Arise with

Agriculture

STUDENTS' BOOK 3

Denis Kakolo
Esmie Chamdimba

CLAIM
mabuku
A world of quality literature

CLAIM Limited
7 Glyn Jones Road,
P.O. Box 503,
Blantyre,
Malawi.

Editor : Andrew Mkwate

Designer : Joe Kima Phulusa

Proofreader : Tapiwa Chavula Kamoza

ISBN : 978-99960-35-99-9

Acknowledgements

The authors would like to thank God for giving them good and vibrant health during the whole period this book was written. They would also want to thank their families for being understanding and supportive. Profound thanks should also go to CLAIM for giving them material, financial and moral support. The General Manager for CLAIM, Mr. Andrew M. Chisamba deserves a pat on his back for giving the authors the opportunity to write through his organisation and Mr. John Yohane of the same organisation for his guidance.
The authors also want to extend their sincere thanks to all the websites and books which have been used as reference materials.

Contents

Unit 1

Physical Properties of Soil

You may recall from your Junior Certificate Agriculture course that soil is a thin layer of loose material covering the earth. You also learnt the roles of soil in crop production and that there can never be any crop production without soil. Soil is therefore the center of any agricultural activity farmers can undertake. In this unit, you will be expected to list the physical properties of soil, describe these physical properties of soil, determine the physical properties of soil, identify types of soil structure and how soil structure can be destroyed.

Listing Physical Properties of Soil

The soil has a variety of physical properties all of which are very vital as they provide a medium for plant growth. You will carry out an activity to list these different physical properties of soil.

Activity 1

Listing physical properties of soil

- Be into groups of at least five to eight each
- Choose a group leader who will chair the deliberations.
- Also choose a secretary who will be taking notes and eventually present the discussions to the whole class.
- Brainstorm the physical properties of soil
- After 15 minutes, go back to class and present your suggestions to the whole class.
- Your teacher will consolidate the physical properties of soil.

Physical properties of soil are:

1. Texture
2. Structure
3. Colour
4. Consistency
5. Porosity
6. Temperature
7. Depth

Describing the Physical Properties of Soil

This sub-topic aims at describing the different physical properties of soil as listed above. An in-depth description of these physical properties will help you understand more about each property.

Activity 2

Describing the physical properties of soil

- Form seven groups.
- Choose a leader for each group. This leader will be called a host.
- Each group should have a chart paper.
- Using an eatery method, each host and customers will be responsible for describing one physical property as follows:
    - The meaning of the physical property.
    - Factors that affect each physical property.
- Each host should present to the whole class points raised by the customers.
- Your teacher should summarise the description of each soil property.

Soil Texture

This is defined as the relative proportion of various sized soil particles found in a soil sample. This means that a soil sample will always contains rock particles which are different in size. It is from texture that names of various soils are derived. Recall that the following soils are derived from soil textural classes.

Clay .....below 0.002 mm in diameter
Silt .....between 0.02 and 0.002 mm
Fine sand ..... between 0.2 and 0.02 mm
Coarse sand ..... between 2.0 and 0.2 mm
Gravel .....above 2.0mm in diameter

Soil Texture Triangle

A soil texture triangle is used to classify the texture class of a soil. The sides of the soil texture triangle are scaled for the percentages of sand, silt, and clay. The boundaries of the soil texture classes are highlighted in dark lines. The intersection of the three sizes on the triangle gives the texture class. For instance, if you have a soil with 20% clay, 60% silt, and 20% sand it falls in the "silt loam" class.

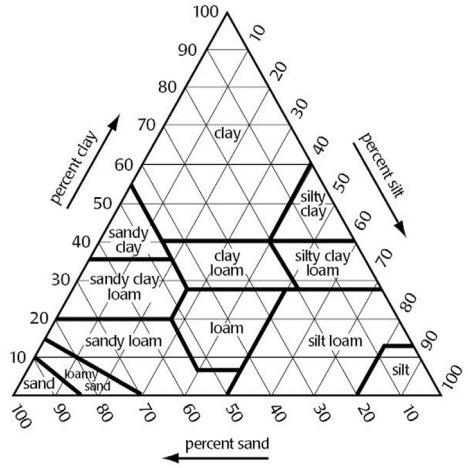


Fig. 1.1 soil texture tringle

How to use the triangle

Recall that soil texture can be described as the percentage of clay, silt and sand in a soil sample. The soil triangle therefore gives these percentages. The total of these percentages should you 100%. For example, point R on the triangle (40% silt, 20% clay and 40%sand) gives a loam texture. Similarly, point N (60% clay, 20% silt and 20% sand) gives a clay texture. You will see that in both cases, the sum of the percentages gives 100%. Repeat the same exercise to identify percentages of clay, sand and silt on different points of your choice in the triangle and then identify the textural class the soil belongs to.

Effects of Physical Properties of Soil on Crop Production

Parent material: This is generally the physical property of the rock material from which a soil is formed. Some rocks are more resistant to disintegration than others. Those which are difficult to break such as granite and sand stones form larger rock particles than those which break easily such as micas and montmorillonite.

Time: This is the time it takes for the parent material to be exposed to weathering (soil forming) agents. Where soil forming processes have taken place for a very long period of time, it is obvious that the soil will contain particles much smaller than when the processes have been in progress for a short period of time. Time therefore determines maturity of soil.

Climate: Rainfall and temperature are the major climatic factors which influence rate of weathering. When it is raining, rain water combines with atmospheric carbon dioxide to form carbonic acid which when it falls on rocks containing carbonates, will easily dissolve away the rocks. On the other hand, the rain water carries rocks which may knock against each other and break into smaller particles. High temperatures cause rocks to expand and when the temperature falls suddenly, the rocks break up into smaller particles.

Soil Structure

Soil structure involves the arrangement or packing together of individual rock particles called primary particles to form aggregates. This aggregation of soil particles which forms secondary units occurs naturally over a very long period of time.

Soil aggregation can be affected by many factors. Most important of all are:

- **Organic matter:** This provides a cementing agent of the individual rock particles forming aggregates. This is why application of organic matter

helps to improve soil structure

- **Climate:** Of all, the most important is rainfall. Whenever it rains soluble salts like clay and iron oxides leach down. These minerals are very important in cementing together rock particles. Their leaching leaves rock particles on the top horizon loosely arranged because there is very little or no cementing agents.

- **Parent material:** As stated already, clay minerals and humus are the cementing agents. It follows therefore that a soil formed from rocks that give rise to clay or organic matter is likely to give rise to a soil which will be well aggregated.

Soil Colour

This is the physical appearance of soil which comes as a result of parent material, aeration and drainage and the amount of organic matter it contains.

- **Parent material:** Reddish or brown soils indicate that they contain iron oxides; soils that originate from silica or quartz (limestone) are whitish in colour.

- **Organic matter:** Soils containing large quantities of organic matter are usually dark in colour.

- **Drainage and aeration:** As you move around a swampy land you will notice that the soils are usually grayish as opposed to well drained soils which are brownish in colour.

Soil Consistency

This is a combination of properties of soil that determine its resistance to crushing and its ability to be molded or changed into shape. The state of soil when it is under different moisture content describes soil consistency. You might have noticed that some soils like clay will be sticky when they are wet. The same soil will be very difficult to break when it is dry. This implies that such soils are difficult to work with.

Some soils are soft. They break easily into primary grains when they are pressed lightly. Others, on the other hand, are friable. Such soils break easily when they are moist but their particles still hold each other.

Soil Porosity

This means the percentage volume of the total bulk of soil which is not occupied by soil particles. Soil structure describes a situation in which soil particles are neatly combined to form aggregates creating pores in between them. The proportion of the pore spaces created as the soil particles are being aggregated is what constitutes to soil porosity.
Some soils are more porous than others. This is because they have more and possibly bigger pores than those which are less porous.
Soil structure creates soil porosity. Destruction of structure destroys porosity too. Porosity therefore influences air circulation and water infiltration and percolation in the soil.

Soil Temperature

The heat a soil is capable of holding is of primary importance to the chemical and biological activities occurring in the soil for the good of plant growth. Soil temperature is affected by soil colour, vegetative cover, soil moisture content and latitudes.

- **Soil colour:** Black soils absorb and keep more heat than any other soil colours. However, it must also be noted that most dark coloured soils are as a result of organic matter which are generally moist and therefore may not always be the warmest. Red and yellow coloured soils have shown a more rapid temperature rise than white ones.

- **Vegetative cover:** A soil covered by vegetation receives less heat from the sun than the soil which is on open ground.

- **Soil's moisture content:** A moist soil is generally cooler than a dry soil.

- **Latitude:** This deals with position of the sun as it shines on the earth. Temperatures along the equator are the hottest as compared with all other places because the sun overhead more times than most of all other places on earth. It therefore follows that the soil along the equator is likely to be the hottest.

Effects of soil temperature on crop growth

- **Water evaporation:** The soil loses water through evaporation depending on soil temperature. This becomes critical when rains become scarce.

- **Chemical reactions in the soil:** Mineral salts must dissolve into soluble minerals which become available to plants. The rate of such reactions depends on soil temperature.

- **Seed germination:** The process of seed germination involves enzyme activation by water; break down of reserved food in the seed and translocation of the nutrients to the embryo. All these are chemical reactions which need favourable temperature.

- **Microbial activities:** Some micro-organisms in the soil decompose organic matter, while others fix nitrogen. These are very beneficial activities carried out by micro-organisms living in the soil. Unless the soil has a favourable temperature, it will be difficult for them to multiply and carry out these activities. The best temperatures for the activities are between 25c and 40c.

Soil Depth

When crops are growing in the field, their roots need a big soil volume from which they can absorb water and nutrients. This large soil volume depends on depth of soil. Deep rooting crops such as cotton, tea, coffee need deep soils in order to grow well.
Soil depth is influenced by many factors. Most important of all are:

- **Slope of land:** Soils on steep slopes are shallow because of erosion. The flat and low land areas have deeper soils because there is relatively no erosion and some of the soil eroded from the highland is deposited there.

- **Parent material:** Parent materials which are resistant to weathering take long to form soil than those which are less resistant. More and deeper soils are therefore formed making them deeper.

Determining Physical Properties of Soil

Soil Texture

You may wish to recall from your Junior Certificate course that soil texture is the physical appearance of soil on the basis of rock particle sizes found in a soil sample. A soil sample is likely to contain different sizes of rock particles. In this topic, you will carry out activities which can help you find out the different sized rock particles in a soil sample.

Activity 3

Determining texture of soil using sieve method

- Visit a local environment to observe different types of soil
- Collect the different samples of soil

Materials required

- Soil lump.

- Sieves of different sized mesh i.e. 2mm, 0.2mm, 0.02mm, 0.002mm in diameter.

Procedure

- Break the soil lump lightly into small particles.
- Take a sieve of 2 mm mesh.
- Sieve the soil through the 2mm mesh. Soil particles greater than 2 mm in diameter will not pass through.
- Repeat the exercise with sieves of 0.2mm. 0.02mm, 0.002mm.
- By the end of the exercise you will have separated the different soil particles into their textural classes.
- Your teacher will summarise sieve method of determining soil texture.

Assessment

- With the use of the sieves stated above, list the soil textural classes which you have determined.
- Suggest any limitations to this method of determining soil textural classes.
- Explain why this method works with dry soil rather than wet soil.

Activity 4

Determining soil texture using sedimentation method

Materials required

- Lump of soil.
- Water.
- Transparent jar or measuring cylinder.

Procedure

- Put a lump of soil into a transparent container or measuring cylinder.
- Add water until the cylinder is 75% full.
- Shake vigorously.
- Leave the cylinder to allow the soil particles to settle down.
- Draw what you see.
- Determine the percentage of each type of soil found in the cylinder.
- Your teacher will summarise how soil texture is determined by sedimentation method.

Soil texture can be determined by use of the following methods:

Assessment

a. What texture of soil is found at the base of the cylinder?
b. Explain why this texture is found at the base of the cylinder.
c. What is the volume of this texture found at the base of the cylinder?
d. Calculate the percentage volume of the soil texture named in “a” above

Activity 5

Determining soil texture by using "Feel" method

Materials required

- Different lumps of soil
- Water
- Add a little amount of water to the soil.
- Take the soil between the thumb and the pointer finger.
- Feel the soil as you move the two fingers.
- Try to mould the soil.
- Your teacher will summarise feel method of determining soil texture.

Assessment

a. Were you able to make balls from any of the soils you collected?
b. What name is given to the soil from which you made balls?
c. What name of soil was gritty when feeling between your fingers?

1. Sieve method

The different sieves separate the different sized rock particles in the soil.

2. Sedimentation method

In this method, soil will settle down according to their mass. The heaviest will settle first, followed by the second heaviest and so on.

3. Feel method

The aim of this activity is to see the difference in feel between sand and clay. You will see that sand soil feels coarse and gritty while clay particles feel fine and sticky when wet. Clay can also be molded into balls and sausages.

Effect of soil colour on crop production

Soil colour has an effect on crop growth. Black colour in soils is very important as it keeps soil temperature warm. The rate at which mineral salts can dissolve in soil water and become available for plant use depends on soil colour. It also influences the rate at which enzymes in seeds can break down reserved food necessary for germination. Soil colour has a bearing on the temperature that influences the activity of microorganisms which decompose organic matter. Soil temperature is a function of colour. Dark colored soils will absorb more heat than whitish soils which reflect most of its heat. As a result of this, best agricultural soils must be dark which absorb and keep heat.

Soil Consistency

This is a combination of properties of soil that determine its resistance to crushing and its ability to be molded or changed into shape. The state of soil when it is under different moisture content describes soil consistency. You might have noticed that some soils like clay will be sticky when they are wet. The same soil will be very difficult to break when it is dry. This implies that such soils are difficult to work with.

Some soils are soft. They break easily into primary grains when they are pressed lightly. Others on the other hand are friable. Such soils break easily when they are moist but their particles still hold each other.

Determining soil consistency

Activity 6

Determining soil consistency

Materials required

- Hoes
- 10 liters water

Procedure

- Break the class into groups of not more than ten
- Take the class to the environment
- Each group identifies and works on a soil sample to good tilth
- To half the soil add 5 liters of water, to the other half add 2.5 liters
- Work on the two soils with the hoes

Assessment

1) Which soil is easy to work with?
2) Why do you think it is so?

You will see that the soil with 2.5 liters of water is easy to work with.
Soil consistency affects the workability of soil.

Effects of soil consistency on crop production

Poor soil consistency affects workability of the soil. It is difficult to work with and it destroys soil structure. Consistency depends on resistance to pressure and its aggregate. Consistency changes with the amount of water present in the soil. Crop production depends on a good soil consistency as good cultivated soils retain ideal air and water for crop growth.

(i) Soil Porosity

This means the percentage volume of the total bulk of soil which is not occupied by soil particles. Soil structure describes a situation in which soil particles are neatly combined to form aggregates creating pores in between them. The proportion of the pore spaces created as the soil particles are being aggregated is what constitutes to soil porosity.

Some soils are more porous than others. This is because they have more and possibly bigger pores than those which are less porous. Soil structure creates soil porosity. Destruction of structure destroys porosity too. Porosity therefore influences air circulation and water infiltration and percolation in the soil.

You have seen that soil consistency varies with the soil's moisture content. Some soils will be sticky, plasticity (capable of being molded), friable (easy to crush) when they are moist and loose or hard when they are dry. It also exhibits the soil's cementation ability. As a result, soil consistency has the following effects on crop production:

a) Workability. Sticky soils are very difficult for farmers to work with because the soil sticks to farming implements like hoes, ploughs, ridgerse.t.c.
b) Destruction of soil structure. Plastic soils easily get compacted and reduce their porosity. This in turn reduces air circulation, water infiltration and percolation and pant roots penetration through the soil.
c) Erosion. Soils that are weakly cemented easily break into individual soil grains and become more subject to erosion.
d) Seedling emergence. Plastic soils get pulverized easily by heavy rainfall. This makes it difficult for emerging seedlings to get out of the soil.

Activity 7

Determining soil consistency

Materials required

- A lump of soil.
- Measuring cylinder.
- Beam balance.
- Burner.
- Matches.
- Crucible or any metal container.

Procedure

- Break into groups of at least five members and obtain the materials listed above.
- Gently heat the soil until excess water evaporates from the soil. Weight of the soil shall become constant.
- Weigh the soil.

- Find the volume of the heated soil.
- Calculate bulk density.
- Take the volume and weight of soil.
- Compress it.
- Record its volume.
- Calculate particle density as weight of soil solids/volume of the soil solids.
- Calculate %porosity by dividing bulk density by particle density x 100.

ii. Soil Porosity

You may recall that soil porosity is the percentage volume of the total bulk that is not occupied by solid particles. It implies therefore that such spaces are either occupied by water or air or both. It should be noted that the smaller the soil particles, the more tightly packed they are likely to be. For example, clay soils have very small particles and associated with small pores. Porosity affects crop production in the following ways:

a) Aeration. Soils must allow free air entry and circulation. Air supplies oxygen for seed germination, root respiration and microbialactivities such as decomposition of organic matter.
b) Water infiltration and percolation. In soils dominated by micropores water movement through the soil is restricted causing most of the water to be lost as run-off. However, it should be noted that in a sandy soil, in spite of its low porosity, movement of water is surprisingly rapid. This is because macropores are dominant.
c) Nutrient retention. Porous soils are poor in retaining nutrients because most of them are drained to deeper soil horizons where most agronomic plant roots cannot reach.
d) Root penetration and development. Roots must penetrate through the soil to search for water and nutrients. Micropores impede root penetration. The same applies to development of root crops like cassava, potatoes thereby reducing their yield significantly

Determining soil porosity

Soil porosity is best described by bulk density and particle density. Recall that density means weight divided by volume. Thus bulk density means the mass (weight) of volume of dry soil. It is the relationship between the pore spaces and the rock particles found in soil. Particle density is defined as the mass (weight) of a unit volume of soil solids.

Suppose your soil has a volume of 1 cm3 and weighs 5 gm. Calculate bulk density of the soil.

Bulk density (BD) = Weight of oven dried soil/Volume of oven dried soil

If in the field 1 cm^3 of soil weighs 5 grams, then the bulk density will be 5 grams per cubic centimeter. (5 gm/1 cm3)

Particle density = weight of soil solids/volume of the soil solids.
For example: if the soil above was compressed and ended up occupying 75% of the cube.

The volume will be 0.75 cm3 but its weight will not change. The particle density of the soil will be 6.67 grams per cm3 (5 gm/ 0.75 cm3).

% porosity = (bulk density/particle density) x 100
= (5/6.67) x 100 = 74.9%

Effect of porosity on crop production

The percentage porosity depends on the soil texture. It ranges from 40% in sandy soil to about 60% in clay. Loam soil is about 60% porous. The percent porosity affects the availability of air and water for plant growth.

(iii) Soil Temperature

This is the hotness or coldness of a soil. Different soils hold heat differently. This is as a result of factors such as soil colour, moisture content, vegetative cover and temperature of the atmosphere.

The effects of soil temperature on crop production are many. Effects of significant importance are listed below.

a) Chemical weathering rates. Low soil temperatures reduce chemical breakdown and synthesis of chemical compounds found in the soil that make nutrients available for plant use.
b) Biological activities such as decomposition of organic matter, nitrification. For example, nitrification in the does not start until soil temperature is about 200^{c}. The most favourable limit is between 380^{c} and 420^{c}.
c) Seed germination and root growth. Germination of seeds and root development are delayed when soil temperature is low.
d) Absorption and transport of water and nutrients by higher plants is adversely affected by low temperatures
e) Development of potato tubers is at its best when soil temperature is between 280^{c} and 330^{c}

Determining soil temperature

Activity 8

Determining soil temperature

Materials required

- Different soil samples
- Containers depending on the number of soil samples
- Thermometers

Procedure

- Break into groups of five
- Go out of the classroom to observe different types of soil.
- Collect different samples of soil from the outside environment by using the containers
- Get back to class with the soil samples.
- Using the thermometer, measure the temperature of each soil sample
- Report your findings
- Discuss these findings with your teacher
- Your teacher will summarise the soil temperature

Activity 9

Recalling a soil profile

- In pairs, draw and label a typical soil profile
- State the soil horizon where most agricultural activities take place
- State the soil horizon which determines depth of soil

Activity 10

Determine soil depth

- In groups of 5 – 10 members, go out into the field to observe a typical soil profile
- Measure the depth of each horizon
- One member should present your findings to the whole class
- Your teacher will summarise soil depth

iv. Soil depth

In your Junior Certificate agriculture, you learnt about soil profile.

Depth of soil has very remarkable effects on crop production. The most notable ones as follows:
a) Soil depth affects the amount of soil nutrients the soil can hold. The deeper the soil, the lager the volume of soil plants can exploit in search for nutrients.
b) It determines choice of crops that can be grown on a particular land. Soils which are deep and loos are favourable for most crops because their roots can go as deep as they want without restrictions. On the other hand, shallow soils can only accommodate shallow rooted crops.
c) It influences amount of water a soil can hold for plant use. The deeper the soil, the more water it can hold, making it possible for crops to survive longer periods of dry spell.
d) It helps in controlling of soil erosion. Deep soils can hold large volumes of rain water. This in turn reduces possible incidents of soil erosion by running water which occurs because the soil cannot hold any more rain water.

Activity 11

Identifying types of soil structure

- Break into groups of five to ten members each
- Carryout a library search of the types of soil structure
- Record all your findings
- One member of your group should present the findings to the rest of the class members
- Discuss the findings with your teacher
- Your teacher should sumarise the types of soil structure

The soil profile reveals the different soil horizons i.e. top soil, sub-soil, weathered rock and parent material. The subsoil determines productivity of the soil. This is because it is subjected to very little alteration. Permeability and chemical composition of the sub-soil influences productivity of the top soil. However, depth of the top soil determines the volume of soil plants can exploit in their search for water and nutrients.

It is the depth of the top soil which determines soil depth. The term soil is defined as a loose layer of the surface of the earth.

Types of Soil Structure

Recall that soil structure is the aggregation of individual soil particles to

form soil lumps called aggregates. The soil particles form different types of aggregates.

You were right if you came up with the following soil structures:

a. Platy Structure: This structure looks like plates arranged one on top of each other. This is why it is referred to as platy structure. See the horizontal layers on the soil lump put on the surface of the soil in the diagram below.

Fig. 1.2. Platy structure

b. Blocky Structure:

It is blocky or with many sides. Particles are arranged in blocks.

Fig. 1.3. Blocky structure

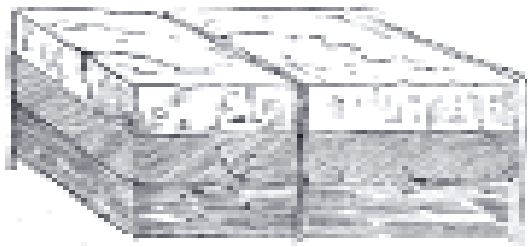


Fig. 1.4

c. Cuboidal

Particles are almost round or spherical Particles are arranged around a central and may be granular or crumb in shape

d. Columnar

Fig. 1.5. Columnar structure

e.Prismatic

In this structure, the soil aggregates are vertically arranged forming columns of different lengths. This depends on the type of soil forming the structure.

f. Granular

The granular structure is made up of rounded granules on the surface of the soil containing high amount of organic matter. It differs from crumb structure through the size of the granules. In granular structure, the granules are less than 1.2 cm in diameter.
(seeNgomwa Anthony M. et al (2012) – Senior Secondary Agriculture Form 3, Longhorn, Excel and Succeed page 13)

g. Crumb

This structure is usually found on surface soils which are high in organic matter content. They are seen as rounded granules which are more than 1.2 cm in diameter and are very porous.

h. Single grain structure

In reality, there is no single grained structure because soil structure is the way how those single grains are brought together. Sandy soil is a very good example of a soil which is described as having a single grained structure because the gains exist individually. As a result of this some schools of thought describe sandy soil as a structureless soil. However, for the purpose of this book, the structure looks like See Ngomwa Anthony M. et al (2012) page 13

How soil structure can be destroyed

You have learnt that soil structure involves natural arrangement of individual soil particles into specific structures. These structures will remain the same as long as the soil is not disturbed. In this topic, you will learn how the structures you have learnt already can be destroyed.

Activity 12

Describing how soil structure can be destroyed

- Form groups of at least five to ten members.
- Carryout a book or website search of the factors that destroy soil structure.
- Record the factors that destroy soil structure
- One member of each group should present findings from the research
- Discuss the factors that destroy soil structure with your teacher
- Your teacher will summarise the factors that destroy soil structure.

Your research should have come up with the following:

1. **Cultivation:** As the land is being ploughed and soil lumps are broken down, the naturally arranged soil aggregates are destroyed. This is made more serious when ploughing is done when the soil is either too wet or too dry.

2. **Use of heavy machinery:** The soil particles are compacted together by the weight of the machinery especially when the soil is too wet.

3. Raindrop impact. As the rain hits bare ground, the soil particles break up and fill up the soil pores making it more difficult for water and air to enter the soil than before.

4. **Overgrazing:** The grazing itself does not destroy soil structure; but it is the animals' hooves which, as the animals move around the pasture land for a very long period of time, compact the soil particles into hard top layer of soil.

You have seen that soil structures are naturally formed and that at times they can be destroyed. When the soil structure has been destroyed, it is not good enough for proper crop growth and yielding. As a result, it is imperative that they should be maintained or even be improved.

How can this be done?

Soil structure can be maintained and improved by the following operations:

1. **Planting vegetation on bear land.** Vegetation protects the soil from raindrop impact which causes break down of soil crumbs and forms an impervious layer of top soil.

2. **Correct crop population.** This is achieved by correct spacing of rows, correct spacing of plants between planting stations and correct number of plants per station. Correct number of plants in a field ensures complete coverage of the soil so that it is well protected from rain drop impact.

3. Use of organic fertilizer (manure). Manure helps to aggregate the soil by cementing the soil particles together. It also ensures stability of the aggregates.

4. **Crop rotation which is dovetailed with a fallow.** Leaving the land crop-free for some years enables it to regain its organic matter which cements the soil particles together to form aggregates.

Methods of Maintaining and Improving Soil Structure

Activity 13

Describing methods of maintaining and improving soil structure

- Break into groups of at least ten members each
- Using cluster method, each group should list and describe among themselves methods of maintaining and improving soil structure
- Each group should submit in turn those methods which have not been submitted already by another group
- Discuss the methods of maintaining and improving soil structure with your teacher
- Your teacher should consolidate the methods of maintaining and improving soil structure.

5. **Proper use of heavy agricultural machinery.** This can be done by using them on a soil with correct moisture content. Impact of the heavy agricultural machinery can be reduced by combining operations so that they can be done simultaneously. For example, farmers can combine ploughing, harrowing and ridge construction. In so doing, the soil cannot be compressed more than when each operation is done at its own time.

6. **Avoiding overgrazing** so that the soil is not compacted significantly and the soil does not lose vegetative cover.

Recall that the physical properties of soil include texture, structure, colour, consistency, porosity, temperature and depth. These physical properties impact plant growth and their yielding ability differently.

Effect of Physical Properties of Soil on Crop Production

Activity 14

Explaining the effects of physical properties of soil on crop production

- Break into seven groups.
- Use a restaurant method to explain how each physical property of soil affects crop growth.
- At the end, each group leader should present what have been suggested by the customers.
- Your teacher should consolidate the effects of physical soil properties on crop growth.

How soil texture affects crop growth

Soil texture has a very large influence on crop growth. The different sized rock particles in the soil influence pore sizes in the soil. The pore spaces in turn influence:

1. **Air circulation.** The soil must allow free entry and circulation of air because

- Seeds need oxygen in order to germinate. The oxygen helps in respiration of food reserves in the seed to release energy necessary for the germination process.
- Plant roots also need oxygen for their respiration so that they can generate energy for their growth and absorption of water and mineral salts.
- Decomposition of organic matter. Light soils like sandy soils contain the least amount of organic matter because there is more rapid decomposition of organic matter than in heavy soils which are compact and contain the least amount of organic matter.

This explains why seeds and roots die and decompose in a soil which is waterlogged because there is no adequate air circulation.

2. **Water entry,** retention and movement through the soil. Water is necessary for seed germination and plant growth. Unless the soil can allow water entry and retention, it will be very difficult for the plant to grow properly. At the same time, it is important for the soil to drain away excess water to avoid waterlogged conditions. Heavy soils hold more water than light soils.
3. **Root development and extension.** A soil which is too hard and compacted prevents roots from extending to search water and mineral salts from a wide volume of soil.

4. **Leaching of mineral salts in the soil.** Very loose soil structures do not hold water. When it rains, the water quickly infiltrates deep into the soil. As the water is infiltrating, soluble salts are also taken together by the sinking water. This in turn reduces amount of salts to be used by plants.

5. **Ease of cultivation**. You might have noticed that heavy soils like clay are too hard to plough when they are dry and too sticky when they are wet. This is not the same with light soils such as sandy soils.

Effect of soil colour on crop growth

As the rock particles are being packed into aggregates, they form pore spaces which are very important in:

- **Water infiltration and percolation.** Large pore spaces increase water infiltration. This is the entry of water into a soil during and soon after a storm. However, when there is no rainfall, water from underground must move upwards and be reached by plant roots. This is called percolation – the movement of water through the soil in all directions. Large pores make it difficult for water to percolate.

- **Air circulation.** The soil must contain air called soil air which provides oxygen for respiration in seeds necessary for germination, roots and beneficial soil organisms like bacteria which decompose organic matter.
- Water retention and drainage. Soils whose particles are tightly packed such as clay retain water more than those whose particles are loosely packed such as sandy soil. Plants need water which is at field capacity. This means that too much or too little water is dangerous for plants. Excess water must drain away; but at the same time the soil must be able to keep just adequate amount of water.

How soil structure affects crop production

- Temperature of soil. Temperature of soil is very important because it affects the rate at which mineral salts can dissolve in soil water and become available for plant use. It also influences the rate at which enzymes in seeds can break down reserved food necessary for germination. Soil temperature influences the activity of micro-organisms which decompose organic matter.

Soil temperature is a function of soil colour. Dark colored soils will absorb more heat than whitish soils which reflect most of its heat. As a result of this, best agricultural soils must be dark so that they can absorb and keep heat.

Unit Summary

The building materials of soils are insoluble mineral particles and organic matter. These substances form soil texture and structure. Depending on their original parent material, soils can differ in their colour, consistency, temperature, porosity and depth. All these attributes of soil have a special contribution towards the soil's ability to support crop growth and yielding. Care must be taken by farmers as they make use of this resource so that they continue to benefit from it indefinitely.

Glossary

Aggregation: The way soil particles are arranged or packed together.
Infiltration: The downward movement of water in the soil as a result of gravitational pull
Percolation: Movement of water in the soil in all directions as a result of capillary attraction

Assessment

1. Define the following terms:
   - Soil structure
   - Soil texture
   - Soil consistency
   - Soil porosity
   - Bulk density
2. Of what use is the soil triangle?
3. Describe any three methods that can be used to determine soil texture
4. With the aid of a diagram describe soil profile
5. Explain how the following can help to maintain soil structure
   - Zero tillage
   - Application of manure
   - Crop rotation

6. Explain why soil temperature is important in crop production.

References

1. http://en.wikipedia.org/wiki/Bulk_density (04/10/2014)
2. http://www.sciencebuddies.org/Files/2392/5/EnvSci_img014.jpg (01/12/2013)
3. http://www4.uwsp.edu/geo/faculty/ritter/glossary/s_u/soil_texture_triangle.html (01/12/2013)
4. Ngugi D. N., Karau P.K. and Nguyo W. (1990), *East African Agriculture* A Textbook for Secondary Schools, Third Edition, Nairobi MacMillan Education.
5. Brady Nyle C. (1974)- *The Nature and Properties of Soil, 8th Edition,* New York: MacMillan Publishing Co. Inc

Unit 2

Chemical properties of soil

It is not enough for the soil just to contain rock particles which form the physical properties of soil. Plants need different types of nutrients for proper growth and yielding. These form chemical soil properties. Other chemical factors include pH, salinity and cation exchange capacity. As a student of agriculture, you need to understand the chemical properties of soil so that you can appreciate why some soils can produce a higher yield than others. In this unit, you will learn in detail how each of the stated chemical soil properties affects crop growth and development.

