MALAWI SCHOOL CERTIFICATE OF EDUCATION

AGRICULTURE

SUMMARY NOTES

UNIT 1

PHYSICAL PROPERTIES OF SOIL

Soil is a mixture of weathered rock particles, organic matter, water and air. It is one of the basic natural resources upon which agricultural production depends.

Its ability to anchor and support plant growth depends on a number of factors. These include the type and depth of the soil, its ability to hold, retain and supply plant nutrients, its moisture content, aeration and drainage as well as microbial activities in the soil.
All these factors are related to the physical properties of the soil. These physical properties of soil are related to the inorganic mineral matter present in the soil.

Soil texture

Soil texture refers to the coarseness or fineness of the soil particles. The coarseness or fineness is due to the amount of sand, silt or clay in the soil. Soil texture therefore can also be defined as the proportion of sand**,** silt and clay in the soil.

Classification of soil particles

Soil particle	Diameter (mm)
Gravel	20.0 – 2.0
Coarse sand	2.0 - 0.20
Fine sand	0.20 – 0.02
Silt	0.02 – 0.002
Clay	Below 0.002

The above are textural classes of soil

NOTE: Sandy soil contains more than 70% sand particles, clay soil contains over 40% clay particles and loam contains 45% sand particles, 35% silt particles and 20% clay particles.

Determination of soil textural classes

These can be determined by three methods, namely: Sieving, Sedimentation and Feel methods

(a) Sieving

- Collect 15 - 20g of soil and then grind it finely.
- Separate gravel and sand particles from silt and clay through sieving. Use four sieves of different mesh sizes (2mm, 0.2mm, 0.02mm and 0.002mm). Stack the sieves together to separate the soil particles.
- Then weigh the amounts of gravel and sand separately and express the mass as a percentage
- Silt and clay are separated through sedimentation in water and weighed.
- Express the various particles sizes, that is, sand, silt and clay as a weight - percentage using the amount of dry soil as the basis.

(b) Sedimentation

Sedimentation is as follows:

- Collect sample of soil, break it down lightly by hand into small lumps.
- The soil thus broken is passed through 2 mm mesh sieve and all the particles with a diameter

smaller than 2 mm pass through, while those having a diameter greater than 2 mm remain in the sieve. The particles that remain are called **gravel**.

- The soil is then placed in a measuring cylinder to a depth of 15 cm and the jar is then filled with water. This mixture is then agitated by shaking it vigorously, after which it is left to settle over a period of say, 24 hours. The different size particles settle as shown below:

The various particle size components are also called **Fractions**

- The fractions are dried and weighed.
- The fractions i.e. sand, silt and clay are expressed as a weight percentage using the amount of dry soil as the basis.

Once these percentages are worked out the **Soil triangle** (triangulation) to classify the texture of the soil is used.

The soil triangle

The **soil triangle** - the dot represents a loam soil with 45% sand, 35% silt and 20% clay content.

(c) Feel Method

This method involves addition of water to a sample of soil to make it moist. The soil sample is then placed between the fingers for feeling.

Using the following guidelines, the texture of the soil can be determined:

Sand: Is coarse to feel, large particles, even when wet in cohesive.
Sandy loam: Has obvious sand particles but can be moulded.
Loam: Contains sand, can be moulded and sticks to fingers slightly when moist.
Loamy sand: Coarse feel but begins to hold together when moist.
Silt loam: Can be moulded but not very sticky.
Clay loam: Sticky soil but no obvious sand particles.
Silt: Smooth soapy feel.
Clay: Soft, plastic and sticky, can be moulded into any shape and can be polished.

Effects (importance) of soil texture on crop production

Sunlight, water, air, CO_2, Correct temperature, relative humidity and soil nutrients are required for proper plant growth. All these, except sunlight, can be obtained from the soil. These are affected by the texture of the soil. Therefore texture will have the following effects on plant growth.

- Water retention for plant growth (dependent on pore space)
- Drainage and aeration.
- Retention and supply of nutrients to growing plants.
- Ease with which plant roots and shoots penetrates and grow.
- How easily the soil will be cultivated at different moisture contents (consistencies).
- Availability of micro organisms (dependent on degree of aeration).
- Resistance to erosion of the soil.

