf at a node. This arrangement of buds and leaves is called 'alternate'. In many other species two buds and two leaves are found at a node. This arrangement of buds and leaves is called 'opposite'. In a few species three or more buds and leaves are found at a node. This arrangement of buds and leaves is called 'whorled'.

Sometimes buds arise independently of a leaf. These buds are called 'adventitious buds'.

The terminal bud of a stem usually grows most actively, while growth of lateral buds is suppressed by varying amounts. Indeed, some lateral buds do not grow at all until the terminal bud of a stem is removed. The phenomenon of suppression of growth of lateral buds by terminal bud growth is called 'apical dominance'.

Activity 5 Morphology of stems

1. Name the different types of buds and their positions on the stems.
2. What type of bud exerts apical dominance?
3. How are buds and leaves arranged on a woody twig?
4. Explain 'apical dominance' in your own words.

Primary stem anatomy in monocot stems

Monocot stems differ in their primary anatomy from dicot stems. One of the most obvious differences is that vascular bundles are scattered somewhat randomly across the stem, rather than being arranged in a ring.

With this arrangement of vascular bundles, the terms pith and cortex are not appropriate so the term 'ground tissue' is applied to the region between the bundles.

However, some monocot stems, particularly cereals, are hollow. The vascular bundles in these hollow stems are arranged in a ring. Some monocot stems, particularly palms, achieve a large diameter through the formation of a primary thickening meristem. This meristem is a saucer-shaped dome beneath the apical meristem.

Secondary growth in monocot stems

Most monocot do not have a vascular cambium. This means they cannot form secondary phloem or xylem. However, there are three mechanisms – one for herbaceous monocot and two for arborescent (tree-like) monocot – by which the plant can increase in size.

Herbaceous monocots increase in size through the growth of rhizomes (underground stem). Vertical stems can arise from any node of a rhizome. Some herbaceous monocots, e.g. bamboos, reach a very large size through rhizome growth.

There are three types of arborescent monocot:

1. palms, which are unbranched and have no secondary growth
2. pandans, which are branched and achieve some stem thickening through continual division of the ground tissue of the stem. This phenomenon is called diffuse secondary growth
3. the Joshua tree, lilies and others, which are branched and achieve stem thickening from a vascular cambium or secondary thickening meristem.

External morphology of a monocot stem

The external morphology of a monocot stem is basically similar to that of a dicot stem in that there are node and internode, and leaves are axillary buds arising at nodes.

These structures are quite obvious in some species e.g.:

- the flowering stalk of a plant from the grass family, e.g. rice, maize, sugarcane
- the vegetative stalks of bamboo
- the trunks of mature palm family plants, e.g. coconut.

In a number of other species, what appears to be a stem is not in fact a stem, but a tube of a leaf sheath called a pseudostem. The true stem, in these species, is in fact a very small structure in the middle of the tube of the leaf sheaths.

Examples of pseudostems include:

- the vegetative stems of grass plants
- the stems of plants from the onion family
- the trunk of a banana plant
- the stem of a taro and other aroids
- the stem of a young coconut.

Activity 6 Comparison of monocot and dicot stems

Materials

monocot and dicot stems from young plants

sharp knife/scalpel

microscope

1. Look at the internal structure of a monocot and a dicot stem under the microscope.
2. Draw and label what you see under the microscope.
3. What are the main differences between the internal structure of a monocot and a dicot stem?
4. Explain the link between the structure of roots, stems and leaves and their different functions.

Stem Branching And Modifications

Stem branching

A few plants have stems that do not branch, but most plants branch during growth. There are two main types of branching:

- monopodial — the apical bud maintains its capacity for active vegetative growth
- sympodial — the apical bud ceases to grow and new vegetative growth comes from axillary buds.

Stem modifications

The most important stem modifications are:

- rhizomes — underground stems which run horizontally in the soil, and function in vegetative reproduction by forming roots and leaves at nodes
- corms — short, vertical, thickened underground stems, e.g. taro
- bulbs — a bulb is similar in appearance to a corm except that thickened leaf bases, not stem tissue, store food, e.g. onion
- tubers — swollen stems with food reserves, mostly found below ground – tubers also function in vegetative reproduction
- stem tendrils — slender coiling structures that are sensitive to stimuli and attach the plant to a support
- cladodes — stems are flattened, simulating a leaf
- spines and thorns — sharpened parts of all or part of a stem
- runners (stolons) — stems running along the surface of the ground, which function in vegetative reproduction by forming roots and leaves at nodes.

Roots

The functions of the root system of a plant are anchorage, storage, conducting and absorption.

There are two main types of root system:

- fibrous root system, where there are many main roots. This root system is found in dicot, e.g. mango tree, tomato, and in monocot, e.g. maize, coconut.
- tap root system, where there is one main root, often with a major storage function. This root system is found mainly in dicotyledon plants, e.g. carrot.

Roots can be formed from:

- true root tissue — these all come from the radical (primary root) of a germinating seed
- stem tissue — if they are from a stem node they are called adventitious roots. If they are from the stem node next to the soil they are called prop roots.

There is so much in common in initiation of roots, absorption by roots and internal anatomy in monocot roots that both will be discussed together here.

Initiation of roots

The root system of angiosperms starts from the embryonic root (radicle) which is found in a germinating seed. The radicle develops into the primary root. The primary root then forms either a tap root or a fibrous root system.

Most angiosperms form only one primary root but cereal grasses, e.g. rice, will grow many primary roots called seminal roots.

Note that the artificial formation of adventitious roots, e.g. by placing cut stems in soil, or in growth regulators (rooting compounds) then in soil, is important in the propagation of both some food crops such as taro, and some ornamental plants.

The absorbing region of roots

Absorption of nutrients by roots takes place in the last few millimetres of the root tip. This region of the root is differentiated into three areas:

- meristematic zone
- region of elongation
- zone of differentiation.

The meristematic zone is covered by a root cap to protect it from being damaged as it is pushed through the soil as cells of the region of elongation grow in length. The region of elongation is the first growing area of a young root.

Function of root hairs

The main function of root hairs is the absorption of water and nutrients (N, P, K, etc.) from the surrounding soil. The fine structure of root hairs presents a very large surface area, which makes it possible for them to absorb the large amount of water and nutrients required by crops.

The coconut palm does not have true root hairs but instead, absorption of water and nutrients is achieved through a ‘region’ just behind the root cap, which specialises in absorbing water and nutrients.

Up to now we have studied the external anatomy and characteristics of one of the most important plant organs, the root. Let us now study the internal structure of the root to understand how it functions.

Internal anatomy of a root

If a cross-section of the absorbing region of a root (the zone of differentiation with root hairs) is examined, it is found that there are three tissues that are the same as in stems:

- ❑ epidermis — some cells with root hairs
- ❑ cortex — outer layer of cells in the root
- ❑ vascular bundle — a single vascular cylinder in the centre of a root, i.e. there is no pith in a root.

However, the vascular cylinder is immediately surrounded by two layers of cells, which have no equivalent in stems. These are:

- ❑ endodermis — the innermost layer of cortex cells which regulate the movement of water and nutrients between soil and living plant cells
- ❑ pericycle — a meristematic layer of cells which will form root branches or contribute to secondary thickening. This layer of cells is not active in the root-hair zone of a root.

The formation of primary tissues

The root apical meristem occurs just behind the root cap in the root tip. The centre of the root apical meristem produces rapidly dividing cells called initials. At the tip end of the root, the initials produce root cap cells. On the inside, initials produce the same three primary meristems as occur in the stem:

- ❑ protoderm — giving rise to epidermis – note that some epidermal cells develop into root hairs
- ❑ ground meristem — giving rise to cortex – note that the inner layer of cortex cells differentiates as endodermis
- ❑ procambium — giving rise to the vascular cylinder.

Root branches

In contrast to stem branches (which arise from bud tissue near the surface of a stem), root branches arise deep in the root at the pericycle. The branches (lateral roots) arise from the group of pericycle cells, which begin to divide rapidly. Ultimately the lateral root breaks through the cortex of the parent root, and the breaking of the cortex can provide an entry point for pathogens into the root.

For secondary growth to occur in old cotyledon roots, a vascular cambium and a cork cambium develop and have the same functions as in secondary growth of stems.

Some roots form associations with micro-organisms from which both benefit since their needs are provided for by their partner and vice versa. The next topic deals with these symbiotic relations.

Root symbioses

Some species of plants form root symbiotic associations with soil micro-organisms. There are two major groups:

- mycorrhizae — fungal associations with roots, which give improved mineral uptake
- bacterial nodules — bacterial associations which allow plants to fix nitrogen.

Roots having micro-organism associations have some characteristic morphological features, e.g. short branching roots for mycorrhizae and nodules for bacteria.

These associations can be significant in managing crop plants.

Activity 7 Root types

Which root type(s) would be more useful for anchorage and absorption? Why?

Materials:

microscope
scalpel
solution
plant tissue – root, stem and leaf
slides
cover slips

Activity 8 Parts of roots

Obtain a few roots from a coconut palm and a breadfruit tree. Wash them clean with water and draw them showing and labelling the following zones and structures:

1. meristematic zone
2. region of elongation
3. zone of differentiation
4. the root cap
5. the root hairs.

Activity 9 Symbiosis

Explain what is meant by symbiosis and give local examples of such associations describing the benefit to crop growth.

Activity 10 Investigation

1. Look at the internal structure of a monocot root and a dicot root under the microscope.
2. Draw and label what you see.
3. Explain the link between the structure of roots, stems and leaves and their functions.

Review

1. Why are structures of leaves, stems and roots different?
2. Name some local products that are leaves, stem and roots.
3. Why is it important for plant growers to understand the functions of plant parts?

Unit 12

Manipulation Of Plant Growth And Seed Viability

Seed Production And Storage

Seeds are expensive and sometimes in short supply. Farmers can collect and store their own seeds from one season to the next. The best seeds are obtained from ripe fruits. This can be done by separating the seeds from its fleshy fruit. Good seeds will sink to the bottom when put in a bowl of water. Seeds that float will not germinate and must be removed. Seeds will stay viable for long periods and not germinate if they are kept dry. Good seeds can be dried in the sun or oven and when dry, they should be dusted with a fungicide or ash and insecticide to protect them from fungus and insects. Seeds must be stored in a cool dry place away from moisture because moisture can encourage fungus growth and seed germination.

It is possible to improve plant production through selection of variety, controlled pollination, asexual reproduction and hybridisation.

Yield can be improved through the selection of improved varieties with higher yields. When deciding to change, one needs to keep in mind consumer preferences, qualities like taste, size, colour and texture as well as the cost of changing from one variety to another. These extra costs could occur as a result of changes in tools, equipment and machinery, fertiliser, techniques used and labour required.

Flowers can be pollinated by wind, insects and man. Wind and insect pollination are natural methods of pollination and the results cannot be controlled. As farming has become more sophisticated and is expected to operate as a business, results or yields have to be controlled, especially in the fruit industry. We can control pollination to get increased yields, provided other factors like the weather are favourable. The placement of beehives on the farm or orchard can improve pollination. The pollination of flowers by hand, for example, in dwarf coconuts, vanilla and passion fruit, improves pollination and the accuracy in forecasting yield.

Asexual reproduction

Asexual reproduction techniques such as budding and grafting improve yields through shortening the maturity period from five to three years. Cuttings can be mass-produced to ensure sufficient planting material is available to farmers. For example, taro, yams and taamu tubers are cut into small pieces and planted in a nursery in fertile soil. This reproductive technique hastens the availability of planting material. Your teacher will demonstrate some common plant propagation techniques to you.

Materials:

ripe fruit, e.g. tomato, beans, eggplant, maize

fungicide

250 ml beaker

small container or plastic bags

Activity 1 Seed production

1. Select some ripe fruit.
2. Separate the seeds from the fruit.
3. Put the seeds in a beaker of water.
4. Remove the seeds that float.
5. Pour the water out and dry the seeds in the sun or an oven.
6. When the seeds are dry dust them with fungicide or ash.
7. Put the seeds in a container or plastic bag and close tightly.
8. Store seeds in a cool dry place.

Activity 2 Demonstration

In pairs investigate, prepare and demonstrate one plant propagation technique, e.g. grafting, budding, cuttings and layering. Your demonstration should include clearly labelled steps of the technique, its benefits, materials to be used, and other factors that will make the method work. Look at texts on plant propagation and Year 9–12 student books which cover plant propagation.

Review

1. Why is it important for farmers to produce their own seeds?
2. What are some risks involved in producing your own seeds?
3. Why do farmers manipulate plant growth?
4. List some methods used to manipulate growth.

Unit 13

Transport Of Materials In Plants

Large plants must have an efficient internal transport system. Water and dissolved minerals must be taken from the roots to the leaves. The food produced by photosynthesis must be transported to cells throughout the plant and to storage organs such as the roots.

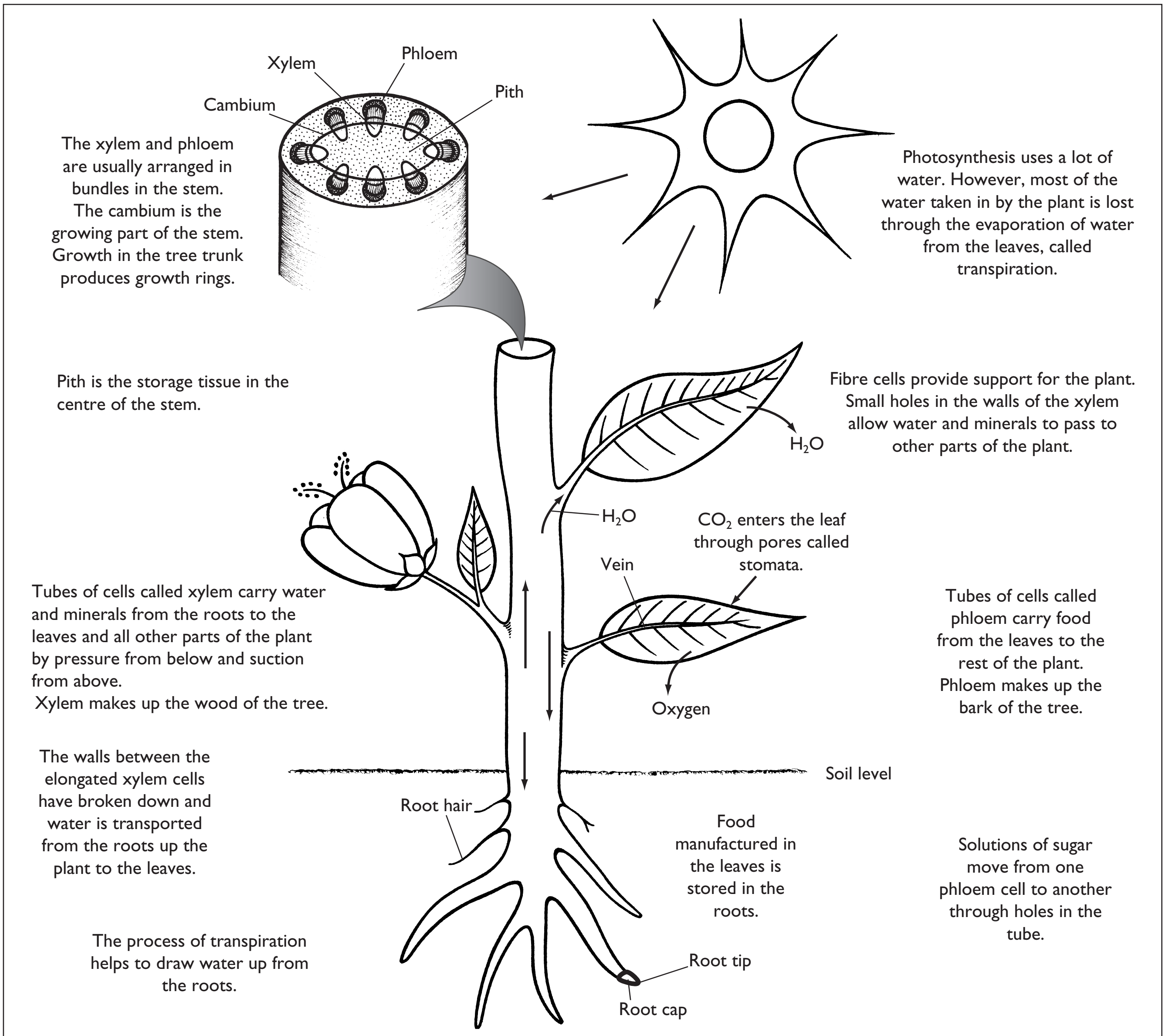

Figure 13.1 The transport system of a dicotyledon

The diagrams below (Figure 13.2) show the cells and tissue that are specialised for transport in the plant. The pattern shown is typical of a young dicot stem. In older stems, and in monocot the pattern is the same.

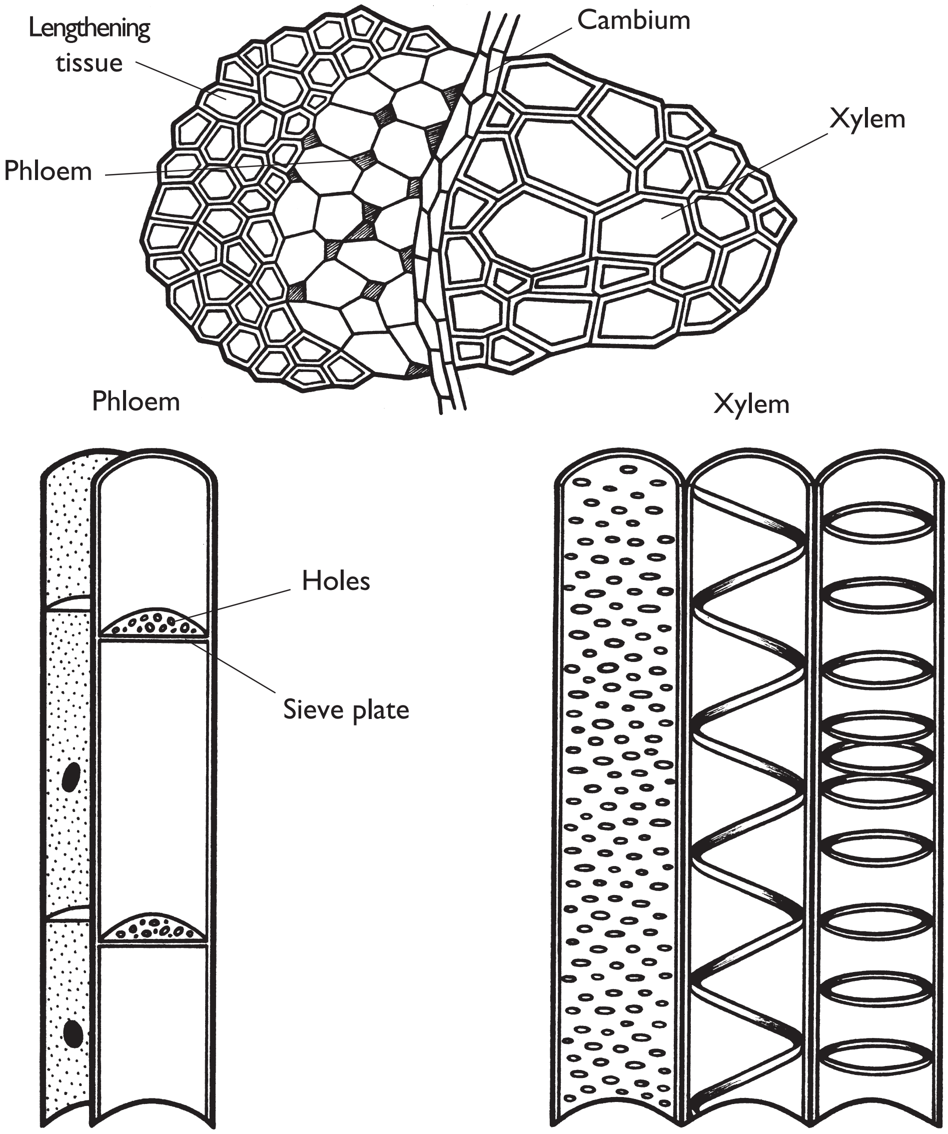

Figure 13.2 The structure of a stem

Transpiration is the loss of water from the surface of leaves. The volume of water that passes through the plants and is evaporated from their leaves is enormous. It accounts for a large proportion of the moisture in the air above the land. The flow of water through the plant involves the pull of evaporation from the leaves, and the push of osmosis in the roots. We can get some measurement of the amount of water, and the conditions that affect the rate of water loss by using a piece of equipment called a potometer.

If a plant is unable to replace the water it evaporates from the leaves it wilts. Wilting is the result of individual cells losing their firmness because of the water they have lost. The replacement water comes from the soil. Because it must move into the roots one molecule at a time, a very large surface area is required. This explains why the roots spread in a fine network through the soil, and also why the root tips are covered by millions of microscopic root hairs. Water moves by osmosis from the soil into the roots of plants.

Plants need more than just water and carbon dioxide. They also need certain minerals in order to grow properly. These nutrients are divide into two groups:

the major nutrients (N, P, S, K, Mg, Fe, Ca)

trace elements which are needed in minute amounts (boron [B], zinc [Zn], copper [Cu], aluminium [Al], molybdenum [Mo], sodium [Na], chlorine [Cl], silicon [Si], manganese [Mn], cobalt [Co]).

Sources of nutrients are minerals weathered from rocks, breakdown of organic materials and fertiliser.

Activity 1 Investigation – The path of water up the stem

Materials:

weeds

beaker

eosin or food colouring

1. Wash the soil from the roots of two garden weeds of the same size and shape.
2. Remove all the leaves from one plant.
3. Stand both weeds in water dyed with eosin or food colouring and leave for 24 hours.