A list of the chemical properties of soil

Before we go into a deeper insight of chemical properties of soil, you will first of all need to list these chemical soil properties.

Activity 1

Listing physical properties of soil

- Brainstorm the chemical properties of soil
- Discuss the chemical properties of the soil with your teacher
- Your teacher will summarise the list of the chemical properties of soil

The chemical properties of soil are as follows:

1. pH
2. Nutrient status
3. Salinity
4. Cation exchange capacity

Describing the chemical properties of soil

You may recall that the soil's chemical properties include its pH, nutrient status, salinity and cation exchange capacity. By the end of this section, you will be able to describe each of these properties.

Soil pH

Soil pH is the degree of acidity and alkalinity of a soil. This is as a result of the hydrogen (H+) ion and hydroxyl (OH-) ion concentration in the soil.

Activity 2

Determining the pH of a soil

- Break into groups of at least five members.
- Each group should go into the field to collect different samples of soil.
- Determine soil pH and soil salinity.

Materials required

1. Soil sample (preferably dry).
2. Universal indicator.
3. pH scale.
4. Distilled water.
5. Test tube.
6. Cork

Procedure for determining soil pH

- Take a small sample of soil and put it in a test tube. The ratio of soil to water should be 1:2.5 by weight
- Add distilled water into the test tube containing soil. This should be followed by a few drops of universal indicator
- Shake the test tube thoroughly
- Let the mixture settle for not less than 30 minutes
- Observe any colour change in the test tube
- Compare the colour you see in the test tube with the colours on the pH scale.
- Record your observations

Questions

a) What colour did you see in the test tube?
b) What do you think is the pH of your soil sample?
c) What conclusion can you make from your investigation?
d) Why do you think it was necessary to use dry soil rather than wet soil?
e) Explain the reason for using distilled water than any type of water.

Soil pH is determined by using a universal indicator. When the soil is acidic, the indicator turns red and when it turns blue, the soil is an alkaline. Below is a pH scale which is used to determine acidity and alkalinity of a soil. The pH of an acid soil is between 1 and 6; the pH of an alkaline soil is between 8 and 14. A pH of 7 indicates that the soil is neutral.

pH scale

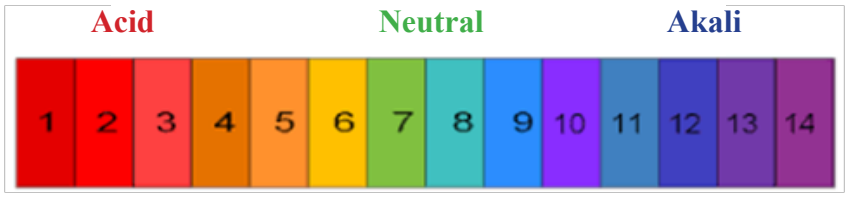


Diagram showingthe pH Scale

Soil pH can also be determined by:

i) Litmus paper. (delete universal indicator)

Materials

a. Soil sample
b. Distilled water
c. Test tube
d. Litmus paper (both blue and red)
e. pH scale

Procedure

a. Put a small sample of soil into the test tube
b. Add water to the same ratio as in activity 2
c. Shake the mixture. Barium Sulphate (BaSO4) can be added to the test tube before shaking. This will help to split the individual soil grains from each
d. Let the mixture to settle down
e. Dip the litmus paper into the test tube
f. See colour change on the litmus paper

Red litmus will turn blue if the soil basic and red if the soil acidic.

ii) Use of pH meter (leave it as it is)

Figure 2.1
pH meter showing both electrodes (OaktonTM Waterproof pH 150 portable meter)

Figure 2.2 pH meter with two elec trode imbedded in one rode (AoktonTM Handheld Ion Meter)

The pH meter measures the concentration of hydrogen ions in a solution

Determining soil salinity

Saline soils are those which contain a concentration of neutral soluble salts with a pH of less than 8.5.

Activity 3

Determining soil salinity

Materials required

- Samples of dry soil from the field.
- Distilled water.
- Test tube.
- Red litmus paper.

Procedure for determining soil pH

- Break into groups of at least five members.
- Collect samples of different soil from the field.
- Collect the other materials from your teacher.
- Mix each sample of soil with distilled water and shake.
- Let the mixture to stand for at least thirty minutes.
- Dip the red litmus paper into the mixture.
- Observe colour change on the red litmus paper.

Assessment

a) What colour did you see on the red litmus paper after dipping it in the soil mixture?
b) What is the pH of the soil?
c) What conclusion can you draw from your observations?

Remember that the aim of the investigation was to find out whether the soil was saline or not. A saline soil contains high concentrations of neutral salts which make the soil alkaline. If the red litmus paper turned blue, then the soil was saline.

Saline soils are sometimes called white alkaline soils. This is when a white layer on top of the soil becomes very visible.

Factors Affecting Soil pH

Soil pH is referred to acidity or alkalinity of a soil. High concentration of hydrogen ions [H+] makes a soil acidic and when hydroxyl ions [OH-] increase in their concentration, the soil becomes basic (saline). In this topic, you will learn what makes the soil to have an increased concentration of hydrogen ions or hydroxyl ions.

Activity 4

Explaining Factors Affecting Soil pH

Procedure

a. Break into groups of at least five members.
b. Research from the library or relevant websites the factors which affect soil pH.
c. Record your findings.
d. One member from each group should report their findings to the whole class during plenary session.
e. Your teacher shall summarise the factors that affect soil pH.

There are several factors which can affect the acidity or alkalinity of a soil. The major ones are as follows:

1. Use of acid-forming fertilizers: for example, when an ammonium containing fertilizer such as ammonium sulphate [(NH4)2SO4] is applied to a soil, the molecule breaks into ammonium [(NH4)2+] and sulphate (SO4-)ions. Then, the ammonium is oxidized to form a nitrate ion (NO3-) for plant up-take, two hydrogen ions (2H+) and water (H2O) as shown below. Then sulphate ion in step 1 will combine with hydrogen ions in step 2 to form to form sulphuric acid in step 3 which will make soil acidic

Step 1: $(NH_4)_2SO_4 \longrightarrow (NH_4)^{2+} + SO_4^-$

Step 2: $NH_4^+ + 2O_2 \longrightarrow 2H^+ + NO_3^- + H_2O$

Step 3: $SO_4^- + 2H^+ \longrightarrow H_2SO_4$

As seen from the equation, the reaction increases concentration of hydrogen ions in the soil.

The ammonium sulphate first breaks into ammonium and sulphate ions. The ammonium is oxidized as seen in the equation above. The sulphate ion combines with hydrogen ion to form sulphuric acid.
This is why sulphate of ammonia is no longer used in maize production as was the case before. However, this fertilizer is used in tea and coffee estates where acid soils are most favourable.

2. Leaching: During persistent heavy rainfall, soluble cations such as Mg2+, Ca2+ are washed down the soil profile leaving hydrogen ion. This is because hydrogen ions are more attracted to clay mineral than most of these cations. As a result of this, hydrogen ions increase in their concentration causing soil acidity

3. Crop removal: As crops are growing in the field, they absorb various types of ions. After harvest, it is expected that the nutrients previously absorbed by the crop may go back to the soil if their residues are incorporated into the soil. However, if the crop residues are not ploughed back into the soil, there is a high reduction of cations in the soil leaving hydrogen ions to dominate.

4. Acid rains: this occurs in industrialized countries where a lot of carbon compounds are emitted into the atmosphere. When rain is falling, the rain water combines with carbon compounds to form carbonic acid which gets incorporated into the soil making it acidic

5. Parent material: A soil formed from sulphur containing rocks release to the soil significant amounts of sulphur elements. The sulphur then reacts with water to form hydrogen sulphide (H2S). Hydrogen sulphide in itself does not make the soil acidic. However, when such a soil is drained, the hydrogen sulphide is oxidized to form sulphuric acid which makes the soil acidic.

Modifying soil pH

Time comes when the soil becomes too acidic or too basic for some crops to grow properly. Under such circumstances, it becomes very necessary for a farmer to modify the level of soil pH.
Your answers were correct if you found the following

Activity 5

Modifying pH

Procedure

- Form groups of at least five members.
- With the use of your school library, research ways that can be used to modify soil pH.
- Record your findings.
- One member of each group should report the findings to the whole class during plenary session.
- Discuss with your teacher how soil pH can be modified.
- Your teacher will consolidate the methods used for modifying soil pH.

1) Application of agricultural lime

Lime exits in many different forms depending on how they are prepared. All of them originate from limestone. The most economic forms of lime used for agricultural purposes are those that exit in form of calcite, also known as calcium carbonate (CaCO3) and dolomite which is calcium magnesium carbonate. When a soil becomes acidic, it means it has a higher concentration of hydrogen ions (H+) than hydroxyl ions (OH-). Liming supplies lime elements which are calcium and magnesium. Through cation exchange capacity, calcium and or magnesium replaces the hydrogen ions to raise the percentage base of the soil.

Liming of acid soils enhances availability and plant up-take of elements such as molybdenum, phosphorus, calcium and magnesium. On the other hand, it drastically reduces concentration of iron, aluminum and manganese which under very acid conditions exist in quantities which are toxic to plants.

The application process is done before the land is ploughed. The lime is spread all over the field manually by hands or by use of a truck as is shown in the picture below or by use of a aircraft. Thereafter the land is ploughed. This incorporates the lime into the soil

2) Application of manure

Manure increases the amount of cations in the soil and reduces the concentration of hydrogen ions. On the other hand, manure is positively charged; and as a result, it helps to hold cations in the soil so that they cannot easily leach. In so doing, the soil becomes less and less acidic.

3) Application of inorganic fertilizers

Use of acid-forming fertilizers such as sulphate of ammonia can be used to increase acidity in an alkaline soil. There are some crops like tea which do well in acid soils. In such situations, it is advisable to use such acid forming fertilizers.

Nutrient status of the soil

This has something to do with availability of different minerals in a soil in right proportions. It is these nutrients which determine a soil's capacity to support crops.

Activity 6

Factors affecting nutrient status of soil

Procedure

- Brainstorm the factors that affect the nutrient status of a soil.
- Discuss the factors that affect a soil's nutrient status with your teacher.
- Your teacher will summarise the factors which affect nutrient status of a soil.

Your answers should include the following points:

1. The parent material from which the soil was formed: parent materials influence the chemical properties of a soil. Soils developed from basic rocks like limestone, tend to have high content of calcium element. On the other hand, soils developed from granite and sandstone give rise to sandy soils which are generally low in mineral content.

2. Soil pH: pH of a soil has direct influence on the availability of nutrients such as phosphorus. In acidic soils, this nutrient becomes insoluble and therefore unavailable to plants. It also influences multiplication and activities of beneficial soil organisms some of which are responsible for nitrogen fixation and decomposition of organic matter.

3. Leaching: In heavy rainfall areas, soluble salts like nitrates are washed down the soil profile, leaving the top soil with low nutrient status. This is more noticeable in sandy soils.

4. Nutrients uptake by plant. Nutrients are continuously taken up by plants. The higher the yield a farmer obtains from a field, the higher the amount of nutrients extracted from the soil. When crop residues are not ploughed back into the soil, more nutrients are lost.

5. Crop removal. Nutrients are removed with crops as they are being harvested.

6. Soil erosion: When top soil is eroded, it goes away with mineral nutrients it contains. This is why erosion should be controlled at all times.

7. Method of cultivation. Farming practices affect the availability and removal of plant nutrients e.g. Use of bush fire to clear land, overgrazing, monocropping, improper use of farm machinery, cultivation of marginal land.

Salinity

Salinity is a condition of the soil that is associated with the accumulation of soluble salts in the soil.

A soil may become saline due to the following:

Activity 7

Determining salinity of a soil

Materials required

- Samples of dry soil.
- Distilled water.
- Test tube.
- Red litmus paper.

Procedure

- Collect samples of different soils from the field.
- Mix each sample of soil with distilled water and shake.
- Let the mixture stand for at least thirty minutes.
- Dip the red litmus paper into the mixture.
- Observe color change on the red litmus paper.

Assessment

Assessment

- What color did you see on the red litmus paper after dipping it in the soil mixture?
- What is the pH of the soil?
- What conclusion can you draw from the activity?

Saline soils are those which contain a concentration of neutral soluble salts with a pH of more than 8.5. They are basic soils. Saline soils are sometimes called white alkaline soils. This is when a white layer on top of the soil becomes very visible. They basically contain high levels of ions such as nitrates, sulphates, chlorides and bicarbonates.

1. Heavy irrigation of land using water with high levels of salts. As the water evaporates, the salts can visibly be seen on the soil surface.
2. Application of fertilizers which eventually lead to accumulation of soluble salts
3. Parent material which as it weathers, it releases its salts into the soil

Cation Exchange Capacity

Cation Exchange Capacity is the ability of the soil to exchange cations. It is a measure of its ability to hold and release various nutrients for plant use. Exchangeable cations are Ca^{++}, Mg^{++}, Na^{+}, K^{+}. Examples of anions are Cl^{-},

Activity 8

Explaining cation exchange capacity

Procedure

- Break into groups of five.
- Using your school library, research on the process involved in cation exchange capacity in the soil.
- Record your findings.
- Choose one member from your group to present your findings.
- Discuss your finding with your teacher.
- Your teacher will consolidate the process of cation exchange capacity.

NO_3^{-} and CO_3^{-}.. Examples of anions are Cl-, NO3-, and CO3-. The cations are held, or adsorbed into clay soil colloids and organic matter, while anions are found in the soil solution. The cations are not easily leached from the soil because they are strongly attracted by clay and organic matter because they are negatively charged. However, they can be replaced by, or exchanged with ions in the soil solution through the cation exchange process. An example is when lime is added to acidic soil (with a high concentration of hydrogen ions). The calcium and magnesium in the soil will replace the hydrogen ions, thereby raising the soil pH. This then improves the soil condition.

Cation Exchange Capacity is important to crop production because it modifies and improves soil pH. The soil pH affects availability and release of plant nutrients necessary for plant growth. At the same time, some plants do well under acidic conditions while others prefer alkaline conditions. This is the more reason why farmers have to make sure that the soil pH is modified by liming, applying organic manure and fertilisers. Organic matter is a 'ware house' for plant nutrients and is crucial for the formation of aggregates.

Plant nutrients found in organic matter include NH_4^{+}, Ca^{++}, K^{+} and Mg^{++}. Thus organic matter contributes to CEC through the exchange of such elements with others that have similar charges.

Generally, the more clay and organic matter a soil holds, the higher the CEC. Clay content is important because of its large quantities of negative charges. The small particles have a high ratio of surface area to volume. Sands have no capacity to exchange cations because it has no electric charge. This can be

improved by adding organic matter.
A high CEC enables plants get nutrients for growth and production.

Unit Summary

Soil is also made up of chemical elements that influence crop production directly or indirectly. These substances affect the soil's capacity to support plant growth and yielding. There are basically four chemical properties of soil and these include; nutrient status, soil pH, salinity and Cation Exchange Capacity (CEC). All these together form a soil which successfully supports plant growth.

Explaining the effects of chemical properties of soil on crop Production

1. Nutrient Status

Farmers are always very concerned about crop yield they get after harvest. However, it must be remembered that any yield ū farmer obtains from her field is a function of nutrients that have been depleted from the soil. Nutrient status of ū soil affects crop production in the following ways:

a) It affects vegetative growth of crops. Nitrogen, for example is responsible for synthesis of protein molecule which is necessary for growth, while calcium, phosphorus are responsible for the skeletal formation of plants.

b) Some nutrients like phosphorus brings forth resistance against diseases to plants due to the lignin they form.

c) They affect maturity of some crops. Tobacco matures if amount of phosphorus supersedes that of nitrogen. Nitrogen promotes succulence while phosphorus brings maturity.

d) Yield potential of crops. The higher the yield a field produces is dependent on the amount of nutrients the soil contains. If the farmer intends to maintain that high yielding ability, then it is imperative to maintain ū high nutrient status of the soil by applying fertilizers.

e) Soil pH. You will recall that soil pH is the preponderance of hydrogen ions in a soil. This implies that if the nutrient status of a soil is dominated by hydrogen ions (H+), the soil becomes acidic and not favourable for some crops. On the other hand, when the soil dominated by hydroxyl (OH-) ions, the soil becomes basic. Soil pH determines choice and productivity of crops.

2. Soil pH

a) It affects availability of some nutrients. At low levels of pH, phosphorus becomes insoluble by forming less soluble compounds of iron and aluminum. Phosphates are readily available at pH range of 6.5 to 7.5. When the pH rises above 8.5, manganese, potassium, boron, iron and zinc become less available.

b) It determines choice of crops to be grown in an area. Acid soils are best

suitable for tea production

c) Very acid conditions of a soil limit the activity of soil microorganisms. This means that when organic matter is incorporated into the soil, it will not be decomposed and nutrients they hold cannot be released for plant growth. On the other hand, nitrification can be put to a complete halt.

d) In acid soils, damage of some crops by nematodes is more serious than in neutral soils. This is because the crops do not develop the much needed resistance since phosphorus that brings resistance to crops is not readily available.

3. Soil Salinity

You will recall that soil salinity is the salt content in the soil. The process by which this salt increases is called salinization. The salts that are generally responsible for salinization are sodium (Na+), potassium (K+), calcium (Ca2+), magnesium (Mg2+), chloride (Cl-). When sodium predominates in a soil, the soil is described as a sodic soil. The effects of this condition to crops are detrimental.

a) It causes plasmolysis in plants. This is a condition in which plants lose water from their cells to the soil in an attempt to balance off salt concentration between the soil and the plant cells. This causes plat death.

b) It causes toxicity to plants especially the roots causing impairment in absorption of water and mineral salts.

c) When sodium increases in a soil, the sodium ions tend to disperse mineral colloids which then develop a tight, impervious soil structure. This prevents drainage of excess water from a farmable land.

d) Since saline soils are generally basic, with a pH of not less than 8.5, this interferes with microbial activities such as nitrification, decomposition of organic matter which are beneficial to crops.

4. Cation Exchange Capacity

Recall the meaning of cation exchange capacity. Also known as "Base exchange capacity", it is a sum of exchangeable or replaceable cations that a soil can absorb. The process of cation exchange which occurs between the soil solution and clay or organic matter is of tremendous value to crops.

a) It enables nutrients that are strongly adsorbed by clay or organic matter to be released to the soil solution where they can become available for plant use.

b) It also enables cations to be transferred from the soil solution and become adsorbed by the clay and organic matter where they cannot easily be lost by leaching.

c) Cation exchange capacity enables hydrogen held by clay colloids and humus be replaced by basic elements such as calcium and magnesium and in the process reduce soil acidity

Glossary

Adsorption: A process by which soil particles attract and hold some mineral nutrients tightly, making them unavailable to plants.

Unit Review Questions

1. State any three chemical properties of soil
2. Describe how each of the chemical properties of soil affects crop production
3. State the factors which determine CEC of the soil.
4. Discuss factors that affect soil fertility
5. Explain why humus is called a 'ware house' for plant nutrients

References

1. http://en.wikipedia.org/wiki/Cation-exchange_capacity (04/10/2014)
2. http://www.sciencebuddies.org/Files/2392/5/EnvSci_img014.jpg (01/12/2013)

3. http://www4.uwsp.edu/geo/faculty/ritter/glossary/s_u/soil_texture_triangle.html (01/12/2013)

4. Ngomwa M., Sigei P. and Cheruiyot D. (2012). *Excell & Succeed, Senior Secondary Agriculture Form 3.* Lilongwe: Longhorn-Greymatter Ltd

5. Kanjala B and Kaperemera N. (2002): *Stride Agriculture book 3* Nairobi Longman Malawi (Pty) Ltd

6. Ngugi D. Karau, P and Nguyo W. (1990): *East African Agriculture, Third Edition,* MacMillan Education

7. Brady N.C. (1979): *The Nature and Properties of Soil, Eighth Edition,* London: MacMillan Publishing Co. Inc.

Unit 3

Agricultural Development Agencies and Their Services

You may recall that agriculture is the practice of raising crops and animals on a farm to support the daily living of humans. As human population increases, demand for food from agricultural products also increases. Unfortunately, land for agriculture remains the same. This therefore calls for agricultural productivity to improve. This is the reason why agricultural development agencies should come into being so that they can help to raise efficiency and productivity of crops and animals on a farm.

Identifying Agricultural Development Agencies and their Services in Malawi

There is a wide variety of agricultural development agencies in Malawi which play positive roles in agricultural production. At this point in time, you will carry out an activity to identify these agencies.

Activity 1

Identifying Agricultural Development Agencies and their Services in Malawi

Procedure

- Brainstorm as many development services required in agriculture as possible.
- Break into groups of at least ten members.
- Identify the agencies offering agricultural services in Malawi.
- Visit a nearby agriculture development agency in your area.
- Evaluate the availability of the agricultural development agency and the services which they provide in your area.
- Record your findings.
- One member from every group should present their findings to the whole class.
- Your teacher shall consolidate your findings.

In Malawi, there is a wide variety of agriculture development agencies which help farmers to improve their agricultural productivity. Below is table 1 showing various agricultural development agencies and the services they provide.

Table 1 showing various Agricultural Development Agencies and the services they provide

Agricultural development agency	Services provided in Malawi
Department of Agricultural Research Services(DARS)	Research
The Agricultural Development and Marketing Corporation (ADMARC)	Marketing
Land Resources and Conservation Unit	Infrastructure
The Agriculture Communication Branch	Extension
Marketing agents	Processing
Department of Agricultural Research Services(DARS)	Production
The Malawi Rural Finance Company	Credit

Describing the services offered by the Agricultural Development Agencies

This subsection aims at providing you with an in-depth knowledge and understanding of the various agricultural development agencies. In order to achieve this, you will be expected to do an activity.

Activity 2

Describing the services offered by agricultural development agencies

Procedure

- Form seven groups.
- Each group should choose a leader who will serve as a host.
- The rest of the members shall serve as customers.
- Using eatery method, describe the services offered by the agricultural development agencies.
- The host should present your descriptions.
- Your teachers will summarise the services offered by the agricultural development services.

a. Research

Research is an investigation that is carried out in order to find out a solution to a problem. It is designed to collect, analyse and interpret data into information which is useful.

The DARS conducts research in order to provide farmers with information which creates an increase to production and their commodities.
The department is responsible for:

- Testing, certifying and monitoring the production, processing, storage and marketing of seeds.
- Breeding and releasing resistant crop varieties.
- Establishing plant quarantines and other government control measures.
- Plant pest diagnostic and advisory services provided by the ADMARC.
- Recommending the use of specific pesticides supplied by ADMARC.
- Improving the genetic makeup of livestock in order to improve production.
- Providing Artificial Insemination services for dairy farmers to achieve cross-breeding.
- Testing, certifying and monitoring the production and release of farm machinery.
- Analysing, testing and making fertilizer recommendations.

In Malawi there is different research stations spread across the country. For example, there is:

1. Lifuwu research station in Salima for rice research.
2. Chitala research station in Salima for groundnuts and cotton.
3. Makoka research station in Zomba for cotton.
4. Baka research station in Mzimba for livestock.
5. Bvumbwe research station in Thyolo for horticulture.
6. Chitedze research station in Lilongwe for legumes and farm machinery.
7. Lunyangwa research station in Mzuzu for pastures and livestock.
8. Mwimba research station in Kasungu for tobacco.
9. Kasinthula research station in Chikhwawa for rice.
10. Kavuzi research station in Nkhata Bay for coffee.

b. Marketing

Marketing means the whole range of activities which are involved in the transfer of a commodity from point of production to point of consumption. The Agricultural Development and Marketing Cooperation is a statutory company mandated by parliament to carry out the various marketing functions. Apart from ADMARC other organizations which carry out one or more of the marketing functions are:

- Co-operatives
- Processors
- Itinerant traders
- Wholesalers
- Retailers

- Commission agents and brokers

The ADMARC play the following roles:
- Planning, monitoring and regulating crop production.
- Licensing crop production for example tobacco.
- Regulating and controlling the quality and supply of seeds.

In general terms an efficient marketing system, needs efficient marketing functions. These are:

i. Buying and selling

This involves transfer of product ownership. The seller accepts to let go of the commodity upon being satisfied with the amount of money offered by the buyer. At the same time, the buyer is ready to let go of his money upon being satisfied with the price and quality of the product.

ii. Product planning

This is an activity which takes place at the very beginning of the product's life. The producer decides on what to produce and how the product should look like. This is in response to the customers' needs at that moment.

iii. Transportation

This deals with space utility. A commodity produced in one area can still exist in an area where it is not produced. For example, tea produced in Thyolo or Nkhata Bay is spread throughout the whole Malawi. It does not make any difference whether you produce it or not. This in turn encourages farmers to produce even more because there is a much bigger customer base.

Transport system must be very efficient to ensure that commodities reach their destinations at the point of the customer's needs. Road network must be passable throughout the year. The railway transport must be fast and reliable; so too air and water transport systems.

iv. Promotion

Promotion involves all the activities which are done to a product so that customers can buy it in larger quantities than ever before. It may involve price reduction for a certain period of time (for example during Christmas), special wrapping, including a different commodity on top of the one being promoted or an offer would be like "If you buy so much quantity, you will get so much quantity of the same product free of charge".

The whole idea behind promotion is to raise demand and therefore volume of sales. A rise in demand will call for increased production of the product and eventually a rise in profit making.

v. Market intelligence

This involves gathering information. A producer gathers information about prices of inputs such as fertilizer, labour, transport etc in advance so that s/he can decide on the most economic method of production. As a seller s/he gathers information about customers' demand for the product. It is this information which will encourage the producer to produce more than ever before or reduce production levels or completely stop its production. Customers' preferences change with time; and as a result producers need to know of these trends to avoid producing more than what customers can buy.

On the side of buyers, market intelligence involves gathering information about quality and price of commodities before purchasing. It is possible that there can be a lot of sellers for one particular commodity. The prices and quality may differ too. An intelligent buyer should first of all go around checking all these attributes before buying to avoid regrets.

vi. Grading

Grading involves putting together commodities which have the same attributes. For example, a farmer may wish to grade tobacco based on leaf length, colour, thickness, and spots. Those with the same attributes will be put together and be given the same price. If a farmer mixes tobacco leaves with different attributes, then its grade will be based on the worst attributes. This in turn reduces its price; and consequently, the famer may not make profit.

vii. Storage

This has to do with time utility. Most agricultural products are produced seasonally and yet they are required all year round. This implies that there must be a mechanism which ensures that supply of the commodity perpetuates despite its seasonality.

Another advantage of storage is that the commodity can be sold at a time when its supply is low but with high demand. At this time, its price goes up. There is therefore need for efficient storage facilities so that the commodity does not lose quality and quantity while in store.

viii. Advertisement

This is different from promotion because advertisement involves informing customers about the existence of a product and its associated attributes. In so doing it helps to persuade the buyer so that the product can be tried and eventually the customer becomes loyal to the product.

Unless customers are informed about the existence of a product, it will be very difficult for them to buy it.

ix. Market research

This involves gathering information about customers' needs since these needs keep on changing. For example: Should Malawi continue producing tobacco just because it is our highest foreign exchange earner or there is need to turn to another crop since the world is advocating about anti-smoking campaign? There is need to carry out market research in order to establish amount of demand for the commodity.

x. Pricing

It is a process during which the minimum price of a commodity is established. Farmers need to consider all the inputs used for production, including taxation, transportation, storage, advertisement and the like. The price of a commodity at break-even point is when a commodity is sold at a price where the seller does not make a profit or a loss. Anything above the break-even becomes the farmer's profit. It is important to price the commodity very carefully to avoid losses.

xi. Risk bearing

A risk is variable outside the farmer's control in which there is divergence between expectation and the real outcome. For example, a farmer may plan to make a profit of about K20,000,000.00 from the sale of tobacco. This is an expectation. Unfortunately the real outcome becomes a loss because more than half of the tobacco caught fire. The risk is the fire which came unexpectedly.

In order to ensure the profit despite a risk, a farmer must prepare for the eventuality through risk bearing. This can be in form of:

- buying an insurance cover
- diversification
- embarking on less risky enterprises

xii. Financing

Farm operations need funding. Farmers need inputs, hired labour, transportation of the agricultural inputs and outputs, risk bearing and all the marketing functions already discussed above. Farmers must decide the sources of finance for these operations.

Some possible sources of finance are:

- Personal savings
- Borrowing from friends, commercial banks such as National Bank, Standard Bank, Opportunity Bank etc. money lending institutions like MICRO-LOANS, FINCA

What should be remembered is that loans attract interest and this is a cost the farmer will incur; and therefore has a bearing on profit making.

c. Infrastructure

This is a collective name to include transport facilities like roads, abattoirs, storage facilities such as grain silos, and market structures which have a direct impact on agricultural production. Sometimes farmers fail to raise production because they do not have reliable transport networks or there is no efficient storage facilities for products such as dairy products.

d. Extension

You have learnt that research brings about new farming interventions. These interventions must reach farmers because they are the ones who need to use them. Extension services aim at bridging the gap between researchers and farmers. The Ministry of Agriculture and Water Development in Malawi has an extension services department which teaches farmers about new methods of agriculture.

The Department of Agricultural Extension and Training of the Ministry of Agriculture and Water Development offer technical information, advisory and support services to smallholder farmers to enable them increase their agricultural production to meet their needs. There are Extension Departments in each Extension Planning Area of the Rural Development Program which achieve this by;

- Providing direction and technical agricultural advice and information to smallholder farmers.
- Providing training to farmers at Farm Training Centers to change attitudes, and improve knowledge and skills.
- Strengthening links between researchers and farmers.

e. Processing

Public or private manufacturing companies buy agricultural produce as raw materials from farmers or itinerant traders. They process the raw materials, turning them into the finished products required by consumers. Such companies include Rab Processors, Bakhressa Milling Co, Dairy Board Malawi Limited, Nali, Cori Oils, Mapeto (David Whitehead & Sons), Cold Storage Company, Chibuku Products, Bares wheat flour processor, Universal Biscuits and Confectionary. These companies transport and sell to wholesalers or retailers and advertise their products.

f. Production Credit

Credit is a source of capital, which is one of the factors of production. Current agricultural extension service could achieve more results if more capital were available. In order to overcome the capital shortage in agriculture, agricultural credit, which is borrowed resources, is available. The agricultural credit system

facilitates the transfer of other people's savings through credit agencies to the farmers in order for the latter to finance their farming enterprises. Farmers in turn have to pay interest on the capital borrowed.

Three categories of capital exist namely; long term credit, medium term credit and short term credit.

1. Long term credit is used for the purchase of land for major improvement works. It is normally repayable over periods of 15 to 30 years.
2. Medium or intermediate-term credit is used for minor improvements such as fencing, and purchase of machinery and livestock. Repayment period ranges from two to fifteen years.
3. Short-term credit. This is intended for working capital like fertilizer, seed, sprays, fuel, feeding stuffs and hire of machinery and labour. Repayment period is one year.

Credit is used to overcome shortages in capital input where potential for increasing production exists. Capital is both scarce and costly in agriculture. Credit must therefore be used to finance the most profitable activities on the farm.

Relating the importance of agricultural development agencies on a growing population

You may recall from our introductory remark that human population in Malawi continues to rise and yet Malawi as a country shall not increase in its area. This implies that something must be done in order to ensure that Malawi continues to feed itself.

Activity 3

Relating the importance of agricultural development agencies on a growing population

Procedure

- Brainstorm the importance of agricultural development agencies to a growing population.
- Discuss the importance of agricultural development agencies to a growing population with your teacher.
- Your teacher will summarise the importance of agricultural development agencies to a growing population.

These agricultural development agencies are important as they provide a wide range of services already stated above with an aim of increasing agricultural productivity. They specifically carry out the following:

1. Regulating production levels of certain crops in order to raise prices
2. Promoting horticultural production for commercial and self sufficiency
3. Providing efficient transport system to carter for perishable crops like tomatoes so that they do not go bad while in transit.
4. Increasing production of food crops and livestock leading to surplus for export earning foreign exchange
5. Providing credit facilities to farmers to enable them increase the volume of production and hence more food to a growing population.
6. Encouraging bulk selling of commodities by small scale farmers so that they can earn more to meet the domestic demand

Unit Summary

Farmers need access to information in order to improve production. Such services include input provision, credit provision, farm management, food and nutrition, extension and training, market information, Seed technology, crop protection, farm mechanisation and many more. Some of the agencies that provide these services include ADMARC, The Department of Agricultural Research Services, The Extension Department, Dairy Board, Chibuku products, Nali processors and many more.
Agricultural Development agencies assist rural communities to achieve advanced socio-economic autonomy through giving the necessary knowledge, skills and access to services to undertake and pursue sustainable livelihood activities (ranging from agriculture to small and medium business) whilst also increasing awareness on social and health issues.