Different soil textures support different crops

- Well - drained sandy / clay loam soils support tobacco.
- Loam soil will allow maize, vegetables to thrive well.

- Well drained, rich and sandy loam soil support cassava well, however cassava also tolerates poor soils.
- Rich, sandy loam soil grows cotton.
- Light loam soil favours groundnuts.
- Sandy loam too will allow groundnuts.
- Heavy clay soils which retain a lot of water support rice well.
- In light - textured (sandy) soils, water movement into the soil is fast but retention is low.

This is due to the large pore spaces.

- Heavy or fined-textured soils (clay) allow water to penetrate slowly but they are able to retain a lot of water for plant growth. They have small but many pore spaces.
- Sandy soils are more prone to drought conditions, why?
- Soil with a fine or heavy texture also retain more plant nutrients through absorption than coarse - textured sandy soils.

Complete the following table

Characteristics	**Sandy**	**Clay**	**Loam**
Particle size	Large	Small	Medium
Drainage		Slow	
Water holding capacity			
Aeration			
Nutrient holding capacity	Low	High	Easy
Cultivation			
Root penetration			Good

Comparing the water - holding capacity of soils

Maintenance / improvement of soil texture

Note: Very little can be done to improve the texture of the soil. It would be difficult and expensive to replace sandy soil, for instance, with clay soil. So maintenance of soil texture is as follows:

- Soil should be cultivated at the right moisture content.
- Using appropriate physical conservation measures will help reduce soil erosion e.g. waterways, contour bunds, terraces, constructing ridges across the slope.

II. Soil Structure

Soil structure refers to the way the individual particles (sand, silt and clay) are arranged or packed together to form aggregates/groups collections. This aggregation of particles is made possible through cementing agents like organic matter and clay.

Importance of soil structure

Soil structure is important in Agriculture because:

- It influences the movement of air and water in the soil

-Determines the pore spaces (voids) and drainage in the soil
- Determines erodability of a soil

Soil characteristics influenced by soil structure.
- Aeration.
- Water holding capacity drainage
- Cultivatability (is it easy to cultivate or not?)

How does structure influence crop production?
It influences the balance between air and water in the soil in the following ways:
- Large pore spaces (voids) promote air flow, which supplies oxygen to soil for root growth and microbial activities.
- Small pores retain water which is used by plants.
- Seed germination and plant growth are generally limited in soils with many but small pores (such as clay) due to poor aeration.

Types of soil structure
These are mainly two forms of soils and these are:
- Single grained (granular) soils eg. Sandy soils and
- Massive (crumb) soil such as clay soil.

Types of soil structure
1. Flat or plate - like
The soil aggregates (groups) are arranged on top of one another in relatively thin horizontal plates or leaflets. Such structure is common in clay, loam soil, in lower top soil of some clay. The disadvantage of tills structure however, it impedes drainage and root penetration. It also breaks easily during cultivation.

2. **Prismatic (prism - like)**
The soil aggregates are vertically oriented (arranged). This structure is common in clay soils of the sub soils. It is a soil undergoing active weathering.

3. **Blocky (or many - sided)**
Particles are arranged in blocks - equal amounts of flat and upright units easily fit together

4. Crumb / Granular
Almost round or spheroid are formed. Particles are arranged around a central point and may be granular or crumb.
5. **Simple grained / Single grained (structure less)**
This forms no aggregates i.e particles arc not cemented together. This structure is common in sandy soils in top soils. Such soils are usually porous and are excessively drained and have little or no organic matter

Agents helping to form soil structure
- Clay particles flocculating
- Iron and aluminium oxides act as cements.
-n Wetting and drying alternately
- Living things and their products especially humus (ie. organic matter in general)

The structure may be damage by:
- The impact of heavy rains.
- The use of heavy machines when soil is too wet or too dry.