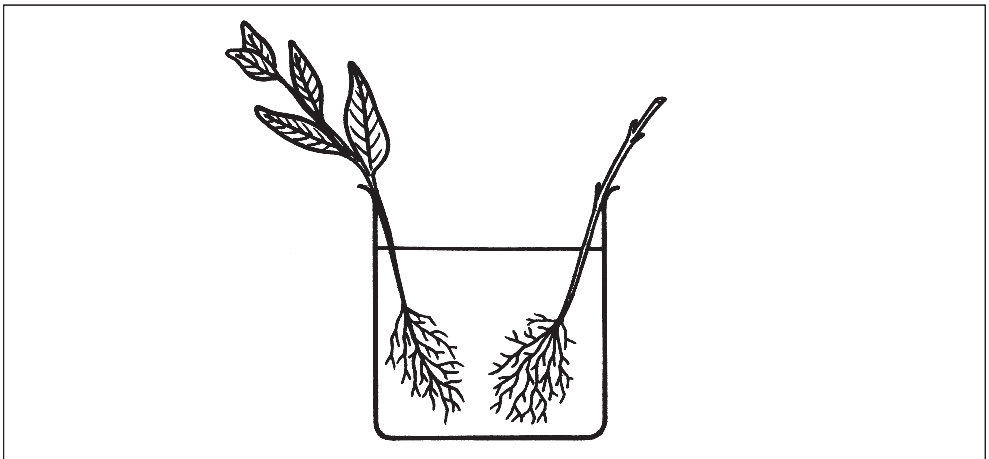

Figure 13.3 Weeds in Eosin

4. Examine the leaves for signs of dye in the veins
5. Cut each stem up into short sections (2 cm). Line up the sections and note how far the dye has travelled up each stem.
6. Compare your sections with these diagrams:

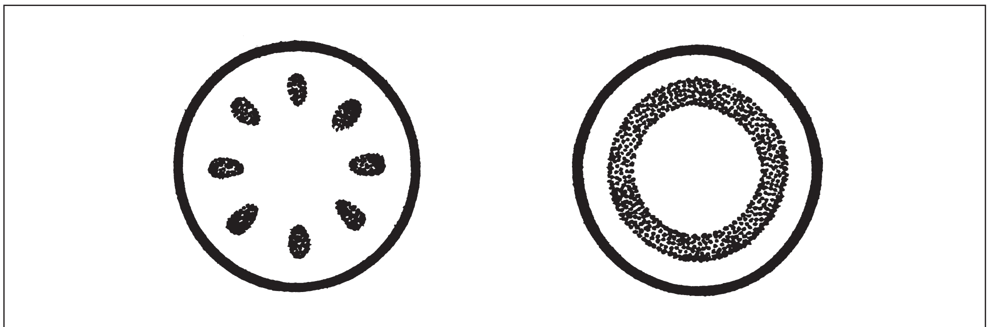

Figure 13.4 Comparing sections of stems

7. Write a report of this investigation in which you use the diagrams to show areas of the stem concerned with transporting the dye and explain any differences in the distance the dye moved up each stem.

Materials:

sharp scalpel
bowl of water
methylene blue solution
microscope

Activity 2 Investigation – Transporting tissue

1. Use a sharp scalpel to slice very thin sections across the stem of a non-woody plant. It is easier to cut very thin sections if you only slice through part of the stem.
2. Float all sections in a bowl of water so you can see which is the thinnest.
3. Mount the best section on a slide and add methylene blue.
4. Examine the slide with a microscope. Look at the cells at the thinnest edge of the section.
5. Compare the cells in your section with the diagrams in Figure 13.2.
6. Draw a series of labelled diagrams showing the detail of the stem tissue.

Materials:

potometer
plant
beaker of hot water

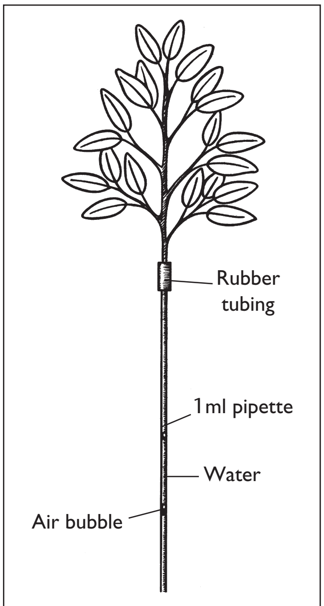

Figure 13.5 Bubble potometer

Activity 3 Investigation – conditions that affect water loss

1. Set up your potometer and leave it for five minutes to stabilise.
2. Place it in still well-lit conditions in the lab or classroom and take readings of the bubble position every two minutes. These readings could be used as a control.
3. Repeat these sets of readings in a series of different conditions. In each case leave the potometer for five minutes to settle down before starting the new set of readings.
4. Each time you change the condition try to change only one factor. Why is this important?

   Some of the factors that you may want to test are:

temperature changes	place a heat source near the plant, or put it in a refrigerator
light intensity changes	put the plant in a dark cupboard or near a bright light. Fluorescent light is best because it gives out less heat
movement of air	use a fan
humidity changes	very humid conditions may be created by placing a beaker of hot water near the potometer and covering the whole set-up with a clear plastic bag.

5. Record all data in a table and then draw a graph.
6. Write a statement summarising the conditions that speed up the rate of transpiration.
7. You are actually measuring the rate of uptake of water, not loss of water. Try to work out a way of seeing if these are almost the same.
8. By taking precise measurements of temperature, or light variations you may be able to draw much more precise graphs of the effects of these conditions.

Activity 4 Investigation – seedlings and osmosis

1 Obtain a container of healthy seedlings, e.g. radish about 2 cm in height.
2 Water them with a strong glucose solution (10 per cent or more).
3 Observe the seedlings over the next two hours.
4 Explain their condition in terms of osmosis.
5 Water them again with water and observe their reaction over two hours.

Materials:

radish seedlings

10% glucose solution

Review

1 Why are water, sunlight and nutrients required by plants?
2 The water and nutrient requirement of most crops can be obtained from MAFFM or other sources. Why is it important for plant growers to know this information?
3 List some practical methods plant growers can use to control the amount of water, light and nutrients supplied to plants?
4 What effect does a lack of water, nutrients and sunlight have on plants?

Unit 14

Plant Protection

With plant diseases, we speak of the disease cycle, which is the series of events from the beginning of the disease process to its completion. The disease cycle sometimes means the life cycle of the pathogen.

The general disease cycle involves the processes of dispersal, inoculation, penetration, infection, pathogen development, symptom development and pathogen reproduction.

Dispersal

This is the movement or dissemination (spread) of the pathogen from the point of origin to another location. Most active pathogens are only able to move short distances – no more than a few centimetres at a time, e.g. nematodes are probably the most active pathogen known yet their movement is restricted to a few centimetres per year. More pathogens are dispersed by various passive mechanisms. These include: wind, water, soil movement, human activity, and animal, bird and insect vectors. Many pathogens are entirely dependent or greatly dependent on their hosts for dispersal, e.g. seeds, tubers, corms, pollen or other plant parts.

Inoculation

This is the arrival of some propagule of the pathogen (part of the pathogen that may be disseminated and reproduce the pathogen) onto the host following dispersal. Vectors (animals or insects able to transmit the pathogen) may be important in inoculation.

The inoculum is the propagule that is inoculated onto or into a plant. There are two types of inoculum: the primary inoculum, which initiates the first cycle of disease in a growing season. It usually arises from some survival structure that has 'over-wintered' or 'over-summered' and it creates a 'primary infection'. The secondary inoculum arises from the initial cycle of disease and it initiates the next disease cycle.

Vectors are extremely important in the inoculation process because they transport the pathogen propagules to a suitable infection site. Some pathogens, e.g. plant viruses, rely entirely upon vectors for inoculation of the host.

The environment must be suitable at the infection site for inoculation to be successful. Often the presence of water or high humidity is necessary for fungal and bacterial germination or infection on leaf surfaces.

Penetration

This is the initial invasion of the host. The pathogen breaks the external defensive barriers of the host and gains access to the internal environment. In other words, this is the internal entrance of the pathogen into cells and/or tissues of the host.

For most diseases, pathogen penetration occurs via one or more of four main mechanisms:

1. direct penetration of outer cell layers, epidermal tissues or equivalent
2. through natural openings, e.g. stomata and lenticels
3. through wounds
4. vector-assisted penetration.

Fungal pathogens use mechanisms 1, 2, 3 and 4.

Bacterial pathogens use mechanisms 2, 3 and 4.

Viral pathogens use mechanisms 3 and 4.

Nematode pathogens use mechanisms 1 and 3.

Infection

This is when the pathogen establishes cellular contact with the host in a non-retractable manner. Once infection occurs, the relationship lasts until the completion of the disease cycle.

At this stage in the disease cycle, the pathogen propagule has committed its resources in the attempt to establish a compatible relationship with the host. It is difficult to say exactly when penetration ends and infection begins because the two processes are so closely linked. In general, infection begins with the appearance of secondary development of the pathogen in the following ways:

fungi	secondary hyphae appear
viruses	replication of the virus occurs
bacteria	cell division occurs
nematodes	there is evidence of nematode growth and development.

After secondary development of the pathogen occurs, the pathogen exploits the host environment. Further growth and development occurs leading eventually to pathogen reproduction.

Pathogen development

This is the growth of the pathogen resulting in the colonisation of the host tissues.

Symptom development

Symptom development is the host's response to pathogenesis and pathogen development. This is caused because the normal metabolic processes within the host cells are disturbed and there is a disorderly utilisation of energy. Symptoms develop because one or more of the basic physiological functions of plants is disturbed or compromised, e.g. storage of food, digestion (use of store food), absorption of water and minerals, growth, respiration, conduction, photosynthesis and translocation. The reason that different pathogen groups (viruses, fungi, bacteria, nematodes) may cause symptoms similar to each other is that these pathogen groups may affect physiological functions of plants in similar ways. Disease is thus an expression of the host-pathogen-environment interaction with the plants' physiological functions.

Pathogen reproduction

This is the production of sexual and/or asexual propagules by the pathogen. These propagules are important in the initiation of the secondary disease cycle, dispersal of the pathogen and/or survival structures.

Pathogen reproduction may occur within a few minutes (as in the case of bacteria), within hours (as in the case of viruses) or days (as in the case of many fungi). Other pathogens and some fungal pathogens may reproduce only once each year. In general, asexual reproduction is more frequent than sexual reproduction (once per year).

Modes and mechanisms of reproduction

Asexual reproduction is any type of reproduction not involving the union of gametes (male or female reproductive cell). Sexual reproduction involves the union of gametes, a product of meiosis, and is important for producing new combinations of genes. These new combinations of genes improve the organisms' adaptability to their environment. In fungi this means production of survival structures that help the fungi survive in unfavourable environments, e.g. cold winter, hot summer, dry conditions.

Bacteria reproduce in a binary fission, i.e. one mature individual splits into two equal smaller individuals. Bacteria reproduce rapidly in infected tissues and under optimum conditions bacteria can divide every 20 to 30 minutes.

Viruses cannot survive without a living host. They reproduce by entering a host cell and they make copies of themselves by forcing the host cell to build all the parts they need for their new cells.

Nematodes reproduce via several mechanisms depending on the species.

Activity 1 The disease cycle of soft rot

Label the different steps of the disease cycle on this diagram.

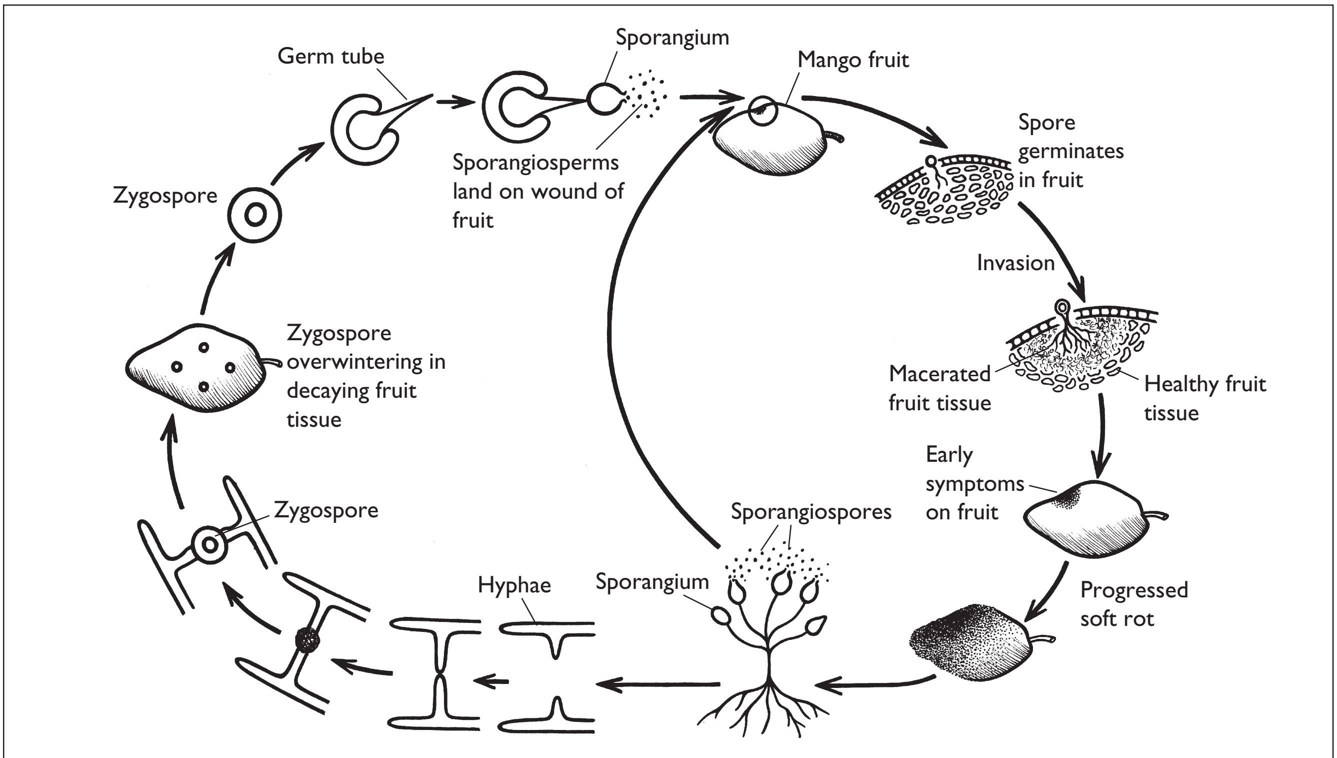

Figure 14.1 Disease cycle of soft rot of fruits and vegetable caused by Rhizopus sp.

Integrated Pest Management

Integrated Pest Management, or IPM as it is commonly called, is not a new term for this course – we've used it on a number of occasions in different lessons – but never actually spent much time discussing it. This is because you need quite a bit of background knowledge about pests and their life cycles, and control strategies, and ecosystem structures, etc., before you can understand some of the more technical ideas behind IPM.

IPM is an approach to pest management that uses a combination of techniques to limit the populations or the damaging effects of particular pests while minimising other disturbances to the relevant ecosystems.

But how does IPM actually work? We can best answer this question by examining the main components of the approach.

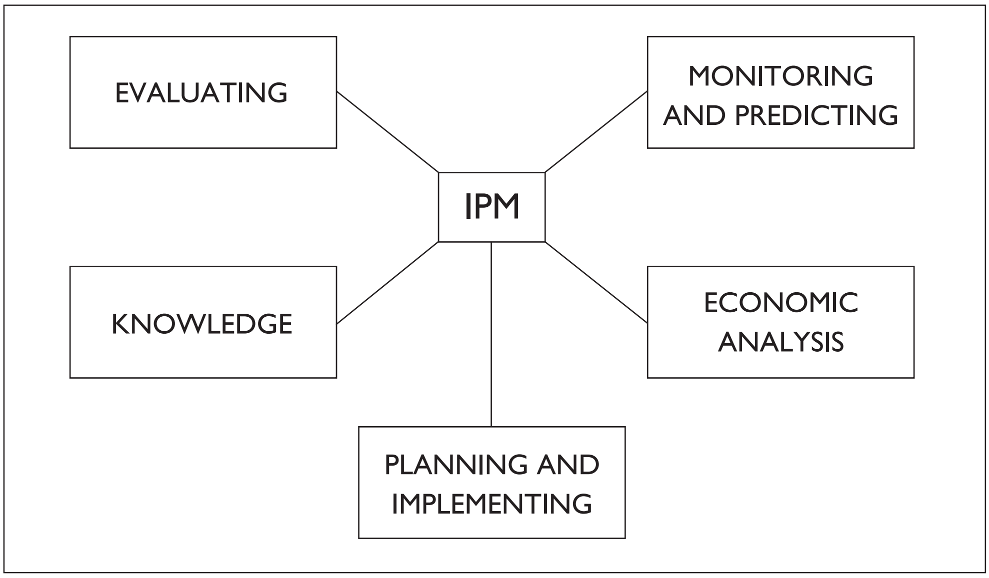

Figure 14.2 The main components of IPM

Knowledge

Knowledge is probably the main component of IPM, and it covers a range of topics, but all the necessary information is readily available – some through observation, some through this book and other publications, some through listening to and discussion with growers, agricultural officers, and teachers, and some through training programmes. The topics include:

Identifying beneficials

The term beneficials is often used to describe organisms in an ecosystem that help to control pests. When designing an IPM programme, it is important to know about these and other organisms in the crop or garden ecosystem so that they can be protected and possibly used as part of the programme.

Life cycles and pest stages

From previous studies in this course, we know that all pests go through different stages as they develop, and that it is often only at one particular stage that the organism actually becomes a pest, e.g. the larval stage of the fruit fly life cycle. Having this knowledge about the pest in question – as well as when and under what conditions the stages occur – is necessary if a planned program is to be successful.

Soil, weather, and seasonal relationships

The interactions between these and other factors can all have a bearing on pest behaviour and development, as well as on those of beneficials. The role each factor plays in the situation should be taken into account when planning an IPM programme.

The pest area

Knowledge about each location where the pest is active, or will possibly be active in the near future, is important. Factors such as whether the growing area is on a hillside, how much sunlight it receives, whether it is close to fields or gardens where similar crops are grown, etc., are all important to know about. This is because they can have some influence over pest behaviour and the techniques that might be used to control the pests.

Control strategies

Knowing about the various sorts of control strategies for particular types of pests is essential if the planned IPM program is going to work. These strategies are often grouped under the general headings of host resistance, cultural control, physical control, biological control, and chemical control. Information about pests in the Pacific Island region can be found from a variety of sources, e.g. the South Pacific Commission (SPC) publications, books, MAFFM, agricultural advisors, etc).

Monitoring and predicting

Monitoring means keeping track of, or keeping a watchful eye on. In terms of IPM, it means going into the area where the crop is growing (and surrounding areas sometimes) and recording pest – and other species – numbers. This doesn't mean you have to count every insect in the field, of course, but you do need to sample numbers in some consistent way, e.g. it may mean counting the number of plants damaged on each plot. With insect pests, you should also record the number of beneficials, e.g. predators of the pest under review, on these plants. Monitoring doesn't require sophisticated equipment but it does require you to be thorough and consistent in your record keeping. If you carry out the monitoring when you are already working in the field, then it only takes a little extra time and the benefits can be well worth the effort.

But why monitor in the first place? The reason is so that you can make predictions about what may happen in the near future if no action is taken against the pests. How much of the crop might be ruined? Does it look like the beneficials are catching up with the pests? What are the other consequences likely to be if nothing is done? These predictions, based on your monitoring data together with expert advice or past experience (either your own or that of others), will take a lot of the guesswork out of the decisions you need to make regarding control strategies.

Economic analysis

Monitoring is important because you can use the results to make predictions about what sort of control strategies you might have to put in place, and the extent to which you might have to apply them. You can also work out the cost of the individual strategies that you are thinking of bringing together – the idea that any strategy has a definite cost is central to IPM. Also, you need to determine the value of the crop that is under threat. You will then be in a position to know what combination of control strategies is economically worthwhile. There would be little point, for example, in applying a set of strategies that would cost more than the value of the crop. When doing the economic analysis you should also be aware that some costs are difficult to express in financial terms. For example, certain control strategies may use up a lot of time but not actually cost anything – what value would you put on this?

Planning and implementing an IPM programme

Planning a programme usually occurs together with the economic analysis. It involves studying the options for combined pest control strategies in the situation you are facing, and working out the total cost for each option. Some combinations may be too expensive, while others may involve a lot of effort but be of uncertain value. All of your prior knowledge about the pest, and relevant information about costs – as well as help from other growers, and agricultural officers – should come together at this stage. Co-operation with other growers is something else you should consider when making your plan – they too might want to deal with the same pest – and together you may be able to implement a programme that would be too costly or difficult to do alone. When you have decide on an IPM programme that makes sense economically and that will have effects on the relevant ecosystems that are considered acceptable, then you will be ready to put your planned programme into action. Preventative control strategies that you will have put into action prior to planting will also be part of your overall programme, e.g. crop rotation, proper spacing between plants, good sanitation practices, etc.

Evaluating the IPM programme

One benefit that everyone hopes will come from putting an IPM programme into action is that the damage caused by the targeted pest will be reduced. But another benefit is the learning that can come from studying and evaluating the programme according to what happened during the current season. How effective has it been? Were there problems in putting it into action? Have there been effects that you didn't expect? Were these good or bad? Were there extra costs that you hadn't considered? What changes would you make to the programme if you were faced with the same pest problem again? These are just some of the questions you should answer in order to become a more experienced and expert user of IPM.

Activity 2 An exercise in IPM

1. Choose one of the three 'pest situations' described below that you want to work on.
2. From the information supplied, and your previous studies in this course, work out the probable identity of the pest, and record it in your notebook.
3. There are five components of IPM. Under the heading 'Knowledge' write down anything that you known (or conclude) about this pest and the situation in which it has been found. Most importantly, include a brief list of the control strategies that you could consider for an IPM programme directed at the pest.

4 The other components of IPM are: 'Monitoring and predicting', Economic analysis', 'Planning and implementing', and 'Evaluating'.

Write down these as headings, and under each, write:

a Anything that you already know about the particular pest situation that is relevant.

b What you need to find out before you can complete an IPM plan.

c How you would go about finding the information you need.

Pest situations

A

Sione has a small plantation of about 200 mature pawpaw trees. He sells most of his produce at local markets. Two weeks ago he noticed maggots in some of his fruit. These maggots were light orange in colour. Last season, a lot more of his fruit were affected in the same way, and on a number of occasions he saw small flies – about as big as house fly – on small fallen ripe fruits. He captured one of these flies and found it to be an orange colour with three yellow stripes along the top of the middle part of its body. The plantation is on a sunny, north facing slope, and there are no other pawpaw plantations around – although there are several small breadfruit plantations nearby. Sione has a large family that depends on the income from his pawpaw, and he is concerned that this pest problem is going to be lot worse next season.

B

Sarah tends her vegetable garden that is near to her village. Like a number of other villagers, she grows a number of different food plants, but in one modest-sized area of about 20 m x 10 m she has, for the last few years, been growing tomatoes and capsicums – selling the produce she does not need for her family. The soil is sandy but the rainfall is good and the location is sunny, and she has been lucky enough to be able to use artificial fertiliser that her farmer-brother brings her a couple of times a year. Despite this, her harvest from this plot has been decreasing over the last couple of years. More and more of her plants haven't grown to their normal size, and the fruits have been small and reduced in number. She has noticed that these plants have 'knots' or galls in their roots, whereas the healthy plants do not. Sarah also has a number of other plots in her garden where she grows other food plants, but they have not been affected. Although there are not too many weeds in amongst the tomatoes and capsicums, there are a lot around the garden. After harvest, Sarah usually leaves the remains of the plants in the garden until she is ready to plant new seedlings. She doesn't have much money and is worried about what is affecting this plot.