Glossary

- **Abattoir:** an animal slaughtering structure.
- **Agency:** a business or an organisation providing a special service e.g. marketing.

Unit Review Questions

1. List the agricultural development agencies found in Malawi.
2. State the services which the agricultural development agencies provide to the Malawi nation.
3. Explain the importance of these services to the growing population.

References

1. http://www.ada-kzn.co.za/ (04/10/2014)

2. Ngomwa A. Sigei P., Cheruiyot D. (2012): *Senior Secondary Agriculture Book 3,* Nairobi: Longhorn-Grey Matter Publishers

3. Kanjala B., Kaperemera N.T. (2002): *Strides in Agriculture Book 3* Blantyre Longman Malawi (Pty) Ltd

4. Ngugi D., Karau P.K, Nguyo W. (1990): *East African Agriculture,* Nairobi Education

Unit 4

Farm Records

In this unit, you will learn the importance of different types of records. Eventually you will practice keeping records of a selected crop or animal enterprise.

The efficient organisation and management of a farm depends on knowledge and information about the farm for future reference. Such knowledge and information would be available only if accurate records are kept regularly. Farm records help farmers assess their management skills. Farming is a business, and just like any other business, farming aims at maximizing profit. This is only possible through keeping of accurate records of all farm transactions and the proper analysis of these records. Proper record keeping will prevent guessing or estimating in the farming business as the records kept are precise, concise, and complete and show actual amounts, weights and measurements.

The meaning of farm records

Farm records refer to systematic entries of various farm business activities and transactions including data on finances and inventory the farm has for a certain given period of time. It must be systematic because the transactions need to be recorded as they occur and in a conventional manner

Types of Records

Farm records vary significantly. This depends on type of information that is being dealt with. You will look into the various examples of records existing on a farm and categorise them.

Activity 1

Describing types of records

Procedure

- Brainstorm in your groups examples of farm records.
- Categorise them into three major categories.
- Report your findings to the whole class during plenary session.
- Discuss the types of records with your teacher.
- Your teacher will summarise the types of records.

Farm records include; planting dates of crops, breeding dates for livestock, types and amounts of fertilizer used for each field, amount and type of feed given to each class of livestock, quantities and types of seeds or tools bought for the farm by date of purchase and the quantities and types of farm products sold by date of sale.

There are three types of farm records and these are:

1. Inventory records
2. Production records
3. Financial records

1.Inventory records

This is an inventory of all assets of the farm. It is a detailed list of assets of the farm with full description and value of each item stated. It includes fixed assets like buildings, sheds and fences and such assets as machinery, tools, equipment and livestock. Any additional or disposals are recorded as they occur. At the end of the farming year, a complete inventory should be taken.

Table 1 below shows a farm inventory record.
Visit a nearby farm to see the inventory records kept. Consider the remarks made if they are practical. Discuss with the rest of the class.

Item	Quantity	Date acquired	Original cost (MK)	Remarks
Cattle	7	13/11/12	900,000	Bought from Research Station, need Artificial insemination (AI)
Sheep	42	21/06/12	420,000	Bred on farm, replace male, inbreeding
Hand hoes	11	13/03/11	50,000	Bought new, not adequate
Plough	1	24/09/13	1,230,000	Bought new, adjust discs
Spray race	1	16/09/13	650,000	Constructed, ready for use

Table 1

The steps involved in taking an inventory;
- count the items physically.
- physical measurement of, for example, size of the land, buildings and other structures, and available crop yield.
- estimating the value of assets using the present market prices.

When estimating the present value of the equipment and machinery, it is important to consider depreciation or loss of value of the item over time. The depreciation value can either be straight line or fixed rate (declining balance) per annum, or sum of digits. Every fixed capital item has a life span. This is the period the item is expected to be in use and its operation is very efficient. The item is withdrawn from use because it has used efficiency and effectiveness.

Let us look at an example of a machine bought at MK9, 000.00 whose estimated scrape or salvage value after 8 years is K1, 000.00. The machine's annual depreciation is 25%.

Calculate the value of the machine at the end of its life span using:
i. straight-line method
ii. reducing balance method
iii. sum of digits method

Table 2

Year end	Straight line annual depreciation (MK)	Remaining value/Book value of the machine at end of each year
1	1,000.00	K9,000.00- K1,000.00 = K8,000.00
2	1,000.00	K8,000.00- K1,000.00 = K7,000.00
3	1,000.00	K7000.00- K1,000.00 = K6,000.00
4	1,000.00	K6,000.00- K1,000.00 = K5,000.00
5	1,000.00	K5,000.00- K1,000.00 = K4,000.00
6	1,000.00	K4,000.00- K1,000.00 = K3,000.00
7	1,000.00	K3,000.00- K1,000.00 = K2,000.00
8	1,000.00	K2,000.00- K1,000.00 = K1,000.00
Total	8,000.00	

$$\text{Depreciation per annum} = \frac{\text{cost of asset} - \text{estimated salvage value}}{\text{Estimated number of years of life of an asset}}$$

$$= \frac{\text{K9, 000.00} - \text{K1, 000.00}}{\text{8 years}}$$

$$= \text{K1, 000.00 per year}$$

Table 3

Year end	Reducing balance annual depreciation at 25%		Remaining value/Book value of the machine at end of each year
1	25% of K9,000.00	= K2,250.00	K9,000.00 - K2250.00 = K6,750.00
2	25% of K6,750.00	= K1,688.00	K6,750.00 - K1688.00 = K5,062.00
3	25% of K5,062.00	= K1,266.00	K5,062.00 - K1266.00 = K3,796.00
4	25% of K3,796.00	= K949.00	K3,796.00 - K949.00 = K2,847.00
5	25% of K2,847.00	= K712.00	K2,847.00 - K712.00 = K2,135.00
6	25% of K2,135.00	= K534.00	K2,135.00 - K534.00 = K1,601.00
7	25% of K1,601.00	= K400.00	K1,601.00 - K400.00 = K1,201.00
8	25% of K1,201.00	= K300.00	K1,201.00 – K300.00 = K901.00
Total value			**K901.00**

Depreciation for the last year = last but one year book value – the scrape value

Depreciation for the 8th year = 7th year book value – the scrape value

= K1, 201.00 – K1, 000.00 = K201.00

Table 3: Sum of - digits method

The digits are summed up. The total becomes the denominator used for solving depreciation. Before calculating the depreciation, subtract the **salvage or scrap value** of the capital item. The value that remains is called **depreciable value or depreciable property**. In our example here, depreciable value is: K8, 000.00 (K9, 000.00 – K1, 000.00.00 = K8, 000.00)

Table 3

Year	Sum of digits annual depreciation	Remaining value/Book value of the Machine at end of each year
1	8/36 of K8,000.00 = K1,778.00	K9,000.00 – K1,778.00 = K7,222.00
2	7/36 of K8,000.00 = K 1,556.00	K7,222.00 – K1,556.00 = K5,666.00
3	6/36 of K8,000.00 = K1,333.00	K5,666.00 – K1,333.00 = K4,333.00
4	5/36 of K8,000.00 = K1,111.00	K4,333.00 – K1,111.00 = K3,222.00
5	4/36 of K8,000.00 = K889.00	K3,222.00 – K889.00 = K2,333.00
6	3/36 of K8,000.00 = K667.00	K2,333.00 – K667.00 = K1,666.00
7	2/36 of K8,000.00 = K444.00	K1,666,00 - K444.00 = K1,222.00
8	1/36 of K8,000.00 = K222.00	K1,222.00- K222.00 = K1,000.00
Σ = 36	= K8,000.00	

Tables 1, 2 and 3 show methods used for calculating depreciation.
Value of depreciation is used to estimate present market price of a machine. Find out the method you would adopt if you were a farmer. Why would you adopt that method?

2. Production records

Visit a nearby farm and find out what production records they keep. Record your findings

Production records show the amount of produce (yield) from crops and animals. They entail recording the operations or activities and inputs used in producing a crop or raising animals and the farm produce or outputs. Farmers use different inputs to grow crops like maize, cotton, rice, tobacco, groundnuts, beans etc. Dairy farmers also use inputs.

Discuss with a friend what inputs these farmers use. Some of the inputs farmers use are as follows:
These farmers use pesticides, labour, seeds, fertilizers and farm implements. The dairy farmer uses dairy animals, drugs or medicine, feeds and dairy farm equipment. Two types of inputs are used in production; variable costs and fixed costs. Variable costs vary with crop grown or animal raised. Fixed costs are used for a long time e.g. buildings and equipment and permanent labour.

Table 4: Egg production record

Date	Number of layers	Number of eggs collected	Number of eggs broken	Number of eggs not broken	Laying %	Remarks

Table 5: Feeding record

Name of enterprise.....Type of feed.....					
Date	Number of animals	Amount of feed received	Amount of feed used	Balance of feed	Remarks

Table 6: Sheep breeding record

Number of ewes	Service period (month)	Lambing date	Number of lambs born	Lambing percentage	Number of lambs weaned	Remarks

Table 7: Crop production records

Crop planted	Date of ploughing	Date of planting	Fertilizer used	Amount in bags	Harvesting date	Remarks
Maize	21/01/2012	10/02/2012	23:21:0+4s	2	07/06/2012	Good harvest
Beans	11/01/2012	12/02/2012	Urea	2	03/09/2012	Good harvest

Tables 4, 5 6 and 7 are examples of production records

Farm produce are also production records. The actual weight of crop and animal yields (kilograms of maize and kilograms of meat per animal, liters of milk per animal or number of eggs per chicken) is recorded. By comparing the yield and inputs, the farmer is able to calculate gross margin and profit for the various enterprises.

3. Financial Record

A record of all farm financial transactions should be made. It should include all purchases of farm inputs and other expenditures such as salary and wage payments, rent, and telephone and electricity bills on the one hand and all sales including receipts from services rendered such as machinery hire. These are normally recorded in the cash book and are the basis for calculation of some important performance measures such as profit.

There are several financial books kept in the farm. Some of them are cash book, cash analysis book, balance sheet, and ledgers. Each type of financial record will be looked separately.

1. Cash book

This is a book of accounts where all financial transactions are recorded. It records money received and paid out. A cash book thus keeps records of transactions that involve receipts and payments of cash or by cheque. The simplest form of cash book is the single column cash book. See Table 8 of single column cash book.

Table 8 Single Column Cash book

Date	Income	K	T	Date	Expenditure	K	T
1/2/14	Balance b/f	4000	00	2/2/14	Bought 3 bags layers mash	3600	00
10/2/14	Sold 2 bags maize	5000	00	11/2/14	Bought 5 bags fertilizer	4800	00
15/2/14	Sold 20 trays of eggs	4800	00	29/2/14	Bought hoes	2400	00
22/2/14	Sold carrots	1200	00	23/2/14	Bought broiler finisher mash	6000	00
25/2/14	Sold broilers	10000	00	24/2/14	Bought Actellic	4000	00
28/2/14	Sold green maize	8000	00	27/2/14	Bought poultry vaccine	2000	00
27/2/14	Sold milk	12000	00	28/2/14	Bought dewormer	3000	00
				28/2/14	Balance carried down	**19,200**	00
	Total	46000	00			**45,000**	00
28/2/14	Balance brought down	**19,200.00**	00				

Stating the reasons for keeping farm records

You have seen that there are several records a farmer can keep. Have you ever thought of reasons why farmers keep records?

Activity 2

Stating reasons for keeping farm records

Procedure

- Visit a nearby farm to research on reasons why the farmer keeps records.
- Record your findings.
- Present the findings to the class during plenary session.
- Discuss the reasons for keeping records with your teacher.
- Your teacher will summarise the reasons.

Farmers keep records for several reasons. Some of the reasons are outlined below.

1. Help in planning and budgeting. This will enable the farmer to make appropriate choices and decisions in the farm.

2. Provide a history of what has been happening on the farm. It can be used for comparison purposes.

3. It is required by financial institutions before any loan can be approved to determine the need and capacity of the farmer to repay the loan as well as to determine whether the farmer can benefit from the credit if advanced.

4. Adequate farm records avoid being overtaxed because the tax will be based only on the actual farm profit.

5. A comparison of the relative profitability of different crop and livestock enterprises will suggest which enterprise should be expanded and which one should be reduced or even eliminated to increase farm profit.

6. Determines financial status of the farm.

7. Help in proper management of various routine livestock or crop production practices e.g. the dates of calving, vaccination, harvesting.

8. For comparison purposes between farmers dealing with the same enterprise. This helps to discover the cause for the difference.

9. They help the farmer know when to breed animals.

10. Help the farmer to calculate how much tax to pay.

2. Cash analysis book

This is a book of accounts that will display all the enterprises, showing their incomes and expenditures separately. Like in the trading account, entries must be made as the transactions occur lest the farmer forgets some of the entries.

Example of a cash analysis book

Suppose Mrs. Jede had three enterprises namely chicken, maize and beans. The following transactions were made in 2015:

- On 1st September, 2015, she had a total opening balance of K1, 258,000. Of this amount, maize had K250,000.00, Chickens had K780,000.00, while beans had K228,000.00
- On 04th September, she bought 10bags feeds weighing 50 kg at K8,000

each

- On 8th September she sold 240 eggs at K14,400.00
- On 10th September she repaired the chicken kraal at K500.00
- On 15th September, she sold 300 eggs at K60 each
- On 21st September, Mrs. Jede bought 4 bags of Diammonium phosphate at K15, 000.00 each for the maize enterprise and 25kg maize seed at K8, 000.00.
- On 25th September, she bought 2 bags of 23:21:0+4S fertilizer for the beans at K12,500 each
- On 30th September she paid two gentlemen who were preparing land for the maize enterprise K21,000.00
- On 12th October, she sold eggs for K25,200.00

Table 9

06/09/2009	**Opening valuation**	**K8,500.00**
02/03/2010	Closing valuation	K10,000.00
04/03/2010	Depreciation	K1,000.00
05/04/2010	Fertilizer application	K7,000.00
06/04/2010	Casual labor	K2,000.00
16/05/2010	Tobacco sales	K24,000.00

- On 24th October she sold out all the chickens at K96,000.00
- On 20th November she paid K6,000.00 for planting maize
- 23rd November, she paid for preparing land for beans planting at K14,000.00
- She sold 540 eggs at K60.00 each
- On 26th May, 2016 she sold beans at K800,000.00 and on the same day, she paid all debts amounting to K158,000.00 whichshe incurred in the course of growing beans
- On 19th June 2016, she sold 85 bags of maize at K12,500.00 each
- On 20th June, 2016 she paid K201, 000.00 to her labourers caring for maize.

Required: Prepare cash analysis for Mrs. Jede's three enterprises between September, 2015 and June, 2016.

The cash analysis book will look like table 10 below.

Cash Analysis book for Mrs. Jede (September, 2015 to June 2016

Purchases and Expenses (K)							Sales and Receipts (K)					
Date	Description	Total Payments	Feeds	Seed	Fertilizer	Labour	Date	Description	Total Receipts	Chickens	Maize	Beans
04/09/15	10 bags feeds	80,000.00	80,000				1/09/15	Opening bal-				
10/09/15	Kraal repairs	500.00				500		ance	1,258,000.00	780,000		228,000
21/09/15	4 bags fertilizer	60,000.00			60,000		08/09/15	Egg sales	14,400.00	14,400	250,000	
21/09/15	25 kg seed	8,000.00		8,000			15/09/15	Egg sales	18,000.00	18,000		
25/09/15	2 bags fertilizer	25,000.00			25,000	21,000	12/10/15	Egg sales	25,000.00	25,000		
30/09/15	Land preparation (maize)	21,000.00				6,000	24/10/15	Chicken sales	96,000.00	96,000		800,000
20/11/15	Maize planting	6,000.00				14,000	29/11/15	Egg sales	32,400.00	32,400		
23/11/15	Land preparation (beans)	14,000.00				201,000	26/05/16 19/06/16	Beans sales Maize sales	800,000.00 1,062,500.00		1,062,500	
26/05/16	Labour costs (beans)	158,000.00					30/06/16	Total Receipts	3,306,300.00			
20/06/16	Labour costs (maize)	201,000.00							3,306,300.00	965,800	1,312,500	1,028,000
30/06/16	Total Payments Closing Balance	573,500.00 2,732,800.00	80,000	8,000	85,000	242,500						
		3,306,300.00					01/07/16	Opening bal-ance	2,732,800.00	885,300	1,016,500	831,000.00

3. Balance sheet

This is a statement of all assets and liabilities of a business for a specific period of time. It is usually prepared at the end of a financial year to show how much the business is worth. It shows the value of assets such as crops, livestock, machinery, buildings, cash in hand and also the value of liabilities such as loans, inputs like fertilizers, feeds and any other items that were delivered but have not been paid for yet.

Example of a balance sheet for Mr. Nthewa, a flue-cured tobacco farmer. At the end of 2014 crop growing season the following were his assets and liabilities.

- Cash in hand: K215,000.00
- Cash at the bank: K1,340,000.00
- Land value K3,500,000.00
- Remains of fertilizer K85,000.00
- Bank loan K102,000.00
- He owed some of his workers K85,000.00
- Value of barns K175,000.00
- He owed MRA some tax K140,000.00
- Value of farm equipment K120,000.00

Required to draw a balance sheet for Mr. Nthewa for the period ending 31st July, 2014

Balance Sheet for Mr. Nthewa as at 31st July, 2014

Liabilities	MK	Assets	MK
Bank Loan	102,000.00	Cash in hand	215,000.00
Debt payable	85,000.00	Cash at Bank	1,340,000.00
Tax Payable	140,000.00	Land Value	3,500,000.00
Total Liabilities	327,000.00	Value of fertilizer	85,000.00
		Value of barns	175,000.00
Net Capital	5,108,000.00	Value of farm equipment	120,000.00
5,435,000.00		Total Value of Assets	5,435,000.00

Unit Summary

Farming as a business requires accurate and up-to-date records. Three types of records have been studied. These are

- Inventory records
- Production records
- Financial records

A complete picture of the farm cannot be obtained without taking into

account all farm transactions during the farming year. Outstanding receipts and payments as reflected in the debts are important components of the farm transactions.

Questions

1. Why is it important for farmers to keep records and accounts?
2. Of what use is an inventory?
3. A farmer kept the following information on his farm
   - 02/03/2010 He sold 30 units of eggs at K7.00 per unit
   - 03/03/2010 He bought one bag of layers mash at K800.00
   - 02/03/2010 He bought 2 bags of manure at K50.00 per bag.
   - 05/04/2010 He sold vegetables at K500.00.
   - 10/06/2010 He sold 6 bags of maize at K15,000.00.
   - 12/08/2010 He sold 3 bags of cassava at K6,000.00.
   - 15/09/2010 He sold 5 bags of groundnuts at K15,000.00.
   - 06/12/2010 He bought 2 bags of CAN at K 12,000.00.

(a) Using this financial record, calculate the profit or loss.
(b) Explain any two importance of keeping financial records on the farm.

4. Table 9 below shows transactions that were recorded on a farm. Use it to answer questions that follow.
   a. Prepare a profit and loss account.
   b. Calculate the farmer's profit or loss.
   c. Describe any three uses of this type of record on a farm.
   d. Explain the benefit of calculating depreciation on a farm.

Glossary

1. **Inventory**: contains information about the type and amount of stocks an entity possesses
2. **Depreciation:** This is loss of value of the item over time
3. **Depreciable property**: This is value of the capital from which depreciation can be calculated
4. **Salvage value:** This is value of an asset at the end of its lifespan.

Reference

1. http//www.bing.com
2. Kanjala B. M., Kaperemera N.T *Strides Agriculture Book 3.* Blantyre : Longman Malawi
3. Kayira D.M CHANCO *Teach yourself series. MSCE Agriculture.* Zomba: Chancollor College Publications

4. Ngomwa A., Sigei P., Cheruiyot D.(2012) *Excell & Succeed, Senior Secondary Agriculture Book 3.* Lilongwe: Grey Matter Limited
5. Ngugi D., Karau P.K., Nguyo *W. 1990 East African Agriculture,* Nairobi: Macmillan Education

Unit 5

Budgeting

What do you do when your parents give you pocket money before you start spending it?

I hope you first of all make a budget. What is a budget then?

Defining a Budget

Activity 1

Defining the term budgeting

Procedure

- Brainstorm the meaning of the term budgeting
- Discuss with your teacher the meaning of budgeting
- Your teacher will summarise the term budgeting

A budget is an estimate of expected costs and returns of a business or enterprise. You may recall that farmers need to properly choose what to produce. Farmers may wish to choose those enterprises which can give them the highest profit. This is the function of a budget.
Budgeting is a method of analysing plans for the use of agricultural resources. A Farm plan is a programme of the total farm activity of a farmer drawn up in advance. A Farm plan serves as the basis of farm budgeting. Therefore, a farm plan can be prepared without a budget but budgeting is not possible without a farm plan. In this unit you will learn the commonly used types of farm budgets, namely, partial budget, break even budget and complete budget.
Therefore, budgeting can be defined as:

1. The physical aspect of farm planning when expressed in monetary terms.

2. The expression of a farm plan in monetary terms by estimation of receipts, expenses and net income.

3. Farm budgeting is a process of estimating costs, returns and net profit of a farm or a particular enterprise.

4. Budget is a statement of estimated income and expenditure.

Types of farm budgets

Farmers are faced with different situations that require estimates before implementing them. As the situations differ, so do the types of budgets.

Activity 2

Stating types of farm budgets

Procedure

- Brainstorm types of farm budgets
- Discuss these types of budgets with your teacher
- Visit a nearby farm to see the types of budget the farmer formulated
- Report your findings to the whole class during plenary session
- Your teacher consolidates the types of farm budgets

There are three types of budgets

a. Partial budget
b. Break-even budget
c. Complete budget

a.Partial budget

Partial refers to estimating costs and returns and net income of a particular enterprise. It refers to estimating the returns for a part of the business i.e. one or few activities for example

i. To estimate additional cost and returns from growing one hectare of hybrid maize in place of local maize.
ii. To estimate additional cost and returns by adopting foliar application of chemical fertilizers instead of soil application

Partial Budget Components

Partial budgets are based on the principle that small business changes have effects in one or more of the following areas

1. Increase in income
2. Reduction or elimination of costs
3. Increase in costs
4. Reduction or elimination of income

The net impacts of the above effects will be the positive financial changes minus the negative financial changes. A positive net indicates that farm income will increase due to the change, while a negative net indicates the change will reduce farm income.

A partial budget consists of two columns, a subtotal for each column and a grand total. The left hand column has the item that increases income while the right hand column notes those that reduce income for a farm business.

Uses of a partial budget

Brainstorm with your partner, the situation in which a farmer would find a partial budget useful. Some of your findings should be as follows:

1. Introduce a new enterprise without necessarily changing other enterprises
2. Change one enterprise for another- sometimes referred to as substitution
3. Expand the existing enterprise or make additions to existing enterprise e.g. increase the area for crops or increase livestock herd for beef, dairy, broiler, egg production, sheep, goats
4. Buy new farm machinery or equipment
5. Adopt a change in method of production, for example, introducing the use of a milking machine instead of hand milking

Table 2: An example of a Partial budget in which the farmer switches from

Added income due to change	**Added cost due to change**
Sell raised heifer calf:500kg @K120.00	**Purchase bred heifer**
K600.00	**K1,200.00**
Reduced cost due to change	**Reduced income due to change**
Pasture maintenance	
20.00	
Concentrate feed	**None**
40.00	
Supplementation and Mineral	
45.00	
Hay fed	
120.00	**Subtotal**
Health, utilities and other costs	**1,200.00**
55.00	
Labor	
50.00	
Subtotal	
930.00	

Table 12

raising replacement Heifers to Buying Heifers.
Partial budgeting can be useful in the decision process farm owners and managers use to decide on alternative uses of resources they have in their businesses. Partial budgeting is a systematic approach that can assist the manager in making informed decisions. But this budgeting process can only estimate possible financial impacts, not assure them. Management decisions and chance can change the projections. These may result in better or poorer than expected performance. Repeating the analysis using different assumptions about key variables will give some idea about the degree of risk involved in making the proposed change.

Example of a partial budget

Mr. Senzani has 2 hectares of land on which he grows NSCM 41. He however wants to make the following changes;

- To apply 4 bags of urea instead of 6 bags per hectare at K1,300.00
- To sell 40 bags of maize at K1, 000.00 per bag to Chibuku Products Limited instead of K850, 000.00 per bag to ADMARC.
- To store maize in 50kg sacks at K30.00 each instead of storing it in the nkhokwe.
- To spend K500.00 instead of K300.00 on Actellic.
- To spend K600.00/hectare instead of K300.00/hectare on casual labor.

a) Prepare a partial budget for Mr. Senzani.
b) Should Mr. Senzani go ahead with his plan? Explain your answer.
c) Explain any two uses of the partial budget prepared above to Mr. Senzani.
d) Explain the major weakness of the partial budget prepared above.

Cost (MK)		Income (MK)	
4 Bags urea @K1,300.00 K5,200.00	=	40 bags @K1,000.00	= K40,000.00
40 bags maize@K850.00 K34,000.00	=	6 bags urea @ K1,300.00	= K 1,300.00
50 Sacks@K30.00 K1,500.00	=	Actellic @ K300.00	= K 300.00
Actellic @ K500.00 K500.00	=	2 Casual labor @ K300.00	= K 600.00
Casual labor K1,200.00	=		
Total Cost K42,400.00	=	Total income	= K48,000.00

Table 13

The farmer would require rates to be less than K339/hr for a contractor using the same machine as he was considering purchasing before he would contract the machine. Based on 5.85ha/hr, the rate equates to K58/HA. As the farmer can get his harvest done by contract for approximately K35/ha, he is keen to look further into contracting.

The same technique can be used to look at the breakeven rate given different proportions of the crop being downgraded, for different price discounts etc. For example, the farmer uses the technique to determine the financial impact if the contractor did not arrive on time by changing the proportion of grain received for different grades to 70% grade 2 and 30% for grade 3. The breakeven rate is K9/ha, well below the anticipated K35/ha. The farmer can now make an informed decision about his machinery decision problem noting that the K150, 000 received from the sale of his old machine could be put to good use, funding his investment in beef cattle.

b.Break-even budget

The break-even level or break-even point (BEP) represents the sales amount—in either unit or revenue terms—that is required to cover total costs (both fixed and variable). Total profit at the break-even point is zero. Break-even is only possible if a firm's prices are higher than its variable costs per unit. If so, then each unit of the product sold will generate some "contribution" toward covering fixed costs

In economics, business and cost accounting, the break-even point (BEP) is the point at which total cost and total revenue are equal: there is no net loss or gain, and one has "broken even." i.e. both sides of the equation are the same. A profit or a loss has not been made, although opportunity costs have been "paid," and capital has received the risk-adjusted, expected return. In short, all costs that need to be paid are paid by the firm but the profit is equal to 0.

For example, if a farmer produces and sells less than 250 bags of maize each year, she/he will make a loss; and if she sells more, she/he will make a profit. With this information, the farmer will then need to see if she/he is able to produce and sell 250 bags of maize in a year. If she is able to produce more than 250 bags, then she/he can go ahead and embark on the enterprise because she/he is now sure of making a profit. On the other hand, if she/he sees that it is impossible but still wants to embark on the business, then s/he must try doing the following:

1. Try to reduce the fixed costs (by renegotiating land rentals for example, or keeping better control of telephone bills or other costs).
2. Try to reduce variable costs through input substitution – adopting organic

farming.
3. Increase the selling price of the maize. This can be achieved through selling the maize in times of scarcity.

The aim is to reduce break-even point and increase profit.

Purpose

The main purpose of break-even analysis is to determine the minimum output that must be exceeded in order to make profit. It also is a rough indicator of the earnings impact of a marketing activity.[1]
The break-even point is one of the simplest yet least used analytical tools in management. It helps to provide a dynamic view of the relationships between sales, costs, and profits.

Figure 5.1.Showing break-even point.

For example, expressing break-even sales as a percentage of actual sales can give managers a chance to understand when to expect to break even (by linking the percent to when in the week/month this percent of sales might occur).
The break-even point is a special case of Target Income Sales, where Target Income is 0 (breaking even). This is very important for financial analysis.

Construction

In the linear cost-volume-profit analysis model (where marginal costs and marginal revenues are constant, among other assumptions), the break-even point **(BEP)** (in terms of Unit Sales **(X)**) can be directly computed in terms of Total Revenue **(TR)** and Total Costs **(TC)** as:

TR = **TC** (this is break-even point, the result is zero)

$$P \times X = TFC + V \times X$$
$$P \times X - V \times X = TFC$$
$$(P - V) \times X = TFC$$
$$X = \frac{TFC}{(P - V)}$$

This is an algebraic presentation in which **X** is being made subject of the formula where:

- **TFC** is total fixed cost,

- **P** is Unit Sale Price,
- **V** is Unit Variable Cost,
- **X** is the total number of units to be sold – in our example number of maize bags

The Break-Even Point can alternatively be computed as the point where **contribution equals fixed costs**. The quantity, **(P-V)**, is of interest in its own right, and is called the **unit contribution margin (C)**: It is the marginal profit per unit, or alternatively the portion of each sale that contributes to Fixed Costs. Thus the break-even point can be more simply computed as the point where Total Contribution = Total Fixed Cost:

Total contribution = Total fixed cost

Unit contribution x number of units = Total fixed costs

Number of units = total fixed costs / Unit contribution

Limitations

- Break-even analysis is only a supply-side (i.e., costs only) analysis, as it tells you nothing about what sales are actually likely to be for the product at these various prices.
- It assumes that fixed costs (FC) are constant. Although this is true in the short run, an increase in the scale of production is likely to cause fixed costs to rise.

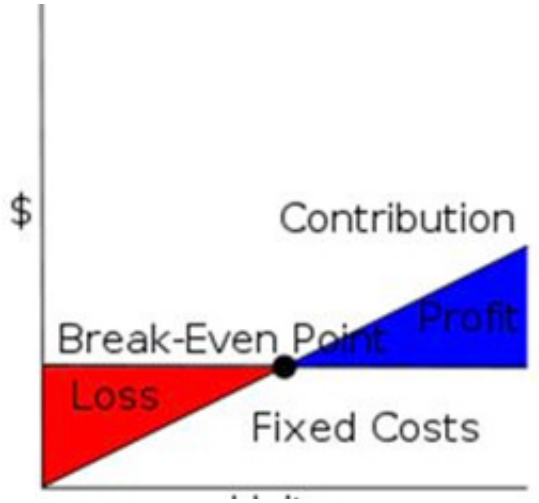


Figure 1 showing break-even point.

Figure 5.2

- It assumes average variable costs are constant per unit of output, at least in the range of likely quantities of sales. (i.e., linearity).
- It assumes that the quantity of goods produced is equal to the quantity of goods sold (i.e., there is no change in the quantity of goods held in inventory at the beginning of the period and the quantity of goods held in inventory at the end of the period).
- In multi-product companies, it assumes that the relative proportions of each product sold and produced are constant (i.e., the sales mix is constant).

c. Complete budget

1. Complete Budget

This budget also known as whole farm budget looks into every detail of the farm. It includes budgeting for both fixed and variable costs. In fact this is the budget that is prepared when a farmer wants to start a farming business. A complete budget is prepared when:

i) A farm plan is prepared for a new farm

ii) When drastic changes are suggested in the plan of the existing pattern on an established farm. Complete budgeting can be prepared for short run (annual budget) and for long run.

An Example of a Complete Budget.

The table shows the fixed costs and the variable costs for maize, cassava, tea and rice at a certain farm in Mulanje.