- Cattle treading and trampling soil.
- Monocropping

Characteristics of a soil with a good soil structure

Crumb in the top soil of the size to suite the crop.
Stable against the rain, wind and traffic
Retains useful amount of water but lets (allows) air too
Allows an even root penetration, development and supports high population of soil microorganism.
Has good sub soil drainage.
Contains a lot of nutrients and is easy to cultivate (ie workability)

Maintaining and improving soil structure

Farmers can not do much to improve soil texture, however, they can do a lot to improve soil structure and preserve it.

- Protecting soils from raindrops impact. A crumb structure is easily destroyed through splash erosion. Planting vegetables cover (such as grass), close - growing crops (such as groundnuts, sweet potatoes), mulching will check splash erosion.
- By addition of certain chemicals such as lime, humus, manure. These have a cementing effect.
- Avoid overgrazing which leads soil to becoming vulnerable/susceptible to soil erosion.
- Crop rotation. Leaving the land to fallow helps the soil to rebuild itself.
- Using machines properly ie. Avoid using heavy machines (drawn by tractors) when the soil is too wet or too dry. Also avoid excessive use of machinery.

III. Colour of Soils

- The colour of the soils varies with its origin (i.e. parent materials) and method of formation.
- Colour can be observed easily and has been used as a basis for classification.

Colouring agents (i.e. factors influencing soil colour)

Organic matter: Soils rich in organic matter are darker in colour ranging from black to grey - brown e.g. forest soils.
Iron compounds: The oxides of iron in the soil makes it yellow, orange, red and brown.
Red soils indicate the drying out of iron - rich soils by a long hot season.
Mica: A soil containing mica has a glittering appearance.
Silica: Soils rich in silica (quartz) are whitish or greyish white in colour.
Drainage: Poorly drained soils or waterlogged soils look greyish while those which are well drained will look brown, red or yellow in colour.

Importance of soil colour

It influences heat absorption and retention. Warmth is essential for soil microbes and crop roots. Dark soil absorb more heat than light in colour soils.

IV. Soil Temperature

Importance of soil temperature

It affects the following:
- Soil formation
- Evaporation and transpiration.
- Maturation
- Drying of crops.
- Seed germination.
- Root growth.
- Chemical reactions in the soil.
- Activities of soil micro organisms; optimum microbial activity such as decomposition happen when temperatures are between 25^{o}c and 40^{o}c

Factors that influence soil temperature

- **Soil colour:** Dark soils tend to absorb more heat (energy) from the sun than soils which are light in colour.
- **Vegetative cover:** Soil temperatures does not fluctuate as much under vegetative cover as it does when the soil is bare. Bare soil warms up easily during the day and cools off more rapidly at night.
- **Direction of slope:** A garden which slopes towards the north, if it is in the southern hemisphere, is heated more than land which faces south.

How soil temperature can be altered or modified:

- Mulching the soil.
- Planting vegetative cover
- Irrigating the soil.
- Draining excess water from the soil.

V. Soil Consistency

Soil consistency refers to the state of soil under different moisture conditions.
When the soil is dry it does not break down easily. Thus it is either hard or very hard. Dry soils also tends to be loose as in sandy soils.
Other soils break easily into single grains when slight pressure is applied. Such soils are said to be soft when they are dry.
When soil is moist and pressure is applied to it, it tends to be **friable**
(i.e. it crushes under slight pressure). However, the particles hold together. If a wet soil cannot be crushed when pressed between thumb and finger, it is said to be f**irm.** Wet soil tends to be sticky and plastic, this is especially true of clay soils.
NOTE : Consistency depends on :

(i) Soil resistance to pressure and the way the particles hold together (aggregate)
(ii) The amount of water present in the soil.

Importance of soil consistency in crop production

- It affects the workability (ability to be cultivated) of soil. Soil should be cultivated when it has the right moisture content. It should neither too wet nor too dry. Soil can be destroyed if cultivated when it is too dry - the soil particles break down easily into dust and can be eroded.
- Soil sticks to implements and it puddles when cultivated wet. Clay soils arc hard to work with when too wet or too dry
- One way to modify soil consistency is to drain the soil when waterlogged. And if it is too dry then irrigate it. Also use appropriate farming equipment.