C

Timothy and his sister Maria have established a thriving cassava plantation of about one hectare on some land that is surrounded by forest. The soil is rich and full of organic matter, and the area receives good rainfall. They tend their plantation with great care, and each season they sell their entire harvest to a number of buyers. A short time ago, however, they found some large snails in one of their plantations. These snails had started to do significant damage to a number of plants, and after a morning of searching, they collected about 100 of the snails from the affected area. Maria also found some of the snails at the base of a small native plant in the forest area next to the plantation. The snails had conical shells 15 cm long that were brown and creamy coloured. There are other cassava gardens in the area and their owners have also recently reported finding the snails. One grower had lost much of his crop after returning from a three-week absence. Timothy and Maria are unsure of what to do.

Activity 3 Life cycle of pests

1. In groups of three study and discuss the life cycle of a common pest of an animal or crop on a farm.
2. Discuss and recommend the best time in the pest's life cycle for controlling it.
3. Give reasons for your answer.
4. Prepare a strategy for controlling the pest including the steps you would follow and possible control methods that can be used. Also indicate the likely costs and people or institutions you may seek advice from.

Review

1. Why do we need to protect crops from pests?
2. List some methods we can use to protect crops?
3. List the main factors we should keep in mind when selecting methods to use?
4. Explain why is it helpful to understand the life cycle of pests?
5. Define Integrated Pest Management or IPM.
6. State four problems that are associated with relying on pesticides, and that led to the development of IPM.
7. List, and briefly describe, the five main components of IPM discussed in this lesson.

Unit 15

Practical Experience

In pairs study the following three crops and do the activities that follow.

Winged bean

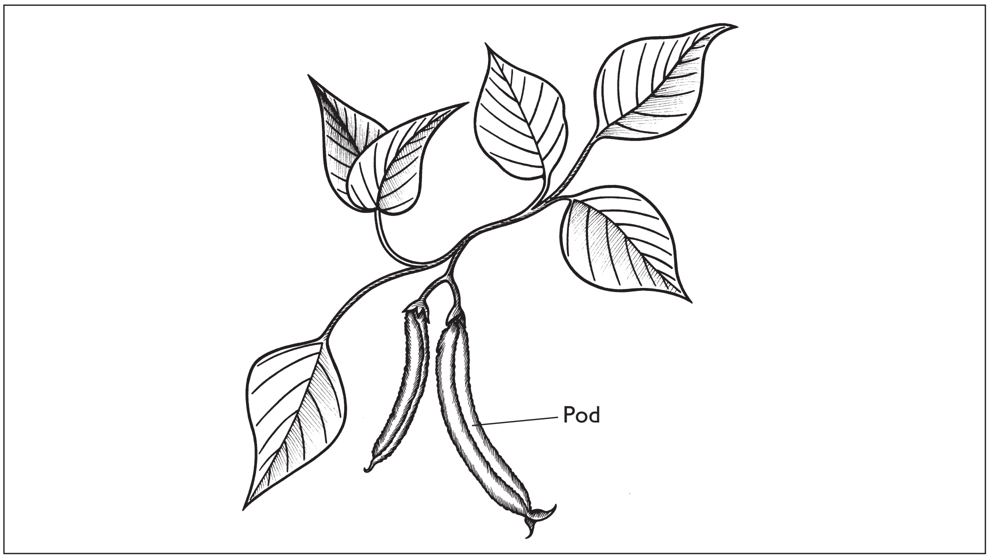

Figure 15.1 Winged bean Psophocarpus tetragonolobus

The green and purple cultivars are recommended.

Environmental response:

- well adapted to humid climate although a dry period is favourable to fertilisation and the production of mature pods
- medium loam soils are generally suitable although growth is satisfactory on a wide range of soil types – a high level of nodulations can compensate for a lack of soil nitrogen
- good drainage is essential since the crop is sensitive to water logging – well-distributed rainfall in the range of 1500–2500 mm is normally required and many cultivars are sensitive to long periods of drought
- most cultivars are tolerant to temperatures in the range of 25–35°C. Elevations of up to 2000 m are considered suitable for satisfactory growth.
- a day length of 12 hours or less appears to be required for flower initiation, development and pod set of plants grown from seed. Plants produced from tubers of the previous season appear to flower under slightly longer days.

Propagation and planting:

- seeds are sown on prepared beds or ridges 90–100 cm apart with 45–60 cm between plants, or at a spacing of 1–1.5 m x 1–15 m for long-duration crops grown for pod production
- plants require support from stakes or trellis to a height of two metres
- in some areas, the root tubers are allowed to remain in the soil to produce planting material
- seed requirement is 10–15 kg/ha.

Irrigation:

- irrigation may be required to maintain adequate soil moisture reserves during the active growing period when large and numerous nodules are formed on the roots.

Nutrient requirements:

- NPK applied before sowing with routine applications at 21-day intervals has been reported to stimulate growth, however in some areas nitrogenous fertilisers may promote excessive leaf production.

Growth period and harvesting:

- immature pods may be harvested when 15–20 cm in length and 2–25 cm wide. The first pods are produced at about 60–80 days from planting and harvesting may continue for a considerable period
- the seeds may take up to 180–270 days to become mature
- mature tubers may be harvested from 120–240 days from sowing, when they have developed to 7.5–12 cm in length and 2.5–5 cm in diameter
- tubers which remain in the soil will initiate new shoots the following season – these are sometimes used for propagation.

Yield:

- approximately 35 000 kg/ha of green pods and 900–2000 kg/ha of seed are produced
- tuber yields vary from 2.5–6 tonnes/ha have been obtained
- there may be a correlation between green pod and tuber yield – pod removal may have low tuber yields.

Storage:

- the conditions recommended for garden peas are generally suitable, although the pods are sensitive to chilling
- the storage temperature should be in the region of 10°C
- in a relative humidity of 90 per cent, storage for up to 21 days is possible, with a weight loss of up to 20 per cent.

Use:

- immature pods, young leaves, flowers and shoots are all used as a cooked vegetable
- the tuberous roots are eaten raw or cooked
- the mature seeds can be roasted.

Pests:

- ❑ some common pests that attack winged beans are aphids, spotted pod borer, root knot nematode. However with low incidence it is not economical to control pests.

Diseases:

- ❑ leaf spot, anthracnose, root rot, false rust are all common diseases of winged beans which affect the plants late in their growth period – in most cases it is uneconomical to control, but locally available fungicides are recommended if they need to be controlled.

Carrot

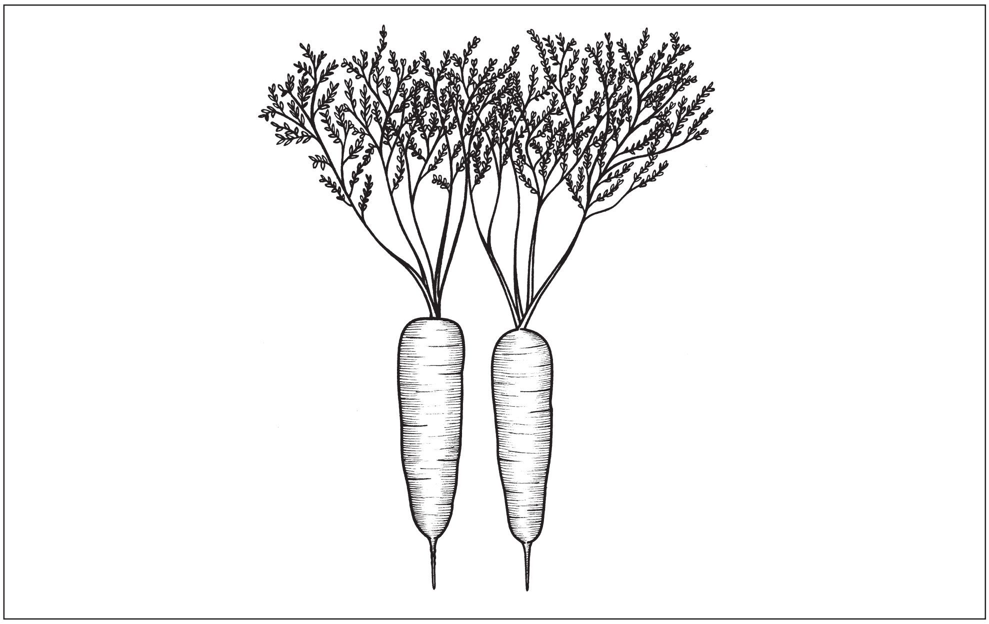

Figure 15.2 Carrot Daucus carota

Carrots can be planted all year round. The recommended varieties are Chetenney, Manchester Table and New Kuroda.

Yield:

- ❑ with favourable conditions expected yields are around 10–15 tonnes/ha.

Planting time:

- ❑ the best planting time is April–October.

Plant density:

- ❑ recommended spacing are 30 cm between rows and 5–8 cm within rows.

Seed rate:

- ❑ 250 gms/ha is recommended.

Soil requirements:

- ❑ carrots require well drained, well structured alluvial soil.

Method of planting:

- ❑ direct sowing on very well prepared fine soil.

Fertiliser requirements:

- ❑ poultry manure at the rate of 12 tonne/ha or NPK (13:13:21) at 200 kg/ha – poultry manure must be applied one to two weeks before sowing to allow it to decompose
- ❑ top dress with urea at 100 kg/ha – this should be applied when plants reach 3–5 cm high (remember to keep urea away from base of plants).

Plant protection:

- ❑ keep carrots weed free by removing weeds early
- ❑ common pests and diseases are nematodes and alternaria leaf blight – to control nematodes use crop rotation or fumigate the soil with Formalin 21 days before sowing. Use Mancozeb (a protectant fungicide), or Bravo or Rovral (both broad spectrum fungicides), to control alternaria leaf blight.

Time to Maturity:

Carrot mature about 10–15 weeks from planting – this is the best time to harvest.

Bunching onions

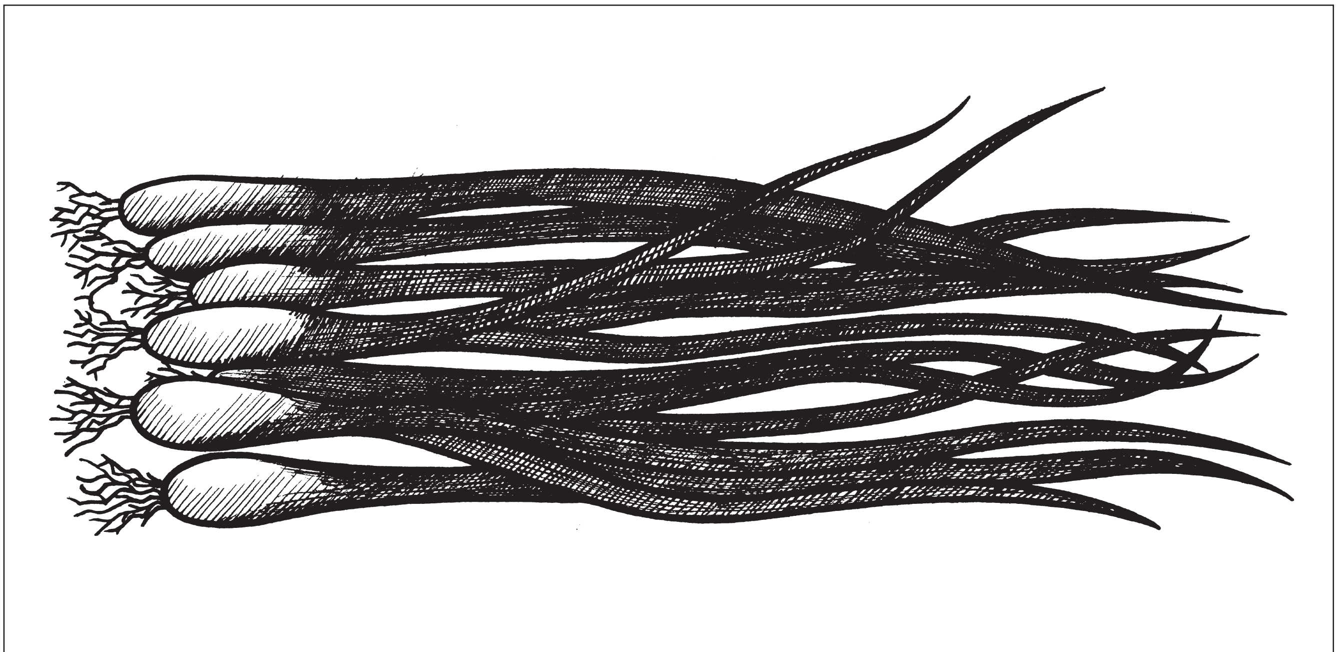

Figure 15.3 Bunching onion or Welsh onion Allium fistulosum

There are many local and commercial cultivars, including both tall and short leaved forms.

Soil requirements:

- ❑ well drained loams, with a high level of organic material are generally suitable
- ❑ grows well in areas of high rainfall.

Seed rate:

- ❑ 4 kg/ha gives a density of 300 000 plants/ha.

Method of planting:

- seeds are sown in containers or in a seed bed
- seedlings are transplanted, when 15–20 cm in height
- prepare beds with rows 24–30 cm apart, plants should be 15–20 cm apart in the row
- most cultivars are easily propagated by division of the basal roots produced by the parent plant. These are detached and planted at similar spacings.

Fertiliser requirements:

- NPK fertiliser should be applied before planting, followed by dressing of potash and nitrogen at intervals during the growth period.

Time to maturity:

- plants are normally mature enough for harvesting 60–120 days from planting.

Yield:

- an average of yield of 20 tonnes/ha may be obtained.

Harvesting:

- harvesting may be spread over a long period by detaching the outer leafy shoots from the main cluster without disturbing the parent plant.

Plant protection:

- there are rarely any serious pests and diseases of spring onions, but they must be kept weed free to ensure good yields.

Pruning

The main aim of pruning is to develop a strong shaped framework, to promote optimal plant development and crop yield. Dead or diseased wood should be removed, and pruning can be used to limit some pests and diseases. Removal of unwanted growth provides ready access for harvesting and other field operations. As flowers are borne on older leafless wood on cocoa plants, heavy pruning of developing trees will seriously reduce early yields and heavy pruning should be avoided. The multiple stems developed near ground level by trees grown from cuttings are usually thinned to give a balanced framework of three to four main branches and these 'trunks' are kept free of undergrowth. Chupons or water shoots (shoots that grow from the stem of branches) on cocoa seedlings develop a higher second jorquettes (point or area where 4 or 5 branches meet) after pruning, a process which may continue with the formation of a third and subsequent jorquettes. In some countries, this growth is restricted by pruning to the first jorquette, but there is no clear evidence for or against this practice.

In cocoa the branches that should be removed are chupons, certain fan branches, low hanging branches, over-shaded branches, interlocked branches, branches that are too long, diseased and damaged branches. A pruning knife, saw or secateur can be used for pruning.

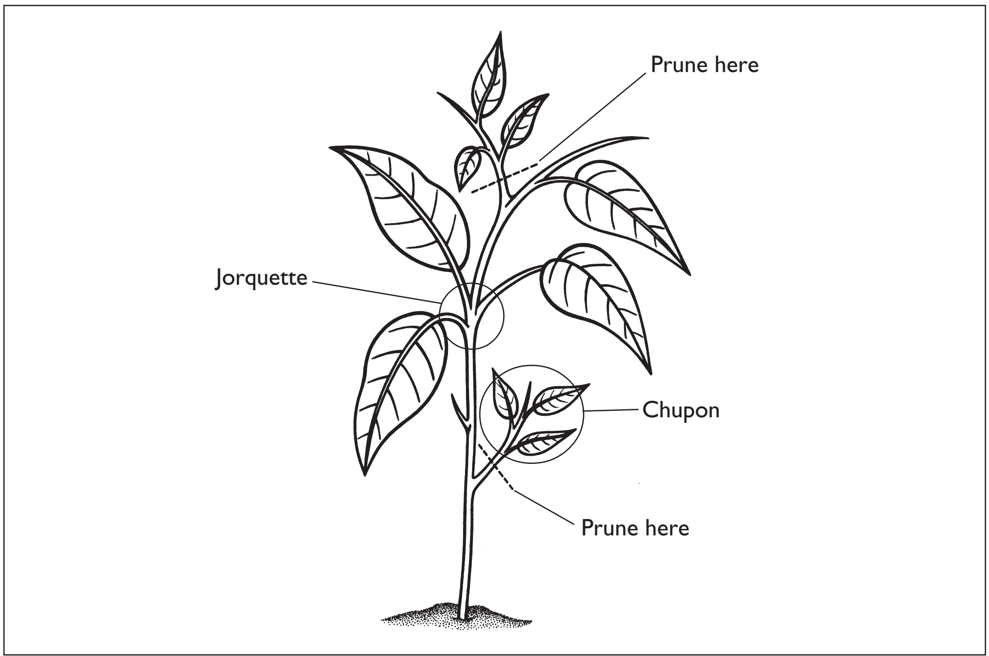

Figure 15.4 Pruning – Cocoa

Activity 1 Intercropping and phase planting

1. In pairs plan an intercropping or phase planting programme using winged beans, carrots and/or spring onions.
2. Use a plot size of 1 m × 10 m.
3. Prepare the plots and plant the crops according to your plan. Use the recommended plant spacing.
4. Record all activities and costs involved.
5. Manage the crops by applying fertiliser, weeding, watering, training and controlling pest and diseases if necessary.
6. Record yield at harvesting.

Materials:

- spade
- bush knife
- oso
- hoe
- digging fork
- measuring tape
- watering can
- hose pipe
- sprinkler
- fertiliser – NKP and poultry manure
- string (20 m)
- seeds – winged beans, carrot and spring onions (can use cuttings as well)
- secateurs or pruning saw
- knapsack sprayer

Activity 2 Pruning demonstration

1. In pairs select a crop and prepare a flow chart on how to prune your crop plant.
2. The chart should show the steps and key points of pruning.
3. Demonstrate to the class within ten minutes how to prune your plant using the steps on the chart.

Review

1. List the advantages and disadvantages of intercropping, phase planting and pruning.
2. What are the key points we should keep in mind when planning intercropping and phase planting and pruning programmes.
3. What are some other methods we can use to help us improve crop production?
4. Describe the nutritional and economic value of winged beans, carrots and spring onions.

Part 5 Animal Production

Unit 16 Pig Breeds And Breeding

Most pigs in Sāmoa are local, indigenous or crossbreeds that are well adapted to local climatic conditions. They are also well adapted to local management systems, local feed and are hardly affected by local pests and diseases. The major pig production systems practised in Sāmoa are the traditional or free-range system and the semi-intensive system. Both systems raise Samoan breeds, which are mainly fed with coconuts, fruit, grass and kitchen waste. There are few commercial pig farms in Sāmoa. They keep improved breeds, e.g. Landrace, Large white and crossbreed stock.

Breeding for efficient production in pigs

Traits are inherited through genes. Simply inherited traits are determined by one or two pairs of genes. A pair of genes may be transmitted or expressed in one of two forms; dominant or recessive.

The dominant gene, whether it is paired with a recessive gene or with a similar dominant gene, will still express its effect. For example, white colour is dominant to black. Thus, when a Large White boar is mated to a black sow, all the offspring will be white. However, not all the white pigs in the litter carry the genes for pure white colour, and if a boar from this litter (first generation) is crossed with a female (a gilt) litter-mate, the resulting offspring in the second generation will be on average 75 per cent white and 25 per cent black in colour. The black pigs, possessing recessive genes, will breed pure for black colour (Figure 16.1).

Recessive genes do not show their effects in individual animals that also possess a dominant gene. They are transmitted from generation to generation without being noticed. The traits controlled by a recessive gene will only appear in offspring if a boar and a sow with the same recessive gene are mated. Recessive genes may produce either desirable or undesirable traits.

Examples of the effects of undesirable recessive genes in pigs are scrotal hernia and inverted nipples. Thus, if these traits appear in a herd, the boar and the sow as well as their litter should be culled as it is impossible to known which pigs possess the recessive genes (Figure16.1).

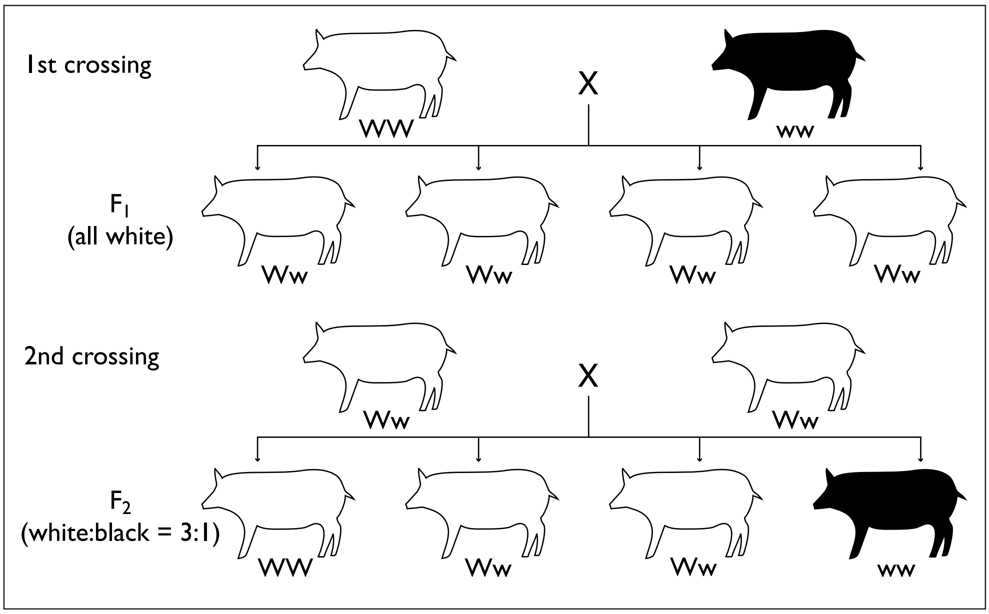

Figure 16.1 Dominant-recessive cross

There are other traits, more complex in inheritance, that are of interest to pig breeders and producers, e.g. rate of weight gain, efficiency of converting food to growth, and carcass quality. These traits are controlled by many pairs of genes and the genetic process involved is very complex. However, when an unrelated sow and boar are mated, the resulting offspring show better production performance than either parent. They are said to exhibit hybrid vigour and the less the parents are related the greater the expression of hybrid vigour.