	Maize	Cassava	Tea	Rice
Yield (kg/ha)	400	450	800	2,000
Price (MK/kg)	8,000	50	200	25
Gross income (MK)	80,000	22,500	160,000	50,000
Variable costs (MK)				
Seed and Fuel	1,000	500	800	500
Fertilizer and transport	8,000	-	10,000	20,000
Pesticides	5,000	150	1,000	-
Casual Labor	100	150	200	80
Total Variable Costs (TVC)	–6,100	800	12,000	20,580
Gross Margin/ha =GI - TVC	65,900	21,700	148,000	29,420
Fixed cost for all the four enterprises (maize, cassava, tea and rice) (MK)				
Regular/permanent labor			20,000	
Rent and fuel			5,000	
Depreciation			250	
Maintenance & Repair			3,000	
Land Tax			3,000	
Loan repayment			2,000	
Administration & office expenses			1,000	
General overheads like licenses and car expenses			8,000	
Total fixed costs (MK)			42,250	

Table 10

Study the table thoroughly and answer questions that follow.
1. Find two crop enterprises that have the highest gross margins (GM).
2. i Which crop would you advise a farmer to grow?.
ii Why would you advise a farmer to grow the crop you have mentioned in (i) above?
3. Which crop would be the worst for the farmer to grow?
4. Calculate the whole farm gross margin.
5. Work out the whole farm profit.

Table 11 Difference between complete budget and partial budget

	Complete budgeting		Partial budgeting
1	The whole farm is considered as one unit	1	It is adopted when a minor aspect of farm organisation is touched
2	All the aspects like crops, livestock, machinery and other assets are considered	2	It is practiced within the existing resources structure of the farm
3	Both fixed and variable costs are calculated for working out costs and returns	3	Only variable costs are considered
4	Net income is estimated by deleting fixed costs and costs of variable inputs from the value of the product	4	Net income is estimated by deleting only costs of variable inputs from the value of the product
5	It requires more efforts and time for preparation	5	It requires relatively less efforts and time and time for preparation

Table 11

Every farming activity calls for its own type of budgeting. However, the general activities are the same.
How to Budget for an Agricultural Enterprise

Activity 2

Describing how to budget for an agricultural enterprise

Procedure

- Brainstorm activities in volved in budgeting for an agricultural enterprise.
- Discuss these activities with your teacher.
- Collect data from agricultural enterprises.
- Prepare budgets using the data collected.
- Your teacher will summarize the steps involved in budgeting.

Steps Involved in Budgeting

a. A farmer should decide on what to produce. This should be based on the farmer's skill and customer demand.
b. Estimate the input requirement such as fertilizer, seed, labour, transport and the like. The farmer should make sure that every input that will be sourced should be included in the estimate.
c. Make an estimate of the expected yield. This can be in terms of volume for example, liters of milk or mass such as kilograms of maize. The estimates should be realistic. To avoid over or under-estimating a farmer can get estimates from extension service personnel.
d. Make an estimate of prices for the yield. Prices differ with market. Ministry of Agriculture can provide estimated prices of different commodities at different locations.
e. Estimate fixed costs of buildings, machinery depreciation.
f. Calculate total cost.
g. Calculate total revenue.
h. Calculate net revenue. If the net revenue is positive, the enterprise has made a profit. If the net revenue is negative, the enterprise has registered a loss. If the net revenue is zero, the enterprise has neither made a loss nor a profit. A farmer must choose an enterprise which brings positive net revenue. The farmer's interest should be centered on the margin of profit. The higher the profit, the better for the enterprise.

2. Partial Budgeting: A Financial Management Tool

Partial budgeting (also known as marginal analysis) is a management tool that can compare the costs and returns that are affected by a potential change in a business. It is especially useful in evaluating budgets that involve small, specific, and limited changes within a business by helping to determine the profitability of that change. If the potential change will impact several aspects of the business, then it will be necessary to use a whole-farm budget. Whole-farm budgets contain both cash and non-cash income and expenses; and they also consider fixed costs that are associated with the business. You may want to do a complete whole-farm budget of your business to see if it has profitability, liquidity, and solvency subsistence over the long term.

As a reference, there are also three additional types of budgeting that may be more suitable to your needs than a whole-farm budget or a partial budget.

- Enterprise Budgeting contains all of the income and expenses associated with a single enterprise,
- Cash Flow Budgeting depicts monthly cash surpluses or deficits and can be used for the entire business or for an individual enterprise, and
- Capital Budgeting summarizes the capital investments the business plans to make and the profitability of those investments.

If your operation seems to need fine-tuning, then a partial budget would

be a more appropriate tool to analyze its performance. Business managers should evaluate their individual situations and make an informed decision about how they will be impacted by future events when considering their options regarding the proposed change. It is especially important to keep in mind that the answers you obtain from partial budgeting are no better than the quality of the information used in the analysis.

When Should You Use A Partial Budget?

You might want to use a partial budget to analyze the effect of:

1. Expanding an enterprise (for example: adding 20 cows to a 100-cow herd),
2. Substituting commodities with similar requirements (example: substituting 50 acres of tomatoes for 50 acres of peppers)
3. Buying new equipment or machinery (example: buying new equipment rather than leasing or custom-hiring or vice versa),
4. Changing or adopting production practices (example: changing feed rations in a livestock enterprise),
5. Participating in a government program, or,
6. Considering an alternative enterprise.

This gives you an idea of the types of changes that partial budgeting can analyze. However, you should always keep in mind that partial budgeting can only analyze small changes within the business, not major reorganizations.

Limitations of Partial Budgeting

Although partial budgeting can be applied in a variety of situations it does have limitations to its use.

a) It is restricted to evaluating only two alternatives.
b) The results obtained from a partial budget are only estimates, and are only as good as the original data that is entered. If you enter inaccurate information in the budget, you receive inaccurate results.
c) Partial budgeting does not account for the time value of money. That is, the difference in the value of cash received and/or expended now, versus its value at some future date.
d) Partial budgeting only provides an estimate of the profitability of an alternative relative to current operations. It does not provide an estimate of the absolute profitability of the business.
e) Costs and returns that are not affected by an intended change are not included in the partial budget. In other words, you can only use the partial budget to consider the costs and returns of a specific action. If you cannot determine all the areas that will be affected by the intended change, it might be better to use a whole-farm budget to evaluate the impacts of the change.

Components of Partial Budgeting

In order to use partial budgeting to evaluate a potential change in a busi-

ness, a manager must first be able to answer four questions about that change:

1. What new or additional costs will be incurred?
2. What current costs will be reduced or eliminated?
3. What new or additional returns will be received?
4. What current returns will be reduced or lost?

The partial budget can be divided into three main sections:

(I) Costs,
(II) Benefits,
(III) Analysis.

The analysis section includes net change in profits and a break-even analysis (also known as benefit/cost ratio).
The possible changes that can occur in a business fall into four categories. These categories are added returns, reduced returns, added costs, and reduced costs. Added costs and reduced returns compose the cost section of the partial budget. They represent the negative effects of a proposed change. Added returns and reduced costs fall into the benefits section of the partial budget and are the positive effects of a proposed change in the business.

The analysis section of the partial budget contains both net change in profits and benefit/cost ratio analysis. Net change in profits is the factor that determines whether the change can improve or hurt the current financial situation. If the benefits are greater than the costs, the change will have a positive net benefit. If costs related to a proposed change are greater than the benefits (negative valued net benefits), then the proposed change should not be considered or reconsidered, as it will cost more than it will return.
The benefit/cost ratio looks at the relative values of the benefits and costs when the profits from two considered alternatives appear to be the same value. Using the benefit/cost ratio can help the manager determine which option would produce better returns. Both net change in profits and the benefit/cost ratio should be used to evaluate the results from a partial budget.

In many instances, these components of partial budgeting will not apply to your situation. However, it is a good idea to evaluate all of the four possibilities to ensure that some variable or impact has not been overlooked, and to reduce the chances that variables or impacts have been counted more than one time. Remember that you do not need to evaluate costs and returns that are not affected by the proposed business change.
A partial budget can be arranged into the following format:

Problem (Proposed Change	
Section 1: Costs	Section 2: Benefits
A. Additional Costs (These will be the costs incurred as a result of growing a new commodity or using a new practice.)	D. Additional Returns (These will be the returns received as a result of growing a new commodity or using a new practice.)
B. Reduced Returns ((These will be the returns that are given up as a result of no longer producing the current commodity being grown or practice being used.)	E. Reduced Costs (These will be the costs that will no longer be incurred as a result of giving up the current commodity or practice for a new one.)
C. Total Costs (A + B)	F. Total Benefits (D + E)
Section 3: Analysis	
G. Net Change in Profits (F – C)	
H. Benefit/Cost Ratio (F ÷ C)	

Example of a partial budget

Mr. Senzani has 2 hectares of land on which he has been growing Mkango maize variety for so many years. He however wants to make the following changes;

- He decides to use for producing Kholophethe beans variety.
- The yield of maize has been 80 bags weighing 50kg each per hectare. He expects to produce 60 bags of beans weighing the same per hectare.
- The price of maize is K250.00 per kilogram while beans is expected to be sold at K450.00 per kilogram
- In both cases, sacs are needed at the cost K150.00.00
- Mr. Senzani will need to apply Actellic dust to both at the rate of 5 bags per tin of Actellic. Its cost K2, 500.00 per tin.
- Labour requirement for maize production is K150, 000.00 per hectare. Beans on the other hand shall require K120, 000.00 per hectare.
- Fertilizer requirement: 4 bags of 23:21:0+4S and 2 bags of urea for maize per hectare at the cost of K21,000.00 each; and 4 bags of 23:21:0+4S per hectare for beans costing the same price.
- Mr. Senzani will be expected to buy 4 bottles of Cypermethrine at the cost of K4, 500.00 per bottle to control bean beetles.
- Labour for controlling the bean beetle is expected to be K30,000.00 per hectare.

Steps in Constructing a Partial Budget

The partial budget is ready to be developed after all appropriate data is produced. Again, only the costs and returns that change as a result of proceeding with the specific change should be included in the partial budget. An example of how to perform a partial budget follows. For analysis purposes we will be comparing two proposed changes against our current business practice. This will require two separate partial budgets, because if you will recall, one of the limitations of partial budgeting is that you are restricted to evaluating only two alternatives per budget. Finally, an evaluation of the

benefit/cost ratio result is provided to explain how to compare the results of the partial budgets for the two proposed changes (when they seem to produce equal profits).

Problem: Maize Production vs. Beans Production	
Section 1: Costs	Section 2: Benefits
A. Additional Costs vBeans • 4 bottles Cypermethrine @ K4,500 = K18,000.00 • Labour for applying Cypermethrine = K30,000.00 • Total: K48,000.00 B. Reduced Returns • 00.00 C. Total Costs A + B (K48,000.00 + 00.00)=K48.000.00	D. Additional Returns v Beans • K350,000.00 (value of beans minus value of maize) E. Reduced Costs v Beans • Sacs = K3,000.00 (20 additional sacs for maize @ K150.00 each) • Actellic = K10,000.00 • Labour = K30,000.00 • Urea = K42,000.00 F. Total Benefits D + E = K435,000.00
Section 3: Analysis	
G. Net Change in Profits: F – C = K435,000.00 – K48,000.00 = K387, 000.00 H. Benefits/Cost Ratio = F ÷ C K435,000.00 ÷ K48,000.00 = 9.06	

In this example, the benefits/costs ratio means that for every K1.00 spent on production of beans, the famer will be making K9.06 more or a profit of K8.06

3. Breakeven Budget

Breakeven, in simple terms is how many units an organization must sell (in units or money) in order to breakeven covering all fixed and variable expenses. It is important to know your breakeven as gives you realistic estimates of how much your sales need to start marking a profit. In fact a breakeven analysis is one way to know whether you should go forward with a business.

Example

Suppose a farm that produces tobacco has the following information:

1. Fixed costs
   a. Land (rent): K50,000.00
   b. Production salaries K120,000.00
   c. Barns: K30,000.00

2. Variable Costs
   a. Fertilizer K1400.00
   b. Seeds K400.00
   c. Chemicals K200.00
3. Sales price: K4,000.00 per kg

To find the breakeven we use the following formula:
Fixed Costs ÷ (sales price – variable cost)

Calculations

Total fixed cost = K200, 000.00
Total variable costs:K2, 000.00
Breakeven = Fixed cost ÷ (sales price –variable cost)
K200, 000.00 ÷ (K4, 000.00 – K2, 000.00)
K200, 000 ÷ K2, 000 =100 units
Please note that the variable costs are per unit.
This farmer must produce 100 units of tobacco in order to break even.

How to Budget for an Agricultural Enterprise

Every farming activity calls for its own type of budgeting. However, the general activities are the same.

Activity 2

Describing how to budget for an agricultural enterprise

Procedure

- Brainstorm activities involved in budgeting for an agricultural enterprise.
- Discuss these activities with your teacher.
- Collect data from agricultural enterprises.
- Prepare budgets using the data collected.
- Your teacher will summarise the steps involved in budgeting.

Steps involved in Budgeting

1. A farmer should decide on what to produce. This should be based on the farmer's skill and customer demand.
2. Estimate the input requirement such as fertilizer, seed, labour, transport and the like. The farmer should make sure that every input that will be sourced should be included in the estimate.
3. Make an estimate of the expected yield. This can be in terms of volume for example, liters of milk or mass such as kilograms of maize. The estimates should be realistic. To avoid over or under-estimating a farmer can get estimates from extension service personnel.
4. Make an estimate of prices for the yield. Prices differ with market. Ministry of Agriculture can provide estimated prices of different commodities at different locations.

5. Estimate fixed costs of buildings, machinery depreciation.
6. Calculate total cost.
7. Calculate total revenue.
8. Calculate net revenue.

If the net revenue is positive, the enterprise has made a profit.
If the net revenue is negative, the enterprise has registered a loss.
If the net revenue is zero, the enterprise has neither made a loss nor a profit.
A farmer must choose an enterprise which brings positive net revenue. The farmer's interest should be centered on the margin of profit. The higher the profit, the better for the enterprise.

Unit Summary

Budgeting is an estimate of the future expenses and income of a proposed farm plan. It is a translation of a physical plan into financial terms.
Farming is a business, like any other business, it requires advance planning for the available resources. As such, it requires an estimate of the expected expenses and to some extent a prediction of the outcome. Budgets also provide a useful yard stick against which farmers can measure their activities.

Partial budgets help farmers to expand the existing enterprise or make addition to the already existing enterprise. A partial budget helps the farmer to come up with a change in method of production of his/her enterprise. Partial budget shows the financial implications of a proposed small change in the farm that is, increasing a particular enterprise at the expense of another. A partial budget is also known as a change in the production techniques. A partial budget will help to determine whether the change will be profitable or not.

Simply, four questions are important in partial budgets:

i. What extra costs (EC) are to be incurred?
ii. What present /existing income or revenue is to be forgone or given up?
iii. What present costs will no longer be incurred?
iv. What extra income is to be earned?

Total gains = Extra revenue + Cost saved
Total Cost = Extra Costs + Revenue forgone
Net gain/loss = Total gains – Total costs

If the costs are more than the income, it is not advisable to implement the proposed change. If the net gain is positive, the proposed change is profitable. A partial budget only includes resources that will be changed e.g. variable costs. It does not consider the resources in the businesses that are left unchanged.

Only the change under consideration is evaluated for its ability to increase or decrease income in the farm business.

The break even calculation show that it will require a certain amount per unit before the plan will break even with the existing enterprise. If it means borrowing funds to engage in another enterprise it will require a higher return to meet the repayment.

A complete budget is a type of budget which examines the effect of changes made to the whole farm. A complete budget is mandatory when a farmer;

-Is opening a new farm.
-Makes new changes in the farm.
-Is making major reorganisation the farm.

Reference

1. http://en.wikipedia.org/wiki/Break-even_%28economics%29 (04/10/2014).
2. http://www.agriinfo.in/?page=topic&superid=10&topicid=239 (30/06/2014).
3. www.extension.iastate.edu/agdm/.../c1-50.html (30/06/2014).
4. www.agric.nsw.gov.au/econ/budget..
5. D.A. Patton (2001): *Evaluating enterprise change and capital investments - partial and break-even budgets.* Agfact M1.2 second edition, Agricultural New York: Research Centre, Trangie.
6. Kanjala B.M and Kaperemera N.T, (2012): *Strides in Agriculture Book 4, Revised Edition,* Blantyre: Lonjgman Malawi.

Unit 6

Farm Business Decision —Making

Time has come when farming should be taken seriously as a business. In every business venture right decisions are the basis for high returns on investment. Farmers need to value very highly any of their investment, whether it is money, time or energy.

This is why decision making becomes very important to a farmer and indeed in this unit. You will in this unit learn among many other things, the economic principles in farm business decision making, how each of these principles help in decision making.

Stating the Economic Principles in Farm Business Decision—Making

The idea of decision making on a farm is to enable the farmer maximise profit. Farmers therefore need to make the right decisions at all times so that even when it is difficult for most farmers to prosper, this particular farmer should still stand out and make profit.

Activity 1

Stating the economic principles in farm business decision making

Procedure

- Form groups of at least five members
- Using your library or internet, research on the economic principles farmers use when deciding on what to produce, how to produce, how much to produce, when to produce and where to buy and sell.
- Record all of your findings
- Each group should present the findings to the class
- Your teacher will summarise the economic principles that farmers use in decision making

The economic principles that farmers use in deciding on what to produce, how to produce, how much to produce, when to produce and where to buy and sell are;

a. Opportunity cost
b. Comparative advantage
c. Substitution of inputs
d. Diminishing marginal returns

Explaining how each of the economic principles helps in decision making in farm business

You have seen that farmers need to think very critically about what to produce, how to produce it, when to produce it, how much to produce it and where to buy input and sell the produce. You are now ready to learn how the economic principles stated above can help farmers to make right decisions.

Activity 2

Explaining how the economic principles can help farmers in decision making

Procedure

- While with your teacher in the classroom, brainstorm how each of the economic principles helps in decision making in farm business
- Discuss these economic principles with your teacher how they help in decision making in a farm business
- Your teacher shall help you summarise how each of the economic principles can help in decision making in a farm business

a. Opportunity cost

This is the value of a foregone alternative. When a farmer decides to produce maize instead of groundnuts, the difference in value between groundnuts and maize is a foregone alternative and therefore an opportunity cost.

For example: If maize production (which is a major food crop for most Malawians) produces a surplus whose profit is K250, 000.00; while groundnuts makes a profit of K350,000.00. This farmer foregoes K100, 000.00 if she/he chooses to grow maize rather than groundnuts. The opportunity cost here is K100, 000.00. This implies that every decision a farmer makes has a consequence. As a result farmers must give every decision a very serious thought.

b. Comparative advantage

This is another principle that is used when choosing enterprises. Farmers must concentrate and take advantage of enterprises which best suit the environmental conditions of their areas. For example, farmers in Tsangano have a comparative advantage over farmers in hot areas of Malawi in production of Irish potatoes. Farmers need to appreciate that they cannot venture into every enterprise. It is best to choose only those enterprises which suit best in their locality. Comparative advantage also works where the farmer has skill for a particular enterprise. As a result, farmers are advised to choose those enterprises which they are able to handle due to skill or those enterprises which best suit the environment.

c. Substitution of inputs

The underlining issue is profit maximisation. Inputs contribute a great deal to cost of production. Efforts must be made by farmers to reduce as much as they can to reduce this cost. One way is to substitute inputs. For example, prices for organic fertilizers continue to go up. These fertilizers can be substituted by organic fertilizer. Use of machinery can economically substitute human labour. This is why some enterprises are embarking on outsourcing certain services instead of hiring permanent labour.

d. Diminishing marginal returns

This is a law in production decision making which states that *if a variable input is increased while all other inputs are held constant, a point is eventually reached where the additional output for every additional input will decline.* The law is clearly advising farmers to decide on the right amount of inputs for every enterprise because too much of the input is dangerous.

Meanings of the following words should be understood:
1. **Diminishing** means declining or getting reduced
2. **Marginal** means additional or incremental
3. **Return** means output or yield

This law is about declining of additional yield as a result of additional level of input being used.

Drawing a graph to illustrate the law of diminishing marginal return

You have learnt that the law of diminishing marginal return helps farmers to decide correctly. In this section, you will learn how to illustrate the law graphically.

Activity 3

drawing a graph to illustrate the law of diminishing marginal return

Procedure

Break into your groups

- Collect data on level of input and the corresponding yield for any given enterprise
- Tabulate the collected data
- Draw a graph using the tabulated data
- Your teacher will consolidate the graph

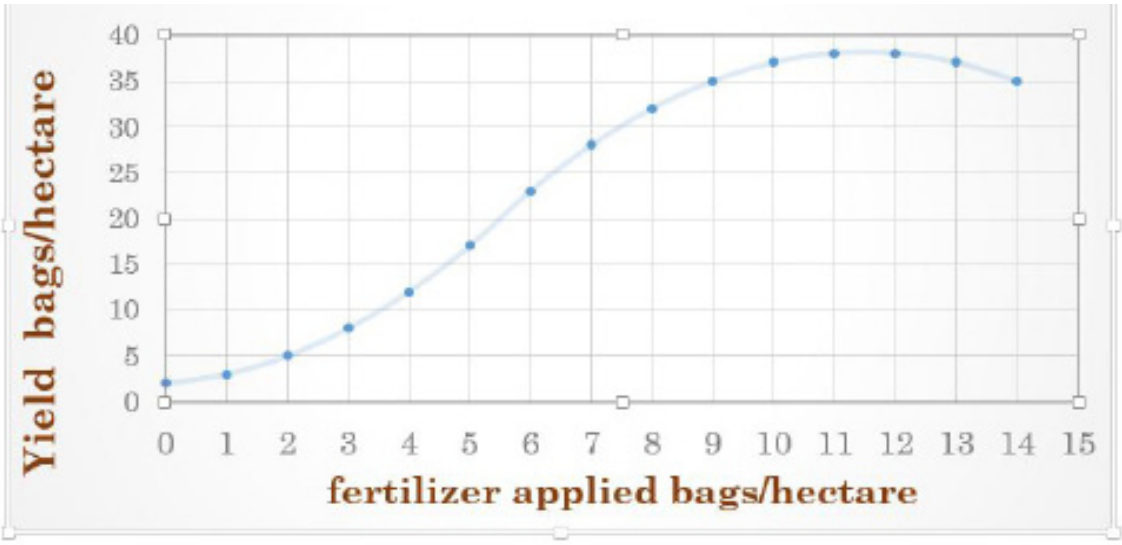
In your activity 3, you were correct if you collected data as found in the table 14 below
Imagine if a farmer grew maize on one hectare. He applied different fertilizer levels as seen in the table 14.

Land (hectare)	Level of fertilizer applied (bags/ha)	Level of output or yield (bags/ha)
1	0	2
1	1	3
1	2	5
1	3	8
1	4	12
1	5	17
1	6	23
1	7	28
1	8	32
1	9	35
1	10	37
1	11	38
1	12	38
1	13	37
1	14	35

Table 14

Table 1 showing the relationship between level of input (fertilizer) and its corresponding yield.

Interpreting the graph as a farm business management tool



The size of land is being held constant while level of fertilizer is being increased by equal amount.
You have seen the shape of the graph. What shape does it have?

Activity 4

Interpreting the graph as a farm business management tool

Procedure

- Break into your groups.
- Suggest the meanings of the following words:
  - Diminishing
  - Marginal
  - Return
- Using the table above add the following columns as seen in table 2 below.
  - marginal return
  - income assuming 1 bag of maize costs K4,000.00.
  - cost of input assuming 1 bag of fertilizer costs K12,000.00.
  - profit
  - fill the additional columns
- From the table, identify the level of marginal return which is the highest.
- From the table, identify the level of input which brings the highest profit.

Land (hectare)	Level of fertilizer applied (bags/ha)	Level of output or yield (bags/ha)	Marginal output	Income from maize sales	Cost of fertilizer	profit made
1	0	1	-	4000	0	4000
1	1	2	1	8000	12000	-4000
1	2	4	2	16000	24000	-8000
1	3	7	3	28000	36000	-8000
1	4	11	4	44000	48000	-4000
1	5	16	5	64000	60000	4000
1	6	22	6	88000	72000	14000
1	7	27	5	108000	84000	24000
1	8	31	4	124000	96000	38000
1	9	34	3	136000	108000	38000
1	10	36	2	144000	120000	24000
1	11	37	1	148000	132000	16000
1	12	37	0	148000	144000	4000
1	13	36	-1	144000	156000	-12000
1	14	34	-2	136000	168000	-32000

Table 15

The graph depicts three segments.

1. The first segment is where the yield of maize is increasing at increasing rate. The rate of increase is the marginal output. You will notice that in this segment the marginal output is increasing until it reaches 6.
2. In the second segment, the yield continues to increase but at a declining rate. The declining rate is the marginal output. In this section, the marginal output is declining from 6 to 0.
3. The last segment is where the maize yield starts to decline from 37 bags to 34 bags.

Farmers must choose the right amount to produce based on the second segment. This is the segment where maximum profit can be attained. To be more specific, the farmer should produce 31 bags of maize using 8 bags of fertilizer in order to attain maximize profit of K38,000.00. If the farmer produces 37 bags of maize using 11 bags of fertilizer, he only makes a profit of K16,000.00.

Unit Summary

Farming as a business is about making right decisions. Right decisions form the basis for profit maximisation. There are economic principles which farmers must use when making decisions concerning their operations. These are opportunity cost, comparative advantage, input substitution and the law of diminishing marginal return.

Glossary

Opportunity cost: The value of the foregone alternative
Return on investment: Profit

Review Questions

1. Define the following terms:
   - Comparative advantage
   - Marginal return
   - Economic optimum point
2. Explain how farmers can use the following to increase profits on a farm
   - opportunity cost
   - law of diminishing marginal return
3. From table 2 above, explain why it is not maximum return that gives maximum profit.

Review Questions

1. http://en.wikipedia.org/wiki/Comparative_advantage (04/10/2014)

2. http://en.wikipedia.org/wiki/Opportunity_cost

3. http://en.wikipedia.org/wiki/Diminishing_returns

4. http://www.agriculturesnetwork.org/magazines/global/changing-farming-practices/input-su

5. Kanjala B.M. and Kaperemera N.T. (2002): *Strides in Agriculture Book 3,* Blantyre: Longman Malawi (Pty) Ltd

6. Ngugi D.N. Karau P.K. and Nguyo W. (1990): *East African Agriculture, A Textbook for Secondary schools, Third Edition.* Nairobi: Macillan Education

Unit 7

Enterprise Combinations

In the previous unit, you learnt that it necessary for farmers to decide on what to produce. You have seen farmers in your area producing a wide variety of crops and animals on the same farm. This is enterprise combination because the farmer is producing different crops and animals. In this unit, you will learn what farmers consider when choosing enterprises to combine and also the types of enterprise combinations which can exist on a farm.

Outlining factors to be considered when selecting enterprise combinations

Many farmers, (subsistent or commercial), combine enterprises. Have you ever thought of why they do this?

Activity 1

Outlining factors considered by farmers when combining enterprises

Procedure

- Visit a nearby farm
- Find out from the farmer what s/he considered when choosing the enterprises for the farm
- Present your findings to the class during plenary session
- Discuss your findings with your teacher
- Your teacher will consolidate the factors considered by farmers when combining enterprises

There are many factors farmers consider when combining enterprises. Most important of these are the following:

1. **Profitability of the enterprise:** In trying to maximize profit, farmers choose those enterprises whose total profit can be significantly high.

2. **The farmer's food requirements:** Most farmers in Malawi produce for consumption. It is the excess which they may sell for money. In this connection, a farmer can choose those enterprises which bring sufficient balanced food for the family. Most families in Malawi believe that "Kulemera ndi kudya", which literally means the rich, are those that have food on their table.

3. **Resource availability:** Success of every enterprise depends on availability of production resources in right amounts and at the right time. The major production resources which must be available are land, labour, capital and management. There resources are explained below:

i. Land: This resource determines the size of an enterprise. It also determines how many enterprises can be combined successfully. Type of land (in terms of slope, soil type) can also determine type of enterprises a farmer can venture into.

ii.Labour: This is the amount of work done by humans. Families which depend on family labour cannot successfully run a combination of many enterprises even if they may have adequate land.

There are instances when a farmer combines two or more enterprises and the enterprises are competing for labour. A farmer needs to establish a labour profile. This is an outline of labour requirements for each of the enterprises so that the farmer can know how much labour is needed during the whole production period.

Activity 2

Drawing a labour profile

Procedure

- Form groups of at least 5 members.
- Use the instructions and data provided below.
  Suppose a farmer wants to grow maize, groundnuts and tobacco. He has a labour supply of 250 man days on the farm. Below is table 5 showing labour requirements in man days for each enterprise.

Crop	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Maize	20	0	10	30	60	80	60	30	20	10	90	80
G/nuts	60	20	0	30	80	60	60	40	40	90	80	80
Tobacco	30	40	60	60	120	130	110	80	140	120	100	80

- Draw a bar chart using the data in table 5 above to show a labour profile for the three enterprises. Your teacher shall provide you with a chart paper.
- One member of your group should present your work to the whole class.
- Discuss the labour profile with your teacher.
- Your teacher will consolidate the labour profile.

Many farmers, (subsistent or commercial) combine enterprises. Have you ever thought of why they do this?

Assessment for learning

- Identify the months in which the labour supply was lower than labour requirement.
- Suggest a name which is given to the period when labour requirement is higher than labour supply.
- How can such months be dealt with so that the enterprises continue to receive the attention they deserve?
- Identify the months in which labour supply is higher than labour requirement.
- What name is given to the period whose labour requirement is lower than labour supply?
- How can excess labour be dealt with on a farm?

iii. Capital: This is a term used to describe live and non-living stock on the farm used for production. It also includes money for everyday running of the business. Capital is what is used to start a business with and indeed for its everyday running. Since capital is always scarce, it is important for farmers to use it economically.

iv. Management: This is a skill inherent in the farmer to assist in decision making. The farmer must have sound managerial skills in order to decide on the most economic enterprise combinations and how well the other resources can best be put into use.

4. Nature of enterprises: Enterprises fall into three major types.
   i. Competitive enterprises: These compete for production resources
   ii. Supplementary enterprises: One is the main enterprise while the other is just an additional one.
   iii. Complementary enterprises: The two enterprises help each other

5. Opportunity cost: This is a foregone alternative. A farmer would want to reduce this foregone alternative as much as possible. As a result it would be necessary to combine those enterprises which are not competitive.

6. Comparative advantage: This is a principle in which a farmer chooses those enterprises which perform very well in that area. This ensure high productivity and profit maximisation.

7. Risks and uncertainties: These words are at times used interchangeably as if they mean the same. However, they are different. A risk is a situation in which it is possible to predict its outcome. Those who take risks are aware of possible outcomes which are generally bad but in case they succeed, the result is more rewarding than when it is avoided. Usually,

high risk enterprises are most rewarding – high risk high returns. For example, tobacco is a high risk enterprise. It is purely commercial faced with possible unpredictable price fluctuations, bad weather such as wind, hailstorms, fire and diseases. When all is well, farmers make a lot of money.

Uncertainty is a bad situation of not knowing what will happen in the future. No one knows whether or not there is going to be favourable weather condition in a particular growing season; and yet farmers start investing way before the onset of the rainy season.

A risk is predictable while uncertainty is not. One can insure against a risk but not uncertainty.

How to safeguard against risks and uncertainty

i. Diversification: venturing into several enterprises with the hope that not all of them can fail.

ii. Choosing enterprises which are of low risk

iii. Buying an insurance cover so that when the enterprise fails beyond the farmer's control, the insurance company can compensate

iv. Input substitution so that the farmer does not invest a lot into inputs. For example, use of locally prepared feeds rather than using commercially prepared ones; or use of manure rather than organic fertilizers which are generally very expensive

v. Flexibility in methods of production. Farmers are advised to use capital items which can easily be turned for a different enterprise.

8. The farmer's ability: This has to do skills in managing the enterprise. For example, although tobacco is a high paying enterprise some farmers are not interested in it because they do not have the skills. Some farmers choose easily managed enterprises although their profits are low.

Explaining Types of Enterprise Combinations

You have learnt the factors which farmers consider when combining enterprises. Based on the reasons for combining the enterprises, three types of enterprise combinations exist.

Activity 3

Explaining types of Enterprise Combinations

Procedure

- Form groups of at least five members
- Use your library or internet to research on the three types of enterprise combinations.
- Explain the types of enterprise combinations.
- Present your findings to the whole class during plenary session.
- Discuss the types of enterprise combinations with your teacher.
- Your teacher will summarise the types of enterprise combinations for you.