VI. Soil Depth

- Soil depth, as a physical property of soil, is associated with the soil profile.
- Soils which are well developed and mature tend to be deep. Under - developed soils tend to be shallow
- The slope of the land also affects the soil depth. Soil depth increases as you go down the slope. The soil tends to be shallow on the steep as a result of soil erosion and this explains why crops do not do well on a steep slope.
- Parent material also affects soil depth. Soils which are formed from parent material that is resistant to weathering may tend to be shallow as opposed to those that are formed from parent material that weathers more easily.

Importance of soil depth

- It affects root development.
- It affects the amount of water held by the soil.

Maintenance / improvement of soil depth

- Using appropriate farming equipment.
- Draining the soil.

VII. Porosity

- A substance is porous if it allows water or any liquid, or air to pass through it. Porosity is the condition of being porous.
- This condition is due to the presence of air and water spaces in the soil. These are called pore spaces. Remember that structure of the soil determines the air and water spaces.
- When the soil particles are close together, as in sandy soil, the total porosity is low. Porosity in clay soil is high because air spaces though tiny, are many. Pore spaces can make up as much as 40% of sandy soils and over 50% of other soils. The pore spaces in sandy soils are large in size, mostly influence air flow. This is why sandy soil does not retain much water.

Importance of porosity in crop production

It influences air and water movement / availability in soil.

Factors influencing porosity

- All those factors that influence structure. This is because porosity is associated with soil structure (so refer to notes on maintenance of soil structure)

Bulk Density

- Porosity is associated with Bulk Density.
- Bulk Density is the sum total of the pore spaces and soil particles of the soil.
- The formula for measuring bulk density is:

$$BD = \frac{W}{V}$$

(where BD = bulk density; W= weight of oven - dry soils; V= Volume of oven-dry soil)

- Porosity is the proportion of the volume (total) of soil that is taken up by pore spaces.
- Bulk density, however, takes into consideration both the solid component and the pore spaces of the soil. (i.e. entire soil). Therefore, we use bulk density to determine porosity of soil as shown in this equation.

$$\% \text{ porosity} = \frac{\text{bulk density} \times 100}{\text{particle density}}$$

- Bulk density for clay is about 1.0g / cc and for fine sandy loam it is 1.3g / cc
- The figure 2.65g / cubic cm is generally regarded as the average particle density.
- Percentage of air and water in an ideal (good) soil is about 50%
- Percentage of porosity depends on the soil texture. It ranges from 40% in sandy soil to about 60% in clay soil. Loam soil is about 55% porous.

Maintenance and improvement of porosity

- Adding organic material.
- Cultivating the soil.

UNIT 2

CHEMICAL PROPERTIES OF SOIL

Introduction

- The chemical properties of soil include soil pH, cation exchange capacity (CEC) and salinity.
- Like the physical properties of soil, chemical properties of soil too influence crop production directly or indirectly.
- They affect the availability of mineral elements for essential plant growth and the activities of micro organisms.

I. Soil pH

- The term "Soil pH" is used to describe the acidity or alkalinity of the soil. This is also referred to as **"Soil reaction".**
- The ions that determine the soil pH are the hydroxyl ion (OH^-) and the hydrogen ion (H^+). When these ions are in equal concentration in the soil, the soil tends to be neutral (pH 7)
- However, when the hydrogen ions in the soil solution are in greater concentration than the hydroxyl Ions attached to the soil particles, the soil is said to be acidic. This is why pH is sometimes referred to as the concentration of hydrogen ions. The soil tends to be alkaline when the hydroxyl ions are greater than the hydrogen ions concentration.

Factors that affect or increase hydrogen ion concentration.

(i) Leaching of some mineral elements, which arc replaced by hydrogen ions. During continuous heavy rainfall, plant nutrients such as Ca^{++} (calcium), Sodium(Na^+), magnesium (Mg^+) and potassium(K) are leached down the soil profile. These elements are then replaced by hydrogen ions.

(ii) The use of acid - forming fertilizers.
Continuous and heavy application of sulphate of ammonic makes the soil acidic.

(iii) Microbial activity
Microbial activity increases soil pH as hydrogen ions are released during the decomposition of organic matter. Again, the carbon dioxide which is produced by microbes dissolves in water and forms carbonic acid, which increases soil pH.