Breeding systems

Breeding systems are those methods used by breeders for mating their livestock. The system of mating is particularly important in pig improvement since use of the correct system can greatly increase production. The three main systems are:

- ❑ outbreeding — pigs that are not related are mated – outbreeding tends to produce litters with greater vigour and productivity
- ❑ crossbreeding — pigs of different breeds that each have desirable characteristics are mated. Some of the genes that influence vigour may exist in homozygous form or in pairs of the same genes. Crossbreeding results in heterozygous individuals in which most pairs of genes contain one of the dominant genes that influence vigour.
- ❑ inbreeding — related individuals or those with a similar pedigree are mated, increasing the similarity of the animals within the group. Inbreeding usually decreases vigour because it brings together the recessive genes with undesirable effects in the resulting crossbred animals. These homozygous recessive individuals are usually inferior. Inbreeding, however, is not always disadvantageous, provided there are no undesirable recessive genes existing in the stock. If strict selection is practised, inbreeding may be useful for the purpose of eliminating defects. It brings out the desired character in a pure form and this character may then be retained.

Many improvements achieved in pig production during the past years have resulted from improved breeding and the use of productive breeds in upgrading, purebreeding and outcrossing (Figure 16.2).

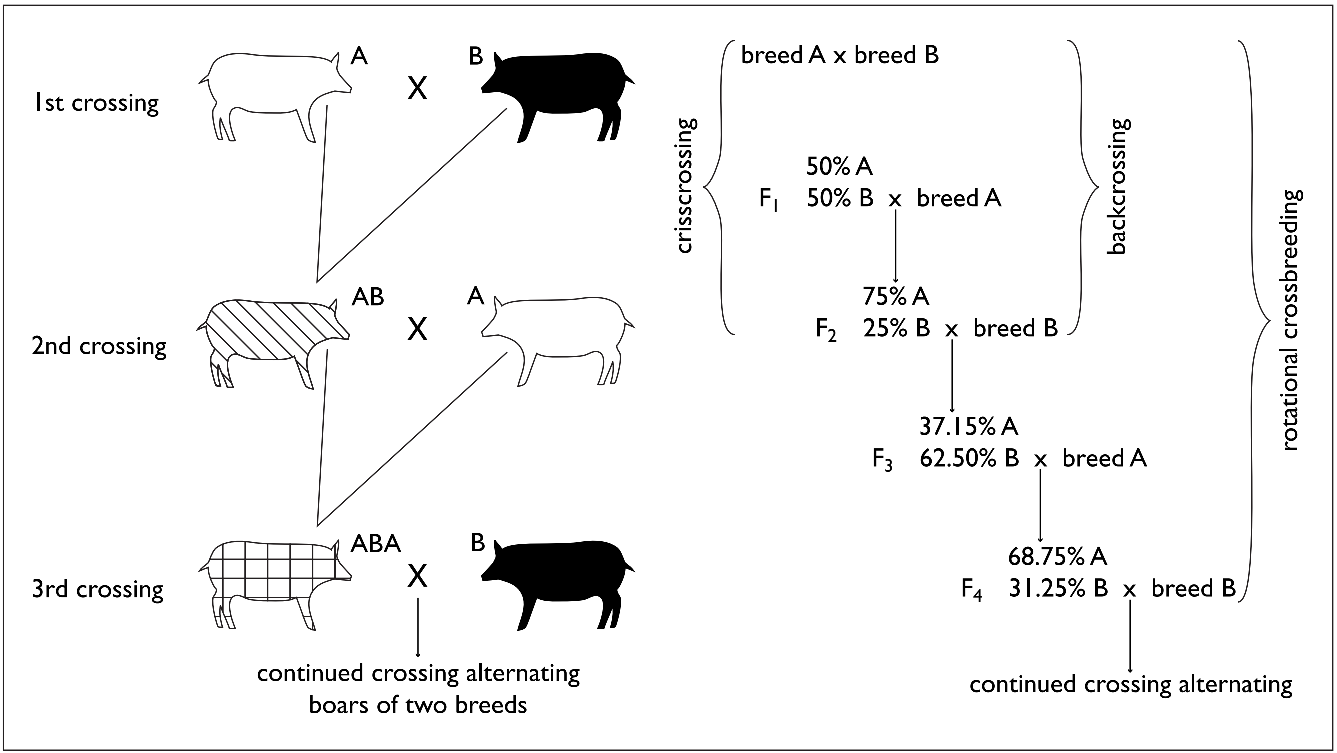

Figure 16.2 Crisscrossing of two breeds

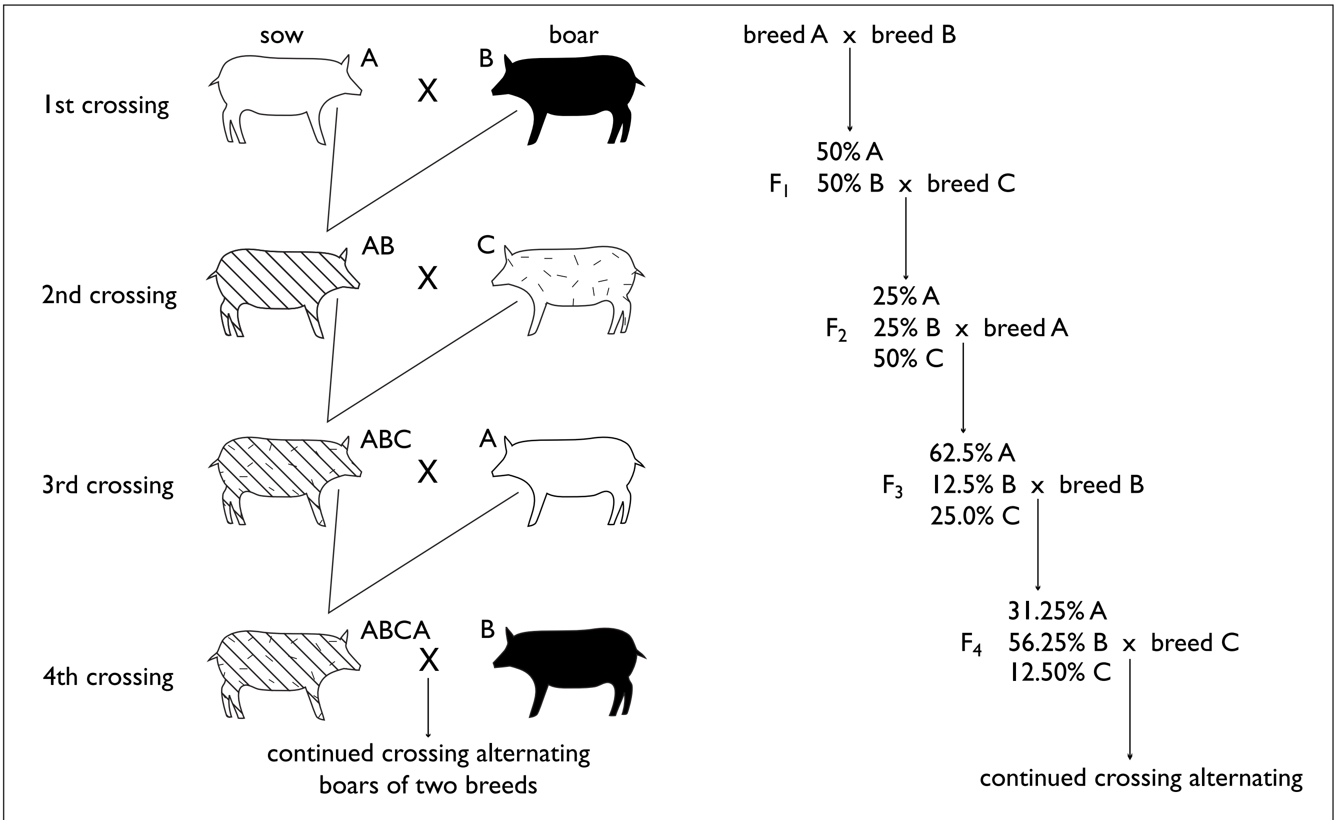

Figure 16.3 Triple crossing of three breeds

Crossbreeding for pork production

Crossbreeding is the most practical approach to increasing production in tropical countries. About 80 to 90 per cent of the pigs marketed by commercial and backyard farms in the tropics are crossbreeds. This large proportion indicates that both small- and large-scale pork procedures have found crossbreeding to be an essential and profitable management practice.

Examples of crossbreeding are:

- crossing two different breeds – this involves the mating of purebred boars to purebred or high grade sows of another breed
- crisscrossing, otherwise known as a two-breed rotation – boars of two different breeds are used in alternate generations. Crossbred sows are retained each generation and bred to boars of the same breed as the grandsire (grandfather) on the dam's (mother's) side. Under this system, both sow and piglets are crossbred after the first crossing. Boars are purebred and come from a herd with proven high performance. Crossbred vigour usually results in an increase in litter size, viability and growth rate (See Figure 16.2).

In triple crossing or a three-breed rotation, the first-cross gilts are mated to a boar of the third breed. The process is continued by using a sire selected from each of the three breeds in rotation (See Figure 16.3).

Multiple crossing is a system using boars of different breeds at specific breeding cycles in order to prevent the production of pigs with excessive fat. By using boars of the bacon-type such as the Landrace-crossed strains, hybrid vigour and approved type are maintained. However, traits that demonstrate the most hybrid vigour in crosses are those that show the lowest heritability.

Activity 1 Investigation of breeds

Materials:

notebook

Your class can get the information required for this activity by either inviting a livestock farmer and a livestock officer to visit the class or by visiting a farm or the livestock office and livestock division farms.

1. In pairs investigate the types of pig and cattle breeds traditional and commercial farms keep.
2. Find out from farmers or agricultural livestock officers why farmers keep such breeds.
3. Suggest the ways in which breeds can contribute to improvement in livestock production.
4. List the types of products pig and cattle in Sāmoa are farmed for. List potential products from pigs and cattle.

Review

1. Why are breeds important in animal production?
2. List some methods of improving breeds.
3. List some unimproved and improved breeds of pigs and cattle.
4. What are the current breed improvement programmes used by the MAFFM?

Unit 17

Pig Farming

Without doubt, management has the main influence on the profitability or otherwise of a pig herd. The producer must think about the well-being and productivity of his animals and the costs of production. Success of an enterprise depends on a high degree of attention to detail in both these areas.

Stockmanship

Stockmanship concerns the personal relationship and rapport between a stockman and his animals. Pigs and cattle are very responsive to quiet, calm conditions. The good stockman is firm, but understands the needs of his animals. He will always be on the watch for anything unusual in the behaviour or condition of an animal and thus learns to anticipate problems before they arise.

Pig and cattle handling is part of good stockmanship, and should be carried out in as calm a way as possible. It is particularly important to minimise the upset to pigs and cattle when they are caught or driven.

When catching a suckling pig, it should be approached from behind and lifted suddenly by one or both hind legs above the knee-joint or hock. It can then be held round its shoulder. Bigger pigs can be caught by grasping with both hands behind the shoulder of the pig, lifting it off the ground and then holding it firmly against the body. If pigs have to be driven, it is essential to remember that they cannot be led by the head (like a cow, for example), but must be driven from behind. The natural instinct of the pig is to head for any gap and the skill is, therefore, to make maximum use of any walls, solid hurdles or pig boards to ensure that the only gap is in the direction you wish the pig(s) to go.

Occasionally, it is necessary to restrain a sow or boar for treatment purposes. The best method is to make a slip-knot in a two-metre length of rope and allow a sufficiently large noose around the pig's mouth. The rope should make a circle around the snout close up against the position where the upper and lower jaws join. When it is in place draw the noose tight. If necessary, twist the surplus rope round a railing or pole, but normally a man holding firmly at about 35° to the horizontal will be able to hold the pig, which will always pull against the pressure and stand firm for any treatment. For quick release, do not pull the rope right through when completing the knot, but leave it in a loop. When the loose end is pulled, the knot will fall apart.

Hygiene

The importance of good hygiene in a piggery cannot be over-emphasised. Not only does it help to reduce the incidence of disease in the pigs, but it also has a beneficial effect on staff morale by improving the working environment. Any cleaning program that is designed should allow for the periodic emptying and resting of each house. For the farrowing house, this should consist of a week's rest in between each batch of farrowing sows. For fattening pens, a five-day break after each group of fatteners is adequate. Immediately after it is empty, each pen should be thoroughly scrubbed and cleaned, washed and soaked in disinfectant and allowed to remain dry for the remainder of the period that is empty.

Boars

Although it is often said that 'the boar is half the herd', management of boars is frequently one of the most neglected aspects of pig enterprise.

The young boar

When a young boar is brought into a herd the farmer must pay attention while they settle into their new surroundings. Boars should be purchased well in advance of their expected use and housed on their own for a minimum of a month. They should not, however, be isolated from sows and gilts. On arrival, they should be dosed for worms and sprayed/dipped against infection. It is recommended that the young boar is exercised daily. This has the added advantage of allowing him to get used to his stockman, and the sights and smells of the piggery. The boar should be fed to provide for continued growth, but should not be allowed to become fat and sluggish (2–2.5 kg of a standard sow and weaner meal each day is usually adequate for this purpose).

A boar should be ready for service at seven-and-a-half to eight months of age. In the first instance, he should be introduced to a small sow who is well on heat and standing firm. This will prevent him becoming frustrated and allow for a successful first service and a favourable sexual experience. At no time should a young boar be introduced to a group of females, as the bullying that may occur can adversely affect the boar's libido for some time afterwards. For the first few months of his breeding life, the boar should not be overworked and a maximum of two services per week should be the rule.

Mature boars

Maintaining a boar in the lean, hard condition which is ideal for service requires good stockmanship. A balanced ration should be fed at a level, which prevents the boar becoming either too fat or too thin. Research has shown that isolation of mature boars (i.e. older than 10 months) from female pigs can severely reduce their level of sexual behaviour. Thus, boars should be housed within sight and sound of sows and gilts so that they obtain the necessary stimulation from the presence of female pigs.

Under tropical conditions, it is essential that boars are protected as much as possible from high temperatures. Otherwise, they will suffer from suppressed libido and low sperm production. In hot climates spraying with water, either by hand or sprinklers which are timed to operate intermittently, and allowing access to wallows can reduce heat stress and sunburn. Conducting matings either early in the day or in the evening when temperatures are normally lower is also important.

Boar-to sow ratio

To avoid overworking boars the ratio of sows to boars should not be too large. The standard recommendation is one boar to 20 sows and gilts. However, this must be related to peaks of service activity. In units where boar numbers are low, it may be beneficial to allocate two days each week instead of one for servicing to spread the work-load of the boars.

Frequency of use

There is a great variation between boars, but in general terms overworking a boar will reduce the quality and quantity of the sperm produced, leading to small litters and an increased number of sows returning to service.

By 10 months of age, a well-managed boar should be able to cope with five to six services per week and still maintain good fertility levels. On the other hand, a boar should not be under-worked, and intervals of over 14 days will most likely lead to reduced litter sizes because the semen becomes less fertile.

Lameness

Surveys from many countries have shown that some 20 per cent of boars are culled for foot problems and lameness. Prevention is better than cure, and care should be taken to ensure floors are not rough or dirty. New concrete is particularly damaging to skin and feet because of its extreme alkalinity.

Supplementary biotin (a vitamin) in the food and the use of footbaths containing either five per cent formalin or five per cent copper sulfate solution can help to harden the claw horn.

Sows

The young sow (gilt)

Normally, sows are culled after their fourth lactation. This means that sows with their first litter contribute some 25 per cent to herd productivity and highlights the need to optimise their performance.

Gilts which are selected on the farm should be moved out of fattening pens at five months of age into groups in well-bedded pens or yards, or even outside paddocks. They should be fed to continue growth without becoming overfat (2–2.5 kg of a standard sow and weaner meal a day is usually adequate).

If gilts are brought into a herd, special care and attention and a period of 'integration' into the herd are essential. Ideally, they should be purchased in batches at least six weeks before they are due for service. They should be examined carefully to see that they are not damaged in any way. They will need encouragement to start eating normally in their new environment. The gilts can be housed in pens or yards, and given access to dung and waste from the farrowing house, allowing them to build up immunity to infertility, viruses and other diseases. Thereafter, they can be gradually integrated into the main gilt/sow herd.

The major objective of gilt-management should be to induce all replacement gilts to reach puberty as soon as possible after selection. This will allow the following objectives to be achieved

- disposal of gilts which are not showing any breeding activity at an early stage
- access to a pool of young, sexually-active gilts
- gilts at second heat or more at first mating – this will increase the size of the first litter.

In order to help stimulate the onset of puberty, a boar should be introduced to the gilts for 10 to 15 minutes every day. The boar used for this purpose should be at least nine to 10 months of age and actively working so that he is producing enough of the necessary odours (pheromones) to have a stimulatory effect on the gilts. Gilts are most sensitive to boar stimulation at 145 to 170 days of age.

If gilts are slow to come on heat for the first time, other techniques which can sometimes be beneficial are mixing them with strange gilts, moving them into new accommodation and taking the gilts for a ride in a truck or trailer.

Gilts of exotic breeds should be over 120 kg body weight when served and in good active condition. Free access to feed (ad-lib feeding) for 14 to 21 days prior to service helps stimulate the number of eggs released and consequently can increase litter-size. Care must be taken so that the boar used on gilts is not too heavy, otherwise he may cause damage. If the boar is too heavy, a service crate can be useful. The sow stands in the crate and the boar takes some of his own weight on his front legs which rest on the crate. However, successful service using a service crate is not always easy to achieve, and it is generally best to try and avoid too much difference in weight between the boar and the gilt.

Lifetime productivity

The ultimate measure of the productivity and profitability of a sow is the number of healthy weaners reared in her lifetime. Management strategy must therefore try to maximise this output within the constraints of each enterprise.

However, before considering the separate phases in the breeding cycle of a sow, namely farrowing, lactation, weaning, mating and pregnancy, it is essential to realise that they cannot be dealt in isolation. Each phase will affect the other and feeding, for example, can have a large carry-over effect from one phase to the next.

It is best to minimise bodyweight changes over the entire reproductive cycle. This means relatively low levels of feeding during pregnancy and high levels during lactation. Not only does this prevent the sow becoming too fat and heavy at farrowing, which minimises farrowing problems, but it also keeps her from becoming too thin at weaning which can cause delay of oestrus and rebreeding. At the same time, allowance should be made for continued growth and weight-gain for at least the first three to four reproductive cycles. In this respect, it is often recommended that a sow should gain some 12 to 15 kg of bodyweight from weaning to weaning for the first four breeding cycles (see Figure 17.1).

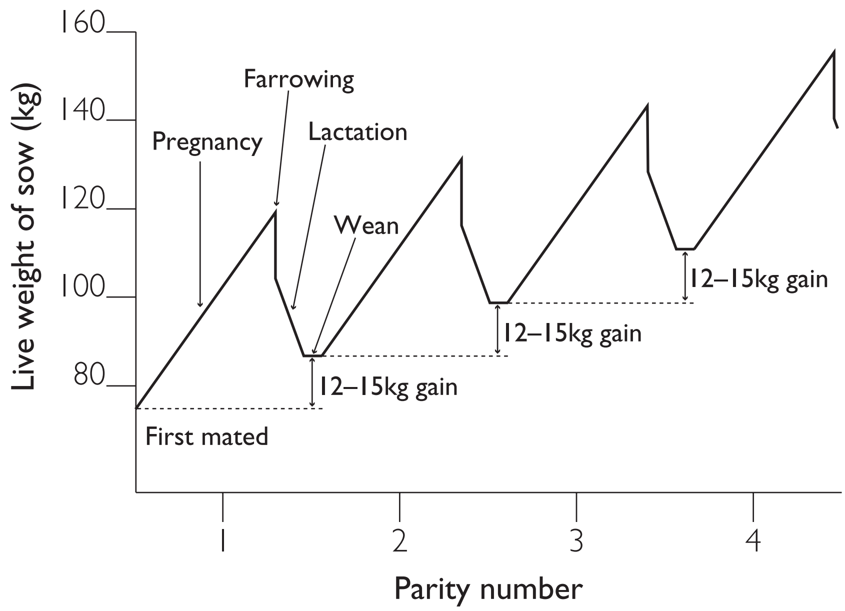

Figure 17.1 Recommended bodyweight increases in sows over successive breeding cycles

The state of the sow's body-fat reserves is likely to be more important for reproduction than weight gain. For example, a 160 kg sow may be a small-framed animal carrying a large amount of fat, or a much larger-framed animal in very poor condition. As a consequence, a sow-condition scoring technique has been developed using a combination of visual appraisal and physical feel at various points such as the pin bones. The scoring system is given in the table below. By aiming to achieve certain condition scores at set points throughout the breeding cycle, it provides a very useful guide to management and feed requirements.

Table 17.2 The sow-condition scoring system

Score	Description	Assessment of fat cover at the pin bones
0	Emaciated	Exposed, no cover on bones
1	Poor	Bones prominent, little cover
2	Moderate	Bones easily felt without palm pressure
3	Good	Bones only felt with firm palm pressure
4	Fat	Bones cannot be felt with firm palm pressure
5	Grossly fat	Further disposition of fat impossible

The change in approach from feeding according to set requirements to the more flexible system of feeding according to the body condition of the sow is particularly appropriate in the tropics. Feeding according to body condition makes it easier to use less conventional foods that have a lower nutrient value. The effect of these foodstuffs can be assessed by the responses in sow condition particularly when they are fed to dry sows.

The Breeding Cycle

Farrowing

Farrowing or birthing is undoubtedly one of the most critical stages in the whole reproductive cycle. Problems at this stage lead very quickly to high mortality rates and reduced efficiency of both sows and piglets. The skill of the stockman is to learn to recognise the conditions of a normal farrowing so that any differences from normal can be detected and corrected.

Two to three weeks prior to farrowing, the sow should be dewormed to minimise the possibility of the sow passing worms to the new-born litter. She should be moved to her farrowing quarters a week before she is due to farrow. A sow should be washed with soapy water to remove any dirt before entering the farrowing pens. She should also be sprayed to kill any mites and lice on her body.

At this stage it is essential to avoid constipation in the sow because it interferes with the farrowing process. It may be necessary to supplement the diet with bran, green feed or extra fat for the last week of pregnancy.

There are two sure signs that farrowing is about to commence:

- ❑ The sow will show increased restlessness (in direct contrast with the peaceful animal of the late pregnancy), and will start to make a nest by rearranging her bedding.
- ❑ Milk can be withdrawn from the udder about 12 hours prior to the start of farrowing.

Sows should be supervised by an experienced stockman at each farrowing.