Enterprises fall into three major types.

i. **Competitive enterprises:** These are enterprises which compete for resources. In fact, most enterprises fall into this group. When increase in one enterprise causes a decrease in the other, it means that these are competitive enterprises. For example: If a farmer has four hectares of land; and he wants to combine maize and forestry, it means that if he decides to increase maize enterprise, he must reduce land for the trees.

ii. **Supplementary enterprises: T**hese enterprises do not compete for resources. In fact they at times support each other. One of the enterprises is the main one while the other is there as just an additional one. For example, maize grown together with beans. The beans support maize with nitrogen which it fixes while the maize provide the beans with support. The farmer does not need to reduce size of maize enterprise in order to introduce or expand the beans enterprise.

iii. **Complementary enterprises:** These are enterprises which are combined specifically to assist one another. The example given above explains a complementary relationship. Another example can be ducks and fish raised in a pond. Ducks provide manure to the pond while fish meal can be fed to the ducks.

Unit Summary

Many farmers diversify enterprises. Farmers have to consider a number of factors when deciding on the type of enterprises to combine. Some of them are profitability, farmers' food requirement, management skill and nature of the enterprises among many more factors.

The idea behind enterprise combination is to maximise profit.

Farmers must therefore understand that there are different types of enterprises depending on their nature. Some compete for resources, while others supplement each and there are yet others which complement each other. Competitive enterprises need a deep thought before they are chosen because they are associated with opportunity cost. As the other enterprise increases, the other decreases, thereby foregoing an income.

Glossary

Risk: A bad situation with full information which denotes the difference between expectation and real outcome.

Uncertainty: A bad situation with less than full information whose outcome cannot be predicted

Opportunity cost: This is a foregone alternative

Unit Review Questions

i. Define the term complementary enterprise.
ii. Outline factors to consider when choosing an enterprise.
iii. Describe how labour can affect enterprise productivity.
iv. Explain how the factors outlined above affect the choice of an enterprise.
v. Explain the difference between labour supply and labour requirement.

References

i. Barnard C.S, Nix J.S. (2011): *Farm Planning and Control, Second Edition,* Cambridge: University Press
ii. Kanjala BM and Kaperemera NT (2002): *Strides in Agriculture Book 3,* Blantyre: Longman Malawi (Pty) Ltd
iii. Chard P.G.D (1995): *Focus on "O" Level Agriculture Book 4,* The College London: Press (Pvt) Ltd
iv. Ngugi D.N Karau P.K and Nguyo W. (1990): *East African Agriculture, A Textbook for secondary schools, Third Edition.* Nairobi Kenya

Unit 8

Agricultural Cooperatives

Individual farmers are often faced with challenges ranging from inadequate capital, difficulties in marketing of their agricultural produce and access to loans in order to expand their businesses. To address this problems, farmers come together to form cooperatives. These are members, who share common interests, are willing to pull their resources together and derive much economic benefit from interests. This avoids middlemen taking advantage of smallholder farmers who are generally illiterate and do not have a financial muscle.

Importance of Agricultural Cooperatives

By choice, individual farmers join agricultural cooperatives. They have their own goals to achieve. What is the importance of agricultural cooperatives?

Activity 1

Explaining importance of agricultural cooperatives

Procedure

- Brainstorm the meaning of the term agricultural cooperatives.
- Discuss with your teacher the meaning of the term agricultural cooperative.
- In groups, Research from your school library and the internet or from a nearby agricultural cooperative in your area on the importance of agricultural cooperative.
- Visiting an agricultural cooperative to observe its activities.
- Report your findings to the whole class.
- Discuss the importance of agricultural cooperatives with your teacher.
- Your teacher summarise for you the importance of agricultural cooperatives.

An agricultural cooperative is a group of farmers who come together on voluntary basis for the purpose of achieving a common goal for mutual economic benefit. In general, agricultural cooperatives are very important to farmers because of the following:

i. Cooperative societies help to reduce marketing costs for small scale farmers. By collecting small amounts of produce from individual farmers and bulking the produce into larger quantities for processing or transport, they lower per unit costs of processing or

transportation and enable farmers to benefit from markets which would otherwise be inaccessible to individual farmers.

ii. Cooperatives also help in the procurement of various inputs farmers need for the production of crops and livestock products. They pull their resources together and be able to access large quantities of inputs more cheaply than would be individually.

iii. They have a stronger price bargaining power. As a group, they form a strong monopoly and become price makers rather than being price takers when they operate as individuals.

iv. They are more credit worthy as a cooperative because the group serves as a security. Most individual farmers do not have collateral for loans. This makes it difficult for them to access loans needed to expand or increase their agricultural productivity.

Principles for Formation of Agricultural Cooperatives

An agricultural cooperative is a group of farmers who come together on voluntary basis for the purpose of achieving a common goal for mutual economic benefit.

Activity 2

Identifying principles for agricultural cooperative formation

Procedure

- Visit a nearby agricultural cooperative
- Research on how the agricultural cooperative was formed
- Record your findings
- Present the findings to the class during plenary session
- Discuss the principles for agricultural cooperative formation with your teacher
- Your teacher will summarise the principles for you

When a group of people have agreed that they form a cooperative, they abide by the following:

- A cooperative should be legally constituted with guiding rules and regulations.
- Participation is free, people are free to join or withdraw.
- tCooperatives should be impartial, non-partisan and non-religious.
- The cooperative must be efficiently and effectively organised
- It must be open to all farmers who share a common interest.

- The cooperative should have enough capital/funds
- Cooperatives are organised and run according to democratic principles (one person, one vote)
- A cooperative must continually educate its members to improve their productivity and marketing skills
- Members managing the funds are skilled, trustworthy and highly motivated
- All members are committed to the cooperative and its success
- The cooperative should have adequate infrastructure (staff houses, offices, storage facilities), personnel, transport, equipment and supplies.
- Should join from the local to the national level

- It must follow the legal procedures of forming and registering a cooperative as follows:
  - Minimum number of eligible persons to form a cooperative being ten
  - Elect an interim committee
  - Draft the cooperative's rules and by-laws (constitution)
  - Articulate the objectives of the cooperative
  - Suggest a name for the cooperative.
  - Apply for registration to the relevant agricultural authorities.

There are different types of farmer cooperatives depending on the membership and purpose for its setup. Most commonly they include:

- Farm production cooperatives
- Marketing cooperatives
- Consumer cooperatives
- Savings and credit cooperatives

Farm production cooperatives

They deal with the production of particular crops and livestock keeping. Members work on the farm as a group. At the end of the production and marketing, the members share the profit. Farm production cooperatives are able to exploit the economies of scale through large –scale production.

Marketing cooperatives

They assemble, process, and sell farm produce. Individual farmers carry out the production and bring their produce together so as to transport and process as a group. In this way operation costs are reduced. An example in Malawi is the National Small Holders Farmers Association of Malawi (NASFAM).

Consumer cooperatives

They deal primarily with farm inputs. They buy inputs in bulk and then sell

to members at subsidised prices. They may also offer marketing services to their members.

Savings and credit cooperatives (SACCO)

They encourage their members to save their earnings and later provide them with loan facilities. The given loan is always proportional to the savings one has made but a low interest rate is paid as compared to the commercial banks. In general, most cooperative societies also offer savings and credit services. In Malawi, there are many SACCOs registered under Malawi Union of Savings and Credit Co-operative Organization (MUSCCO), the umbrella body for all SACCO.

Explain Challenges of Running Agricultural Cooperatives

Activity 3

Explain Challenges of Running Agricultural Cooperatives

Procedure

1. Brainstorm the challenges of running agricultural cooperatives.
2. Discuss the challenges of running agricultural cooperatives with your teacher.
3. Your teacher will summarise the challenges of running agricultural cooperatives.

The challenges are many

i. Lack of loyalty to the cooperative. This occurs when members fail to abide by their own rules and regulations especially on issues of repayment of loans. Some members deliberately do not want to pay back loans. This brings quarrels and divisions within the cooperative

ii. Misuse of funds by executive members. This is a serious issue because members of the executive need to be trustworthy.

iii. Lack of sound economic base of the cooperative which makes it impossible for members to obtain loans and other benefits. Members have very high expectations from the cooperative; as a result of this they lose confidence when their needs are not met.

iv. Lack of knowledge about the rights and obligations of members. When members do not have adequate education on their rights and obligations, they get frustrated when they don't get what they think are their entitlements.

Solutions to The Challenges Faced in Running Agricultural Cooperatives

Agricultural cooperatives have a very important role in improving agricultural production by smallholder farmers in Malawi. Despite the challenges being faced, there is still need to encourage their existence.

Activity 4

Describing solutions to the challenges faced in running agricultural cooperatives

Procedure

- In groups of two suggest solutions to the challenges faced in running agricultural cooperatives
- Present your suggestions to the class
- Discuss the solutions with your teacher
- Your teacher should summarise the solutions to the challenges

For the cooperatives to be successful, it is vital to ensure that challenges are minimised.

1. Lack of loyalty to the cooperative can be solved through advocacy.Members must learn to believe that the cooperative is their own and they cannot afford to see it fail since its failure is their failure. Education about cooperatives can best solve this problem.

2. Misuse of funds by executive members. This can be checked through putting in place mechanisms of transparency. Members should be able to monitor what is going on in the cooperative.

3. Lack of sound economic base can be solved through ensuring that members meet their subscriptions and high financial prudence by the executive. Some cooperatives especially those that deal with production close up because they fail to pay utility bills. This is a good example of lack of financial prudence which eventually erodes the entire economic base for the cooperative.

4. Lack of knowledge about the rights and obligations of the members. This can be solved through orientation. Members must be oriented on their rights and their roles. Each member must be given a copy of these rights and obligation so that they can recite when need arises.

Unit Summary

An agricultural cooperative is a group of farmers who come together on voluntary basis for the purpose of achieving a common goal for mutual economic benefit.

They come together to leverage on issues of input procurement, access to loans and determination of prices for their commodities. Misunderstandings may arise when management of the cooperative by the executive is compromised with personal interests. The executive and the general membership should take the cooperative as a personal organisation so that it can be sustained for their benefit. Otherwise cooperatives have collapsed and failed to meet their intended purposes.

Unit Review Exercise

1.Define an 'agricultural cooperative'.
2.What factors contribute to the success of the cooperative?
3.Outline the benefits farmers get by being a member of an agricultural cooperative.
4.Name two types of cooperatives.

Reference

1.http://en.wikipedia.org/wiki/Agricultural_cooperative (02/10/2014)
2.http://www.wfo-oma.com/documents/agricultural-cooperatives.htm (02/10/2014).
3.Ngomwa M. Anthony et.al, (2012) *Excel and Succeed Senior Secondary Agriculture Form 4.* Lilongwe Grey matter. Longhorn Publishers.
4.Ngugi D.N., Karau P.K., Nguyo W. (1990) *East African Agriculture Third Edition (1990).* Nairobi Macmillan Publishers.
5.Kanjala B.M, Kaperemera N.T (2002) *Strides Agriculture Book 4.* Longman Malawi. Thirteenth impression 2011.

Unit 9

Vegetative Planting Materials

Living things must multiply in order to maintain their species. In your Biology lessons, you learnt that living things reproduce sexually and asexually. Crops, like any other living thing, reproduce using sexual and asexual methods. In sexual reproduction of crops, true seeds are used to raise the new offspring. However, some crops are raised by planting parts of the old plant. These are vegetative planting materials. In this unit, you will learn about the vegetative planting materials which farmers can use, names of the parts of the vegetative planting materials, advantages and disadvantages of vegetative planting materials.

Listing Vegetative Planting Materials

There are many crops which cannot be raised using true seeds. However, these crops must also multiply so that they do not become extinct.

Activity 1

Listing Vegetative Planting Materials

Procedure

- Break into your groups.
- Brainstorm the various crops which are planted by using parts of the old plant.
- List the names of the vegetative planting materials these plants use for their reproduction.
- Present your findings to the class during plenary session.
- Discuss the vegetative planting materials with your teacher.
- Your teacher will consolidate the vegetative planting materials.

You might have seen that there are many crops which are propagated using parts of the old plant. The table 17 below shows crops and the type of vegetative planting material that is used.

Vegetative planting material used	Name of crop(s) planted by the vegetative planting material
Stems	Sugarcane, cassava
Leaves	Cactus and some flowers
Suckers	Banana
Tubers	Irish potato
Bulbs	Onion
Corms	Cocoyam
Rhizomes	Star grass
Runners	Sweet potato, straw berry, star grass

Table 17

Table 17 showing vegetative planting materials

Production of new individuals along a leaf margin of the air plant, **Kalanchoe pinnata.**

Figure 9.1 : Examples of air plant

Bryophyllum daigremontianum produces plantlets along the margins of its leaves. When they are mature enough, they drop off and root in any suitable soil beneath.

Labeling Parts of Vegetative Planting Materials

The vegetative planting materials must have certain parts to ensure growth. Not every part of the vegetative plant can grow into a new plant. In this section, you must identify those parts of a plant which are very important in the growth of a new plant.

Activity 2

Identifying and labeling parts of the vegetative planting materials

Procedure

- Form groups of at least five members.
- Obtain from your environment as many plants as possible which are planted by vegetative planting materials.
- Identify the parts of vegetative planting materials which are important for growth of a new plant.
- Draw the vegetative planting material.
- Label the parts of the vegetative planting material
- Present your findings to the class.
- Discuss your findings with your teacher.
- Your teacher shall summarise the parts of the vegetative planting materials.

I am sure you carried out a very good research

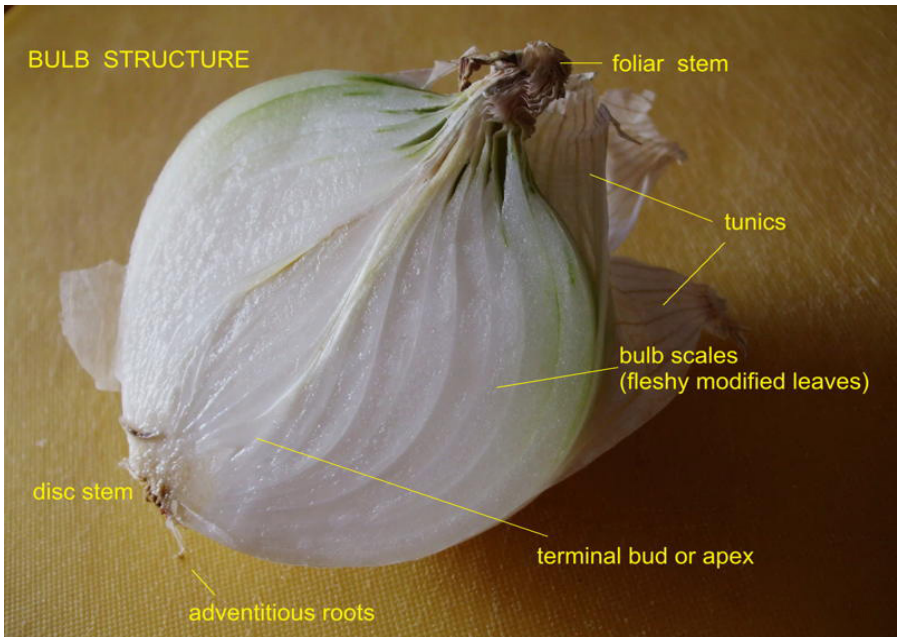


Figure 9.2

Explaining the advantages of vegetative planting materials

Did you know that sugarcane produces seeds and yet farmers do not use them? Instead, they use stems. Have you tried to think about why farmers do this?

Activity 3

Identifying and labeling parts of the vegetative planting materials

Procedure

- Brainstorm the advantages of vegetative planting materials.
- Discuss these advantages with your teacher.
- Your teacher shall consolidate the advantages of using vegetative planting materials.

Vegetative planting materials use parts of the old plant. This method of propagation is called asexual propagation. Advantages of this type of propagation are:

- The vegetative planting materials are readily available to farmers from the previous crop. In case they have to be obtained from another supplier, they are relatively cheap.
- The vegetative planting materials have enough food reserves that can be used to sustain growth of the new plant. This increases survival rate of the new plants.
- The method ensures genetic uniformity as such the offspring resembles the parent plant. This becomes an advantage in situations where the parent plant was superior in terms of traits such as high yielding, disease and pest resistance.
- The vegetative planting materials are not subjected to dormancy as is the case with some seeds such as tomatoes which must be dried first before they can germinate.
- They provide the only way of propagating crops whose seeds do not germinate or do not breed true.
- Plants propagated by this method grow faster and mature earlier than those established using "seeds". This is because of the large amount of food reserves the vegetative planting materials have.

Explaining disadvantages of vegetative planting materials

Activity 4

Explaining the disadvantages of using vegetative planting materials

Procedure

- Brainstorm the disadvantages of vegetative planting materials.
- Discuss these disadvantages with your teacher.
- Your teacher shall consolidate the disadvantages of using vegetative planting materials.

Disadvantages of vegetative planting materials

- They cannot be stored over a very long period as is the case with "seeds" because they can wilt and eventually die.
- They are usually bulky and therefore difficult to transport over a long distance
- They need to be handled with care during transportation otherwise the growing points can easily be destroyed.
- There is a very high risk of transferring diseases from the parent plant to the new plants.
- It is difficult to introduce variation into the crop. As a result crop improvement becomes difficult.

Unit Summary

Use of vegetative planting materials has given an opportunity to plants which do not produce true seeds to multiply as well. Many crops such as onions, sugarcane, most grass pastures, potatoes, cassava and many more are propagated in this way. It would have been difficult for them to perpetuate their species if they did not use vegetative materials for reproduction. It has been found out that plants propagated in this way have higher chances of survival than those that use true seeds because of the large quantities of food reserves they have. However, it is very difficult to introduce superior variations in these crops.

Glossary

Suckers: These are shoots which arise from the axillary bud at the base of a parent plant. They can be uprooted and planted elsewhere

Corms: They are enlarged base of an underground stem which stores food

Rhizomes: Thick, horizontal underground stem. They contain buds from which new shoots and roots grow

Tuber: A stem tuber is an underground swollen portion of the plant which acts as a food storage organ, such as irish potato

Runners: They are stems that grow horizontally on the ground with internodes from which new shoots and roots can grow

Unit Review Questions

1. Mention the vegetative planting materials farmers can use for propagation
2. Draw a well labeled diagram of the vegetative planting materials mentioned in question 1 above.
3. Explain the advantages and disadvantages of propagating crops by using vegetative planting materials.

References

1. http://en.wikipedia.org/wiki/Vegetative_reproduction (03/10/2014)
2. Ngomwa Anthony M., Sigei Peter and Cheuiyot Daniel (2012): *Senior Secondary Agriculture Form 3,* Longhorn Publishers
3. Kanjala BM and Kaperemera NT (2002): *Strides in Agriculture Book 3,* Longman Malawi (Pty) Ltd
4. Owen G.H. (1998): *O-Level Agriculture, Longman Group Limited*
5. Ngugi DN, Karau PK and Nguyo W (1990): *East African Agriculture, A Textbook for secondary schools, Third Edition*

Unit 10

Cropping Systems

In unit 7 you learnt that farmers raise different types of crops and animals. This was referred to as enterprise combination. In this unit you will learn how crops can be grown on the same piece of land. The arrangement of different crops on the same piece of land during the same crop growing season is called cropping system.

Outlining Cropping Systems

Different crops can be arranged on the same piece of land differently by different farmers depending on their needs. You may recall that farmers in the villages can grow many crops on the same of piece of land during the same crop growing season. This is an example of a cropping system; but it has a special name. In this section, you will list names of different cropping systems which farmers can use on their fields.

Activity 1

Outlining cropping systems

Procedure

- Brainstorm the meaning of "cropping system"
- In your groups, research from your school library or anywhere the different cropping systems which exist
- Present your findings to the rest of the class
- Discuss your findings with your teacher
- Your teacher should consolidate the cropping systems

Cropping system which are practiced by farmers are:

a. Monoculture.
b. Monocropping.
c. Continuous cropping.
d. Mixed cropping.
e. Crop rotation.
f. Bush fallowing.
g. Shifting cultivation.
h. Organic farming.
i. Agroforestry.

Analysing Activities Involved in the Cropping Systems

The cropping systems you listed above are significantly different from each other depending on how they are carried out. This section will look into the activities which are involved in each cropping system.

Activity 2

Analysing activities in the cropping system

Procedure

- In your groups carry out a book research on activities involved in each of the cropping systems listed above.
- Record your findings.
- One member of every group should present your findings to the class during plenary session.
- Discuss these findings with your teacher.
- Your teacher will help you summarise the activities of each cropping system.

There are many cropping systems which farmers practice as they grow their crops. These cropping systems are:

a. Monoculture

Here the farmer grows every crop on its own plot. The farmer can grow many different crops but they are grown separately on what is called pure stand.

b. Monocropping

In monocropping, a farmer solely grows one crop on the farm and nothing else. While in monoculture a farmer can grow several crops but on pure stand, here the famer grows only one crop throughout the whole crop growing season. Tea estates are a very good example of monoculture; but this can also apply even to annual crops such as maize, groundnuts, beans and the like as long as the farmer grows entirely one crop in the crop growing season.

c. Continuous cropping

This is a system of growing crops on a piece of land every year without fallowing (allowing the land to rest). Most farmers in our villages practice this type of cropping system because they do not give time for their fields to rest and regain fertility. This is because most farmers do not have large land holding for fallowing.

d. Mixed cropping

This means growing different crops on the same plot during the same crop growing season. Farmers can grow maize together with beans or maize together with groundnuts planted between the maize stations. The system maximises land use.

Fig. 10.1 Example of mixed cropping

Forms of mixed cropping

1.Mixed intercropping

Crops are mixed up together without any pattern in the field. Crops grown in this way are those that are planted by broadcasting.

2.Row intercropping

Different crops are grown on the same ridge. Here it can either mean planting the two or more crops on the same planting station or planting the other crop between planting stations of the main crop. For example, soya beans can be planted between maize planting stations.

Fig. 10.2 An example of row intercropping

3.Relay intercropping

The farmer first plants the main crop on the field. As the main crop is about to mature another crop is planted on the same field. The practice is successful where the rainy season is longer than required by the first crop. This is common with maize and beans. As the maize is about to mature, the furrows are prepared for the next crop. The maize leaves are removed to allow sunlight penetrates to the second crop. The maize is then harvested when it dries up completely.

Fig. 10.3 An example of relay intercropping

This system is called relay because there is a time when the two crops are allowed to grow at the same time after which the first one is harvested to

leave the land to the send crop. Think of how relay race operates! The second runner starts running but slowly as the first one is approaching.

e. Crop rotation

It is a practice of growing different crops which have significantly different growing habits and nutrient requirements in an orderly sequence on the same piece of land every year. In practice, farmers must choose properly the type of crops to be included in the rotation so that its objective of maintaining soil fertility and productivity is achieved.

When planning a rotation, there are some guidelines which must be followed.

- Crops with high nutrient requirement should come first in the newly cultivated land so that they can take advantage of the high soil fertility already existing in the field.

- Deep rooted plants should alternate with shallow rooted plants. This ensures that the deep rooters absorb nutrients from the deep soil horizon and bring them to the top horizon for the shallow rooters to use.

- Crops that suffer from the same diseases and pests should not follow each other in order to break their life cycle.

- In trying to control weeds, crops which are difficult to weed for example wheat (because they are grown too closely) should be followed by those that are easy to weed.

- At the end of the rotational program, the land should be allowed to rest so that the soil can rebuild its fertility through control of diseases and pests and increasing of organic matter.

Plot	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Maize					
2	Groundnuts					
3	Cotton					
4	Millet					
5	Tobacco					
6	Cassava					

Table 18

An example of a rotation

Complete the rotational program in the table 18 above so that they follow the pattern you see in table 19 below?

Maize →	Groundnuts →	Cotton ↓
Cassava ←	Tobacco ←	Millet

Table 19 Crops rotating in a six year rotational program

Fig.10.4 Land left to generate bush

f. Bush fallowing

To fallow means to rest without being planted with a crop. In this cropping system, a farmer leaves a piece of land when yield starts to decline so that it can regain fertility before she comes back again. The land is left bare and is subject to high risk of erosion. In some cases the famer may plant cassava and go away to another land.

g. Shifting cultivation

This is a cropping system where land is cultivated for several years until the crop yield starts to decline. The farmer then shifts to start farming on another land. The practice is best practiced in areas which are scarcely populated and a lot of land stays idol. This is why it is possible for the farmers to shift from one land to another.

The land which is left is under fallow. As population increases, land for shifting cultivation declines, as a result, the farmer may come back to claim all the plots left behind although not at the same time. Today shifting cultivation is not practiced in this country because of land scarcity.

h.Organic farming

It is a cropping system where crops are grown using organic inputs such as manure (organic fertilizer) rather than inorganic inputs like commercial fertilizers. Pests, diseases and weeds are not controlled by chemicals but by ecologically friendly methods such as cultural, biological and physical methods. The aim is to ensure that the environment is not polluted by the inorganic chemicals that are used to fertilize the soil and to control pests, diseases and weeds. As a result of this organic farming is also referred to as eco-farming (ecological farming) or biological farming.

i.Agroforestry

This is a cropping system in which agronomic crops are grown in association with forest trees. The trees are planted in such a way that they leave a sizeable strip of land where the agronomic crops are grown. They are best planted in east-west direction so that sunlight can still reach the field crops. Most common trees which are incorporated in agroforestry are leguminous trees used as livestock feeds such as Leucaena, Sesbania sesban (locally known as jerejere).

Forms of agroforestry

1. Agrosilviculture

What does "agro" mean? What about "**silviculture**"?

The word agrosilviculture is made up of two words – "agro" which means field crops, while "silviculture" means growing trees and shrubs. Agrosilviculture is the practice of growing of field crops and trees, shrubs together on the same piece of land. It involves planting rows of field crops to be followed by rows of trees. The spacing of the rows should be large enough to allow the crops access the sunlight.

Fig.10.5. Field crops and trees

2. Silvopastoral

Trees are grown in association with pasture. The word is derived from silviculture and pastoral. Pastoral means rearing animals. Farmers can grow forest trees or fruit trees together with the pasture. What it is required is that the trees should give sufficient space for the pasture to receive sunlight. 8 – 20 meters space for trees before the next strip of pasture can be enough

Fig.10.7.

3. Agrosilvopastoral

Agronomic crops, pasture and trees or shrubs are grown together.

Activity 3

Explaining advantages of each cropping system

Procedure

- Form nine groups.
- Each group should choose a leader to serve as a host.
- The rest of the members shall serve as customers.
- Each group should have a flip chart on which to write the advantages
- With the use of eatery method, explain advantages of the cropping systems.
- Record all the advantages raised by the customers on the flip chart.
- The host should present the advantages to the rest of the class during a plenary session.
- Discuss these advantages with your teacher.
- Your teacher shall summarise the advantages of each cropping system.

Explaining the advantages of each cropping system

As you have already noticed the different activities involved in the different cropping system, I hope that you have already noted some positive contributions of each cropping system.

In your activity, I am sure that you came up with the following advantages

a. Monoculture

- It is easy to determine the right quantities of inputs such as fertilizer, pesticides and herbicides because they all land on the intended plant.
- Possible competition for crop growing resources such as sunlight, nutrients and water is reduced.
- It is easy to mechanise operations in the field. For example planting, weeding and harvesting can easily be done in crops which are planted on pure stand.

b. Monocropping

- It reduces the cost of start-up capital because the farmer invests in one crop only.
- The farmers specialise in the management of the crop; and as a result, it becomes very easy to perform the operations with precision.
- As a result of the farmer's specialisation, crop productivity increases. The farmer knows what to do and when because s/he has grown the crop several times before.
- The farmer makes a lot of profit since s/he enjoys economy of scale because monocropping is usually associated with large scale farming.

- It is easy to mechanise farm operations because the farmer grows one crop only which needs its special type of machinery.

c. Continuous cropping

- Since the land is not given time to rest, there is maximum land utilisation and the entire land contributes to economic returns for the farmer. There is no land which remains idle.
- With proper crop management, the system contributes to the farmer maximum returns in terms of money and or food because the whole land is put into use.

d. Mixed cropping

- It insures against total failure through diversification since not all the crops are going to succumb to adverse weather conditions or poor prices equally.
- Where legumes are included the system increases soil fertility through nitrogen fixation by the legume.
- There is high total yield per unit area of land. The sum of the two or more crops gives a higher total yield than when one crop is grown on pure stand.
- The mixture of different crops on the same land increases plant population which in turn covers up the whole field and controls soil erosion.
- A farmer is self-sufficient in food because he can grow all the food crops needed by his household.
- It is possible for farmers with small land holdings to grow a wide variety of crops from the same piece of land.
- It helps to control pests and diseases because some of the crops serve as trap crops, meaning instead of the disease or pest to attack crop "A" the pest attacks the other crop.

e. Crop rotation

- It improves soil fertility. This occurs when legumes are included in the rotational program. The legumes fix nitrogen into the soil which can be used by itself and the non-legume growing in association with each other.
- There is maximum utilisation of nutrients in the soil when deep rooters are rotated with deep rooted crops. The shallow rooted crop extracts nutrients from the top soil horizon. In the process some of the nutrients may leach down. When a deep rooted crop comes in, it will use the nutrients which leached.

- It controls pests and diseases. There are some pests such as nematodes (eelworms) which attack tobacco, cabbage. These are best controlled by rotation because the practice replaces the susceptible (favourable) host (tobacco/cabbage) for the nematode with a non-susceptible host.

- It controls weeds. This is done like this:

- When crops which are difficult to weed are replaced by crops which are easy to weed. Weed build up in the field is reduced
- Witch weed, a parasitic weed to plants of the grass family, can be controlled if crops of the grass family are replaced by crops from a different family. In so doing, this parasitic weed has no host from which to survive.

- Since crop rotation involves growing of many crops, it ensures maximum utilisation of labour during the growing season. As a result, possible trough months which are characterised by less work on the field can easily be dealt with.

f. Bush fallowing

It helps to control soil erosion. During the resting period, the field is covered by natural vegetation. This vegetation protects the soil from all agents of soil erosion. The practice may also help to maintain or even improve soil fertility. When the vegetation which grows during the resting period dries up, it gets incorporated into soil to form humus. It is also cheap because generally, it does not require a lot of capital investment. The farmer leaves the land under fallow because the land has lost fertility and it is difficult for him to buy fertilizer.

g. Shifting cultivation

It is cheap because it does not require use of inorganic fertilizers. Weeds and pests are controlled during land clearing. At this time the cleared plant residures are set on fire which in the process kills the pests and weeds as well.

h. Organic farming

It is cheap because farmers do not have to buy fertilizers and pesticides. Water pollution by chemicals such as fertilizers, herbicides and pesticides used in agriculture is controlled. The ecosystem is not also disturbed. The use of chemicals usually kills even beneficial organisms such as nitrogen fixers, pollinating insects, earthworms and the like which makes the world good enough to live in. The use of manure improves soil structure which in turn improves water and air circulation in the soil.

i. Agroforestry

The farmer has a large source of income base. Apart from the agronomic crops, the farmer can also sell tree products like poles, fuel wood, timber. The farmer maximises the use of land resource. Since trees are generally deep rooted, they get their nutrients from the deep horizon and bring them to the surface as their leaves fall and decompose. Where legume trees are used, the system improves soil fertility through nitrogen fixation by the legumes

- The trees help to control soil erosion. Their roots open up the soil and increase water infiltration rate while at the same time their foliage intercepts rain drops before falling to the ground. In turn, they help to conserve water in the soil since apart from increasing water infiltration rate, water loss through evaporation is reduced.
- The trees protect the crops from strong wind.
- Legume trees such as Leucaena and Sesbania sesban are a good animal feed.

Explaining Disadvantages of the Different Cropping Systems

Activity 4

Explaining disadvantages of different cropping systems

Procedure

- Form nine groups.
- Each group should choose a leader to serve as a host.
- The rest of the members shall serve as customers.
- Each group should have a flip chart on which to write the advantages.
- With the use of eatery method, explain disadvantages of the cropping systems.
- Record all the disadvantages raised by the customers on the flip chart.
- The host should present the disadvantages to the rest of the class during a plenary session.
- Discuss these disadvantages with your teacher.
- Your teacher shall summarise the disadvantages of each cropping system.