(iv) Weathering of parent material.
Parent material contains different mineral elements which when weathered, affect soil pH, For instance, soil pH is increased if the parent material contains sulphur. This is through the formation of sulphuric acid. Soils formed from lime have a high pH. The weathering of parent material may also result in the accumulation of such ions as K^+, Na^+, Ca^{++} and Mg^+. These tend to increase soil pH.

(iv) Nutrients up take by plants
Plants absorb nutrients from the soil to manufacture their own food. When the crops are harvested, the nutrients absorbed by the plants are also lost from the soil. These lost nutrients tend to be replaced by hydrogen ions, which lower the soil's acidity.

(vi) Poor drainage
Drainage depends on the texture of soil and this is linked to leaching. Sandy soils are more prone to leaching than clay soils. Consequently, soil pH tends to be lower in sandy soils than in clay soil.

(vii) Type of vegetation.
The type of vegetation growing in a soil affects the soil pH in several ways. For instance, the decomposition of organic matter influences soil pH through the release of nutrients. Above all, the type of vegetation contributes greatly to providing protection to the soil against rainfall impact and soil erosion. It is known that soils in forests tend to have a lower pH than those in grasslands, where loss of nutrients through leaching is reduced.

The modification or improvement of soil pH.

- Acid soils can be corrected by adding lime or fertilizers containing calcium ammonium nitrate. Lime tends to neutralise soil acidity.
- Soil pH can be decreased through the addition of acid - forming fertilizers such sulphur or phosphate fertilizers.
- Add organic matter.

Importance of soil pH in crop production

(i) Soil pH affects crop production both directly and indirectly. Some crops do well under acid conditions and others do well under alkaline conditions. Tea, pineapples and berries do well in acid conditions. Beans, peas, soya beans, groundnuts, cabbage and sunflowers refer alkaline soil.
Maize, wheat and sorghum do well under a moderate pH (pH 6 and 7).
Millet, rice, cotton, water melons and cowpeas do well when the pH is between 5 and 6.5

(ii) Soil pH affects the availability of soil nutrients needed for plant growth. Elements such as Zinc (Zn), Iron (Fe), Manganese (Mn), Copper (Cu) and Cobalt (Co) become less available in soil with pH above 5.5

- However molybdenum, an important micro-nutrient, becomes available in soil with a pH between 5.5 and 9.
- Nitrogen (N), Potassium (K), and Sulphur (S) become readily available when the Ph is above 5.5
- Calcium (Ca) and Magnesium (Mg) become available when the soil pH is between 6 and 8.5.
- Phosphorus (P) is "locked up" in soil of pH is below 6.

Most plant nutrients tend to be available when the soil pH is between 6 and 7.

(iii) Microbes such its bacteria, tend to be active when the pH is above 5.5. Fungi, however tolerate a wide range of soil pH. Bacteria and fungi are important for the decomposition of organic matter.

Nitrification and nitrogen fixation by bacteria takes place vigorously at pH 5.5

On the whole beneficial micro organisms tend to function well in soils between pH 5.5 and 7.5

The modification or improvement of soil pH

Acid soils can be corrected by adding lime or fertilizers containing calcium ammonium nitrate. Lime tends to neutralise soil acidity.

Soil pH can be decreased by the addition of acid - forming fertilizers or phosphate fertilizers.

The pH scale

The scale is from pH 1 – 14.

A pH of 7 is neutral. The soil is acid when the pH is below 7, and is alkaline above pH 7. The pH is referred to as low (acidic) when it is below pH 7 and high when it is above pH 7 alkaline.

The soil pH is usually measured using a **pH meter**. However, it can also be measured using a **universal indicator**.

The indicator changes colour when mixed with a solution of soil and distilled water. The soil pH is determined by comparing the colour change with that on the colour chart. If the soil is acid, the indicator will turn red and blue if the soil is alkaline or basic.