Two major problems encountered during farrowing are:

- ❑ The process may become painful, particularly for gilts if the piglets are relatively large. This can result in the sow savaging her litter. In this case, all piglets should be removed until farrowing is completed and then reintroduced slowly under supervision. Exercising the sow can also help, but it may be necessary to muzzle (part of the leg of an old gumboot is very useful for this purpose) or tranquillise the sow.
- ❑ Delayed farrowing. After farrowing has started, any time-gap of greater than 30 minutes between presentation of piglets probably means that a piglet is stuck in the birth canal. In this case, the stockman should disinfect and soap his arm and then gently work it into the birth passage to release the stuck piglet. Because the sow will often stop straining in this situation, a simultaneous injection of oxytocin will usually get contractions going again and farrowing will then proceed normally. The only certain sign that farrowing has been completed is the passage of the afterbirth.

Stillbirths

Seventy per cent of stillbirths in pigs are caused by asphyxiation or weakening during the birth process. About 70 per cent of these occur in the last piglets born in a littler. This is because of the length of a sow's uterus which means that piglets from the far end have to travel some 0.3 m after their umbilical cord has ruptured. The intact cord supplies the piglet with oxygen from its mother's blood. Once the cord is broken, the piglet will start gasping for oxygen. It then has five minutes to get to the outside before it will stop breathing.

Many factors can cause delays in the farrowing process and thereby increase the incidence of stillborn piglets. They are:

- Large litters. Because the whole process will take longer, the last piglets to be born have a higher risk of being asphyxiated.
- Very small litters. These may not provide enough stimulus to the sow to start effective uterine contractions.
- Older sows. After five or six litters, uterine tone declines, resulting in a less efficient birth process.
- Genetic make-up of the sow. Variations can occur between families in the efficiency of farrowing. If a strain of pigs is identified which regularly have more stillbirths they should be culled.
- Nutrition. Sows should not be overfat or, alternatively, too thin with insufficient reserves of energy.
- High ambient temperatures. Sows will tend to tire more quickly in hot conditions.
- Piglet diseases. Dead piglets can slow down the birth process leading to a greater risk to the live pigs.

If stillbirths are a problem in the herd, every attempt should be made to minimise the effects of any or all of the above factors.

The newborn piglet

The key to piglet survival is to remember that piglets are born with very limited supplies of energy. Often these have been reduced by the stresses of the birth process.

A healthy, good-size piglet will get to its feet within minutes of birth and instinctively try to reach the sow's udder. Once the first successful suckle of colostrum has been achieved, the piglet is better able to continue to get a teat. However, weaker and lighter piglets (less than 1.0 kg at birth for exotic breeds), are less able to reach the udder, are generally less competitive if they do, and are more likely to die if they are not assisted.

Apart from air, colostrum is the most important substance a piglet takes in during the first few hours of its life. Colostrum is a source of both essential energy and antibodies and without it piglets will die. Management techniques which can assist in piglet survival are:

- Maintain an even temperature. Ensure piglets are not exposed to cold or draughts, because they will use their limited energy to keep warm.
- Cross-fostering. This is a well-proven and widely-adopted technique. When sows farrow within a few hours of each other, litters are evened up by transferring piglets from sows with large litters to those with smaller litters. This increases the survival chances of the smaller piglets in the original larger litters. It is advisable to transfer the bigger piglets on to the foster mother. Check that the teats of the foster mother are not too big for the fostered piglet to suckle successfully.
- Split suckling. After the larger piglets in the litter have had a good suckle of colostrum (approximately 1 hour at the udder), they are shut away in a warm box for the next two hours. This gives the remaining smaller piglets access to the udder to get their share of colostrum. This can be repeated twice in the first 18 hours.

- Supplementation. The supply of colostrum to small and weak piglets can be supplemented with colostrum which has been stored. Colostrum can be obtained by milking sows before they farrow, or during farrowing. Store it in the deep freeze. This can then be given to needy piglets via a bottle, or more effectively, via a stomach tube. The latter consists of a soft tube around 25 cm long which is inserted down the throat directly into the stomach.
- Extra fat in the sow diet. The addition of some supplementary fat in the diet of sows for seven to 10 days before farrowing can increase the fat and, therefore, energy content of the sow's milk. It may also increase piglet energy reserves and vitality.

Other routine operations which it is advisable to carry out at this stage are:

- Navel cords should be immersed in a dilute solution of iodine within 12 hours of birth. Any individual navel cords which are very long should be trimmed to about 5 cm before immersion in the iodine solution. This prevents infection entering through the navel and causing joint ill, a condition causing swollen joints. Piglets with the condition will not thrive and may die.
- Eye teeth should be clipped within 24 hours to remove the points. This process helps to prevent teat and udder injuries.
- Within three days after farrowing, housed piglets should receive supplementary iron to prevent anaemia. This can be given by injection, which is preferable. If injectable compounds are not available, soil enriched with ferrous sulfate should be placed in the pen.
- Ear notching, or other systems of identification, can also be carried out at this stage.

The lactating sow

Contented sows make the best mothers, and management should be aimed at keeping sows as comfortable as possible.

Directly after farrowing, the sow should be examined for any disease problems, particularly mastitis, metritus and agalactia (MMA) and if symptoms are seen, she should be treated immediately.

As the sow can lose up to eight litres of body fluids from the uterus and associated tissues over a four-to-six hour period at farrowing, it is essential that she has access to plenty of fresh water. Failure to provide water at this stage can lead to agalactia.

The lactating sow should be fed at a rate designed to minimise her bodyweight-loss during lactation. Unless she has a very small litter, this generally means feeding as much as she will eat, twice daily. If a sow continues to show significant weight loss in spite of feeding to appetite, intake can be stimulated by feeding more frequently. Also, giving wet rather than dry food, particularly in hot climates, helps to further stimulate appetite.

Because of the heavy demands on the sow during lactation, care must be taken to ensure that temperatures are at an even and comfortable level for the sow.

In tropical regions, the recommended lactation period is a minimum of five weeks. In certain cases, it may be more cost-effective for it to be longer. This contrasts with the situation in developed countries, where four- and three-week weanings are often practised. The lack of quality creep feed for the young pig in developing countries means that attempts to wean earlier than five weeks have generally been unsuccessful.

Creep feeding

The name 'creep feed' has developed because the feed has traditionally been given in the piglets' nest or creep, where it is not accessible to the sow. The milk supply of the sow reaches a peak about three weeks after farrowing and thereafter declines. Therefore, at this stage it is necessary to provide the piglets with some solid food to make up the shortfall.

Other benefits that accrue from offering creep feed are:

- It enhances the growth in piglets compared to those that only have access to sow's milk.
- The piglet's digestive system adjusts to the change from milk to a solid diet. This reduces the chances of digestive upsets and improves the growth rate at weaning.
- It helps reduce the drain of nutrients from the sow. It minimises her weight loss during lactation and leaves her in better condition for rebreeding.
- It attracts the piglets away from the vicinity of the sow and reduces the chances of the piglets being crushed by the sow.

Creep feed needs to be specially formulated so that it is highly digestible and palatable. It is required to meet the nutritional needs of young pigs prior to weaning and afterwards up to eight weeks of age. Ideally, therefore, it should be based on skim-milk powder with added unsaturated fats and good quality non-milk proteins. Because milk products tend to be both scarce and expensive in the tropics, and often restricted to human use, creep feeds tend to be of relatively low quality. Nevertheless, simpler diets based on maize and soyabean meal can still be very effective.

Creep feed should be first offered to piglets at about seven days of age in very small amounts in order to accustom the piglets to consumption of some solid food. It can then be increased according to appetite up to weaning. The feed should always be offered fresh on a 'little and often' basis and a separate supply of fresh water for the piglets will help stimulate food intake.

Weaning the sow

At weaning, the aim must be to dry the sow off and stimulate her to exhibit oestrus and conceive again as soon as possible. At the same time, she should be induced to release a large number of eggs at ovulation as the first step towards a large litter at the next farrowing.

Under normal conditions the removal of the sow from her litter will trigger oestrus within four to seven days. Management aids which can be used to help ensure that oestrus is not delayed are:

- Move the sow into a house of other newly-weaned sows because other sows coming into oestrus will help the stimulation process. Newly weaned sows should not be mixed unless/or until they are used to each other.
- Sows should be able to exercise.
- Feed the sows at a high level after weaning until oestrus occurs. This is particularly beneficial for young sows after their first litter or for sows that are thin.

Mating management

The crucial points in effective mating management are to recognise the onset of oestrus and then to introduce the boar at the correct time. Ensure sows are mated during the period of peak fertility to reduce the likelihood of sows returning to service or producing small litters.

Characteristic signs of oestrus are:

- swelling and reddening of the vulva (not always obvious)
- sows will spend less time lying down
- sows will be more alert and the ears will stand up in prick-eared breeds
- sows will allow themselves to be mounted by the boar or other sows
- sows will give a characteristic 'grunt'
- sows will exhibit the 'standing reflex', i.e. they will adopt an immobile posture when pressure is applied to the back.

Under careful management, a single mating should give rise to good conception rates and large litters. However, it is generally safer to serve sows twice, once approximately 12 hours after the sow is first seen to be on heat, and the second time 12 hours later.

In the tropics, sows can quite easily be serviced outside under a tree. This is generally preferable to serving in the boar pen if a special service area is not available.

The pregnancy period

The day after service, reduce the amount of food available to sows. High feed levels during this stage are associated with increased loss of embryos.

All sows should be checked early to detect any that have returned to oestrus so that they may be serviced again. If available, a pregnancy-detecting instrument can be used to confirm pregnancy. There is a variety of instruments available. Most use sonar to detect the increased blood flow to the uterus and foetal heart beats that occur in early pregnancy.

Weaners

Objectives at weaning

The objectives must be to wean young pigs without limiting growth or mortality. The aim is to obtain accelerating growth over the period. This is important because the young pig's potential for efficient growth is high at this time, and any factor which reduces growth rates can be costly. However, the risk is that the major change in diet can lead to digestive scours, providing an ideal environment for multiplication of *Escherichia coli* (E. coli) and problems of gastroenteritis and bowel oedema.

Management considerations

The three-week period after weaning is a critical time for the young pigs.

Good management over the weaning period can minimise the stress and result in uninterrupted growth and low mortality. Some important considerations are:

- immediately before weaning, pigs should be handled and disturbed as little as possible. Any essential management tasks should be carried out at least two weeks before weaning
- piglets should be encouraged to consume as much creep feed as possible before weaning and should continue to be fed creep feed for at least two weeks after weaning
- ad lib feeding is recommended in order to capitalise on the high growth potential of the young pig. However, as soon as any scours are seen, feed intake should be restricted. If the problem persists, consideration should be given to increasing roughage levels and reducing the protein content of the diet.

- Antibiotics can also be included in the diet to help prevent scours. However, use of an antibiotic as a prophylactic can lead to the build-up of resistance in the bacterial population. This makes the antibiotic relatively ineffective if there is an outbreak of a major disease. To avoid the build-up of resistance, care must be taken that antibiotics are always used at the correct dosage rate, and that some antibiotics are reserved only for therapeutic use.
- At weaning, batches of pigs should be made up by selecting them from different litters according to bodyweight. Excessive fighting after mixing can be avoided by supervision for a few hours or, alternatively, by smearing the pigs with oil. Pigs can be retained in their litter groups, which overcomes any problems of fighting, but batches of different sizes tend to give rise to uneven growth rates.
- Excessive variations in ambient temperature within the house should be minimised. Pens should never be overcrowded, otherwise pigs cannot spread out to keep cool. Wet floors or wallows should be provided if excessive heat is a problem.
- Ideally all piglets should be in good condition at weaning, so that they possess some fat reserves to help combat stress. Poor litters should be allowed to remain with the sow for longer than five weeks. A technique of 'split' weaning can also be beneficial, whereby the large piglets are weaned first and the small ones are left with the sow for a further week.
- Fresh water must be available at all times to the piglets. This encourages higher intakes of creep feed.

Growing and finishing pigs

Objectives

By eight to nine weeks of age, the growing pigs are over the stresses of weaning. Their digestive systems will be able to deal with a range of protein and energy sources. Some 80 per cent of the food used in a pig unit is consumed by the growing and finishing pigs, so the efficiency of food utilisation during this phase is a crucial factor affecting profitability.

The management system which is used must relate to the specific objectives of each unit and these may range from home consumption of the cheapest carcass possible to the production of sophisticated bacon products. These considerations determine the type of pig to be produced. Feeding and management must then be planned to optimise performance. The small scale rural producer, for example, will attempt to maximise the use of cheaper, lower quality feedstuffs. It must be remembered, however, that the growing pig has only a limited ability to digest and utilise fibre in the diet and too much bulky food may reduce growth so much that its use as a feed is uneconomic. Under commercial conditions, different priorities may be given to factors such as food-conversion efficiency and food cost per pig, growth rate and carcass leanness. The main categories of slaughter pigs on commercial pig farms have been:

- porkers, which are slaughtered at liveweights up to 65 kg
- baconers, which are slaughtered from 70–90 kg liveweights
- heavy hogs, which are slaughtered at liveweight 90–140 kg.

In general, the heavier the pig is at slaughter, the lower the cost of each kilogram of meat produced.

Feeding system

The major decisions to be taken in relation to the feeding system are as follows:

- Restricted or ad-lib feeding. In the past, all fattening pigs were usually fed on restricted feeding regimes to avoid producing carcasses that are excessively fat. However, modern exotic strains of pig (e.g. Duroc), can grow through to slaughter at younger ages without getting too fat, and can therefore be fed ad-lib. Thus the decision on whether it is necessary to restrict feed intake will depend on the circumstances of each unit.

  The advantages of ad-lib feeding are that it saves labour, gives faster growth-rates and larger carcass-weight at a given age. In general, it will result in more contented pigs and avoids problems of competition at the feed trough. Ad-lib feeders need to be designed to operate efficiently in order to minimise waste. If it is necessary to limit nutrient intake, dietary fibre levels can be increased.

  Obviously, various combinations of ad-lib and restricted feeding periods can be used in order to yield the most desirable result, e.g. it is common to feed ad-lib up to 50 kg body weight and then restrict intake until slaughter.

- Feeding in a trough or on the floor. Bullying and competition are reduced. However, although feeds should be restricted to what is consumed in 20 minutes, it leads to more waste and greater problems with dust. If scouring occurs there is a greater risk of transmission of disease. If pigs are fed in troughs it is critical that adequate trough space is provided.

  Frequency of feeding in a trough can also influence the efficiency of feed usage. Research has shown that by feeding twice a day rather than once, small improvements are achieved in growth rate, food required to slaughter and killing-out percentage (see below).

- Wet or dry feeding. There are two main types of wet-feeding systems. Either the food is diluted so that it can be delivered to the pens by pipeline or continuous trough (river system) or water is added to food in the trough. The first system is really appropriate only in larger units, where the mixing and delivery can be semi-automated. Trials in Zimbabwe have shown that the addition of water to food in the trough, at a meal-to-water ratio of 1:1 or 1:2 can save some 5 per cent in food usage and decrease time to slaughter by 10 days when compared with dry feeding. However, wet food must be totally consumed each day in order to avoid spoilage.

- Meal or pellets. Pelleted feed is better than meal by about 5 per cent in promoting liveweight gain and food conversion efficiency. However, these improvements in performance have to be compared with the extra cost of pellets. Also pelleted food is not always available in the tropics.

- The handling of bulky food. A system which has proved successful in small- and medium-scale operations is the separate feeding of base feed and protein concentrates. In systems in Madagascar, for example, fresh cassava roots are dug twice a week and fed directly to the pigs ad lib. Protein concentrate is then fed daily according to a fixed rate (500 g for weaners up to 50 kg liveweight, 750 g for finishers above 50 kg). Such 'separate feeding' may not be the best in terms of nutrient balance, but they optimise the economic efficiency of production.

Water

The importance of water to the growing pig in hot climates cannot be over-emphasised. The absence of a regular supply of clean, fresh water is often the first factor that limits food intake. Food intake must be stimulated for successful fattening.

Gender

If pigs are reared intensively and achieve fast growth rates, there is no need to castrate male pigs. Instead it is recommended that, except for small units where it is impractical, the sexes should be separated for fattening purposes. This allows for the provision of different feed requirements and also prevents the early maturing boars from continually riding the gilts. However, in large units where males grow more slowly it may be necessary to castrate males to avoid the occurrence of boar taint (odour in the meat that occurs as boars approach puberty) in the carcass at slaughter.

Vices

Tail-biting is the most common vice, but other forms of cannibalism such as ear-biting and vulval-biting can occur. Once blood is drawn, very serious wounds can develop which often lead to secondary infections.

Usually this is a response to boredom. Providing bedding will always prevent tail-biting. If this is not possible, it can be helpful to hang a chain from the roof as a toy. But in hot conditions, overstocking, lack of bedding, poor ventilation and lack of salt may also trigger tail-biting.

Killing-out percentage

The killing-out percentage is the ratio of carcass mass to live mass. It can have a significant effect on profitability. Pigs fed bulkier foods of lower nutrient and energy density will develop a larger gut capacity in proportion to body size and therefore have a lower killing-out percentage.

Culling of sows

It is important to have a culling policy so that sows are removed at the correct time. In the majority of cases the reasons for culling sows will be obvious, e.g. lameness, other injury, farrowing problems, poor litter-size, poor mothering ability and low fertility. However, the performance of a sow which regularly produces a good litter will eventually start to decline with age, probably around her tenth litter. If she is producing well, a good guide is to allow her to remain in the herd until her performance falls below the average of the gilts in the herd. At the same time it is important to have a supply of pregnant gilts available to replace sows that need to be culled.

One-bred gilt

There is a relatively new system of producing weaners which could be useful in the tropics. This involves the serving of gilts at an early age and then slaughtering them after they have weaned their first litter. The carcass of the gilt is very similar to that of the heavy hog. The system takes advantage of pregnancy anabolism, whereby the deposition of maternal tissue during gestation is very efficient in terms of food utilisation. Approximately 50 per cent of the total weight gain during pregnancy will be body gain. It should be considered as an addition to a conventional sow-based system. However, some older sows are required in a herd to maintain immunity against reproductive diseases. Nevertheless, it could prove a useful way of producing cheaper meat in a pig enterprise.

Keeping records

In order to monitor both the technical and economic efficiency of a pig enterprise, it is absolutely essential to keep some basic records. These should cover all aspects of the enterprise, so that evaluations can be made of boar performance, sow productivity, weaner growth and grower/finisher efficiency. By looking at the recent history of the enterprise, each phase of production can be critically examined and weaknesses pinpointed. It is possible, based on facts, to plan to correct weaknesses. See Unit 6.

Day-to-day records can then be used to complete individual animal and herd performance sheets for assessment.

For breeding, it is essential to keep an accurate service record of all sows and gilts in the piggery. Farrowing and lactation performance details can then be kept on individual sow record cards. A sow lifetime-record card enables an assessment of her contribution to herd performance. This information can also be used to compile a record on individual boar performance. As major differences in boar performance become evident, the lower performance boars can be removed from the herd.

These data can then be combined, together with details of pigs sold, to give an overall herd performance report. This allows the producer to monitor the performance of the herd on a monthly and six monthly basis.

Commercial Pig Farms

Commercial pig farms, with large herds, require good management and stockmanship. Some important aspects to consider are:

- provision of adequate deep shade and wallows
- sitting farrowing nests that are far enough apart to allow sows to establish their territory at farrowing time
- provision of bedding material for nest-making purposes
- ensuring that stockmen gain the confidence of sows so that they can be handled easily during critical periods such as farrowing time
- ensuring that bulky foods are spread over a large area at feeding time so that all sows have the opportunity to gain access to the food – a dominant sow will often guard food placed in a heap preventing timid sows from eating
- provision of an adequate boar:sow ratio
- adoption of a rigorous de-worming programme, unless regular rotation of sows on to new land is practised.

Preparation Of Meat

Slaughter procedures

For reasons of animal welfare, pigs and cattle should always be stunned before they are bled. Effective stunning ensures quick and more complete bleeding and also minimises intensive muscle contractions. The main methods of stunning are mechanical, electrical and gas. For stunning animals a captive-bolt pistol or other implement is used to stun the animal. A pair of tongs is used to apply an electrical charge to the pig's head. A current of 1.25 amps and 300–600 volts renders the pig unconscious within one second. Pigs can be led into a tunnel containing 70–80 per cent carbon dioxide, when they will lose consciousness within two seconds.

Bleeding

Immediately after stunning the animal should be suspended by its hind legs, and the blood vessels of the neck completely cut through to ensure complete bleeding. The blood should be collected in clean containers.

Scalding and de-hairing

By immersing the carcass in water at 65–75^{o}C, the hair is loosened and can be removed by scraping. Any excess hair can be burned off by a flame.

For the small-scale producer who is slaughtering on the farm, a drum of water over a fire is adequate for scalding purposes. Alternatively, when water is scarce, and if the skins are not going to be used, de-hairing can be achieved by covering the carcass with a 5 cm deep layer of straw or dry grass and burning it. The skin can then be scraped to remove the carbonised surface and any remaining hair.

Evisceration

A long cut is made down the belly from the breast to the hams. To prevent the meat being contaminated, the entire length of the gut should be removed intact. Other internal organs can then be separated, and the gut emptied and cleaned away from the rest of the meat.

Meat hygiene

The freshly killed carcass is an ideal breeding ground for bacteria, and hygienic conditions are essential to prevent infections. Ideally, carcasses should be chilled immediately after slaughter, and the meat should remain chilled until it is cooked. Where refrigeration is not available, carcasses should be hung in a cool room, protected from flies by gauze, and then sold and eaten as soon as possible.

At any slaughterhouse, all carcasses should be examined by a qualified meat inspector. He/she will examine the carcass and offal for signs of parasite infection, e.g. 'measly' port, 'milk-spot' livers, damaged lungs, etc., and other health problems. Meat that does not pass inspection is condemned and should be burnt.

The carcasses from pigs slaughtered on the farm should also be examined carefully so that the transmission of disease and parasites from pigs to humans can be avoided.

Carcass quality

Every country has its own system of assessing the quality of the carcass and generally carcasses are graded according to a number of criteria. These criteria are used to determine the price paid to the producer. The four main considerations are conformation, degree of fatness, lean content of the carcass and fat quality.

Meat quality

Meat quality, as distinct from carcass quality, relates to the desirability of the meat to the consumer. The most important aspects are colour, texture, flavour and smell.

Activity 1 Handling animals

1. In pairs investigate the local and standard animal handling procedures during one management operation, e.g. castration, injection, drenching, attaching identification and branding. You can get information from livestock farmers, the livestock division of MAFFM, the USP, the Internet and textbooks.
2. Discuss and suggest improvements on how the animal is handled so that minimum stress is caused to the animal.
3. Demonstrate your suggestions to the class where practical.

Activity 2 Keeping meat safe

> Sāmoa currently does not have an abattoir where animals can be slaughtered and meat inspected before being sold to the public. During traditional ceremonies animals are slaughtered in the villages and meat distributed for consumption without being inspected. Individuals also slaughter their own animals for consumption. The MAFFM livestock officers regularly inspect and conduct tests on livestock farms.