You were correct if you came up with the following disadvantages of the various cropping systems. Compare them with the following disadvantages:

a. Monoculture

- There is less total yield per unit area as compared with mixed cropping although individually a crop produces a much higher yield when grown on pure stand than in a mixed stand.
- Pests and diseases can spread more rapidly because there are no trap plants in the field which help to trap the diseases as is the case in mixed stand.

b. Monocropping

- The farmer faces a high build-up of pests and diseases in the field because the susceptible host for the pests and diseases are always available in the field. The farmer must make heavy investment in disease and pest

management in order to succeed the fight against them.
- There is much higher risk of total loss in times of crop failure or low market prices than in (monoculture, crop rotation, mixed cropping and agroforestry) because the farmer grows one crop in a whole crop growing season.
- If the farmer grows a non-cover crop, the soil is subject to high risk of soil erosion.
- There is rapid exhaustion of land because the crop uses nutrients from the same soil horizon.

c. Continuous cropping

- There is high risk of soil exhaustion as the crop exploits the same soil horizon and the soil is not given time to rest and rebuild its organic matter content
- High build-up of pests and diseases in the field since the favourable host is available all the time.
- Since the soil loses much of its organic matter because it is not given time to rest, soil structure is destroyed.

d. Mixed cropping

- It is difficult to determine right quantities of inputs such as fertilizer and pesticides. The farmer either ends up applying more than required or less than required.
- It is difficult to mechanise operations on the farm because every crop may require its own machine specifications.
- The farmer requires to have a wide range of skills and knowledge for the various crops that are grown on the farm.
- There is need for high start-up capital because every crop may need its own capital investment.
- There is always low yield per unit area because the crops compete for growing resources such as water, nutrients and sunlight.

e. Crop rotation

- It requires a large land holding to carter for all the crops that are included in the rotational program.
- It requires high capital investment on capital inputs for the various crops under the rotation.
- It may not be practical where the farmer intends to use much of the land for his/her most preferred crop because she may end up using the largest piece of land on a less profitable crop.
- Where the rotation is not well planned, it may result in low profitability if some of the crops included in the rotation are of low value or low demand.

f. Bush fallowing

- As the land becomes exhausted, the farmer realises low crop yield
- It cannot be practiced where there is limited land supply because the farmer would not have anywhere to go when the land becomes exhausted
- The farmer does not put long term investment in land management; and as a result the land may be subject to erosion even at the time the land is under use.

g. Shifting cultivation

- Since land clearing is usually done by fire, it destroys beneficial soil organisms, organic matter and the some volatile nutrients such as nitrogen escapes into the air.
- It is not possible in areas where there is high human population and people scramble for land.
- Farmers usually realise low yields from the fields.
- It exposes land to erosion because vast pieces of land are cleared.

h. Organic farming

- Organic inputs are usually slower than the inorganic inputs.
- In case of organic fertilizers, they may not always be readily available for large farms.

i. Agroforestry

- Agronomic crops may not produce high yield because of shading from the trees.
- It cannot be practiced where land is scarce to carter for both trees and the field crops.
- There is high labour demand as the trees may need regular pruning to ensure that there is limited shade in the field of crops.

Describing Cropping Systems which can Promote Crop Yields

Farmers use these different cropping systems because of different reasons. However, some of them promote crop yields while others do not. In this section you will choose and describe the cropping systems which can promote crop yields.

Activity 5

Describing those cropping systems which can promote crop yield

Procedure

- Break into groups of at least five members.
- Evaluate each cropping system.
- Choose the cropping systems which can promote crop yields.
- Record your findings.

- One member from your group should present your findings to the whole class.
- Discuss these findings with your teacher.
- Your teacher will consolidate the cropping systems which can promote crop yield.

It is becoming evident that Malawi should do everything possible to raise crop productivity so that she can feed itself as well provide enough agricultural raw materials to ensure that agro-industries should flourish and create jobs for the growing population. Although we have so many cropping systems, very few of them can help to promote crop yield.

In the meantime, Malawi emphasise the need to produce enough for consumption. As a result, our local farmers are encouraged to diversify production to meet this need. However, Malawi needs to put an extra gear to promote crop production for export. A careful analysis of what countries in the developed world are doing now is that farmers have specialised in specific crops so that they can develop sufficient skills to promote crop yield. The only cropping system which has achieved this is monocropping. However, monoculture coupled with crop rotation and organic farming are also playing a significant role.

1. Monocropping

Monocropping is the agricultural practice of growing a single crop year after year on the same land. It is economically a very efficient system, allowing for specialisation in equipment and crop production techniques because the operations are carried out by the farmer repeatedly year after year. This is turn increases crop yield. Farmers must choose an enterprise they are highly conversant with and whose capital resources they can afford. They should also adopt the principle of comparative advantage, otherwise the system can flop.

The system has challenges. Monocropping can damage the soil ecology (including depletion or reduction in diversity of soil nutrients) and provide uncushioned advantage for parasitic species, and increasing crop vulnerability to opportunistic insects, plants, and microorganisms. The concentrated presence of a single cultivar, genetically adapted with a single resistance strategy, presents a situation in which an entire crop can be wiped out very quickly by a single opportunistic species. An example of this would be the potato famine of Ireland in 1845–1849, and according to Devlin Kuyek, it is the main cause of the current food crisis with monoculture rice crops failing as the effects of climate change become more acute.

The success of the system is a highly increased dependency on pesticides and

artificial fertilizers.
Monocropping increases crop production because crops grow independently. As a result:

a. It is easy to determine right quantities of inputs such as fertilizer, pesticides
b. It easy to mechanize operations which makes it easy for farmers to finish operations in time but at the same time cultivate large farm holdings from which they can produce highly
c. Crops do not compete for growing resources such as space, nutrients, water, light etc. the result of which is high yield
However, monocropping requires heavy chemical fertilizer application and proper pest and disease management in order to sustain high yield.

2. Monoculture

Monoculture is almost similar to Monocropping in that crops are grown in pure stand the only difference is that in this system farmers grow a wide variety of crops in those pure stands. Because of this diversification, farmers are more secured than in Monocropping. In case of crop failure due to unfavorable environmental conditions, farmers can still survive on the other crops since not all the crops can be affected in the same way.
The system can encourage crop rotation which can help to enrich the soil and control crop diseases. Monoculture can maximise land utilisation in such a way that if the land consists of swampy soil, this can be used for paddy rice production; if there is a hilly land, it can be used for silviculture and so on. The sum of all these enterprises increases very tremendously the amount of crop production by farmers.

3. Organic Farming

Locally available inputs are used for crop production. These are organic manure, cultural methods of controlling weeds, pests and diseases. What this cropping system implies is that farmers do not need high capital investment in order to produce. Everyone interested to grow crops can and the yield is equally high. Since the largest proportion of farmers in Malawi is those that cannot afford inputs, this system therefore brings everyone on board and make those landholdings which are presently failing to produce due to lack of inputs become productive.

Unit Summary

A wide variety of cropping systems are practiced in Malawi. The most common ones are mixed cropping, crop rotation, monocropping and monoculture. To lesser extent some farmers practice agroforestry and organic farming.

Shifting cultivation and bush fallowing systems are becoming extinct because of land shortage. Farmers choose a cropping system they find most suitable for them. Each farming system has its own merits and demerits. Farmers need to be advised as to which cropping systems can promote crop yield to sustain Malawi's ever growing population.

Review Questions

1. List the cropping systems which farmers can adopt when growing crops.
2. Analyse activities involved in any five cropping systems of your choice.
3. Explain why farmers these days are adopting organic farming.
4. Discuss the challenges associated with Monocropping.
5. In your own words analyse the best cropping system you can recommend to farmers as the best in increasing crop yield.

References

1. http://en.wikipedia.org/wiki/Cropping_system (02/10/2014).

2. https://extension.cropsci.illinois.edu/handbook/pdfs/chapter05.pdf (02/10/2014).

3. http://en.wikipedia.org/wiki/Monocropping 02(10/2014).

4. www.fao.org/ag/ca/.../06CROP1.PDF (03/10/2014).

5. Ngomwa A.M., Sigei P. and Cheuiyot D (2012): *Senior Secondary Agriculture Form 3,* Longhorn Publishers. Nairobi

6. Kanjala B.M and Kaperemera N.T. (2002): *Strides in Agriculture Book 3, Longman* Blantyre: Malawi (Pty) Ltd.

7. Owen G.H. (1998): *O-Level Agriculture,* Longman: Longman Group Limited.

8. Ngugi D.N, Karau P.K and Nguyo W. (1990): *East African Agriculture, A Textbook for secondary schools, Third Edition.* Nairobi: Macmillan Education

Unit 11

Mushroom Productions

Since time in memorial mushrooms have been growing wildly in the bush. For many years, the Malawi Nation has depended on naturally growing mushrooms, collected from the forests and gardens only during the rainy season and sometimes in localised areas. Wrong identification of mushrooms has resulted in poisoning hence the need to have cultivated strains that are known and are safe for consumption. As a result, mushrooms have now become a very important crop.

Describing mushrooms

I am sure that you have ever seen mushrooms locally growing in your area. In this lesson you will learn more about parts of a mushroom.

Activity 1

Describing mushrooms

Procedure

- Brainstorm the parts of a mushroom.
- How many types of mushrooms do you know?
- Visit your environment and identify species of local mushrooms.
- Be careful because some wild mushrooms are highly toxic.
- Draw a well labeled diagram of a mushroom.
- Discuss the parts with your teacher.
- Your teacher will consolidate the parts of the mushroom.

Mushrooms are fungi, and a member of the basidiomycetes. Mushroom is a tightly interwoven mass of hyphae. It forms from the fusion of hyphae from two different mating hyphae from two different mating types. Haploid spores are produced on the hyphae lining the gills of the mushroom. A mushroom may produce millions of spores.

Mushrooms are distinguished by their possession of club-shaped reproductive structures called basidia. Many fungi reproduce asexually; most important method of asexual reproduction is the production of spores. It is composed of a hyphae, as are all fungi. There is an extensive mass of hyphae in the soil. The above-ground portion, or fruiting body, of many mushrooms is only a small part of the total plant. Many of the largest and most conspicuous fungi- puff

balls, mushrooms, toadstools are bracket fungi. Typically, the life cycle of a fungus involves a haploid and a diploid stage. The diploid stage is usually very short.

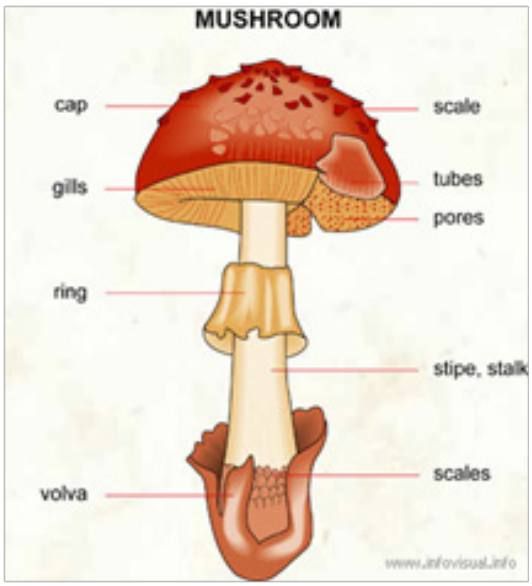


Fig.11.1. Parts of Mushroom

Fig.11.2. Parts of fungus

Discussing parts of a mushroom

- Spores
- Basidium
- Nucleus
- Cross wall
- Hyphae
- Micorrhizae

Identifying Cultivated Species of Mushrooms

The wild mushrooms you obtained from your local environment just grow wildly on their own. Due to high demand for mushrooms, efforts have been made to start cultivating mushrooms so that they can become available all year round.

Activity 2

Identifying cultivated species of mushrooms

Procedure

- Visit a nearby mushroom farm.
- Identify mushroom species being cultivated at the farm.
- Form small groups.
- Using your school library or internet, research on different mushroom species that are cultivated.
- List the cultivated mushroom species.
- Choose the suitable mushroom species for your area.

- Present your findings to the rest of the class during plenary session.
- Discuss these species with your teacher.
- Your teacher will summarise the species of mushrooms.

Two types of mushrooms are grown in Malawi. They are Oyster and Bottom mushrooms.

(a) Oyster Mushrooms

Oyster mushroom (Pleurotus spp) is a relatively new type of mushroom in Malawi and is picking up very well. It is very versatile and relatively easy to grow than button mushrooms because of its low input requirement and nature. Yield levels are very elastic, varying from one substrate to another. The biological efficacy ranges from as low as 20% to as high as 10%. Different species of Pleurotus spp are suited for growing within the temperature ranges of 15^0`C – 30$^0$`C. Pleurotus spp. can be grown on most lignocellulotic agricultural and forestry waste. Most of the substrates require pasteurisation to give economic yields.

Fig.11.3. Oyster Mushrooms

Pleurotus sajor caju, which is highly adaptive, prefers temperatures of between 22^0`C and 24$^0$`C, while Pleurotus ostreatus produces very well at 12^0`C – 20$^0$`C

b) Button mushroom

Two varieties are recommended

i. **TNS 1** which requires a cropping temperature of 16^0`C – 20$^0$`C. It is white in colour and has a potential yield of 15 kg per square meter.

ii. **TNS 2** requires a cropping temperature of 18^0`C – 22$^0$`C. It is bigger than TNS 1. It is white in colour and is scaly with a potential yield of 15kg per

square meter. These temperatures are prevalent between March and July in most parts of the country. Mushrooms therefore can be best grown during these months.

Mushroom picked from the forest are not easy to identify if they are poisonous or not. Go to the forest and identify edible and uneatable mushrooms.

Fig. 11.4 Button mushroom variety

Explaining the Importance of Mushroom Production

You have seen that people in your area eat mushrooms and that they are a popular meal during the rainy season. In this section you should research deeper the importance mushrooms.

Activity 3

Explaining the importance of mushroom production

Procedure

- Brainstorm the importance of mushrooms in your groups
- Present your findings to the rest of the class during plenary session
- Discuss your findings with your teacher
- Your teacher will consolidate the importance of mushrooms

Mushrooms are an important crop in several ways. Most important of all are as follows:

1. They are a source of food, providing proteins, vitamins and minerals which are vital for good health.
2. They are also a good source of income to growers.
3. They are a source of foreign exchange.
4. Mushroom production can assist in diversification and provides a better way of utilising crop, forestry and animal wastes. Mushrooms do not require a large piece of land for cultivation. Production can be done at a time when most agricultural activities have ended. Mushrooms can be grown throughout the year in cool areas but during cool months in warm areas.

Listing the Husbandry Practices for Mushroom Production

From what you have learnt so far about mushroom production, you are slowly becoming mushroom experts. I now want you to list the husbandry practices for mushroom production.

Activity 4

Listing husbandry practices for mushroom production

Procedure

- Form nine groups.
- Using the chalk board one member of each group should in turn go to the board and list one husbandry practice for mushroom production.
- Make sure that no group repeats what the other group has already listed.
- Discuss the husbandry practices with your teacher.
- Your teacher will summarise the husbandry practices for mushroom production.

Congratulations for your effort. The husbandry practices for mushroom production are listed below.

1. Selection of species.
2. Site selection.
3. Construction of incubation and production shade.
4. Substrate preparation.
5. Spawn source – it can be bought or prepared at the farm.
6. Substrate treatment.
7. Mushroom seeding.
8. Mushroom fruiting management.
9. Harvesting.

Describing a Suitable Site for Mushroom Production

You may recall in your Junior Certificate Agriculture that vegetable growing needs a special site for successful production. Production site for mushrooms has a direct impact on survival and productivity of mushrooms. As a result, farmers need to think seriously about site selection to avoid losses.

Activity 5

Describing a suitable site for mushroom production

Procedure

- Brainstorm the qualities of a suitable site for mushroom production.
- Visit a nearby site for mushroom production.
- Record your findings.
- Report your findings to the class during plenary session.
- Discuss the qualities of a suitable site for mushroom production with your teacher.
- Your teacher will summarise the qualities of a suitable site for mushroom production.

Cultivated mushrooms are grown in a house. The house provides conditions favourable for the growth of mushrooms. The important conditions include humidity, temperature, ventilation and moisture.
The house should be free from any obstruction and be oriented in such a way that ventilators and doors face in the direction of the wind to allow free air movement. The house should be constructed away from livestock kraals, rubbish pits and latrines to avoid attraction of flies to the mushroom house.

Describing How to Construct Incubation and Production Sheds for Mushroom Production

Cultivated mushrooms are grown in a house. The house provides conditions favourable for the growth of mushrooms. The important conditions include humidity, temperature, ventilation and moisture.

Activity 6

Describing how to construct incubation and production sheds for mushroom production

Procedure

- Brainstorm suitable materials for constructing an incubation and production sheds for mushroom production.
- List them down in your notebooks.
- Assemble the suitable materials.
- Your teacher will demonstrate how to construct the incubation and production shed for mushroom production.
- Construct the mushroom incubation and production shed.

Materials used for constructing the mushroom incubation and production shed:

a. Poles
b. Heavy (500 or 600) gauge plastic sheet
c. Grass
d. Bamboos

e. timber
f. Nails
g. Wire or plastic gauze

Constructing the incubation and production shed

The house should satisfy the following conditions:

i. Sitting

The house should be free from any obstruction and be oriented in such a way that ventilators and doors face in the direction of the wind to allow free air movement. The house should be constructed away from livestock kraals, rubbish pits and latrines to avoid attraction of flies to the mushroom house.

ii. Frame work

The mushroom house should have a wooden framework covered with a heavy gauge plastic sheet for controlling humidity and outer grass thatch for insulation. Requirements for construction of a mushroom house include wooden poles, 500 or 600 gauge plastic sheets, bamboos, timber nails, thatching grass and wire or plastic gauze.

iii. Dimensions

Suitable houses for growing mushrooms have dimensions of 5m x 3m x 2m for smaller houses, and 7m x 5m x 3m for larger ones. Mushrooms are grown on shelves inside the house. These shelves can be as long as the house itself or slightly less. The width of the shelves range from 0.5 m to 1.0 m, depending on the sizes of fruiting bags.

Explaining Substrate for Mushroom Production

Mushroom grows in very special medium. This is prepared in advance before seedling.

Activity 7

Explaining substrate for mushroom production

Procedure

- Brainstorm the meaning of the term substrate in mushroom production.
- Identify materials suitable for substrate preparation
- Collect materials for substrate preparation
- Your teacher will demonstrate how to prepare the substrate
- Prepare the substrate for mushroom production

A substrate is a special material which is organic in nature prepared for the purpose of planting mushroom. It is prepared from maize stover or rice straw. Other ingredients include molasses, fertilizers (sulphate of ammonia, single superphosphate) lime, chicken manure, soya and bean powder.

Procedure

Substrate preparation involves two phases of composting. This is a process whereby organic materials are connected into a satisfactory and stable medium for the growth of mushrooms. The recommended quantities of ingredients based on one tone (1,000kg) of well dried cut maize stover or rice straw are as follows:

- 20kg Sulphate of Ammonia.

Day	Activity
1	Pre-wetting of straw
2-4	Add water to straw if necessary
5	First turning of compost. Add whitewash lime, chicken manure and half the amount of sulphate of ammonia
6-7	No activity
8	Second turning of compost. Add calcitic lime and single superphosphate.
9	No activity
10	Mix and wet soybean powder or cotton seed cake, rice bran and molasses in a drum.
11	No activity
12	Third turning of compost. Add the wetted mixture prepared on day 10 and the remaining sulphate of ammonia.
13-14	No activity
15	Fourth turning. Loosen the compost
16	Filling: transferring of the compost on to growing beds up to 15 cm deep. Close all ventilators and doors.

Table 20: Procedure for phase 1 composting

- 20 kg Soya bean powder or cotton seed cake.
- 20kg whitewash lime.
- 20kg molasses.
- 30kg of single superphosphate.
- 30kg of rice bran.
- 150 kg of chicken manure.
- 10kg of calcitic lime.

There are 2 composting phases; the first phase is out door while the second is indoor.

Day	Activity
17	Introduction of live steam into the mushroom house
18	Maintain compost temperature at 65^0C to 70^0C for 4 – 10 hours.
19-21	Decrease temperature slowly to between 50^0C and 52^0C by opening vents and reducing fire
22-25	Decrease temperature to between 40^0C and 45^0C
26-28	Aerate and cool compost to 25^0C by opening ventilators
29-30	If there is ammonia odour and the compost has high moisture content continue aerating

Table 21

Preparation of different materials as substrates for oyster mushroom

Can you guess what happens outdoor and indoor? Brainstorm with your friend.

i) Phase1

This is also known as outdoor composting because the activity is done outside the house under shed. This phase involves wetting and mixing of the compost ingredients. The first step is to cut the straw or stover into pieces of 3 to 4 cm in length. Thirty kilogrammes of dry cut stover or straw is enough to fill one square metre of bed. The outside composting takes about 16 days. A summary of activities on a daily basis is presented in Table 20

ii) Phase 2

This composting takes place inside the mushroom house. The main objective is to pateurise and condition the compost. Pasteurisation is accomplished by introducing live steam generated from a broiler outside the house through metal pipes into the mushroom house. This phase lasts 12 to 14 days and is a continuation of phase 1, as seen in Table 21 Below

The higher the nutrient content the substrate has, the higher the yield but also less selective it is. This also influences the handling of the substrate at pasteurisation and spawning stages.

i. Maize stalks or rice straw and banana leaves

Pre-wet the chopped maize stalks or rice/wheat straw or banana leaves and incubate them on a cemented platform or on a plastic sheet overnight. Optionally, after soaking overnight and draining, they can be supplemented with rice/wheat, water hyacinth and calcite lime. Supplementation significantly improves the yield.

Figure 11.5: Growing oyster mushrooms in plastic bags inside a mushroom growing house in Zimbabwe. **Photo Credit: Practical Action / Warwick Franklin.**

ii. Cotton wastes

The cotton waste is soaked or wetted for a few hours in water to which detergent has been added as a softener and disinfectant. The water is squeezed out and the cotton waste loosened. It can either be pasteurised or unpasteurised. Supplementation with lime ($CaC0_3$) and other materials can be done to improve pH and aeration.

iii. Saw dust from hardwood

Saw dust for the production of oyster mushroom should be that from hardwood or broadleaved trees. This is wetted and incubated overnight with supplements added and then pasteurised. Sometimes it can be allowed to ferment for a few days before pasteurisation.

iv. Corncobs

Corncobs should be shredded into 1-2 cm pieces. The cobs can be moisturised and incubated for 1-2 days and then pasteurised. Supplements including calcite lime are normally added before pasteurisation. Sometimes the immersion-in-hot-water method is employed with use of corncobs. This is done to leach the readily available nutrients in order to reduce the risks of contamination.

v. Maize stalks, maize stalks + maize husks (makoko) and cotton waste.

The maize stalks and husks should be shredded and these are suitable substrate for oyster mushroom cultivation. These are cheaper means of producing planting spawn as well as improving yields for oyster mushroom.

Treating Substrate for Mushroom Production

The substrate must first of all be sterilised before seeding. This ensures successful establishment of the mushroom. In this section, you will learn different ways of treating the substrate used for mushroom production.

Activity 8

Treating the substrate

Procedure

- Visit a nearby mushroom farm.
- Research the different ways that are used for treating the substrate.
- Record your findings.
- Report your findings to the class.
- Discuss the ways with your teacher.
- The teacher will summarise the ways of treating the substrate.
- Your teacher will demonstrate how to treat the substrate.
- Treat the substrate.

(a) After the substrate preparatory stage for the different substrates, the substrates are packed into a home-made sterilizer which can be made from an open drum with a platform with holes. After loading, it is tightly covered with a plastic sheet or sealable cover with an opening. This is a semi-bulk pasteurisation but where auto-clavable bags are used, pack them into the wire mesh basket and then put the basket into the sterilisation unit. (b) Pasteurise for 1 hour and then empty the pasteurised substrate onto a plastic sheet for it to cool down to about 400C. In cases where the hot water immersion is used, immerse the substrate for 30 – 40 minutes.

Fig.11.6. Spraying the mushrooms to keep them wet. **Photo credit: Practical Action Southern Africa**

Explaining How to Seed the Substrate for mushroom production

After the substrate has been sterilised, it is now ready for seeding. Have you ever observed how the process is done? Let us do this activity.

Activity 9

Seeding the substrate for mushroom production

Procedure

- Visit the nearby mushroom production farm
- Find out from the farmer all the details about seeding the substrate
- Record in your note books what you learn from the farmer
- Report your findings to the class
- Your teacher summarises the procedures involved in seeding the substrate
- Your teacher will demonstrate how to seed the substrate
- It is now your turn to seed the substrate

The procedure for seeding the substrate is explained below:

i. Pack the substrate into bags while adding planting spawn and then tie the mouth of the bags. This should be done in an enclosed place or where there is no air current.

ii. Incubate the spawned bags in the dark or alternatively cover with a plastic sheet until the bags are fully colonised. It normally takes about 14 - 40 days at 240`C for full colonisation to take place. This period depends on the size of the bags and spawning rate.

iii. When the bags are fully colonised transfer them into the fruiting house. The fruiting house should provide enough light for the mushroom to start forming. Light, which would enable one to read a new paper when inside the mushroom house, is just enough. The bags should be opened after exposure to light for one day. If tray fruiting is used, open one end facing the passage. For the hanging method, tie them onto the racks and make a few long slits on the bags using a clean sharp knife or clean razor blade.

iv. Maintain the temperature at about 180°C - 250°C and the relative humidity at 80% - 90%. The air freshness in the mushroom house also needs to be maintained at this stage. Relative humidity is maintained by applying water several times a day on the floors and walls and the air freshness by routine opening of the vents. Insufficient fresh air (too much carbon dioxide) leads to failure to fruiting and or development of deformed fruits.

The planting of mushroom seeds is called spawning. It should be done when the moisture content of the compost is about 70%. This is when a handful of

compost is squeezed in the hands 4 to 6 drops of water should come out. Ensure that there is no ammonia odour in the house and the compost temperature is about 250°C. The recommended spawning rate is 400 ml per square metre.

The actual spawning is done by broadcasting three quarters of the required spawn quantity onto the compost and mixing it thoroughly with the compost right down to the bottom.The remaining one quarter is broadcast on top and incorporated into the remaining very top layer of the compost (about 1 cm deep). Doors and ventilators should be closed from spawning day to 3 days after spawning. From day 4 introduce ventilation once in the morning and evening for 30 minutes at each time. Colonisation of the compost by the mushroom fungus takes 12 to 14 days after spawning.

Casing

Casing is the addition of moist pasteurised soil onto the compost. Casing soil must be clay loam sub soil, low in organic matter content and must have a pH of 7.0 to 7.5. Normally casing soil is obtained after removal of 10 to 13 cm of the top soil layer. Casing soil is pasteurised by steaming at 70 to 800`C for 15 minutes.

Casing is done at end of about 14 days when the compost is completely colonised by white mycelia. Casing soil stimulates and promotes the formation of fruiting bodies and retains needed moisture for mushroom growth. The casing soil is put on top of the compost to a thickness of 3 to 4 cm. About 30 liters of soil will be required per square metre. From casing to formation of fruiting bodies, the casing should be moist at all times and the temperatures should be between 16 and 220C. Mushroom pinheads start forming from day 16 after casing.

Describing Management of Mushroom Fruiting

It is very important to monitor the mushrooms very closely when fruiting starts so that any unusual occurrence happens, the farmer can take remedial steps. Let us carryout an activity on management of mushroom fruiting.

Activity 10

Describing management of mushroom fruiting

Procedure

- Visit a nearby mushroom garden
- Research on the management practices of mushroom fruiting
- Record in your notebooks whatever you learn from the your visit
- A selected number of you should present to the whole class about your findings
- Discuss the management principles with your teacher

- The teacher will demonstrate the management principles of mushroom fruiting
- You will thereafter take part in the management of the mushroom fruiting

In management of mushroom fruiting, farmers must look into the following areas:

i. Spawn running
ii. Colour change
iii. Hanging in production sheds
iv. Watering

If the substrate in the plastic bags is green or pink in any part and only partly showing signs of white mycelium growth then the ambient temperature may be too high. This may result in competitor moulds growing in place of the desired mushroom crop. If the mycelium has not grown to any extent but there are no signs of growth by other moulds then the temperature may be too low.

If the mycelium has not grown in the bottom of the bag then this indicates that the substrate is too wet. This can happen if the bag has not been drained properly after the fermentation stage so that water remains trapped at the bottom.

If the mushrooms are wrinkled and brown at the edges then it has been too dry during growing and more moisture should have been provided during the growing stage. They need to be sprayed with water on a regular basis.

Disease and Pest Control

- Mushrooms are fungi; do you think they are attacked by pests or diseases? Talk to your partner about this.

You were right if your answer was affirmative. Among the pests and diseases that attack mushrooms are discussed below.

Diseases

Cladobobotryum spp (Cobweb moulds)

This is usually due to too little air movement, high relative humidity and relatively high temperatures in the mushroom house. This fungus parasitises the mushroom mycelium and has a tendency of spreading very fast. In the mushroom house you observe cobweb-like structures growing rapidly from dead stumps or dead primodium, forming a veil which spreads rapidly. Spread

is through aerial hyphae, pickers and insects. The fungus colour, with time changes to yellowish-pink. Control is by removal of stumps and dead mushroom regularly from the beds or bags at the end of picking. One can also spray a 0.55 formaldehyde-solution on the spots where the cobweb occurs or use of fungicides like Benomyl, Carbendazim or Thiofanate methyl in severe cases between flushes.

Penicillium spp

Few penicillium species cause trouble in mushroom growing. If they occur, it is usually a sign of improper substrate pasteurisation or unsterile conditions during spawning of sterilised substrate. This fungus typically produces a large number of spores, which look like smoke when contaminated compost is touched. The mycelium is white at first, and later it turns brown, infections can reduce yields by up to 80%. Effective control is achieved through observation of hygienic conditions during spawning and the immediate removal of infected substrate.

Trichoderma spp (Green moulds)

This comprises a group of very common green moulds that is often encountered in mushroom cultivation. The spores are sticky and can easily be carried by flies, mites and picker's hands to uninfected areas. Trichoderma spp can be found as spots on dead mushrooms, stumps and both pasteurised and sterilised substrate, as well as in freshly cut wood logs. They can bring havoc on the whole farm. The main problems arise when the substrate is infected within a week of spawning. Reinfection may occur if contaminated substrate is left near the farm. Once the substrate is severely infected, it cannot be saved. Remove contaminated substrate as quickly as possible from the farm and dispose it at considerable distance. Spawning should occur in a disinfected room. If heavy infections occur, use Deosan super or Adecol for disinfection.

Pests

Snail

These appear in different forms and normally eat the mushroom during the night. In the early days when the populations are low, they can be controlled by hand picking, use of baits and traps.

Phorid and Scarid flies

The larvae of these flies feed on the mushrooms mycelia and eventually tunnel into the mushroom fruiting body. They also act as transport agent of mites and other fungal contaminants. They are less of a problem during spawn run in sterilised mushroom bag production system since the bags are sealed.

Beetles

These actually chew the mushroom from the inside (gill side) and tend to tunnel holes and hide in there when disturbed. They have a red or orange head and dark wings.

Mites

These are very tiny spiders, which feed on mycelium or on the mushrooms themselves. Mites are also carriers of unwanted fungal spores into the substrate. They can be effectively controlled by use of Malathion or by sprinkling with quick lime.

1. Disease control

Diseases can be controlled in several ways.

i. Dry bubble (Verticillium fungicola)

Dry bubble is most severe in summer months especially when fly populations are high It is characterised by pale brown spots on the cap. Practicing farm hygiene to reduce fly population can reduce the disease. In addition, reduction in air temperature and humidity helps control the problem.

ii. Olive green mould (Chaetomium spp)

The mould appears on compost surfaces soon after pasteurisation and can also lead to complete failure of mushroom growth. It is characterised by green grit-like projections on the compost.

Control is achieved by proper pasteurisation of compost. Avoid over wetness, compaction and over pasteurisation of compost.

iii. Mat (Chrysosporium spp)

This disease is characterised by a creamy to yellow mycelia fungal growth on both the compost and casing soil, coating it completely. The mat impedes air and water penetration. Prevent the disease by ensuring that casing is not shallow. Farm hygiene is important in reducing this disease.