2. **Cation Exchange Capacity (CEC)**

Introduction

Soil pH affects the availability of plant nutrients. The nutrients are in the form of positively charged ions called **cations** and negatively charged ions, called **anions.**

Examples of cations

Are Carbons (C), Magnesium (Mg^{+}). Sodium (Na^{+}) and Potassium (K^{+}**)**

Examples of anions

Chlorine (Cl^{-}), Nitrate (NO_3^{-}) and Carbon nitrite (CO_3)

- The cations are absorbed or held into soil colloids, and anions are found in the soil solution. The cations are not easily leached from the soil. However, they can be replaced by, or exchanged with the ions in the soil solution through the cation exchange process.

- The term **"cation exchange capacity"** refers to the ability of the soil to exchange cations (at a given pH and per unit weight of soil)
- An example of cation exchange process is when lime is added to acid soil (with a high concentration of hydrogen ions). The calcium and magnesium in the lime will replace the hydrogen ions, thereby raising the soil pH. This in turn, improves the soil condition.

Importance of CEC to plant growth

Soil pH is modified or improved through CEC and that soil pH affects the availability and release of plant nutrients vital to plant growth. Soil pH also affects availability of microbes. Some plants do well under acidic conditions while others prefer alkaline conditions.

NOTE:

- Plant nutrients found in organic matter include NH_4, Ca, K and Mg. So organic matter contributes to CEC through the exchange of such elements with others that have similar or like charges.
- Organic matter helps in the formation of soil aggregates collections of soil particles)

3. Salinity

This is a condition of soil that is associated with the accumulation of soluble salts in the soil. Example of salts that may accumulates in the soil are nitrates NO_3, sulphates (SO_4^+) and chlorides (Cl^-)

Soils which have a concentration of soluble salts are called **saline** soils.

Why do soils become saline?

- Irrigating virgin land with water which contains salts. When water evaporates, the salt builds up in the soil.
- The application of inorganic fertilisers.
- Parent material which contains a lot of salts.
- Low rainfall and evaporation. Salts accumulate on and below the soil surface due to capillary action. They also accumulate because there is limited leaching.
- Poor drainage. Salts tend to build up in soils with poor drainage.

Sodic soils

Are those that contain high amount of sodium.

Saline soils

Are soils that contain soluble salts

Saline - sodic soils

Are soils which contain both soluble salts and sodium salts. The amounts of salts in these soils are toxic to plants.

Chikwawa, Kasungu and Mzimba are some of the districts that have sodic soils. People make salt from such soils. Such soils are also liked by goats and cattle. Sometimes sodium salts tend to accumulate on the surface of soil as a white substance.

The effects of salt accumulation

a) High salt accumulation lead to an increase in soil pH.
b) Accumulation of salts in soil affects seed germination and subsequently plant growth. How?
Because:
(i) Affects the availability of water because of the high osmotic concentration of the soil solution. High osmotic pressure reduces the ability of the plant roots to suck in (or absorb) water.
(ii) There is a high level of exchangeable sodium (Na) I
Exchangeable Na affects the physical and chemical properties of soil. When there is high

excess Na, clay is dispersed, resulting in aggregates being broken down. This in turn reduces the permeability of the soil by water and air

c) Salts may also be toxic to crops. Crop sensitivity to salt varies according to type and varieties. Some crops are sensitive to a high concentration of salts while others may tolerate the salts.

The table below shows the sensitivity of some crops to salts

Low salts tolerance	Medium salts tolerance	High salt tolerance
Green beans	Rice	Cotton
Field beans	Sorghum	Spinach
Apples	Maize	Rape
Pears	Wheat	Barley
Citrus	Tomatoes	Sugar beets
	Oats	

Managing saline soils

- Irrigating soil by flooding repeatedly. The salts are flushed out and become leached. Use salt-free water.
- Drainage. As water is drained, it carries some of the salts with it.
- The application of Gypsum. Gypsum helps to convert insoluble carbonate salts into sulphates which are readily soluble and easily leached through irrigation. Preventing or reducing evaporation.
- Growing salt tolerant crops e.g. Cotton, spinach, rape etc.

Maintenance or improvement of soil chemical properties.