1. In groups of three discuss the situation in the paragraph and state if your group agree or disagree with the slaughtering and animal health management strategy.
2. Discuss and put together suggestions for a submission to the MAFFM livestock division on how to improve the situation.
3. Present your plan to the class in a flow diagram for discussion.

Review

1. List advantages of good management in animal production.
2. List the key points in good livestock management.
3. How can farmers reduce the stress caused to animals when handling them for different purposes, e.g. branding in cattle?
4. Do the benefits of castration outweigh the effects on the animal? Are there better alternatives or options?

Unit

18 Reproduction And Growth

Growth And Development

In practical terms, growth is measured as the increase in body weight, and is largely dependent on the amount of food, or total nutrient, intake. However, there are major differences between the food intake of different breeds of pig and how it affects their growth rate. Because humans have selected pigs for high growth rates in order to improve efficiency of production, they have selected for a larger size at maturity. Unimproved breeds of pig common in developing parts of the world, which have not been selected for increased growth rates, will tend to grow more slowly and be smaller at maturity than improved breeds (B in Figure 18.1). So, if unimproved pigs are slaughtered at the same weight as their exotic counterparts, they will be more mature.

As important as rate of growth is how the pig develops. Selection has resulted in a greater propensity to lay down protein tissue in improved breeds. As the level of feed intake increases, the unimproved pig will deposit more fat (A in Figure 18.1), in comparison with improved breeds (B in Figure 18.1). Because too much fat is neither a consumer desirable, nor is it cheap to produce (approximately five times the nutrient cost of lean tissue), it is crucial that pigs are fed according to their ability to grow and lay down lean tissue.

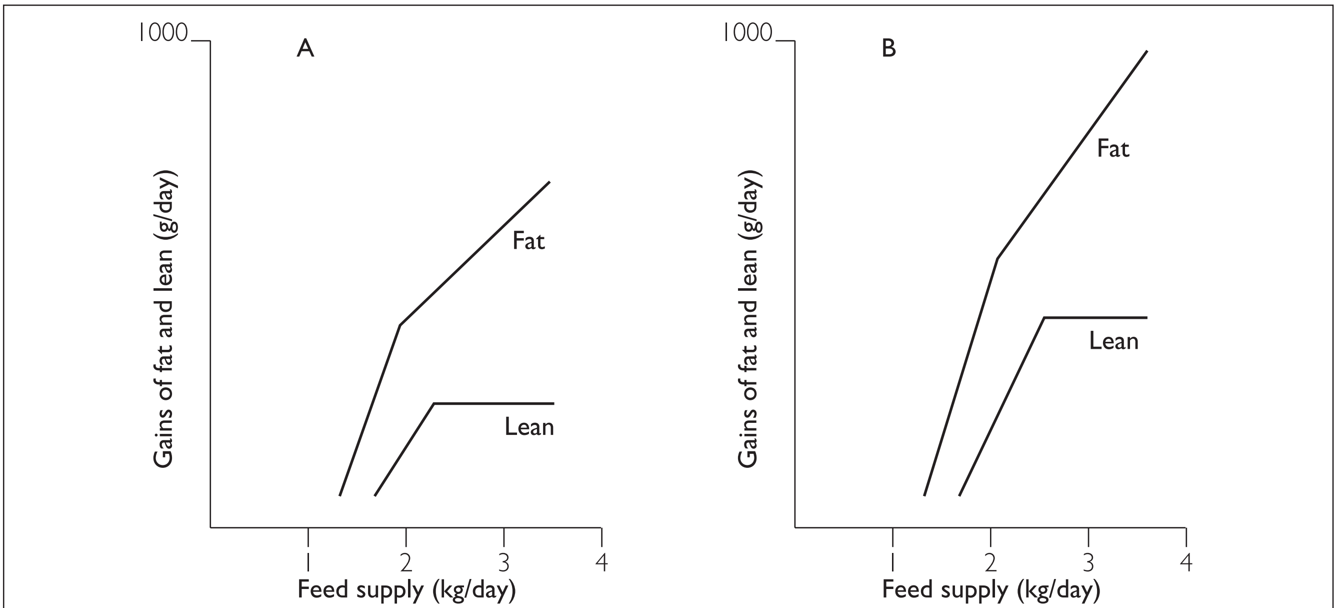

Figure 18.1 Typical differences between unimproved (A) and improved (B) pig breeds in their ability to lay down lean and fat tissue as food intake is increased

Entire male pigs grow faster; have leaner carcasses and convert feed more efficiently than females. If males are castrated the case is exactly opposite. Traditionally, pigs have been castrated in order to improve carcass quality and to prevent boar taint. Nowadays, modern pigs grow faster and are slaughtered at younger ages and the problem of taint is considerably reduced. Unless pigs are grown slowly or are required for a niche market, there is no justification for castration in pigs raised for meat production.

Baby pigs are born with less than two per cent of fat in their bodies, which makes them particularly susceptible to cold stress. Thereafter they deposit fat rapidly, and will usually have a body fat level of over 15 per cent by the time they are three weeks old.

Reproduction

Males

The male reproductive system (see Figure 18.2) is characterised by a pair of relatively large testes, which can weigh over 300 gm each in some exotic breeds. Together with the secretions from the accessory sex glands, the testes can produce up to a litre of semen in a single ejaculate.

To facilitate the transfer of these large quantities of semen at coitus, the end of the penis of the boar is spiral in shape which enables it to lock into the cervix of the sow. The duration of coitus varies but may last for 20 minutes.

Puberty, or the ability of the boar to serve a sow, generally occurs around four months of age, but may be earlier in unimproved breeds. However, boars should not normally be used until seven months old. Young boars are likely to be bullied by mature sows, and this may negatively affect their later mating performance.

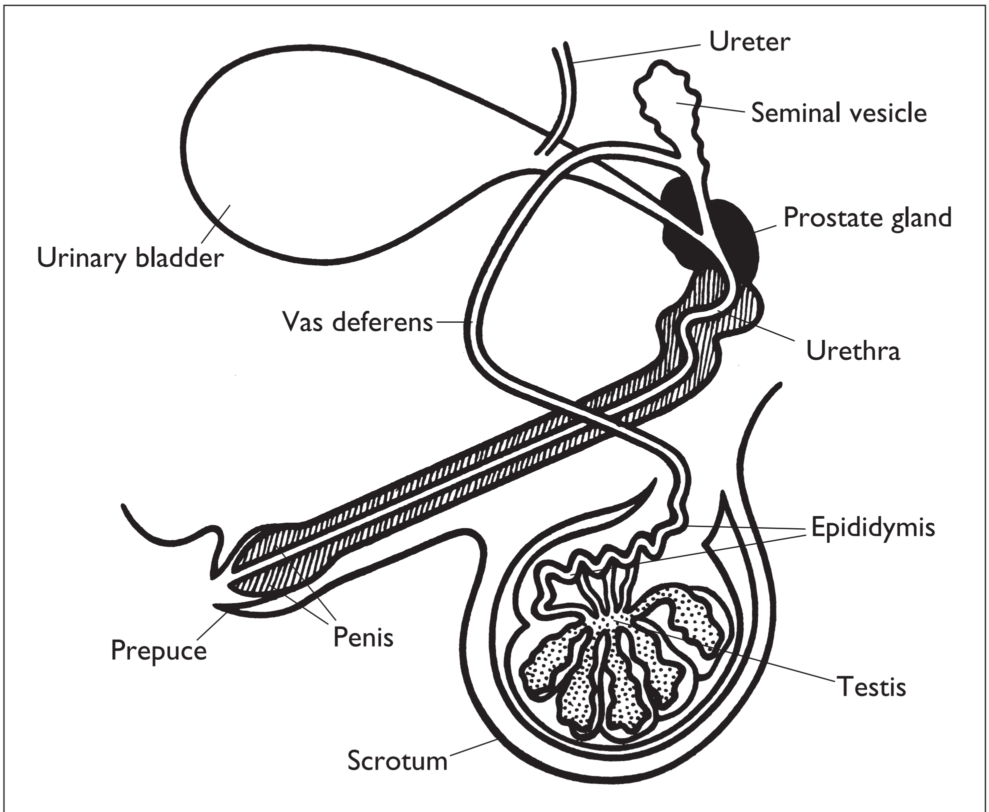

Figure 18.2 Male reproductive tract

Females

The female reproductive tract of the pig is characterised by the long, convoluted uterine horns (700–800 mm in length), which can accommodate large numbers of foetuses (see Figure18.3). The sow will ovulate at the same time from both ovaries, normally releasing between 11 and 24 eggs.

Puberty, the start of oestrous cycles, occurs between five and seven months, but may be as early as three months in unimproved breeds. The number of eggs released at ovulation, and therefore potential litter-size, increases gradually over the first few oestrous cycles.

The sow will cycle and show heat every 21 days (range 18–24). She will not cycle when she is either pregnant or lactating, although sows will sometimes show heat during lactation when run in groups. Heat lasts from one to three days, and ovulation occurs by the second day of oestrus or any time thereafter.

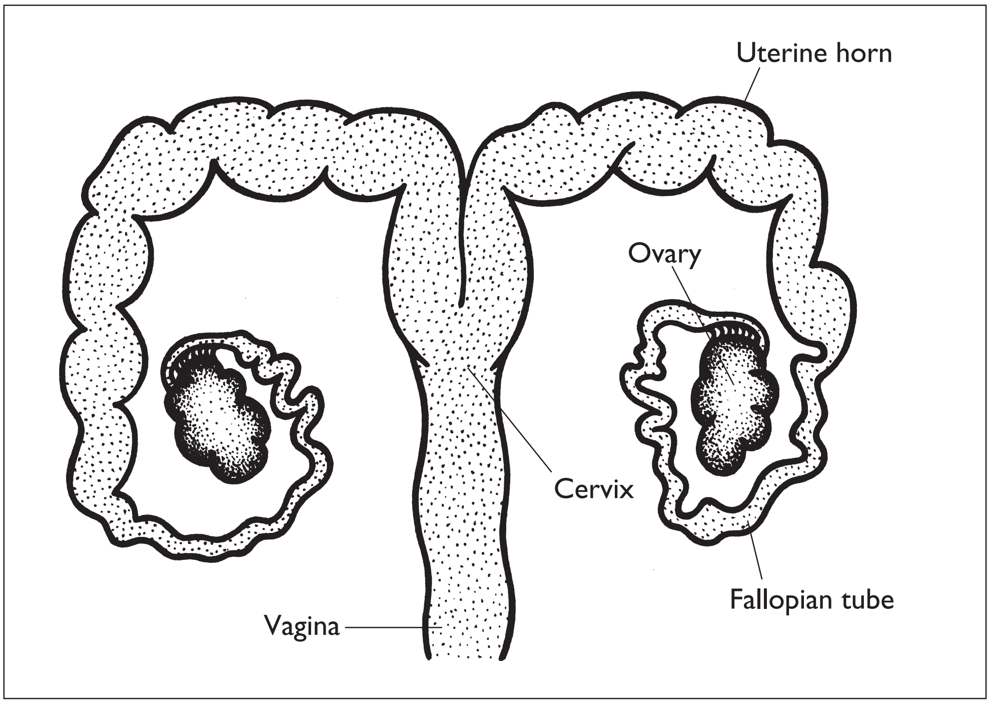

Figure 18.3 Female reproductive tract

Artificial insemination

Artificial insemination (AI) involves the collection of semen from a boar and then the introduction of semen into a sow or gilt at a later stage by means of a catheter. This contrasts with natural service where a boar mounts a sow and introduces his semen.

Benefits

The major advantage of AI is that it allows for the wider use and distribution of boars of high genetic merit. The ejaculate from one boar can be extended to inseminate up to 25 sows. Recent improvements in methods of boar semen storage make it possible for developing countries in the tropics to import the very top genetic stock from developed countries. For example, in the United Kingdom, only the top five percent of boars performance-tested by the Meat and Livestock Commission are eligible for entry to AI studs. This quality of genetic material would not otherwise be available to developing countries. It overcomes the need to purchase, house and feed a boar. This is particularly relevant to the small-scale producer who cannot justify keeping a boar for a small number of sows, and who cannot afford a boar of good quality. AI is especially relevant where small-scale producers are involved in group or co-operative pig development schemes, and their units can be serviced from a central boar-holding centre. It prevents the transmission of disease from farm to farm by the sale and purchase of boars and on-farm reproductive diseases cannot be spread by boar-to-sow contact. It overcomes the practical problems of differences in size of males and females. Sometimes, this problem can severely limit the use of boars of high quality. It also reduces the risk to stockmen of handling boars for natural service.

Technique:

a Semen collection

Although various artificial-ejaculators are available, they are not necessary for successful semen collection. Boars can be easily trained to mount a dummy sow device or an oestrous sow, and firm pressure on the penis by a gloved hand causes ejaculation to occur. The first low-sperm fraction of the ejaculate should be discarded, and then the second sperm-rich fraction can be collected through a filter funnel, which removes the gelatinous fraction, into a warmed (30^{o}C) bottle.

A drop of semen can be observed under a microscope to check fertility characteristics and, if desired, the semen can then be diluted. A number of diluters and extenders are available, and the individual doses are normally stored in 50 ml plastic bottles for up to three days at 15–20^{o}C. The number of spermatozoa used under commercial conditions for one insemination normally varies from $1x10^{9}$ to $3x10^{9}$.

b Insemination

A rubber spiral catheter (Figure 18.4) is inserted into the sow's vagina. It is then rotated in an anti-clockwise direction (Figure 18.5) until the tip locks into the cervix. The bottle containing the semen dose can then be attached to the other end of the catheter and the semen runs in under gravity or slight pressure (Figure 18.3). The insemination process may take up to 15 minutes.

c Heat detection and timing of insemination

It is very important that conception rates achieved with AI are close to those that occur with natural service. Therefore, accurate heat detection must be carried out, preferably using a boar twice a day in order that the timing of insemination is correct. Inaccuracies in the detection of the start of oestrus and natural variation in time of ovulation can occur. Therefore, it is advisable to carry out two inseminations approximately 12 hours apart. More recently, devices have been developed which measure the electrical resistance of the vaginal mucus. As this varies in relation to hormonal changes, it can be used to predict more accurately the timing of ovulation, and hence the optimum timing of insemination.

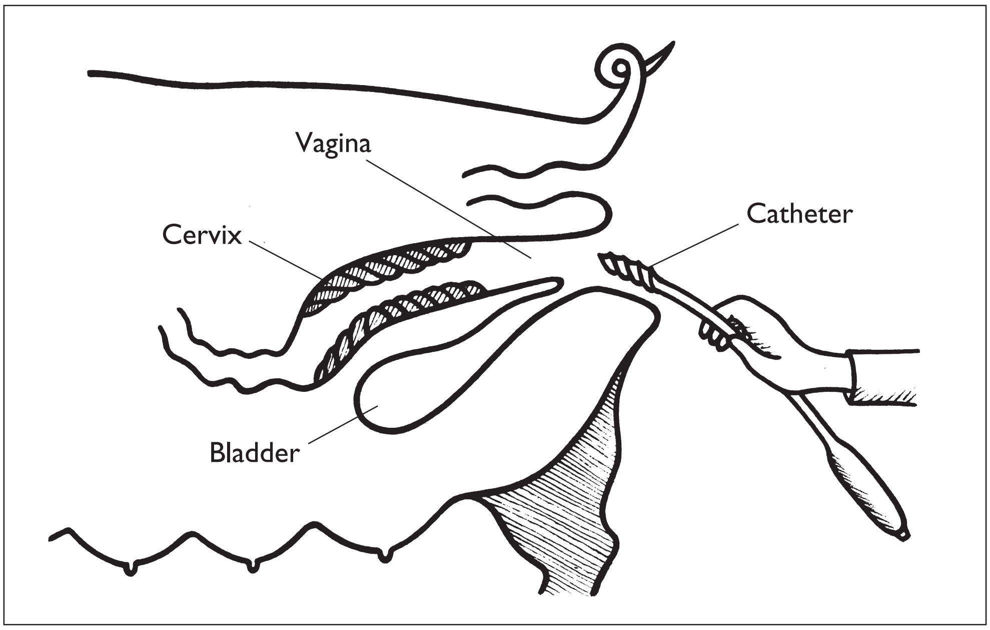

Figure 18.4 Insertion of catheter

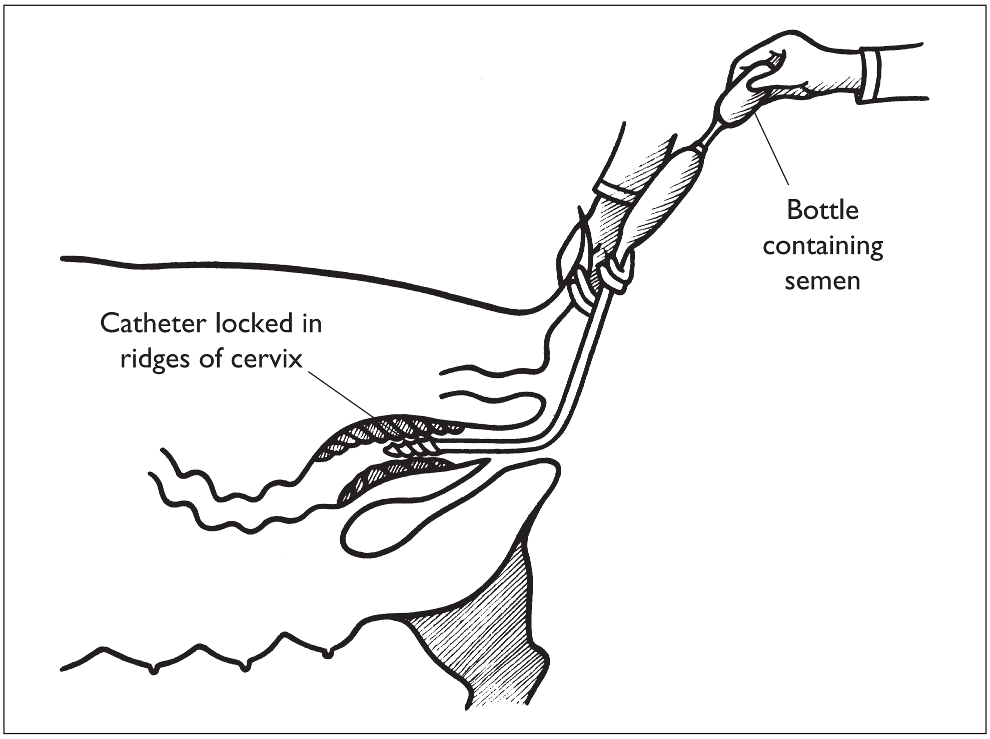

Figure 18.5 Bottle containing semen

System of semen storage

a Frozen semen

In contrast to bull semen, boar semen is easily damaged by the freezing and thawing procedures. Techniques for freezing boar semen are a recent development. Frozen semen can now be obtained in either pellet form or in straws. This has provided a major breakthrough for the introduction of good genetic material into developing pig industries. Nevertheless, there must be strict attention to detail in the handling of the semen in order to achieve acceptable conception rates. Also, boars differ in the 'freezability' of their sperm, and the semen of individual boars must therefore be screened before it is used for the production of frozen semen.

b Long-life semen

Extenders have now been developed which allow fresh semen to be stored for up to seven days without any great loss in fertility. Fresh semen can be flown around the world and used to successfully impregnate sows in the country of destination.

Activity 1

A pig farmer has good sows (Large White breed) and boars (Landrace breed) and is feeding his pigs with the required diet. However, litter sizes are small and his pigs are not growing fast enough.

In groups discuss and use the information in Unit 17 and 18 and information from other sources to develop a programme to solve the farmer's problem.

Activity 2

1. A beef farmer has come to you for advice about using artificial insemination to improve the quality and quantity of his stock.
2. In your groups discuss the options the farmer has.
3. Present your options to the class for discussion.

Review

1. How can farmers use knowledge of reproduction and growth to help them improve production?
2. List mating methods livestock farmers use to ensure good production rates in pigs and cattle.
3. List the advantages and disadvantages of artificial insemination?
4. How can livestock farmers control the growth rate of their animals?
5. Why do farmers want their animals to achieve certain weights at certain time periods?

Unit 19 Animal Health

Disease Prevention

If disease affects a pig or cattle herd the impact on profitability can be enormous because of the costs of disease control and decreased productivity. The first priority must always be to try to prevent the occurrence of disease. Thus, many management procedures are aimed at disease prevention or at reducing the effects of those diseases that cannot be prevented. With skilled management, combined with well-designed housing and good nutrition, an overall strategy to minimise the possibility of disease attack can be formulated.

At the same time a basic knowledge of the main diseases which may affect a pig or cattle herd is necessary so that a producer can diagnose the conditions and implement control measures as quickly as possible. This is particularly important under tropical conditions where the regular services of a veterinarian are often not available. The major disease problems are parasites, infectious diseases and a few non-specific diseases.

Parasites

Parasites are defined as organisms, which live on and obtain food from the body of another, known as the host. They may live on the exterior of the animal, or within the internal tissues and organs. Parasites will seldom result in the death of the host except in the case of massive infestations or if the host is also stressed in other ways.

External parasites

External parasites, also called ectoparasites, live on the skin of their host animal. They mainly cause irritation to the skin surface, often leading to wounds and an increased susceptibility to other infections. The most common external parasites are mange mites, ticks, lice, fleas and flies.

Mange mites

Mange mites, which are scarcely visible to the naked eye, spend their entire life cycle under the skin of the pig, but they can survive off the host for as long as eight days. The most common species is *Sarcoptes scabiei* (the scabies or itch mite) which causes sarcoptic mange.

First signs of infection are a crusty, dry-looking skin around the eyes, ears and snout. The mites then spread and multiply over the body. The animal will constantly rub itself and its performance will be depressed.

Regular treatment, either dipping or spraying with an anti-mange medication, is the best way to control mange mites. This includes spraying of pens. Chronically infected animals should be culled. There are also some recently developed systemic drugs which are very effective against mites.

Ticks

Ticks are only a problem where pigs scavenge for food and on large commercial pig farms. There are a number of different species which suck blood and can transmit serious diseases. They generally require more than one host to complete their life cycle. Ticks are easily controlled by spraying or dipping with suitable acaricides (substance poisonous to mites or ticks).

Lice and fleas

Lice and fleas can become a problem in dirty and unhygienic conditions. They live on the skin surface, suck blood and cause irritation. Spraying of the pigs and the pig quarters with suitable insecticides are effective ways of controlling the pests. In the case of lice, particular attention should be paid to the ears.

Flies

Flies are a major nuisance around pigs. They cause annoyance, can bite, and carry infectious diseases. They are always attracted to any fresh abrasion or wound on the animal.