Pest control

Pests can be controlled in a number of ways

i. Mushroom flies (Megaselia agarici)

Mushroom flies feed on the mushroom fruiting body and mycelia. They also cause indirect damage since they carry mites, eelworms and spores of the other moulds. Control is by sanitation on and around the farm, removal of leftover compost and burying of stems and pieces of mushroom.

ii. Mites

Mites are a problem because they feed on mushroom mycelia and on the developed mushroom causing surface discoloration. Control is kept by keeping the mushroom house and surrounding clean.

iii. Rodent

Rodent (Rattus spp) feed on the mushroom fruiting body and mycelia. They are very destructive as they make unwanted holes in the casing and compost. Rodents can be controlled by physically killing them or using traps.

iv. Mollusc control

Snails and slugs feed directly on the mushroom. Control is by hand picking.

Harvesting Mushrooms

Time has now come when the mushroom we grew can be harvested. Do you know the factors that should be considered when harvesting mushrooms? Let us go back to our nearby mushroom farm to find out what they consider

Activity 11

Describing mushroom harvesting

Procedure

- Visit the nearby mushroom farm
- Research on the factors the farmer considers when harvesting mushrooms
- Record your findings
- When you go back to school, a selected number of students should present the findings to the whole class
- Discuss these factors with your teacher
- Your teacher will consolidate the factors
- Your teacher should demonstrate how to harvest mushrooms
- Harvest the mushrooms

Factors to consider when harvesting mushroom

1. Maturity of the mushrooms

i. Mushrooms are ready for harvest once buttons appear. Buttons are the round-topped mushrooms that are still closed. These can be harvested once they start appearing and should be done quickly enough so that they do not start to open. Buttons fetch a lot more demand on the market than when harvesting is delayed.

ii. However, harvesting can be delayed so that caps should appear. Caps are when the mushroom veils have opened or are likely to open. The caps are still round topped.

iii. Farmers can harvest the mushrooms when flats appear. At this time, veils open up and the caps are flat with gills fully exposed.

2. Market requirement

As stated above, mushrooms can be harvested at different stages of maturity. This is because of differences in consumers tastes. Most consumers prefer buttons to the rest. This is why they fetch a lot of money on the market. Flats have the least demand on the market and therefore fetch very low income

3.Plucking

Pluck when fully grown. It takes about 5-9 days for the flush to come out after opening the bag. Mushrooms are ready for harvesting 14 to 20 days after casing and they come in weekly flushes. To harvest, hold the cap, twist the mushroom and pull it together with the roots. Cut off the roots and dispose of them by burying. The holes left behind by harvested mushrooms should be filled with fresh casing soil. Watering of beds should be done soon after harvest and all vents opened for 1 to 2 hours to dry the surface.

4. Yield

Depending on the variety, compost type and management, yield of mushrooms range from 5 to 10 kg per square metre under smallholder farming. A cropping period of 8 to 12 weeks is normal. After the cropping period, the soil and compost should be removed in preparation for a new season. It is possible to grow 2 crops in a year.

5. Marketing

.The size and degree of maturity determines when to harvest. Mushrooms ready for the market are divided into various grades depending on size and degree of maturity. The right stage for harvesting, however, depends on one's own market. Mushrooms may be divided into 3 grades:

i. **Buttons** - These are closed mushroom, they could be small or big. They fetch the highest price on the market.
ii. **Caps** – These are mushrooms whose veils have opened or are likely to open. They still have a rounded cap. They normally have a medium value.
iii. **Flats** - The veils have opened and the caps are flat and gills exposed fully. They normally fetch low prices.

Unit Summary

Mushrooms are an important source of proteins, Vitamins and minerals which are vital for good health. Mushroom production can be done at a time when most agricultural activities have ended. Mushrooms can be grown throughout the year in cool areas but during cool months in warm areas. Mushroom production can assist in diversification and provides a better way of utilising crop, forestry and animal waste.
Wrong identification of mushrooms has resulted in poisoning hence the need to have the cultivated strains that are known and are safe for consumption. National aims are to satisfy domestic demand whilst broadening the source of protein, vitamin and minerals and increasing the smallholder farmers' income.

Farmers wishing to grow mushrooms should contact Bvumbwe, Chitedze, Lunyangwa Agricultural Research Stations and Bunda College of Agriculture.

Review questions

1. What are the membranes of a mushroom cap which produce spores are called?
2. A mycelium is made up of branching structures. Name these structures.
3. What is a fruiting body?
4. Certain kinds of mushrooms grow only at the base of a particular species of tree. Explain why this happens.
5. Give two importance of mushroom.
6. What is the National aim in mushroom production?
7. Why has forest mushroom harvesting become a threat to people in Malawi.

Glossary

Mushroom: A tightly interwoven mass of hyphae
Spawning: The planting of mushroom seeds
Plucking: Harvesting of mushroom
Casing: The addition of moist pasteurised soil onto the compost
Composting: This is a process whereby organic materials are connected into a satisfactory and stable medium for the growth of mushrooms

Reference

1. www.practicalaction.org (02/10/2014)
2. http://practicalaction.org/media/view/10556 (01/10/2014)
3. Ministry of Agriculture and Food Security. *(2012): Guide to Agricultural Production in Malawi.* Revision, Lilongwe Malawi
4. *Heath. Biology. Teacher's Edition, Introduction* – Videodisc Edition
5. *Keeton William T. Biological Science,* Cornell University, New York

Unit 12

Livestock Feeds And Feeding

In Form 1 you learnt about four main livestock management activities which are: housing, feeding, breeding and controlling parasites and diseases. You learnt what these activities are, what each activity involves, how each is done, and how each affects livestock production. On livestock feeding you learnt that all animals need feed and that different kinds of feeds have different kinds of nutrients. Each kind of nutrient has its own use. In this unit, you will learn more about different feeds given to farm animals. You will also learn how to formulate rations as well as factors to consider when feeding animals for proper body functioning.

Classes of Livestock Feeds

Farmers keep different types of animals on their farms. These animals have different feed requirements due to the differences in their digestive systems. It is against this background that animal feeds are grouped into different classes of feeds.

Activity 1

Distinguishing classes of feeds

Procedure

- Observe different samples of feeds which your teacher has provided you with
- Discuss these feeds within yourselves
- Classify the feeds into two major categories
- What name is given to the two categories of feeds stated above?
- Discuss your observations with your teacher
- Your teacher will consolidate the classes of feeds

Various sources of feed-stuffs are grouped into:

1. Roughage
2. Concentrates
   - Energy concentrates
   - Protein concentrates.

Animal feed are termed as feeds. A feed is a mixture of several feedstuffs that will supply the required nutrients to animals. Feedstuff is food material containing one or more nutrients.

1. Roughages

These are feeds basically from plant matter. They have high crude fiber content. They contain over 20% crude fiber in their dry matter. They are low in digestibility because of their fibre content. They therefore form the bulk of the ruminant diet.

Roughages can either be:

- Succulent or green roughages or
- Dry roughages

Succulent roughages:

These are bulky, with a high mass matter per unit. Usually they have high moisture content (20 – 50%) with low dry matter content. They are rich in carbohydrates and low in proteins. Often times they have high crude fiber content. They contain carotene, which is rich in vitamin A. The forage type and stage of maturity determines their nutritional value.

Examples of succulent roughages are:

1. Fresh young grass such as star grass, kikuyu grass, elephant grass, giant star grass, silage, banana stems.
2. Legumes pastures which are rich in proteins, for example: Lucerne, Leucaena, Desmodium spp, Glycine spp and the like.
3. Browsing trees and shrubs which are mainly found in semi-arid areas e.g. Acacia.
4. Vegetables such as cabbages and kale.
5. Sweet potato vines and turnips.

Dry roughages:

They are also known as coarse roughages. They contain very little moisture (less than 20%) and are high in crude fiber. However they have the advantage of being bulky. Examples of dry roughages include hay, straws and maize stovers, groundnut haulms. They are prepared from grasses, legumes and other crop residues as hay.

Dry roughages are very fibrous, have low energy value and are used to provide bulk feeding in animals.

2. Concentrates

Concentrates are high in protein and carbohydrates in their dry matter; they are low in crude fiber usually less than 20%. They supplement grazing in ruminants. While the feeding value of roughages is quite variable, that of concentrates remains fairly constant. In practical feeding, they are divided into two types:

- Energy (carbohydrates) concentrates
- Protein concentrates

The diet of non-ruminants is usually made from concentrate feed because these animals cannot handle high amounts of crude fiber.
Energy concentrates are the chief source of energy in the diet and include grains and their milling by-products e.g. maize, madeya, wheat meal, sorghum and millet. Grain legumes and their by-products include groundnuts, groundnut cake, soya meal, beans, bean meal.

Protein concentrates include meat, bone meal, and fish meal. Oil cake from cotton seed, groundnut, soya bean and sunflower are also protein concentrates.

Molasses from the sugar industry is also a source of energy for animals. Animals are also given additives such as mineral and vitamin supplements.

List Nutrients in Livestock Feeds

You have now known that feeds fall into major classes. In this section you will be expected to list the types of nutrients these feeds provide.

Activity 2

Listing nutrients in livestock feeds

Procedure

- In your groups, brainstorming nutrients in livestock feeds.
- Record the names of the nutrients in your notebooks.
- Choose one member from your group to present your findings to the whole class during plenary session.
- Discuss your findings with your teacher.
- Your teacher will consolidate the nutrients in livestock.

Nutrients in livestock feeds are:

1. Water
2. Carbohydrates
3. Fats and oils
4. Proteins
5. Vitamins
6. Minerals

Explain Functions of Nutrients in Livestock Feeds

You may recall that there are six groups of food in humans. The six groups are the ones that we have listed above. You may also recall that humans are encouraged to take all the six food groups in order to live a healthy life. The same thing applies to animals.

Activity 3

Explaining functions of nutrients in livestock

Procedure

- Form groups of five members
- Use your school library or the Internet to carry out research on the functions of different nutrients in the life of an animal
- Make sure you record your findings
- When you finish your research come back to class
- Choose one member from your group to present your findings
- Discuss your findings with your teacher
- Your teacher will summrise functions of nutrients in livestock

Water

Water is essential for body fluids. The largest proportion of the animal's body is made up of water. Water maintains body shape. This is because it is the essential component of all body cells and activities. Thus all animals should have ready access to water at all times. Death from water shortage ensutes within a few days or weeks, while death from food shortage occurs after a long period of time. Water is the most limiting factor for grazing animals in many farms.

Carbohydrates

Carbohydrates are made up of starches and simple sugars.
Functions of carbohydrates:

- They provide energy to the body for daily requirements.
- Any excess carbohydrates are stored in form of fats and stored as energy reserves within the body.

Fats and Oils

Fats are a dietary source of energy for the animal. They provide a basis from which other compounds such as amino acids can be made.

Functions of fats:

- They are essential constituents of body cells.
- They serve as condensed energy reserves. Fats provide twice as much energy as the carbohydrates.
- Excess fat stored in the body act as insulating layer in animal's body and prevent loss of heat.
- They are carriers of fat soluble vitamins A, D, and K.

Proteins

Proteins are made up of amino acids. There are two types of amino acids:

Essential amino acids and Non-essential amino acids. There are about 20 amino acids found in proteins.
Essential amino acids are those required by the animals but cannot be synthesised by their bodies, while non-essential amino acids are those that can be synthesised in the body and so need not be supplied in the diet.

A protein is said to be of high quality if it can supply all the essential amino acids as needed by a particular animal.

Functions of Proteins are:
- Essential for building of animal body tissues.
- Repair and replacement of worn out body tissues.
- Essential component of enzymes, hormones and antibodies.
- Excess proteins are metabolised into energy.
- Making of protein molecules (antibodies) involved in protecting the animal from diseases.

Vitamins

Vitamins are organic substances that are required in small amounts for the well being of the animal. They are grouped into two; Fat soluble vitamins (vitamin A, D, E and K) and water soluble (B and C). The major functions of vitamins include:
- Growth promotion.
- Act as organic catalysts in various metabolic and physiological reactions
- Blood clotting
- Bone formation
- Muscular activity

Fat soluble vitamins

Vitamin A

Functions:
- needed for good eyesight and growth
- essential for prevention of diseases

Vitamin D

Functions:
- essential for bone formation
- prevents rickets in animals

Vitamin E

Function:
- essential for the proper functioning of the reproductive system

- prevents sterility in animals

Vitamin K

Functions:

- essential for blood clotting – so prevents bleeding
- helps transport nutrients

Water soluble vitamins

Vitamin B

Functions:

- Helps in the metabolism of carbohydrates, proteins and fats.

Vitamin C

Functions:

- Important for disease resistance

Minerals

Minerals are important but are required in small amounts in the nutrition of farm animals. There are about 15 essential minerals categorised into:

a. Macro-nutrients These are required in large quantities. They include calcium, phosphorus, chlorine, sulphur and magnesium.

b. Micro–nutrients These are required in relatively small amounts. They are also known as trace elements. They include: iron, zinc, copper, manganese, iodine, cobalt, molybdenum, selenium.

Livestock need mineral supplements in their diets to meet their bodily mineral requirement. The mineral requirements for livestock vary with age and level of production. For example, young animals require more calcium and phosphorus for bone formation. Milking cows require calcium and phosphorus for milk formation. Layers need more calcium for egg shell formation.

Excess or deficiency of minerals can be detrimental, so they need to be supplied in correct amounts.

The major functions of minerals are:

- Constituents of bones
- Constituents of blood
- Maintenance of acid-base balance and correct osmotic pressure within the body fluids
- Act as catalysts in body reactions, particularly the enzyme systems
- Act as component of animal products such as milk, eggs, meat and wool.

Calcium and phosphorus
Functions:
- Bone formation
- Essential for milk production
- Calcium for egg shells

Magnesium
Functions:
- For healthy bones and teeth
- Helps to metabolise carbohydrates

Iron
Functions:
- Part of haemoglobin
- Prevents anaemia

Iodine
Functions:
- Essential for the growth of the thyroid gland, which produces thyroxin
- Prevents goiter

Copper and cobalt
Functions:
- Form part of haemoglobin
- And enzymes (cobalt is part of vitaminB12)
- Improve appetite in ruminants
- Prevent anaemia
- Maintain blood pressure
- Essential for bile formation

Sodium
Functions:
- Maintains blood pressure
- Essential for bile formation

Manganese
Functions:
- Helps in bone formation and enzymatic reactions
- Essential for metabolism of proteins and carbohydrates

Chlorine
Functions:
- Part of gastric juice
- Aids digestion

Potassium

Function:

- Helps in the functioning of the muscles and the heart
- Activates enzymes

Zinc

Function:

- Helps in enzymatic reactions

Identify Sources of Nutrients in Livestock Feeds

You have seen that there are so many nutrients that animals need for their daily lives. Animals have to eat a wide variety of feedstuffs in to obtain all these nutrients. Let us now find out the sources of feed nutrients for the animals.

Activity 4

Identify Sources of Nutrients in Livestock Feeds

Procedure

- Form six groups.
- Each group should research on the feedstuffs which supply the given nutrient.
- List the feedstuffs on a chart paper.
- Choose one member from your group to present your findings to the class.
- Discuss your findings with your teacher.
- Your teacher will summarise the sources of nutrients in livestock feeds.

I am very encouraged by the answers you raised. Consolidate your answers with those listed in the table 22 below.

Nutrient	Source
Water	• Drinking water, succulents, milk
Carbohydrates	• Cereals (such as maize, sorghum, millet, madeya), potato vines, grass, root tubers (such as cassava)
Fats and oils	• Oil seeds such as ground nut and cotton seed, soya beans, milk, eggs, meat, fish meal and bone meal
Proteins	• Grain legumes (such as beans, soya beans, groundnuts), meat, liver, milk, bone and fish meal
Vitamins	
• Vitamin A	• Milk, fresh grass, yellow maize, fish, cold liver oil
• Vitamin D	• sunlight, fish liver oil, yeast, green grass, hay
• Vitamin E	• Grains, cereal grains, groundnut oils, green vegetables, green grass and other green fodder, soya beans, grass
• Vitamin K	• All feeds, especially succulent roughages or leafy vegetables
• Vitamin B	• Green vegetables, groundnut meal, cereals, fish meal, ruminants are able to synthesize vitamin B through the micro-organisms that are found in the rumen
• Vitamin C	• Green leafy vegetables, fruits

Table 22: Minerals and their sources

Minerals	
• Calcium and phosphorus	• Milk, meat, bone meal, ground limestone, oyster shells
• Magnesium	• Milk, cereal grains
• Iron	• Egg yolk
• Iodine	• Iodized salt
• Copper and cobalt	• Salts containing copper and cobalt
• Sodium	• Common salt and rock salt
• Manganese	• Most feeds
• Chlorine	• Common salt and rock salt
• Potassium	• Potassium chloride, grass
• Zinc	• Most feeds

Feed rations

No one feed has all the necessary nutrients to keep animals healthy. Feed tables provide information of nutritional composition. Choice of feedstuffs to use depends on:

- Its availability
- The cost of the feedstuff
- Its nutritional composition
- The physical or processing nature of the feedstuff such as colour, smell, particle size

Commercial livestock feeds are expensive. However they contain additives, are well balanced and are close to the theoretical amounts necessary for maintenance and production.

Over the years poultry farmers in Malawi have found difficulties to rear chickens because commercial feeds are expensive. Home-made feeds prepared by the farmers themselves are cheaper but have the following disadvantages.

- Mixing of the various feedstuffs may not be thorough
- Seasonality of the grains. They may not be available at the time they are required
- Farmers may lack technical know-how on feed value formulation

Methods of Ration formulation

Pearson's square

Pearson's square can only be used for two feed stuffs. However, either or both of these can be mixtures of two or more feeds together into a mixture containing a certain definitive percentage of some major nutrient required in the prepared ration. The percentage of the nutrient to be obtained from the feed must be specified. Also the values of the nutrient contained in the two feedstuffs must be known. Those values are obtained from feed tables.

Where there are sufficient grains, rations can be made on the farm. Homemade rations are cheaper by10 – 15% and a farmer can vary the energy or protein content of the ration according to the needs of animals. As you learnt in Form 1 that a balanced ration is an amount of feed that contains all the nutrients discussed in Table 12.1 and in the right proportions.

Example.

Formulate a pig ration containing 20% protein using maize meal containing 7% protein and fish meal (cereal balancer) containing 62% protein. Calculate the amount, in kilograms, of each feedstuff required to prepare 100 kg of the feed.

Procedure

1. Draw a square.
2. Place the desired protein percentage in the ration in the middle of the square.
3. Draw diagonals of the square.
4. Place the percentage of each feedstuff to be mixed at the left corners of the square.
5. Subtract the figures diagonally across the square. Remember to subtract the small number from the large one.
6. Disregard the negative signs.
7. Place the numbers obtained on the right corners, giving the required parts of each feedstuff to be used in the mixture as shown in Figure 2 below. Add up the parts to obtain at the base what will be used to calculate the amount of each feedstuff to be used in feed preparation.

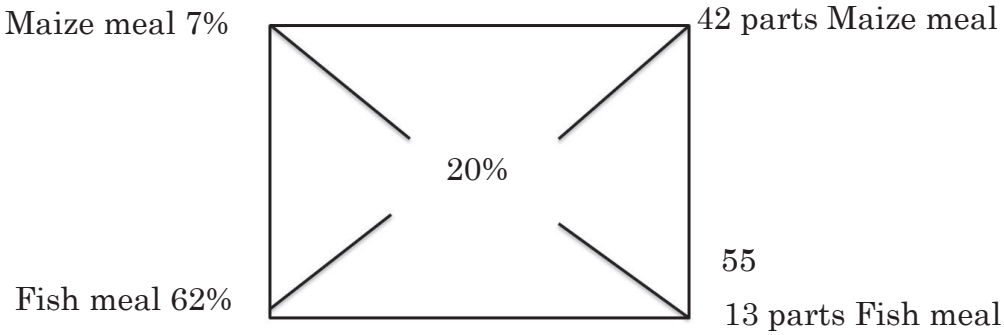


Figure 12.1 Pearson's square

Thus to obtain 100kg of a feed ration with 20% protein, then

Maize meal parts: $\frac{42}{55} \times 100 = \mathbf{76.4\ kgs}$

Fish meal part: $\frac{13}{55} \times 100 = \mathbf{23.6\ kgs}$

From the calculation above,when 42 parts maize meal are mixed with 13 parts Fish meal, the result will be a 20% protein ration.

Explaining the Importance of Feeding Livestock

How would you feel if you went without food for a day? Would it be possible for you to come to school? Animals also need to eat. As students of agriculture you must have empathy towards the animals our parents and guardians rear.

Activity 5

Explaining the importance of feeding livestock

Procedure

- In your groups, use your school library to research on the importance of feeding livestock.
- Present your findings to the class.
- Discuss the importance of feeding livestock with your teacher.
- Your teacher will consolidate the importance of feeding livestock.

For an animal to produce or grow well, it must be fed on a balanced diet or on the correct amount of ration. A balanced ration is a ration that supplies nutrients needed for maintenance and production in the correct amount and proportion. Feeding livestock is important because livestock need nutrients for different functions of the body.

There are two main rations:

- Maintenance rations
- Production rations

A maintenance ration is an amount of feed that the animal needs per day to maintain its bodily processes without gaining or losing weight. The ration is particularly important for young growing animals or animals in gestation.

A production ration is an amount of feed that contains all essential nutrients and in the right proportions given to animals over and above maintenance ration. This ration is essential for animals to produce e.g. for beef cattle and broilers to produce meat and layers to produce eggs.

Explain Factors to Consider When Feeding Livestock

You may recall that there are differences in the types and quantities of feed which animals are provided with. Have you ever thought about why this is like that? You have the opportunity today learn about this fact.

Activity 6

Explaining factors to consider when feeding livestock

Procedure

- Brainstorm factors to consider when feeding livestock.
- Listing factors to consider when feeding livestock.
- Discuss factors to consider when feeding livestock with your teacher.
- Your teacher will consolidate the factors worth considering when feeding livestock.

The amount of feed given to the animal depends on the following factors:

1. **The type of animal** Ruminant animals can digest roughage while most non-ruminant animals cannot. Exotic breeds require good quality feeds to produce high quality products.
2. **The age and body size of the animal** Young animals require less feed than larger animals and some young animals will initially only depend on milk until they are introduced to solid feed.
3. **Physiological condition of the animal** This is an important characteristic. The health status of the animal. Animals should not be allowed to starve since this reduces yield. Pregnant and healthy animals can eat large amounts of feed. Sick animals consume less feed. However, feed should not be wasted as it is expensive.
4. **The purpose for which the animals are kept or level of production** Highly productive animals consume correspondingly large amounts of feed. If animals are kept for draught purposes, they will require high-energy feed. Animals which produce milk, meat and eggs need concentrates.
5. **The quality of the feed.** The feed should be easy to ingest and digest.
6. **Palatability** Some feed may be more acceptable to the animal than others. This is due to taste and smell. Animals like appetising feed.

7. **Digestibility** The degree to which the animal is able to digest the feed. This will depend on the type of animal.

8. **The amount of the feed and its texture** The amount of feed to be given to animals will depend on its quality and type. The coarseness or fineness is an important aspect especially in chickens.

9. **Cost of the feed:** Feed should be given to animals which are in production. Although it is advisable that animals should be fed *adlibitum (*when and as much as they like) the farmer should bear in mind the economic importance of for instance giving layers mash when they are not laying. The cost of the feed will determine the number of animals or birds the farmer is able to keep.

Unit Summary

The purposes for which animals are reared are fulfilled through proper feeding. Livestock must be provided with all the six types of nutrients on daily basis for its normal growth and production and these are carbohydrates, proteins, vitamins, minerals, water and fats.

Farmers must carefully look into factors to consider when feeding livestock. The body mass of the animal, for example, determines the quantity of feed it should receive. The age differentiates the type of feed suitable for an animal. The type of the animal in question determines the type of feed suitable for different classes of animals. This explains why ruminants can survive on vegetative feeds only. It is important to feed the livestock properly in order to maximise returns.

Review Exercise

1. List the nutrients that are found in livestock feeds

2. Explain the functions of nutrients in the life of an animal

3. Using the Pearson square method calculate the proportions of maize meal and bean meal feed ingredients required to formulate a feed ration containing 25% of crude protein from maize which contains 10% crude protein and bean meal which contains 35% crude protein.

4. Explain why dry roughages are less digestible than succulent roughages

5. You are provided with molasses, fresh elephant grass, milk, maize flour, dry groundnuts plants, growers marsh and madeya. Classify these feeds into roughages and concentrates.

Glossary

- **Dry matter**: This is part of a feed with less water which is subject to digestion. It includes even that portion which is voided as feaces
- **Ruminant**: It is an animal which chews a cud (a cud is a feed which was ingested but is regurgitated for further digestion)
- **Succulent**: An animal feed of plant origin containing high water content

Reference

1. Anthony M. Ngomwa, P. Sigel and D. Cheruiyot D. (2012): *Senior Secondary Agriculture Form 3.*
2. B.M. Kanjala and N.T. Kaperemera. (2002): *Strides Agriculture Book 3,* Longman Malawi (Pty) Ltd
3. Chard P.G.D. (1991): Focus on "O" Level *Agriculture Book 4, Pupils' Text Book.* London: College press
4. Ngugi D.N., Karau P.K. AND Nguyo W (1990): *East African Agriculture, Third Edition.* By. MacMillan.

Unit 13

Sheep and Goat Production

Sheep and goats collectively are termed 'small ruminants'. Sheep and goats play a minor role in Malawi agriculture, and at present the local production is less than half the demand for sheep and goat meat. There are neither exports nor imports of sheep and goat meat. If properly managed, sheep and goats can be a profitable farm enterprise in Malawi, and demand for sheep and goat meat is greater than the supply. In this unit you will learn more about sheep and goats production. Sheep (*Ovis aries*) are mainly raised for meat and a source of income.

The sheep population is, however, low because sheep production is constrained by lack of improved breeding stock, poor husbandry practices, parasites and diseases. Sheep require more careful management. This has again to be complemented with a programme of crossing the local with exotic breeds or well selected rams to produce more lamb meat and mutton for both urban and rural markets.

National aims are to increase the numbers of sheep and improve the productivity of indigenous sheep by practicing improved standards of management such as the use of improved breeds, housing, feeding and parasite and disease control.

Goats (Capris hicus) are a source of protein and income to the rural population. They also supply manure which may be used in crop production. Local goats in Malawi are hardy as far as feeding is concerned. They are prolific but do suffer from diseases just like other species of livestock. They are small to medium sized and have slow to medium growth rates. This calls for improvement. The aim is therefore to improve the productivity and off take.

Listing Breeds of Sheep and Goats

Like most domesticated animals, sheep and goats also exist in several breeds.

Activity 1

Listing breeds of sheep and goats

Procedure

- Break into groups of five.
- Go to the library and research from books the various breeds of sheep and goats that exist in the world.
- Classify the breeds according to their use.
- Record your findings.
- Present your findings to the class.
- Discuss your findings with your teacher.
- Your teacher will summarise the breeds of sheep and goats.

Sheep	Origin	Use	Goats	Origin	Use
Local sheep	Malawi	meat	Local goat	Malawi	Meat
Dorper	Persia	mutton	Boer	South Africa	Meat
Hampshire	England	mutton	Anglo-Nubian	North East Africa	Meat
Merino	North Coast of Africa	wool	Saanen	Switzerland	Milk
Karakul	USSR, Iran, Iraq	Skin	Toggenburg	Switzerland	Meat
Black head	Persia	mutton	Angora	Asia	Mohair
Ramney marsh	Romney in England	wool	Alpine	Britain	Meat
Corriedale	New Zealand	Dual	Jamnapari	India	meat
			Small East African goat	East Africa	meat

Selecting Appropriate Breed of Sheep and Goat for their Area

Some of you rear sheep or goats or both at your homes. Have you ever thought of the breed the goats or sheep belong to? This is your opportunity to learn the breed of sheep and goats that exist in your area.

Activity 2

Selecting appropriate breeds of sheep and goats for your area

Procedure

- Visit a nearby village where you will find sheep and goats.
- Observe the characteristics of the different breeds of sheep and goats you will find.
- Identify the breeds of sheep and goats.
- Record all your findings.
- Report the findings to the class.
- Discuss the breeds of sheep and goats in the area.
- Choose the appropriate breeds of sheep and goats based on their use.

Basically, farmers in Malawi keep local breeds of sheep and goats.

1. Criteria are used to select a breed of sheep

i. Climate: The indigenous sheep are suited to the hot, dry conditions of the country.

- The sheep are hardy and adaptable to conditions of low input. The local breed can be improved through cross-breeding and improved management.
- The karakul is adapted to desert conditions, the merino thrives in dry conditions and the black Persian is hardy
- The Hampshire has been used for cross-breeding in Malawi, it can surviv on poor pasture, it is a heavy breed and good for wool production
- The indigenous sheep breeds have more resistance to parasites than the exotic sheep, but drenching is a very important part of sheep management.
- Availability of feed. Sheep are managed best when they are kept in well fenced paddocks

ii. Use:

- Select a breed that will give you the highest production of mutton, wool or skin. The local Malawian sheep produces reasonable amounts of mutton, weighing up to 30kg. The Black Persian is good for mutton, can weigh up to 50kg. Unfortunately, the fat distribution on its body is uneven, but cross-breeding with breeds like Dorset Ram improves this breed.
- Merino sheep are famous for wool production, while Karakul sheep are good for skin or pelt production. The local Malawian sheep can be improved by crossing with exotic breeds to improve mutton, wool and skin production.

Mutton sheep have the following characteristics:

iii. Good mothering ability of ewes

i. Should be fast growing and mature

ii. Size: The exotic sheep are bigger than the local breeds. The Mutton Merino ram weighs between 90 – 130 kg and ewes weigh between 60 – 75kg. The Dorper rams weigh between 80 – 90 kg and ewes weigh between 50 – 65kg. The Corriedale Ram weighs between 84 – 114kg and ewes weigh between 57 – 84kg. The Romney Marsh ram weighs between 100 - 114kg and the ewes weigh between 84 – 100kg. The Hampshire ram weighs between 100 – 136 kg and the ewes weigh between 81 – 102kg, The Romney marsh ram weighs between 100 – 136kg and the ewe weighs between 81 – 102kg. Exotic breeds have high weights but require that management is good. Dosing to kill worms is a very important part of sheep management and availability of feeds when put in paddocks or pens and fattened for slaughter.

vi. Quality of mutton produced

2. Selecting appropriate breeds of goat

Despite some popular prejudice, goats can be a profitable form of livestock under a wide range of conditions in Southern Africa. They are best classified according to the end product for which they are kept, that is meat, milk or mohair.

Many Africans prefer goat meat to mutton, and, of course it is one of the main sources of domestic meat in many rural areas. Goats have a place as source of milk on plots and holdings which are too small to carry dairy cattle.

a. The qualities when selecting a breed of sheep apply to goats. Goats kept for meat production should

- Grow fast and mature early
- Be from nannies with good mothering abilities
- Have a good body shape
- Milk goats should have large well- developed udders.

b. Suitable to local environment and economic environment

- Suited to the climatic and local conditions of the area
- The Malawi goat is hardy and disease resistant
- It is a good scavenger; however, its genetic potential is limited. There will,Therefore, be a need to cross-breed with exotic breeds to improve its meat and milk production. The improved breed will need improved management.

c. Personal preference

Most Malawians consider the local goat meat to be tender and tasty. The milk from the local goat is also easy to digest. However, there is no evidence to suggest that meat from the local Malawian local breed is better than that from the exotic breeds.

The Age at Puberty for Sheep and Goats

Farmers raising goats and sheep would be very interested to gain returns from the animals as early as possible. This is a function of puberty. Puberty is a stage in the life of an animal when it is sexually mature to start reproducing. For females, this is the stage they are able to produce mature graafian follicles that release ova necessary for fertilization after mating. In males, they are ready to release sperms which can fertilize an ovum. The earlier they reach this stage the earlier they are able to raise a new generation and increase in their population.

Activity 3

Stating the age at puberty for sheep and goats

Procedure

- In your groups, carryout a book research on the age at puberty for sheep and goats.
- Report your finding to the whole class.
- Discuss your findings with your teacher.
- Your teacher will summarise the age at puberty for sheep and goats.

Table24: Age at puberty for sheep and goats

	Age (Months)
Sheep	15-18
Goats	18

Terms used with Sheep and goats

Ewe : A mature female sheep which has had more than one lamb

Ram or Tup : A mature male sheep

Wether ; A castrated male sheep

Hoggett : A young female sheep

Lamb : These are very young sheep divided into ram lamb and ewe lambs. Ram lambs which have been castrated and weaned are called *wether*. Ewe lambs which have been weaned are called *hogget*.