These can be maintained or improved by modifying the soil pH and preventing loss of soil fertility. This is achieved by:

- Liming to increase soil acidity.
- Applying organic matter to improve soil structure.
- Apply fertilizer correctly.
- Practising both physical and biological soil and water conservation measures.
- Practising crop rotation.
- Controlling bush fires.
- Planting close - growing crop and/or grass to check erosion.
- Mulching crops to reduce rain-drain impact and retain soil moisture.
- Practising mixed cropping.
- Irrigating land by flooding to remove excess salts.

UNIT 3

SEEDS AND PLANTING NIATFRIALS

Plant propagation is the basis of all crop production. Plant propagation can occur sexually, through seed or asexually through the use of vegetative planting material. Each of these processes has advantages and disadvantages.

Some crops can be propagated only asexually or only sexually while others can be propagated either way.

Seeds

A seed is a mature fertilised ovule. It is produced sexually.

Sexual propagation is a type of reproduction in which male and female gametes unite to produce an offspring.

Structure of a legume seeds

Funicle: A short stalk which attaches the bean seed to the inside of the pod (food for the developing seed passes through the funicle from the plant.)

Helium: a black scar where the funicle is attached (it appears when the seed is separated front the pod after ripening.)

Testa: The seed coat. (It forms a protective- covering for the embryo against mechanical injury and the entry pathogens)

Micropyle: Is a tiny hole which allows air to pass through for the respiration of the embryo.

Cotyledons: A pair of leaves which contain the food for the developing embryo. Seeds with two cotyledons arc known as **dicotyledonous seeds** or "**dicots**" eg beans, cotton, tobacco, sunflower and groundnuts.

Radicle: Part of the embryo which forms the primary root. It lies between the two cotyledons.

Plumule: Is the other end of the embryo which grows into a young shoot that is, the first leaves and tile terminal or the apical bud.

Hypocotyl: The middle part of the embryonic structure which develops into the stem.

The structure of a cereal seed e.g. Maize

Note: The maize is not a true seed. It is actually a fruit.

Fused pericarp and testa: A united fruit wall (pericarp) and seed coat (testa). It protects the delicate internal parts of the grain and is the bran left over after milling.

Silk scar: A crease or depression showing the point of attachment to the silk. As an ovary (fruit) each grain is attached to a silk (pistil) which dries off when the grains ripen off.

Point of attachment to cob: Seen as a remnant stalk at the base of the grain. It loosely or firmly attaches the grain to the cob.

Endosperm: The floury part of the grain. It occupies most of the inside of the grain, surrounding the embryo. It supplies food for energy *for* the germination and development of the embryo. All seeds containing this part are called Endospermic seeds. This includes all cereals and grasses.

Radicle: Develops into primary roots.

Hypocotyl: Develops into stem.

Plumule: Develops into the first leaves.

Coleorhiza: Forms a protective sheath surrounding the roots.

Coleoptile: A protective sheath surrounding the plumule in the grain. It protects the shoot as it pushes through the soil during germination and seedling emergence.

Scutellum: A flattened, fleshy, shield-shape which forms the outer rim of the embryo. Separating the embryo from the endosperm. It is regarded as the cotyledon of the cereal grain. Since there is only one scutellum, such "seeds" are also known as monocotyledon "seeds". Examples are: Maize, rice, sorghum, millet and wheat.

Propagation

Cereals and legumes are propagated through seeds (sexual propagation, usually from two different parents). Seed is the commonest way of propagating both self-pollinated and cross pollinated crops.

Advantages of sexual propagation

- Seeds are relatively cheap
- Seed is easy to sow and prepare for planting.
- Seed is easy to store without significant loss in quality and quantity.
- Seeds can remain viable for long periods especially when stored in a cool dry place for sowing in the next planting season
- Seed can easily be sown mechanically using seed hoppers or drills.
- Seed as a planting material minimises the risk of transmitting diseases from parents to offsprings.
- Seeds offer the only way of propagating some crops that cannot be propagate vegetatively such as maize.
- Seeds produce plants that differ from their parents (as a result of the union of male gamete and female gamete from different parents) so that some of the new plants are better than the parents leading to crop improvement.
- It provides a natural mechanism by which the characteristics of two different parents can be combined.

Disadvantages of sexual propagation

- It can produce serious variations and off-types among the offsprings (new plants since no two gametes may be alike).
- It requires a long juvenile period before bearing fruits or seeds.
- It requires elaborate seed bed (land) preparation for sowing the seed.