Control measures should involve spraying of insecticides on areas suitable for flies to breed, e.g. manure heaps, refuse areas and ponds, buildings and pigs. Baits, which attract the flies and are poisonous to them but not to the pigs and cattle, can also be effective.

Internal parasites

Internal parasites, also called endoparasites, live inside their host animal.

Roundworms

These are a particular problem when pigs are free-ranging or not kept on concrete floors. The main roundworms that effect pig production are:

- **Large round worm** (*Ascaris lumbricoides*). Adults live in the small intestine and can grow up to 300 mm long and 6 mm thick. The female is capable of laying thousands of eggs per day, which pass out in the dung and become infective, if eaten by other pigs. These eggs are extremely resistant and can remain infective for many years. Eggs hatch out in the pig after being eaten and the larvae move through the liver and lung. Irritation in the lungs causes coughing and failure to thrive, particularly in younger pigs. The liver is also damaged. If infection is heavy the adult worms can partly obstruct the small intestine, causing weakness and weight loss.
- **Whip worm** (*Trichuris sui*s). This worm, which is about 35 mm long when adult, lives in the large intestine and causes considerable damage to the gut wall resulting in diarrhoea and weight loss.
- **Nodular worm** (*Oesophagostomum spp*). This nodular worm also lives in the large intestine. It burrows into the intestinal wall forming nodules, and can cause diarrhoea (sometimes bloody) and anaemia.

- **Kidney worm** (*Stephanurus dentatus*). The kidney worm lives in the kidney and eggs are excreted via the urine. When eaten, larvae move through the liver to the kidney and tissue damage results. The kidney worm is a major handicap for free-range pig-farming systems in Madagascar and the Pacific islands, and is often the main reason why pigs are penned.
- **Lung worm** (*Metasrongylus spp*). Lung worm can be a problem in free-range pigs. Infection occurs when pigs eat earthworms, which are the intermediate host. Lung worms cause irritation and coughing and predispose the pig to secondary pneumonia.

Contaminated feed and water are the usual source of infection with internal parasites. Control can be effected by breaking the life cycle by cleaning and removal of faeces in housed pigs. At the same time, unless there is good evidence that there is no worm infection in the herd, breeding pigs should be routinely dosed with broad spectrum anthelmintics (medications used to destroy parasitic worms). Young stock should be dosed soon after weaning.

Tapeworms

The pig is an intermediate host for the common tapeworm (*Taenia solium*). The adult worm lives in man. Pigs become infected by picking up eggs from human faeces and the larvae then encyst in the pig's muscle, particularly in the region of the heart and tongue.

If the pig meat is then eaten by man, the larvae hatch out and the cycle is completed. As a consequence, carcasses which are affected (measly pork) are condemned at slaughter. By preventing pigs having access to human faeces, the parasites can be eliminated. In some countries live pigs are checked at the marketplace by experts for the presence of tapeworm cysts in the tongue. The result of the examination influences the price paid to the producer.

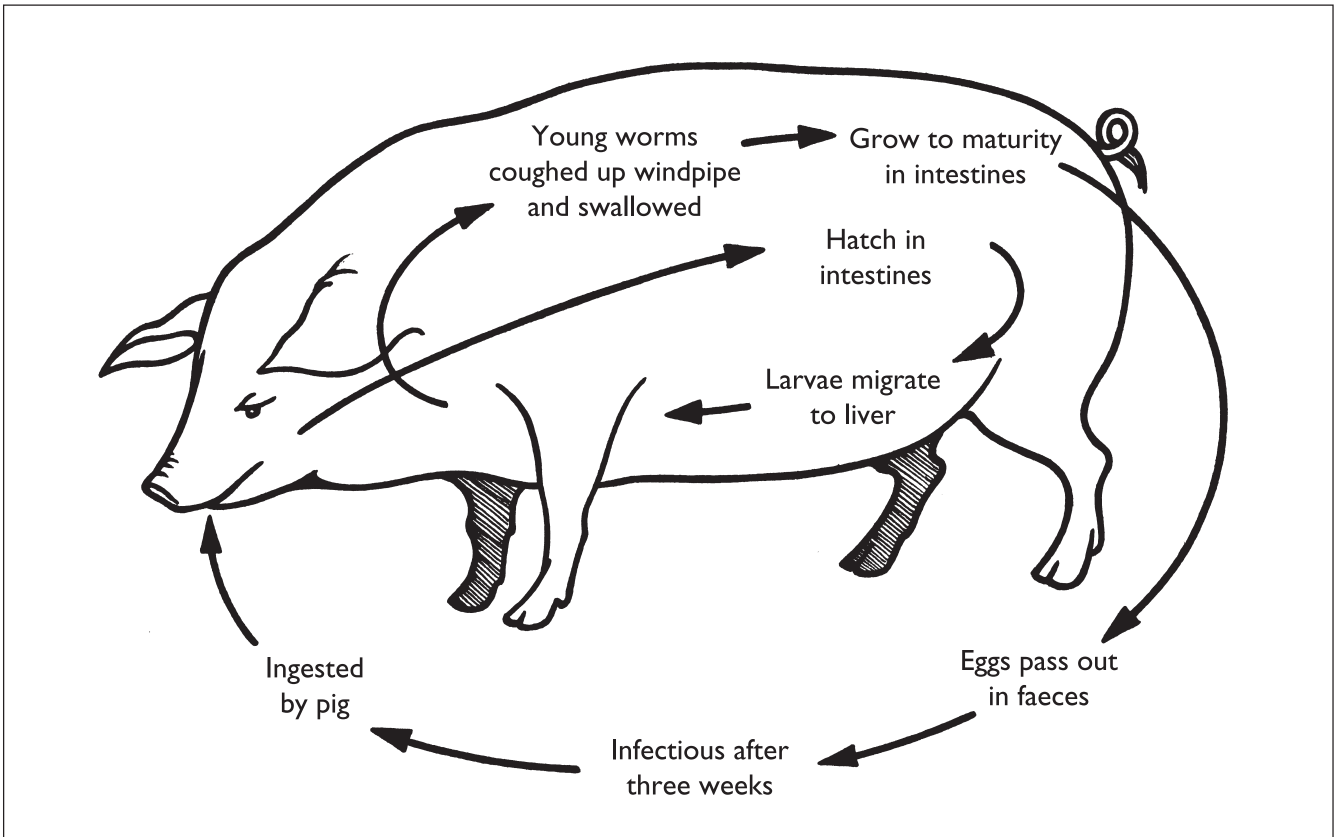

Figure 19.1 Life-cycle of the large round worm

Infectious Diseases

The following diseases are common in Sāmoa.

Brucellosis

This disease, which is caused by a bacterium, is also known as contagious abortion. Brucellosis can result in temporary or permanent sterility in females. Abortion is the most common symptom and can occur at any stage of gestation, depending upon the time of exposure to infection with the bacterium. In boars, testicles may become inflamed and permanent sterility may result.

The disease is transmitted at mating or by contaminated food or water. There is no treatment and infected animals should be culled, particularly as brucellosis can be transmitted to humans, and the risk of transmission is relatively high under some traditional systems of pig and cattle management.

Coccidiosis

This is caused by organisms known as coccidian, of which there are 13 known infective species in pigs throughout the world. They cause damage to the intestinal wall, and are believed to be an increasing cause of diarrhoea in piglets, particularly in confined housing. Piglets show a grey-green diarrhoea, lose weight and rapidly become dehydrated.

Coccidiosis is spread by contaminated faeces and thus good management and regular cleaning of buildings will prevent the disease. Drugs, known as coccidiostats, are available for prophylactic treatment.

Tuberculosis

Tuberculosis (TB) can effect cattle, pigs, birds and humans. The symptoms are coughing, scours and dull, sunken eyes. The most common method used for diagnosis of TB is the single intra-dermal TB test. The site of the test is under the tail close to the body. A positive reaction is indicated by a swelling where it was injected. There is no recommended treatment for TB in animals. Control is based on testing and slaughter of positive reactors.

Mastitis

Mastitis commonly affects the udders of the dairy cow. The causes are numerous and one or more of the teats may be affected. Mastitis is mainly caused by four micro-organisms: *Streptococcus agalactiae*, *Streptococcus aureus*, *E. coli*, and *Pseudomonas spp*. The main symptoms are heat, pain and swelling of the udder. The milk secretion is abnormal and is replaced by a custardy material or yellow/ brown fluid with flakes or clots. The best treatment is injection of antibiotic sulphonamide into the udder through the teat canal. Mastitis can be prevented and controlled by observing proper milking practices and good hygiene. If a mastitis kit is not available use a strip cup to identify mastitis early. A long acting antibiotic should be given in the udder of dried cows.

Table 19.1 Easy diagnosis chart for pigs

Symptoms	Possible disease or condition
Abortion	Brucellosis. Redwater. Any disease causing a high body temperature. MMA. Ergot in feed.
Agalactia	Roundworms. Redwater. Iron deficiency. Trypanosomiasis (sleeping sickness).
Anaemia	African swine fever. Hog cholera. Redwater. Ulcers. Swine influenza.
Appetite (loss of)	African swine fever. Swine influenza.
Breathing (distressed/rapid)	Redwater. Roundworms. Lungworms. Enzootic pneumonia.
Constipation	Swine influenza.
Coughing	Coccidiosis. Enteric colibacillosis. Roundworms.
Dehydration	Hog cholera. Salmonellosis. Swine dysentery.
Diarrhoea (scours)	Transmissible gastroenteritis.
Discharges	Anthrax. Intestinal haemorrhage syndrome.
Anus	Hog cholera.
Eye	MMA.
Vulva	Roundworms. Ulcers. Coccidiosis. Tapeworms.
Emaciation	Salmonellosis. Brucellosis. Stillbirth, mummification, embryonic death and infertility (SMEDI).
Infertility	African swine fever. Hog cholera. Rabies.
Nervous signs	Foot and mouth disease. Rabies.
Salivation	Mange. Lice. Fleas. Erysipelas. Swine pox. Greasy pig disease. African swine fever.
Skin conditions	Anthrax. Acute trypanosomiasis. Acute erysipelas.
Sudden death	Intestinal haemorrhage syndrome.
Swelling/blisters	Foot and mouth disease. Abscesses.
Face	Abscesses. Anthrax. Gut oedema.
Body	Foot and mouth disease.
Feet	MMA.
Udder	All bacterial, protozoal and viral disease.
Temperature elevated	Cystitis. Redwater.
Urine (discoloured)	Cystitis. Redwater.

Activity 1 Identifying disease symptoms

1 The teacher will set up stations of pest and disease symptoms in the classroom.

2 Rotate around these stations and answer the questions at each station. Spend about two minutes at each station. Do not change stations until the teacher says so.

3 After the exercise discuss the correct answers as a class and assess your work.

Activity 2 Investigation on treatment of animals

1 In pairs investigate the attitude of individuals and groups towards the treatment of animals.

2 Interview livestock farmers, livestock officers, butchers, consumers and animal groups such as the local animal protection society and record their views.

3 Download information from the Internet.

4 Put together this information, write your conclusions and make recommendations for Sāmoa.

Activity 3 Worm problem

A commercial pig farmer suspects he/she has worm problems. The farm is far from the nearest livestock office and the livestock officer rarely visits the farm. In groups of four read the information in this unit about parasites. Discuss and develop a practical plan for the farmer to use to control his/her worm problem.

Activity 4

Mrs Paulo, a cattle farmer from Falealili, believes that 'prevention is cheaper than cure' and wants to prevent her cattle from getting TB, mastitis and brucellosis. In your groups read the information above on the diseases. Discuss and develop a realistic plan that Mrs Paulo can use to prevent his cattle from getting the diseases.

Present your plans to the class for discussion.

Review

1 Why do we need to keep animals healthy?

2 List methods that can be used to keep animals healthy.

3 'Prevention of disease is better than cure'. Do you agree or disagree with the statement? Please support your answer with constructive scientific and economic comments.

Unit 20 Nutrition And Feeding

Feeding And Digestion

The first 72 hours after birth are very crucial for the baby pig. During this period the colostrum of the sow has a high content of antibiotics and the piglet intestine is able to absorb intact proteins. As the piglet has very little of its own resistance to disease, it is essential that it gets a good suck of colostrum to acquire passive immunity from the sow.

If it does not get sufficient colostrum the pig will usually develop an infection before it can develop an active immunity of its own. Once the piglet has established a teat position, which normally occurs in the first 24 hours after farrowing, it will retain this position for the remainder of the suckling period. As long as milk production is adequate, a sow will suckle her litter every 60 to 90 minutes.

Alimentary canal

Although pigs in tropical regions may eat a lot of fibre they are simple-stomached animals and not ruminants (See Figures 20.1 and 20.2.). This means their ability to digest and utilise fibre is restricted to that digested by the microbial population in the caecum. The caecum holds a relatively small volume when compared with the rumen. With all pigs, a high-fibre diet will reduce the amount of nutrients available to the animal. In contrast to ruminants, pigs are unable to utilise non-protein sources of nitrogen to produce microbial protein in the rumen. This makes them dependent on both the amount and quality of protein in their diet.

The alimentary tract of the pig (Figure 20.1) is designed to digest and absorb concentrated foods. Food taken in at the mouth is ground into a pulp by mastication. At the same time it is moistened and mixed with saliva. Saliva contains the enzyme ptyalin which initiates the breakdown of starch to simpler carbohydrates. The food then passes on into the stomach, which provides an acid environment due to the presence of hydrochloric acid. The gastric juice contains the enzyme pepsin which begins the breakdown of protein.

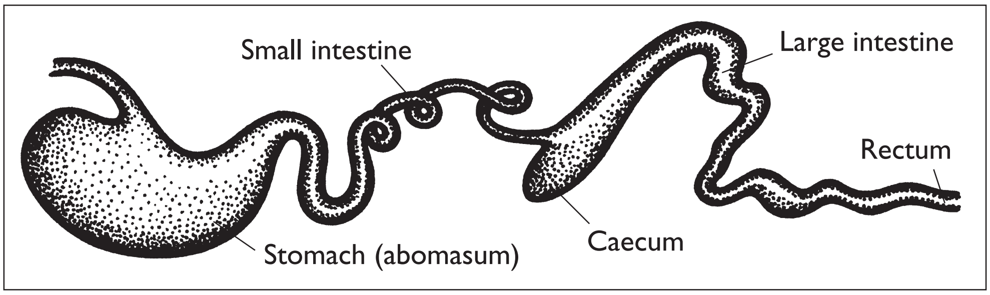

Figure 20.1 Monogastric (pig) digestive system

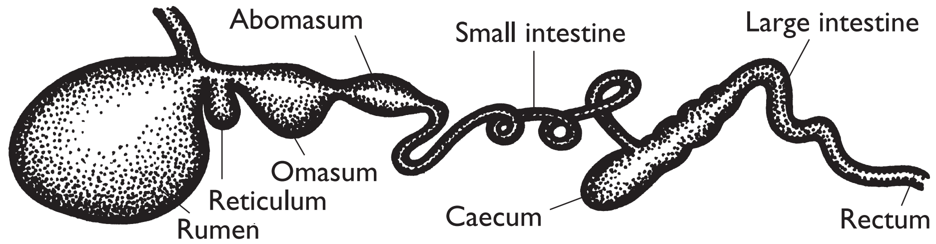

Figure 20.2 Ruminant digestive system

The small intestine is the major site where food absorption occurs, and digestive juices from the pancreas, liver and the small intestine complete the process of digestion as follows:

Starch is hydrolysed to maltose by amylase from the pancreatic juice. Maltose and other disaccharide sugars are broken down by specific enzymes in the intestinal juice, e.g. maltase, lactase and sucrase, into monosaccharides such as glucose and fructose. These are then absorbed through the gut wall.

Trypsin in the pancreatic juice acts on protein to produce polypeptides, which are then broken down to amino acids by various peptidases in the intestinal juice and subsequently absorbed.

Bile, which is secreted by the liver, serves to emulsify fats into smaller globules, which are then broken down by the enzyme lipase into fatty acids and glycerol ready for absorption. Lipase is present in both the pancreatic and intestinal juices.

Pigs are omnivores and will consume a wide range of foods from both plant and animal sources. The natural inclination of the pig is to eat on a 'little and often' basis, and this is likely to maximise both total food intake and the efficiency of food utilisation.

Formulation of diets

The first step in formulating a ration is to define and decide on the nutritional needs of the pigs. Secondly, the raw materials available need to be listed with their nutrient composition. Then the skill is to combine the ingredients into a suitable ration which will provide for the requirements of the pig at the least cost. Allowance should always be made for a margin of safety to cover inexact information about ingredients. Moreover, it is very important in a tropical environment to maintain a flexible approach to formulating a ration, according to resources and conditions. Published estimates of requirements should be considered as guidelines, to be modified in relation to pig performance. In economic terms, providing for maximum performance of the pig may not be the most profitable course of action.

Hand formulation

Diets can be formulated by hand calculations, where proportions of ingredients are varied on a trial and error basis until the desired nutrient requirements are obtained. The procedure for formulating a simple ration can best be illustrated by a simple example. Firstly, list the feed ingredients, which are available to the producer, noting any constraints, which may exist (see Table 20.2).

Table 20.1 Nutrient composition of some typical food ingredients available for a pig diet.				
Name	Digestible Energy MJ/kg	Crude Protein%	Calcium%	Phosphorus%
Maize	13.9	8.9	0.01	0.25
Soyabean meal	12.5	46.0	0.25	0.60
Chickpea meal	10.8	20.1	0.26	0.32
Bonemeal	0.0	0.0	22.00	9.00

Table 20.2 Approximate composition of some tropical foodstuff						
	Expressed as percentages (dry matter + moisture = 100%)					
Name	Dry matter	Crude protein	Ether extract	Crude fibre	Ash	Nitrogen free extract
Banana *Musa sapientum* flour, from green banana rejects	19.50	8.50	2.10		8.90	
Brewers spent grains	89.71	15.40	3.80	18.05	3.76	48.70
Cassava (tapioca, manihot, yucca) *Manihot esculenta*	89.11	4.82			0.10	84.19
Coconut *Cocos nucifera* Desiccated	95.48	7.00	64.59	3.45	1.68	18.76
Coconut meat						
fresh	23.74	3.35	19.42		0.97	
dried	76.67	7.58	69.09			
Coconut extract residue (fresh)	11.10	6.10	5.00			
Fish meal, species not identified	90.46	53.44	4.39	1.74	21.51	9.38
Fruit with peelings mixed varieties, raw, dried	89.56	5.35	1.07	3.52	5.14	74.48
Maize (corn), *Zea mays* maize and cob meal	90.53	10.19	8.70	6.23	1.87	63.54
Pawpaw *Carica papaya*						
fruit, green	7.60	1.00	0.10	0.80	0.50	5.20
fruit, green dried before analysis	93.35	10.59	1.95	13.69	8.65	58.47
Plantain, green, mature, cooked	91.14	3.17	3.26	4.63	4.09	75.99
Plantain, green, mature, uncooked	90.77	3.29	3.10	5.24	4.38	74.76
Plantain, ripened with carbide, uncooked	80.48	3.07	3.85	5.28	4.20	64.08
Snails African, *Achantina fulica* meat, dried	89.91	45.91	8.57		7.75	27.68
Sugar, brown	93.02	0.16		0.46	92.40	
Taro *Colocasia esculenta*						
tuber with peelings, fresh	25.57	1.46	0.52	0.92	1.1	21.51
tuber with peelings, dried	93.16	5.36	1.80	3.43	4.23	78.34
Yam *Dioscorea alata*						
tuber purple, fresh	25.00	1.98	0.28	1.43	1.05	20.26
tuber meal	90.62	7.18	1.03	5.17	3.80	73.44

Then, if a grower ration is required, list the nutrient requirement for growing pigs (Table 20.3).

Table 20.3 The major nutrient requirements in the diet for a growing pig	
Digestible energy MJ/kg	13.00
Crude protein (CP)%	16.00
Calcium %	0.70
Phosphorus %	0.55

The approximate proportions of ingredients to meet these requirements, based on conventional diets, are known to be:

Energy sources	65–75 %
Protein sources	20–25 %
Calcium/Phosphorus sources	2–3 %
Mineral/Vitamin additives + salt	1.5–2 %

To formulate a suitable diet for grower pigs you must first calculate the amount of nutrient each ingredient contributes to the final ration. This is calculated as a percentage, e.g. maize is 72 per cent of the ration and contains 13.9 MJ/kg of digestible energy. Therefore, the amount of energy from maize is:

$$13.9 \times \frac{72}{100} = 10.0 \text{ MJ/kg}$$

The following table shows a possible ration for grower pigs.

Table 20.4 A possible ration for grower pigs

Name	Content (kg/tonne)	Digestible energy MJ/kg	Crude protein%	Calcium%	Phosphorus%
Maize	720	10.0	6.4	0.007	0.18
Soyabean meal	210	2.6	9.6	0.05	0.13
Chickpea meal	30	0.3	0.6	0.007	0.009
Bonemeal	25	0	0	0.55	0.23
Mineral/Vitamin + salt	15	0	0	0	0
Total	**1000**	**12.9**	**16.6**	**0.61**	**0.55**

In comparison with the nutrient requirements for growing pigs, the energy content is slightly low, the protein content is too high, and the calcium content is also slightly low.

As protein is likely to be the most expensive ingredient in the diet, it is important that the protein content is correct. A useful technique for balancing the protein content is the Pearson's square (see Figure 20.3). The protein level required in the diet (i.e.16%) is placed in the middle of the square, and percentage protein content of the ingredient feeds is the two left-hand corners of the square. By subtracting diagonally across the square (16 – 8.9 = 7.1 and 42.8 – 16 = 26.8 in Figure 20.3) the proportion of the ingredients required to give a 16% protein content in the final diet can be read off the right-hand side, i.e. 7.1 soyabean/chickpea to 26.8 maize or 1:3.77. By rounding of the figures, this gives a proportion for a ration, as in Table 20.4, which provides for the growing pig. Suitable mineral/vitamin pre-mixes should be purchased and added to the ration in order to provide the estimated requirement.