Billy/bucks : A mature male goat

Nanny/doe : A mature female goat which has had more than one kid

Kid : A young goat

Breeding sheep should be properly timed so that **lambing** takes place when there is plenty of green grass. In Malawi, the best time is the month of November, so that lambing is in April or early May. In order to plan the best time to mate the animals, farmers should follow the oestrus cycle.

Oestrus cycle refers to the recurring period of sexual receptivity in female mammals.

It is also called heat. The onset of oestrus is a sign of maturity and the ability to reproduce. It may first occur when the female sheep (ewe) are about six to ten months old. The oestrus cycle in sheep is between fifteen and nineteen days. It lasts for 18-24 hours. Two weeks before the ewes are mated, they should be given some concentrates to improve their health and fertility, and it is called flushing. When the ewe has been fertilized, she will not come on heat again until after she has lambed.

In goats, the oestrus cycle is 18 to 21 days and oestrus lasts for one to two days. It is important to ensure that the doe or nanny is served during this period. Once the signs are observed the nanny should be mated. The best time to mate the animals is five months before the rains start, so that the animals will bear a kid when there is plenty of grass.

How do headers know that the doe or nanny is on heat? Discuss with your friend on signs of heat in the doe.

Breeding sheep should be properly timed so that **lambing** takes place when there is plenty of green grass. In Malawi, the best time is the month of November, so that lambing is in April or early May. In order to plan the best time to mate the animals, farmers should follow the estrus cycle.

Oestrus cycle refers to the recurring period of sexual receptivity in female mammals. It is also called heat. The onset of oestrus is a sign of maturity and the ability to reproduce. It may first occur when the female sheep (ewe) are about six to ten months old. The oestrus cycle in sheep is between fifteen and nineteen days. It lasts for 18-24 hours. Two weeks before the ewes are mated, they should be given some concentrates to improve their health and fertility, and it is called flushing. When the ewe has been fertilized, she will not come on heat again until after she has lambed.

In goats, the oestrus cycle is 18 to 21 days and oestrus lasts for one to two days. It is important to ensure that the doe or nanny is served during this period. Once the signs are observed the nanny should be mated. The best time to mate the animals is five months before the rains start, so that the animals will kid when there is plenty of grass.

The following are some of the signs

1. the nanny frequently wags or twitches her tail.
2. she shows signs of excitement.
3. she sometimes mounts other nannies.
4. the vulva becomes red and thick.
5. mucus is discharged from the vulva.

Gestation period for ewe and nanny

Procedure

- In your groups carry out research on the gestation period for ewe and nanny.
- Visit a nearby farm to find out the gestation period for ewe and nanny
- Report the findings.
- Record the gestation period for the ewe and nanny.

Table 25 showing gestation period for ewe and nanny.

	Length of gestation (days)
Sheep	150
Goats	150

Table25

Gestation period is the period between the fertilization of the ewe or nanny and the birth of her lamb. It is 5 months or 150 days. Although young ewes will come to heat for the first time at 5 months old, they are put to the ram at about 1 year old and weighing 30 kg.

During this stage the ewes should be properly looked after to ensure that they are in good health and for the successful lambing. They should be regularly dosed or drenched against internal parasites.They should be regularly vaccinated against diseases. With regard to feeding, they need to be given quality pasture, silage or hay. They should also be given some concentrates one to two months before lambing, this is called steaming up.

Identifying suitable sheep and goat house

You may recall from your previous lesson on livestock management that farm animals should be provided with a suitable house. Sheep and goats need suitable accommodation too. **What type of a house for goats and sheep have you seen?**

Activity 5

Identifying suitable house for goats and sheep

Procedure

- Brainstorm the characteristics of a good house for goats and sheep.
- Discuss these characteristics with your teacher.
- Visit a nearby village to observe houses for sheep and goats.
- Record your findings.
- Report the findings to your class members.
- Choose an appropriate house for sheep and goats.

Goats must be reared under a comfortable place. This can be achieved through a careful consideration of certain characteristics which the house should be accorded with. The characteristics of a good sheep and goat house are:

- spacious.
- strongly built because sheep are prone to predators.
- well ventilated and well lit.
- dry and warm.
- easy to clean.
- easy and cheap to construct.

The type of house provided for goats will depend on the system of management being used, that is extensive, semi-intensive and intensive.

Goats are housed to protect them from adverse conditions of rain, drought, heat and predators like hyenas and jackals. A good goat house should have the following characteristics:

- it is sited on high ground.
- it is cheap to construct.
- it is strongly built.
- it is roomy – with a floor space of about $1.0m^2$
- it is well lit.
- it is well ventilated, drought-free and dry.
- it has a hard floor made of concrete or hardened/rammed earth or clay

- it has a well thatched roof.
- it is well drained and easy to clean.

Kids and nannies are usually housed in separate pens. It is normal practice that the nannies are housed together with one or two billies.

Constructing an appropriate house for sheep and goats

Some of you might have participated in constructing a house for sheep or goats; but some of you have not. This will be your opportunity to have a hands on experience in constructing the house.

Activity 6

Constructing an appropriate house for sheep and goats

Procedure

- Brainstorm materials required for constructing sheep and goat houses.
- Collect appropriate materials for construction of a sheep and goat house.
- Discuss with your teacher the procedure for constructing a house for sheep and goats.
- Invite a farmer who rears sheep or goats to demonstrate how to construct the house for sheep and goats.
- Construct the house for sheep and goats.

The following are materials needed for constructing a local sheep and goat house;

- Poles and twigs for rafters.
- Ropes.
- Sisal, linya and strings.
- Pangas and axes.
- Nails.
- Bamboos.
- Thatch grass.
- Bricks and stones.

Fig.13.1.

1. Assemble the materials required.
2. Lay out the site using tape measure, mallet, pegs and strings.
3. Clear the area of any bush or plants and dig the foundation.
4. Use poles to stake out the corners of the house.
5. Lay stones in foundation until ground level.
6. Built up the wall up to about 60 cm then use bamboo to raise the rest of the wall up to the rafters.
7. Use poles and bamboo to construct the rafters on the roof.

Fig.13.2

8. Cover the roof with grass thatch and use sisal or linya to tie the grass to the roof poles.

The feeding behavior of sheep and goats

Sheep and goats are ruminants. Do you remember from your Junior Course what ruminant animals are?

Activity 7

Describing feeding behavior of sheep and goats

Procedure

- Brainstorm the feeding behavior of sheep and goats.
- Observe goats browsing.
- Report your findings to the class during plenary session.
- Discuss with your teacher the differences between browsing and grazing.
- Your teacher will summaise the differences between browsing and grazing.

Sheep and goats are ruminant animals that depend mostly on pasture or grass. They are browsers. They browse on leaves, bark and green stems from plants while grazers feed on vegetation at or near ground level. Sheep are excellent grazers. On the other hand goats are both grazers and browsers.

There are differences between grazing and browsing.

In browsing, the animal eats any part of the plant. Goats therefore will eat plant leaves, stems and even roots. They eat the bark of a stem. Goats can end up destroying trees to point of death causing deforestation. This is why goats are called browsers.

On the other hand in grazing, an animal will eat grass and or herbs. Where possible, grazing animals can eat selectively, eating only the most palatable plant species. In grazing correct stocking rate prevents pasture destruction. Browsers can destroy trees even when grass and edible herbs are readily available.

Identifying suitable feeds for sheep and goats

You have seen that goats are browsers and grazers while sheep are entirely grazers. However, you need to know the suitable feeds for these two types of livestock.

Activity 8

Identifying suitable feeds for sheep and goats

Procedure

- Brainstorm suitable feeds for sheep and goats.
- Discuss with your teacher the suitable feeds for sheep and goats.
- List the suitable feeds for sheep and goats.

Feeds for sheep and goats can be classified as follows:

- Forage plants.
- Roughage.
- Roots.
- Concentrates.

Table 26: Showing suitable feeds for sheep and goats

Forage plants	Roots	Roughages	Concentrates
1.Grasses 2.Legumes e.g. Lucerne 3.Shrubs 4.Bushes and trees whose leaves are browsed	1.Cassava 2.Sweet potatoes 3.Arrow roots 4.Yams	1. Mature pastures e.g. dry forages 2.Residues from crops e.g. straws and haulms	1. Protein concentrates of plant origin e.g. groundnuts, cotton seed, sesame, soya beans, sunflower, coconut. 2. Protein concentrates of animal origin are by-products from the processing of carcasses, fish or milk.

Table25

Forage plants

Selection of appropriate feeds for sheep and goats is important in order to realise maximum production. Table 17 shows examples of suitable feeds for sheep and goats. Grasses form the largest part of the group. Legumes have higher crude protein and mineral contents. The leaves of bushes and trees are rich sources of nutrients.

Examples of forage plants that are suitable for grazing sheep are: guinea grass, giant star, Rhodes grass, kikuyu grass, cow peas, Lucerne or alfalfa, salt bush, pigeon peas, acacia.Goats browse on a variety of grasses and shrubs.

Roots

Roots are composed entirely of nutrients, water and energy. With most roots, the leafy part is also good quality forage. Sweet potato vines are a particularly good example. Succulents conserved as silage have similar feeding volumes to the parent crop.

Roughages

The main characteristic of roughages is their crude fibre content which limits the digestibility. Their sources are almost entirely from mature plants which means that the proportion of crude protein is low and they are also a poor source of energy. As from the table, two main sources are known; mature pastures and residues from crops from which grain has been harvested.

Dry forages from mature pastures vary considerably in quality, e.g. conserved hay, its nutrient content is dependent on the composition of the plant at the time of conservation and the efficiency of conservation.

Straws and helms are the residues from crops after harvesting cereal or legume grains. Derived from fully matured plants, their nutrients value is often low particularly if the parent crop was a cereal.

Concentrates

They have a large proportion of energy or protein. They are derived from plants at the same time a number of animal by-products are protein concentrates.

Energy concentrates are basically from cereal grain crops like rice, maize, sorghum,millet and wheat.The by-products from the processing of these cereals are often a good source of energy and should be utilised for stock feed. The protein content varies from medium levels in wheat and sorghum to low levels in rice.

Table 4 above indicates the protein concentrates of plant origin.These are used for stock feed most commonly are the by-products from the manufacture of vegetable oils. The oil seeds whose by-products are most frequently available are available in the table.

Protein concentrates of animal origin are by-products from the processing of carcasses, fish or milk. They are a rich source of high quality protein, and minerals and may contain important amounts of vitamins. If available for stock feeding they are usually fed to poultry and pigs rather than sheep.

For an animal to produce or grow well, it must be fed on a balanced diet or on the correct amount of ration. A balanced ration is the daily feed allowance per animal in the correct amount and having all the nutrients in the right proportion. Such rations contain carbohydrates, proteins, minerals, vitamins, fats and water in their right proportions. For an animal to grow and reproduce well, it should be given both maintenance and production ration.

Sheep and goat feed are selected for the following reasons:

- They provide a balanced ration.
- They are locally available since they are made from local crop residues.
- Some can be bought cheaply.
- Some can be grown on the farm.
- They are free from toxic substances.
- They can be dried and stored for use during the dry season.
- They contain a lot of nutrients.

Diseases of Sheep and Goats

Did you know that sheep and goats just like any other animal suffer from diseases? You might have seen a goat or sheep looking dull and differently from normal. This could be a sign that the animal is not in good health condition.

Activity 9

Identifying diseases of sheep and goats

Procedure

- Research on diseases of sheep and goats in the library.
- List the diseases of sheep and goats.
- Describe the signs and symptoms of diseases of sheep and goats.
- Role-play the signs and symptoms of diseases of sheep and goats.
- Record the signs and symptoms of diseases of sheep and goats.

Do you remember the definition of the word 'disease'? Discuss with a partner about this.

A disease is a physiological or anatomical disorder or abnormality in an animal which can be identified through characteristic symptoms on the animal. Most diseases have specific symptoms; though certain diseases have common symptoms. The period of time between infection and appearance of disease symptoms is called the incubation period. Diseases reduce an animal's economic value. Some of the diseases of sheep and goats are:

1. Nasal worm.
2. Foot and mouth.
3. Mastitis.
4. Brucellosis.
5. Pneumonia.
6. Sheep pox.

Activity 10

Explaining how to control diseases of sheep and goats

Procedure

- Brainstorm control measures of diseases of sheep and goats.
- Discuss the control measures with your teacher.
- Observe a resource person controlling diseases of sheep and goats.
- Your teacher will summarise the disease control measures.

Table 27: Showing common sheep and goat diseases and their control.

Disease	Causative agent	Signs and symptoms	Treatment and /or control measures
Nasal-worm	Nasal (worm) bot fly	1.Small grey-green fly with prominent black spots on thorax – fly covered with short light-brown hairs 2.sneezing and thick nasal discharge	1. Spray or dip 2. Use a fly repellant like Stockholm tar to repel flies off feed.
Foot and mouth	virus	1. high fever 2. inflammation of tongue, lips, and gums making it difficult to eat 3. lameness 4. profuse and continuous salivation	1. Imposition of quarantine 2. Vaccination every six months 3. Slaughter, burn and bury infected animals 4. Disinfect animals' hooves

Mastitis	bacteria	1. blood clots or pus in milk 2. swollen udder 3. drop in milk yield 4.rise in body temperature	1. Practice hygiene during milking 2. Treat with antibiotics 3. Use disinfectants 4. Vaccination
Brucellosis	bacteria	1.abortion in late gestation 2.retention of placenta 3. a yellow, brown, slimy discharge from the vulva may occur	1.Cull and slaughter infected animals 2. Disinfect areas contaminated with uterine discharges 3. Proper disposal of aborted foetus 4. Use of artificial insemination 5. A blood test for all breeding herds to detect infected animals
Pneumonia	bacteria	1. severe respiratory problems 2.abnormal lung sounds such as bubbling, hissing and gurgling 3. animal appears dull and loses appetite	1.Keep young animals in warm house 2.Treat early cases of the disease with antibiotics 3. Avoid overcrowding 4. Isolate sick animals 5. Ensure proper ventilation in the animal houses.
Sheep pox	Virus	1.high fever 2. dark red pimples/lesions 3. some lambs die 4. abundant mucoid nasal discharge	

Sheep and goats diseases are categorised into:

1. Protozoan diseases e.g. Anaplasmosis, Coccidiosis, Trypanosomiasis.
2. Bacterial diseases e.g. Brucellosis, Mastitis, Pneumonia.
3. Viral diseases e.g. Rinderpest, Foot and mouth disease.
4. Nutritional diseases e.g. Milk fever, Bloat.

Parasites of sheep and goats

Parasites are organisms which derive part or all their nourishment from other organisms, referred to as, the host. The host-parasite relationship is greatly beneficial to the parasite but harmful to the host. Sheep and goats suffer adversely as hosts to a variety of parasites.

Activity 11

Identifying parasites of sheep and goats

Procedure

- In pairs, research on the parasites of sheep and goats. List the parasites and report to the class.
- Visit a nearby farm to observe how to control parasites in sheep and goats
- Discuss the control measures with your teacher
- Your teacher will summarise the control of parasites in sheep and goats

List of parasites of sheep and goats:

1. External parasites

   (i) Lice (ii) Ticks (iii) Mites (iv) Tsetse flies

2. Internal parasites

   (i) flat worms (ii) roundworms

Table 28: Showing the signs of external parasites attack in sheep and goats

Parasite	Part of the body attacked/damage	Treatment/control
Ticks	• Ears, tail, udder • Suck blood and transmit tick bone diseases like heart water and red water	• Dipping animals regularly fortnightly during the dry season and weekly during the rainy season • Spraying • Hand-dressing
Scaly mites	• Skin • Cause itching	• dipping
Lice	• skin • suck blood	• dipping
Tsetse flies		• spraying • sterilization of the male tsetse flies by use of chemicals • clearing bushes in areas infested by tsetse flies • trapping of the flies using special nets treated with appropriate chemicals. The chemicals are usually laced with insect-attracting pheromones

Ticks

Ticks are common external parasites of sheep and goats responsible for the transmission of a number of serious livestock diseases. They cause anemia and damage the skin as a result of their bites.

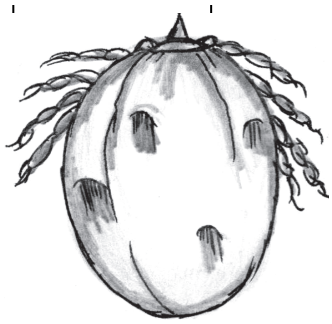


Fig.13. 3.A diagram of a tick

There are two types of ticks

- Soft ticks have a tough leathery outer coating
- Hard ticks have a hard, shield-like covering on the upper surface in males. The females have a small area behind the head.

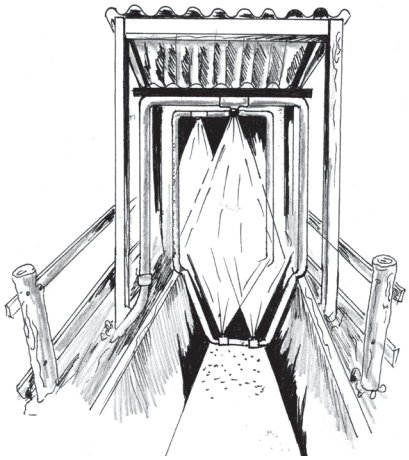


Fig.13. 4.

Hard ticks are more harmful to their hosts than soft ticks. Soft ticks undergo several nymphal stages in their life cycle, whereas hard ticks go through only one nymphal stage.

Ticks are controlled by chemicals called *acaricides* applied once or twice a week depending on the severity of the tick infestation.Follow dilution instructions and apply to all body parts for effective tick control. Three main methods of tick control are used as seen from the table namely dipping, spraying and hand-dressing.

Activity 12

Explaining how to control parasites of sheep and goats

Procedure

- Brainstorm control measures of parasites in sheep and goats.
- Discuss the control measures of parasites in sheep and goats with your teacher.
- Visit a nearby farm to observe how parasites in sheep and goats are controlled.
- Record your findings.
- Discuss the findings from the visit with your teacher.
- Your teacher will summarise the control measures in sheep and goats.

Other tick control measures include;

- Fencing.
- Rotational grazing.
- Burning of infected pasture.
- Ploughing the land.

1. Fencing

Fencing a farm can effectively control ticks. Animal movement is restricted thus minimising the spread of ticks. If coupled with zero grazing units, effective tick control is assured.

2. Rotational grazing

Rotational grazing where practiced, reduces the buildup of ticks in pastures.

3. Burning of infested pasture.

Adult ticks, their eggs and molting larva and the nymphs, can be destroyed by burning infested pasture. This method is mostly used in range lands.

4. Ploughing the land

Ploughing buries ticks deeply in the ground thus killing them.

Mites

Mites are eight legged, round –bodied and crawling arachnids. They are white in colour and have dark legs. They burrow into the skin of the animal causing great irritation. They attack sheep and goats.

Spraying and dipping effectively controls the mites.

In sheep, sheep scab is caused by a mite. The mite lives in the skin of sheep. They pierce the skin and feed on the fluid which oozes from the wound. Clean the sheep with soap and water to remove dirt, skin debris and grease then dip the sheep in acaricide solutions.

Lice

Lice are wingless insects with a diamond shaped body which attack sheep. Lice are usually host-specific therefore; the ones that affect sheep are **sheep lice**

Sheep lice feed on the head and hairy part of the lower body. The foot louse

attaches itself on the foot and lower leg of sheep. The brown body louse sticks on the upper sides of the body.

Lice are a source of irritation to livestock causing restlessness, constant scratching and rubbing of the animal against surfaces. This interrupts feeding and animals lose vitality, lose weight and may have retarded growth.

A single dipping ensures effective control of lice. All sheep must be treated in the same dipping operation as one un-treated animal can re-infect the entire flock.

Tsetse flies

These are blood-sucking insects which attack sheep and goats. They mainly inhabit humid, bushy areas and can be found under certain shade trees. Tsetse flies become active during the day and attack by inflicting painful bites causing the animal to jump or run around in pain. Tsetse flies transmit trypanosomiasis (nagana) in livestock.

Control measures of Tsetse flies are listed in the Table 150. The government must create buffer zones near game reserves thereby preventing the transmission of infection from wild animals to livestock.

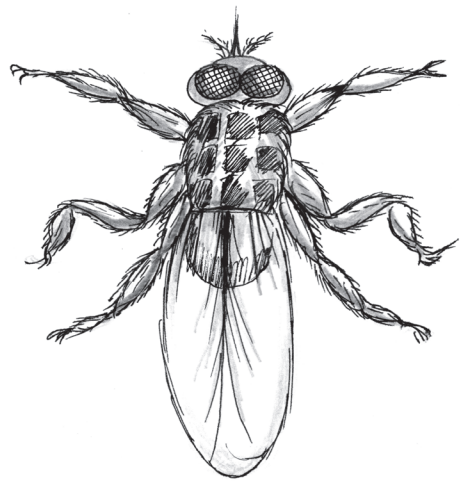


Fig.13.5 Diagram of a Tsetse fly

Internal Parasites

Internal parasites are also known as *endoparasites.*

Endoparasitic worms (helminthes) can be divided into:

- Flatworms (platy helminthes) e.g. flukes
- Roundworms (nemathelminthes)

1. Flatworms

Flatworms can be grouped into:

- Trematodes: These are flatworms with flattened dorso-ventral bodies that is, the back and belly are close together. Trematodes are mostly hermaphrodite, that is, they possess both male and female reproductive organs.
- Cestodes: This group of flatworms has body sections with complete

reproductive organs, with one nervous and excretory system continuous running through the body. The head part attaches the worm to the host of the body by hooks or suckers. The separate sections bud off one by one, making a long chain. Those sections farthest from the head are the oldest buds for example, tapeworms.

2. Liver fluke

Liver fluke attack sheep and goats inhabit bile duct of the animal host and cause damage to the liver. Animals have digestive upsets due to blocking of bile duct, swollen abdomen, d emaciation, anemia due to destruction of liver tissues, edema in the jaws and death due to severe emaciation.

Fig.13.6 Liver fluke

Control measures include;

- Routine drenching using anthelminthic drugs.
- Destroy water snails by treating swampy water with copper sulphate.
- Fence off heavily infested swampy areas to prevent farm animals from grazing in such infested areas.
- Drain swampy areas within the farm.

3. Tapeworms

Tape worms are host-specific. The two most common tapeworms that affect livestock are Taenia *saginata and Taenia solium*.

Tapeworm attacks make rough coat on animals, make digestive disturbances like diarrhoea and occasional constipation, animals develop a pot belly, anemia, edema and presence of egg segments or proglottides in the feaces.

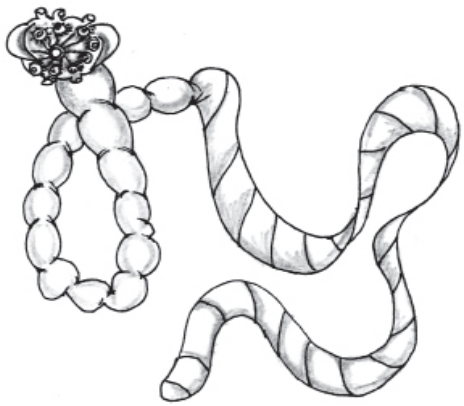


Fig.13.6 Tapeworm

To control Tapeworms

- Routinely de-worm animals using appropriate drugs.
- Plough the pasture land to kill the cysts.

- Proper disposal of human waste e.g. use of latrines.
- Proper cooking of meat.
- Rotational grazing.
- Proper meat inspection.

4. Roundworms

Roundworms are usually cylindrical in shape and pink white in color. They exist separately as male and female. They inhibit the alimentary canal of sheep and goats.

What effect do you think roundworms have on sheep and goats they attack? Talk to your partner about this.

Sheep and goats show;

- retarded growth.
- scours.
- anemia.
- stiff dry coat.
- diarrhoea.
- constipation.
- pot belly.

To control roundworms the following has to be done;

- avoid grazing animals on muddy grounds.
- avoid grazing animals on wet grass early in the morning when larvae are active.
- de-worm animals using appropriate drugs.

General Control of Diseases and Parasites in Sheep and Goats

1. **Vaccination:** Vaccinate the sheep and goats as per recommendations of the veterinary staff against any disease.
2. **Control of mastitis:** Goats with mastitis should be milked last to prevent the spread of infection to other goats as mastitis can cause a reduction in yields of at least 10%

3. **Foot trimming**: Overgrown hooves predispose foot rot infection. They also cause lameness in sheep and goats and make them unable to walk properly. Routine hoof trimming should be done.

4. **Dosing and drenching:** Goats should be drenched on a routine basis once or twice a year, normally at the beginning of the rains. Internal parasites can be controlled through giving drugs especially just before and after kidding. Kids should be dosed 2-3 weeks after birth and then once a month thereafter. However, parasitic infestation can be reduced through the following management practices;

   - Clean housing where no dung or dirt, wet bedding is allowed to accumulate.
   - Clean water supply which has not been fouled by goats
   - The grazing area should be changed every 4-5 days and not be grazed again for about six weeks.
   - Avoid grazing early in the morning while the grass is still wet, there is more danger of taking up parasites than in the afternoon

5. **Dipping or spraying:** Dip or spray the goats against ticks regularly. Use a sheep and goats plunge dip. In intensive system, rotational grazing can control ticks.

Sheep ticks may conveniently be placed in three classes;

i. One-host ticks: The entire parasitic life-cycle is spent on one host.

ii. Two-host ticks: The larvae and nymphae infest one host and the nymphal moult occurs on the ground. The adult seeks a second host on which to feed.

iii. Three-host ticks: All three stages parasites separate hosts and each moult takes place on the ground.

Ticks adversely affect sheep production through direct injury and blood loss, by the introduction of toxins and by the transmission of disease organisms. Toxins introduced by the female tick as she feeds may cause paralysis and death. A wide variety of bacterial, protozoan, viral and rickettsial diseases are transmitted by ticks to sheep.

Nutritional diseases

These are diseases that occur due to nutritional deficiencies and metabolic disorders.

1. Bloat

Is a condition in sheep and goats in which gases accumulate in the rumen due

to rapid fermentation of the feed eaten by the animal. The rumen enlarges that it compresses the lungs and other internal organs. This may result in death of the animal.

Causes of bloat are;

- Blockage of oesophagus by large food particles.
- Abrupt change in feeds given to animals for example, from very dry feeds to very fresh and succulent feeds. The rumen fails to adjust to the new feed so indigestion occurs.
- Feeding animals with large amounts of legume and lush grass e.g. cabbage leaves and lush grass. This causes rapid fermentation producing a lot of gas in the stomach faster than the gas can escape through the esophagus.
- Injury to the nerve supply of the rumen causing paralysis of the rumen.

Symptoms

- Difficulty in breathing.
- Animal lies down and is unable to rise up.
- Grunting and kicking at the belly.
- Salivation.
- Distension of the left side of the abdomen due to gas accumulation, it can be felt by pressing with hand.

Prevention;

- Feed animals on grasses and legumes that have wilted.
- Provide dry roughage just before feeding the animal on grass and succulent or wet pastures.

Treatment;

- Exercise the animal by walking it around. This mixes up the rumen contents and help in the escape of gases.
- Use medicinal oils like liquid paraffin or turpentine mixed with vegetable oil to remove froth in the rumen.
- Empty stomach using Epsom salts as it acts as a laxative.
- A stomach pump can be used to remove the gas in the rumen. The pump is inserted into the rumen through the esophagus.
- Inject Methyl silicone directly into the rumen to prevent frothing.

- In extreme cases, trocar and canula or sharp sterilised knife is used to pierce through the skin of the rumen. After piercing, the gases escape and the animal is relieved.

2. Milk fever

The disease is also known as *parturient paresis*. It affects dairy sheep and goats.

Milk fever is caused by low calcium level in the blood, a condition known as hypocalcaemia.

Susceptibility

The disease is more common in heavy milking dairy goats. Goats that are extensively fed on feeds rich in protein but low in calcium. Hence there is no adequate replacement in the body compared to its removal through milk secretion. The condition is also likely to occur between the 3rd and 4th lactation when milk production is at its highest either a few days to parturition or a few days after lactation.

Symptoms

Symptoms are observable within 12-72 hours before or after calving.

- Staggering as the animal moves.
- Muscular twitching causing the animal to tremble.
- Extremely cold to touch.
- Excitement then falling to the ground.
- Inability to stand, the animal lies down on its side most of the time.
- Dull and staring with dilated eyes.
- Animal lies on the sternum with neck twisted on one side. This is called sterna recumbency.
- Breathing becomes slow and weak.
- Body temperature falls to 35^{0}C.
- Rumen stops moving.
- Saliva oozes from mouth.
- May be in coma.
- General paralysis. The animal's body functions such as urination, defecation and milk secretion stop.

- Death follows.

General control measures

- Feed animals on a diet rich in calcium especially during pregnancy and early lactation periods.
- Give intramuscular injection of calcium 2-3 days before calving
- Dairy goats with past record of milk fever should be partially milked for the first ten days that is, partial milking every two hours for the first few days. Then increase the milking level gradually until after 10 days. Thereafter carry out normal milking.
- Cull susceptible animals.

Treatment;

- Pump air into the udder to limit milk synthesis.
- High calcium content feeds.
- Injection of calcium borogluconate solution intravenously, calfoject or calcijet intramuscularly. Small doses to prevent heart failure.

Unit Summary

Sheep and goats are small ruminants that if well managed can increase meat and milk production. Students should be able to demonstrate an understanding of sheep and goats production. Sheep are distributed all over the country. Description of the indigenous sheep is based on colour, presence or absence of horns and the tail characteristics.

National aims in sheep husbandry are to increase the numbers of sheep and improve the productivity of indigenous sheep by practicing improved standards of management such as the use of improved breeds, housing and feeding.

Goats play an important role in the economy of the drier areas. Traditional husbandry practice emphasises survival rather than productivity of goats i.e. the larger the size of the flock, the greater the chance of survival. Improved management should concentrate less on maintaining large flocks and more on increasing output of meat, mutton and milk through better feeding and disease control.

Local goats in Malawi are hardy as far as feeding is concerned. They are prolific but do suffer from diseases just like other species of livestock. They are small to medium sized and have slow to medium growth rates. This calls for improvement. The aim is therefore to improve the productivity and off take.

Glossary

- **Lush grass**: young shooting green grass.
- **Froth**: foam coming from the mouth.

Review Exercise

1. Explain the importance of sheep and goats in Malawi.
2. State the factors which influence sheep and goat productivity.
3. What is a disease?
4. Differentiate between browsers and grazers in sheep and goat management.
5. What is known as incubation period of a disease?
6. State any four predisposing factors for each of the following diseases;
   i. Mastitis.
   ii. Pneumonia.
   iii. Foot rot.
7. Study the diagram below and answer the questions that follow;

i. Identify the parasite.

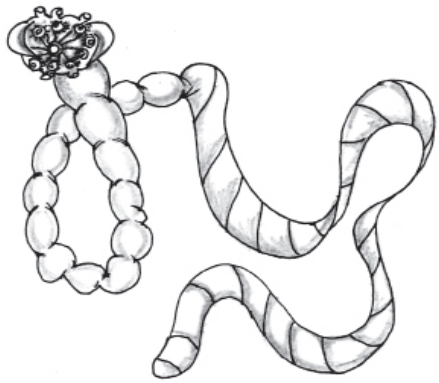


Fig.13.7

ii. How is the parasite passed from livestock to human beings?

iii. State two methods by which this parasite can be controlled.

8. Name two diseases in sheep and goats that occur due to nutritional deficiencies.

References

1. *Ministry of Agriculture and Food Security (2012): Guide to Agricultural Production and Natural Resources Management in Malawi.*
2. *Anthony M. Ngomwa, Peter Sigel and Daniel Cheruiyot (2012): Senior Secondary Agriculture Form 3.*
3. *B.M. Kanjala and N.T. Kaperemera. (2002): Strides Agriculture Book 3, Longman Malawi (Pty) Ltd.*
4. *Chard P.G.D. (1991): Focus on "O" Level Agriculture Book 4, Pupils' Text Book.*
5. *Ngugi D.N., Karau P.K. AND Nguyo W (1990): East African Agriculture, Third Edition. By. MacMillan.*