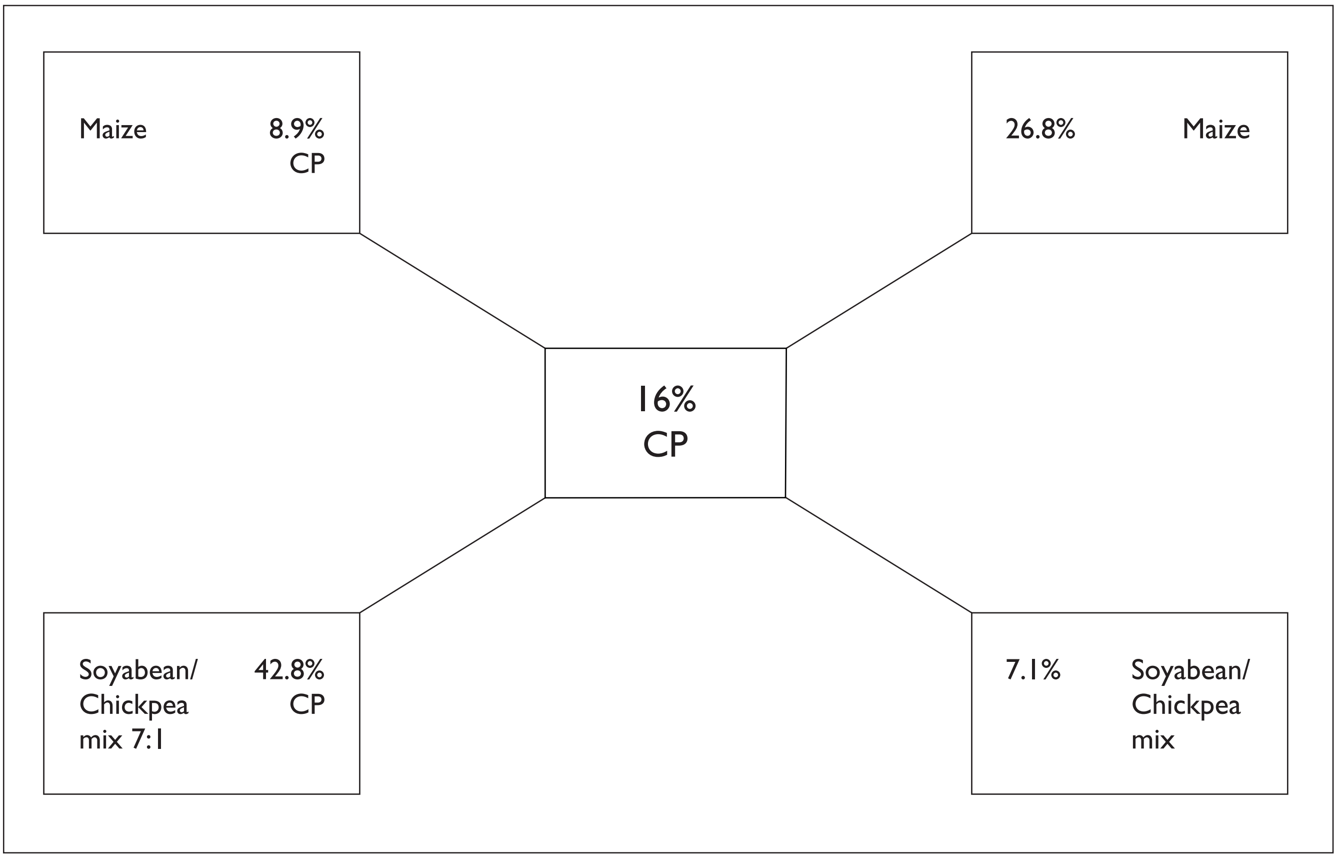

Figure 20.3 The Pearson's square technique for calculating protein levels in diets

Table 20.5 A corrected ration for grower pigs

Name	Content (kg/tonne)	Digestible energy MJ/kg	Crude protein%	Calcium%	Phosphorus%
Maize	720	10.4	6.7	0.007	0.19
Soyabean meal	184	2.3	8.6	0.06	0.11
Chickpea meal	26	0.3	0.5	0.007	0.008
Bonemeal	26	0	0	0.572	0.24
Mineral/Vitamin + salt	14	0	0	0	0
Total	**970**	**13.0**	**15.8**	**0.65**	**0.55**

Computer formulation

Ration formulation can be done by computer programming, and most feed companies and large operations now formulate by computer. A database of available ingredients and their cost is maintained and the computer is programmed to calculate the required diet at minimum cost. It is essential, however, the least-cost ration programming is carried out by a nutritionist, who can check that the end result makes 'nutritional common sense'. The cheapest ration is of no use if the pig finds it unpalatable!

Activity 1 Digestive system

Materials

modelling clay
scissors
glue

1. In groups of three discuss and compare the mono-gastric and ruminant digestive systems.
2. Write down the differences in structure and function.
3. Construct models of the two systems using modelling clay or other local materials.
4. If readily available inspect the digestive systems of a mono-gastric and ruminant animal (optional).

Activity 2 Feed, grasses and legume collection

1. Collect samples of available concentrate feed in small clear plastic bags. Samples can be collected from MAFFM, USP, agriculture supply companies or farmers.
2. Label the samples using a profile indicating name, nutrient content, current price, country of origin, animal the feed can be consumed by and any other relevant details.
3. Collect, dry and attach to pages in a folder five pasture grasses and three legumes. Label the plants using a profile for each plant. The profile should include scientific and common name, site collected from, physiological features, and nutritive content.
4. Display the collections in your classroom.

Activity 3 Calculating a ration

In pairs discuss and calculate a ration suitable for a young boar. The nutrient requirement for the boar is given below. Use feeds given in Tables 20.4 and 20.5.

Table 20.6 Feed requirements for a young boar

Digestible energy MJ/kg	15.0
Crude protein %	20.0
Calcium %	0.9
Phosphorus %	0.57

Review

1. What is the function of the digestive system?
2. Why is the digestive system of a pig and cow different?
3. Why is nutrition important in the growth and development of an animal?
4. Pig farmers are encouraged to use locally available feed? Why is this?
5. Cattle farmers normally provide supplementary feed to their animals, especially during the dry season. Give reasons why this is done.

Part 6 Tools, Equipment And Facilities

Unit 21 Tools And Equipment

Keeping Track Of Tools And Equipment

Farmers depend on tools, equipment and facilities for almost all farm activities from soil preparation through to harvesting and storage of produce. Livestock farmers also need them for their husbandry and management practices. Therefore they must be able to keep track of all tools and equipment and their condition. In order to do this they must have records of each item and the condition they are in. These records will also assist in making decisions about buying additional tools and equipment or replacements. The table below shows what a rural farmer from Savai'i was using.

Table 21.1 Tools and equipment listing

Date	Name of tool/ equipment	Condition	Received from	Borrowed by	Returned on	Comments
2/1/04	Oso	Good		Tevaga	4/1/04	
3/1/04	Sprayer	New	Ag store			control TLB

Materials

- all the school agricultural tools and equipment
- engine oil
- spark plug (if needed)
- tool kit

Activity 1 Design a record sheet

1 In groups of four discuss the table above and design a better record sheet for receiving, storing and giving out tools and equipment.

2 The record sheet must be simple and easy to follow.

3 The record sheet should include date, quantity, quality, name of supplier and user or borrower, name of tool and tool identification number.

4 While designing your record sheet look at the School Management Manual Document provided by your teacher. Look at the Facilities and Equipment section.

5 Present your record sheet to the class.

6 Select the best record sheet and use it for keeping records of tools in the school.

Tools and equipment must be maintained well in order to last as long as and work well. For example, a mist blower must be regularly serviced by changing oil, oiling the moving parts, checking the spark plug and checking for leaks and cracks. When storing tools away after a cropping season or before the school holidays you need to clean the tools and oil them. This will ensure that they do not rust or seize up. A farmer or agriculture teacher must keep records to know when to service equipment and what needs to be done.

Activity 2 Maintenance programme

1. In your same groups you will discuss and develop a maintenance programme for the school's agriculture tools and equipment. Your maintenance programme should include dates, activity/task, person responsible, name of tool/equipment, cost, requirements, e.g. oil and so on.
2. Your teacher will provide the class with a list of all the school's agricultural tools and equipment and their current condition.
3. Present your maintenance programme to the class.
4. Select the best maintenance programme to use for the maintenance of agricultural tools in the school.

Activity 3 Servicing of tools and equipment

1. In pairs select a tool or piece of equipment from the selection provided by the teacher.
2. Discuss and list what needs to be maintained and the materials you will need.
3. List the procedure or steps you will follow to service and store the tool or piece of equipment you selected. Discuss this with your teacher to get his approval before you start.
4. Follow the approved steps.
5. Demonstrate what you did to the class. Start by describing the function of the tool or piece of equipment.

Review

1. In what ways are tools and equipment useful to farmers?
2. Why must tools and equipment be regularly serviced and maintained?
3. Schools always find it difficult to stop tools and equipment from 'walking' (going missing without explanation). Design a system to prevent this.
4. Students must carry and use their tools in the right way and not play when using them. Give reasons why this should be done.

Glossary

Word/phrase	Meaning
Abomasum	Fourth compartment of the ruminant stomach; the true glandular stomach.
Acaricide	Diluted chemical preparation used in dip-tanks or hand-sprays to kill ticks (acarids) on animals.
Ad lib	Providing free access to food.
Adaptation	The development of characteristics which improve the chance of survival in a given environment.
Ambient temperature	Temperature of the surrounding air.
Anaemia	Deficiency in haemoglobin, often accompanied by a reduced number of red blood cells, causing paleness, weakness and breathlessness.
Anthelmintic	Chemical used to kill worms in the digestive tract.
Artificial insemination (AI)	Insemination of the cow artificially by a skilled technician using collected semen and special equipment.
Beneficials	A term commonly used to describe the organisms in an ecosystem that have a beneficial effect in regard to pest control – often they are predators of the pests.
Biological control	The process of introducing an organism that, through some sort of interaction with a particular species of pest, either kills the pest or restricts its growth and development.
Body condition	Fatness, determined by condition scoring.
Browse	Edible parts of trees, bushes and other woody plants (mainly leaves, twigs and fruits) which are available for animal consumption.
By-product	Any part of a crop, other than the main harvested product, which can be used for animal feed.
Carrying capacity	The number of stock that can be supported, either year round or seasonally, over a long period (expressed in hectares per livestock unit).
Chemical control	The process of using chemicals to either kill pests, restrict their growth and development, or stop them from attacking crop plants.
Chronic	Describes a disease continuing, often at a low level, for a long time.
Colostrum	The first milk produced by a female for her offspring to supply the young's initial requirements of nutrients, Vitamins A and D and protective antibodies.
Concentrated feed	Ruminant food made from combinations of good quality constituents, such as oil seed residues, molasses and mineral additives.
Conception	Union of the egg and sperm; fertilisation.
Constraint	A factor which limits the process of change, development or uptake of new ideas; usually grouped under the headings social, economic, technical, political or environmental.

Glossary

Word/phrase	Meaning
Corpus luteum	The yellow body formed in the ovary from the Graafian follicle (after release of the ovum), under the control of luteinising hormone. After fertilisation, it secretes progesterone hormone to maintain pregnancy.
Crossbreeding	Mating animals of different breeds.
Cull	To remove unwanted animal (e.g. non-breeding cows or aged stock) for sale or slaughter.
Cultural control	The process of using pest control practices that can become part of the farming or growing culture in a region; mulching plants, had removal of weeds, and the composting of crop residues are examples of cultural control.
Dry matter (DM)	Part of a food remaining after all the water has been removed from it by drying.
Dry period	Period of non-lactation between two periods of lactation.
Ectoparasites	Parasites which live on the skin of the animal, such as ticks, mites, lice and fleas.
Embryo	Unborn offspring in the process of development from conception (in cattle, from conception to three months).
Endemic	A disease usually existing in an area.
Endoparasites	Parasites which live inside the animal's body.
Evaluating	Determine the value or worth of something, e.g. of an IPM programme.
Extensive	Systems which use large area of land per animal unit.
Fodder	Any bulky green or dried plant material used to feed stock.
Fodder crops	Cultivated annual or perennial crops grown principally for harvesting and feeding to animals in a fresh or dried state.
Foetus	Developing unborn offspring, after the embryo stage (in cattle, from three months to birth).
Food supplement	Food which is given in small amounts to complement a roughage diet.
Forage	Vegetation available as food for livestock or game.
Forage crops	Cultivated crops either grazed or browsed directly.
Genetic capacity	Potential of an animal to produce, as defined by its genetic make-up.
Gestation	Period during which the embryo and foetus grow in the uterus of the mother (in cattle, a period of 40 weeks).
Globulin	One of the groups of protein present in blood plasma; gamma immunoglobulins are associated with immunity and resistance to disease.
Heat detection	A way of identifying animals that are in oestrus.
Heritability	An offspring's ability to inherit traits from its parent.
Heterozygous	Having different alleles at one or more genetic loci.

Glossary

Word/phrase	Meaning
Homozygous	Having different alleles at one or more genetic loci.
Host resistance	The resistance that some varieties of plants (the host) have to the attacks of a particular pest; this resistance is often taken advantage of in the development of cultivars, e.g. some varieties of taro have been developed that have a natural resistance to the fungal disease, taro leaf blight.
Husbandry	The day-to-day practice of looking after farm animals.
Hybrid vigour	Increased vigour (in terms of growth, fertility and production) in a cross between genetically different lines when compared with the same characteristics in either parental line.
Immune	Protected against a specific disease.
Inbreeding	Mating closely related animals.
Indigenous	Originating in and native to a particular region.
Intensive	Agricultural systems which usually use small areas of land, but high inputs of capital.
Joule (J)	International unit of energy (1 calorie [obsolete unit] = 4.2 joules).
Lactose	The sugar in milk.
Libido	Sex drive; usually refers to male animals.
Livestock unit	Standardised animal unit to which different ages, types or species of livestock can be related for purposes of matching forage availability to animal needs.
Luteinising hormone (LH)	Secreted by the anterior lobe of the pituitary LH normally initiates the formation of the corpus luteum in the female and the secretion of testosterone in the male.
Maintenance	Term used to describe the nutrients needed to keep an animal alive, but with no productive capacity.
Metabolism	Life sustaining processes in the body, including nutrition, energy production and growth.
Monitoring	Keeping track of, or being watchful of something – often for the purpose of further action that will depend on what is revealed.
Morphological	Relating to the form of living organisms, and the relationship between their structures.
Oestrus	Recurrent period of reproductive receptivity of females to males, resulting from the regular series of hormonal events known as the oestrous cycle.
Osmosis	The diffusion of water through a semi-permeable membrane, from a higher to lower concentration of water.
Physical control	The process of placing physical barriers between a pest and the host plant, e.g. bagging fruit, netting trees, and fencing gardens.
Physiological	Relating to the normal functioning of living organisms and their parts.

Glossary

Word/phrase	Meaning
Pregnancy diagnosis	Determination by manual examination of the cow's internal genitalia whether or not she is in calf.
Productivity	The efficiency of production; measures of the output made by the producers in terms of inputs.
Puberty	Growing stage during which the reproductive system acquires its mature form and function.
Rumen	First stomach of the ruminant animal in which food is fermented by bacteria, protozoa and fungi before final digestion in the abomasums and lower digestive tract.
Sample	In the context of IPM monitoring, a sample is a selection of plants or of an area that represents all the plants of the whole growing area, e.g. 10 fruit trees in an orchard of 200 trees, or several insect traps spaced around a large vegetable garden. By studying the sample, estimates can be made about the whole area.
Seasonal	Related or linked to the seasons of the year, or to one particular season.
Semen	Fluid, produced by the male reproductive organs, containing sperm.
Service	Mating and fertilisation of the female animal artificially or by a male animal.
Stress	State of mental or physical strain resulting from adverse circumstances/conditions. In this state animals do not thrive.
Subsistence	Production of just enough food to meet the family's day-to-day needs throughout the year.
System	A series of inter-related components which operate together to produce an output.
Translocation	The movement of dissolved substances, e.g. sugars, within a plant.
Transpiration	The loss of water from the surface of leaves by evaporation.
Venereal disease	Disease known to be transmitted during mating, e.g. brucellosis.
Weaning	The process of changing the diet of a young animal from milk to solid food.

Key Vocabulary

Vocabulary	Collocations	Derivations
absorb	absorb fertiliser	absorption
achieve	achieve the best result	achievement
affect	chemicals affect plants animals are affected by human activity	affected by
allow for	allow for stock changes during the year	
apply	apply fertiliser, apply a treatment fertiliser applications	application
arise	root branches arise deep in the root the disease arises from . . .	arose, arisen
basis	a good basis for . . .	based on
balance	soil erosion and formation processes are balanced the two sides of the budget must balance	
characterise	good management is characterised by . . .	characteristics
constant	other factors stay constant, a constant relationship	
crucial	a crucial factor	
dependent on	dependent on favourable conditions	interdependent
determine	the amount of lime is determined by several factors determine the soil properties	
disturb	human activities disturb the environment disturbances to the relevant ecosystems	disturbance
enable	analysis enables farmers to understand the business better	
estimate (n. & v.)	estimate the nutrient supply power of soil provide an estimate	
excessive	excessive amounts of nutrients, excessively fat	excessively
favourable	in favourable conditions	unfavourable
initiate	initiate a project, initiate a disease cycle	initiation, initial
maximise	maximise profits	
minimise	minimise damage and losses	minimal
modify	modify an environment modify the whole system	modification
natural	a natural environment	nature
obvious	the most obvious part	obviously
objective	the main objective is to increase production	
opportunity	an opportunity to improve	
potential	great potential for improvement a potential export product	potentially
proportion	a large proportion of the moisture	in proportion to
provided that	provided that costs remain constant . . .	
rapid	rapid improvement, reproduce rapidly	rapidly
reliability	the reliability of a test	reliable, reliably
remain, remains	to remain in the soil, humus is the remains of organic matter	
requirement	different soils have different requirements	require
scarce	a scarce resource	
status	nutrient status, fertility status	
strategy	a strategy for pest control	strategic
survive	viruses cannot survive without a living host a survival structure	survival
viable	a viable enterprise, improve viability	viability

Topic Specific Vocabulary

Related to Unit 1 Natural And Managed Ecosystems
ecosystem
organisms
sustain
morphological
physiological
nutrient cycle

Related to Unit 2 Genetics
husbandry
genetic merit
heritability
variability
offspring, progeny
production traits
multiple ovulation and embryo transfer (MOET)
hybrid vigour
homozygous, heterozygous
dominant, recessive
genotype, phenotype
breed, variety, cultivar
lactation

Related to Unit 3 Soil fertility management
tillage
symptom
diagnose
organic matter
nutrient, nutritional status
mobile, immobile nutrients
accumulate, concentration
deficiency
soil extractant
lime, liming materials, limestone
cation exchange capacity
decomposition, decompose, decomposers
micro-organisms
leaching

Related to Unit 4 Soil conservation
erosion, erode
deposition
high base status soils
fallow
mulch

Related to Unit 5 Determining what enterprise to operate
gross margin
marginal cost
variable costs, common costs
adjust, adjustments
inventory
viable, unviable
offset
target
partial budgeting
product substitution
disposal

Related to Unit 6 Records
physical records
financial records

Related to Unit 7 Optimum Combination of Inputs
optimum
risk, riskless
incremental increase
marginal physical product (MPP)
marginal value product (MVP)
is assumed to be
costs incurred

Related to Unit 8 Break even and types of costs
projected potential profits

Related to unit 9 Market channels and promotion
agency
wholesale, retail
bulk
barter
merchants
private treaty
promotional material

Related to unit 10 Agroforestry
trends

Related to unit 11 Internal Structures Of Roots, Stems And Leaves
morphology
dicotyledon, monocotyledon
vegetative organs

Related to Unit 12 Manipulation of plant growth and seed viability
asexual reproduction
hybridisation

Related to Unit 13 Transport of materials in plants
potometer
eosin

Related to unit 14 Plant Protection
pathogen
host
vector
infection
virus
mechanism
survival structures

Related to Unit 15 Practical Experience
pod set
top dress
broad spectrum fungicides
chupon
jorquette

Related to Unit 16 Pig Breeds and Breeding
indigenous
gilt

Related to Unit 17 Pig Farming
piggery
farrow
litter
weaner
service
libido
sperm production
lameness
oestrus
stillbirths
uterine contractions
asphyxiate
colostrum
palatable
prophylactic
therapeutic
scours, diarrhoea
carcass

Related to Unit 18 Reproduction and growth
lay down lean tissue
entire males
testes
ejaculate
coitus
ovulate
fraction

(cont.)

Topic Specific Vocabulary

(cont.)

Related to Unit 19 Animal Health	Related to Unit 20 Nutrition and Feeding
parasites susceptibility to infection chronically infected abrasion irritation encyst sterility	masticate ration **Related to Unit 21 Tools and Equipment** seize up

Useful Structures

Descriptive phrases

- **an** incalf **heifer** *moved* from a rearing to a milk production unit . . .
- **a** weaner **pig** *moved* from a breeding to a fattening enterprise . . .
- **some examples** of enterprise gross margins *taken* from surveys of large-scale, mechanised, commercial farms in Zimbabwe . . .

Expressing an extra idea

- **Not only** does it help to reduce the incidence of disease in the pigs, **but it also** has a beneficial effect on staff morale by improving the working environment.
- Partial budgeting **not only** enables them to assess the effect of small changes, such as buying a sprayer instead of hiring one, **but it is also** useful for assessing the likely financial effect of fairly large changes.

Expressing the topic or situation to be discussed

- **With annual crops, like tobacco and cotton**, gross income usually equals total cash income as stock are rarely kept from one year to the next.
- **When crossing the two heterozygous polled cattle**, the second generation will give one homozygous dominant (HH) polled, two heterozygous (Hh) polled and one homozygous recessive (hh) horned.
- **When applying lime**, consider the soil pH, the cation exchange capacity (CEC) of the soil, and the crop to be grown.
- **In planning the food supply on subsistence farms**, the main aim is to produce an adequate diet for the household.

Expressing a necessary condition

- Any increase in whole-farm gross margin will raise profit by exactly the same amount, **provided** common costs stay constant.
- Inbreeding, however, is not always disadvantageous, **provided** there are no undesirable recessive genes existing in the stock.

Referring to the previous sentence

- In a farm situation or managed ecosystem, however, the nutrient cycle is broken. **This** means soils tend to lose nutrients after a few years of intensive farming.
- It is necessary to decide the target whole-farm gross margin needed when planning begins. **This** means listing all expenses to be met other than enterprise variable production costs.
- Partial budgeting simplifies decision making for many problems by giving the most accurate estimate of the financial effect of a proposed change. **This** should prevent unprofitable changes being made.
- Many natural undisturbed soils have a rate of formation that is balanced by a rate of erosion. **Under these conditions**, the soil appears to remain in a constant state as the landscape evolves.
- He needs to produce an additional 30 bags of maize to be able to meet other needs such as purchases of other food and non-food items. **Hence**, the farmer wants to produce 50 bags of maize.
- However, a farmer with only two or three cows has little opportunity to influence the genetic merit of future cows by culling or selection. **Such** a farmer may have only one female calf born each year . . .
- The quickest way to achieve increased milk yield by genetic improvement is by crossbreeding stock with a breed that has a higher genetic potential to produce milk. **Such** a breed is often called an ‘improved breed’ . . .