Cassava, bananas, sugarcane are propagated by using plant parts (e.g. stems, leaves, branches, roots, tubers) and not by seeds. This is known as asexual propagation or vegetative propagation.

Advantages of asexual propagation

- Reduces the juvenile period of the plant because vegetatively produced materials assume the age of their parents faster. Plants therefore mature earlier or start bearing fruits, or producing crop yield, faster than in sexual propagation.
- Eliminates the problems of dormancy, which is a common problem in some seed treatment (such as scarification) in order for them to germinate.
- Ensures genetic uniformity in crops, which in turn affects their appearance, since all offsprings will resemble their parents.
- Is the only way of propagating crops whose seeds are not viable.
- Vegetative organs are more hardy than seedlings from seeds. So they are better off in withstanding environmental hazards in the field, such as drought.
- Vegetative planting materials are readily available to the farmer, from the previous crop, eliminating the need to buy expensive seed each season.

Disadvantages of asexual propagation

- The risk of transferring diseases to new plants is high.
- It is more difficult to introduce variation into the crop, making crop improvements difficult.
- Some of the procedures in vegetative propagation (like layering, grafting, or budding require specialist knowledge and / or skill and are slow and tedious.

Vegetative planting materials and methods

1. **Cuttings:** The stem cuttings (setts) of sugarcane, Napier and cassava are used for propagating

these crops. Pieces or cuttings, of stein that have buds at each node, and that develop adventitious roots are used forr field plantings.

2. **Runners:** A runner is astern which grows along the ground. As a vegetative planting material, the piece must have a node from which routs and shoots can develop. Strawberries, sweet potatoes and star grass arc propagated this way.

3. **Tubers**: A tuber is swollen organ for food storage. There are two types of tubers, namely
   i) Stem tubers: e.g. Irish potatoes (European potatoes) are an underground swollen stem.
   ii) Root tuber: (cassava, sweet potato) is a swollen root.

4. Suckers: A sucker is a shoot (or a tiller) arising from an auxiliary bud at the base of the parent plant. Suckers are cut off or uprooted and planted elsewhere. This is the only way of propagating bananas and plantains which do not have viable seeds. Pineapples can also be propagated using suckers.

5. **Corms**: A corm is a thickened (enlarged) base of an underground stem in which food is stored. A new shoot develops from the bud on the side of the parent corm. The stored food in the parent (old) corm provides nutrients to the new shoot.

6. **Bulbs**: A bulb is a storage organ for onions, tulips and garlic and is made up of closely packed, modified, fleshy leaves. Buds develops in the axils of the leaves that make up the bulb.
   - New shoots develop from the buds, feeding on the fleshy leaves of the bulb. The new shoots then separate from the parent plant, developing new roots.

7. **Rhizome:** A rhizome is a thick, underground stem growing horizontally. New shoots and roots grow from buds on the rhizome. Bananas and bamboo are propagated in this way.

8. **Layering:** A branch of a fruit tree or shrub is pegged down to the ground so that it will develop roots for a new shoot while it is still attached to the plant.

9. **Budding**: This is a plant propagation method where a vegetative bud from one plant is transferred and joined to the stem of another plant, where it develops into a new shoot. A bud is carefully sliced off the branch of one tree. A patch or a T-shaped cut is made on the stem of another tree. (root stock) The bud is carefully inserted into this cut and then bound (tied) with twine (string)

10. **Grafting**: This involves joining a part of one plant (a scion) to another plant (a stock) so that one can have the good qualities of the two different parents.
   - The two parts must be from the same species, and must have the same thickness.
   - The union must ensure that the cambium layers are matched.
   - The cut must be a slant or v-shape. The union must neatly fitted and taped.

UNIT 4

PLANT PARTS AND THEIR FUNCTIONS

- A normal flowering plant has a root, stem and flowers.
- Each of these parts have special features which enable them play a role in crop production.
- Knowing about the structure and functions of these parts can help farmers modify certain farming practices in order to increase crop yields.
- A typical flowering plant like legumes and cereals has a root system (structures below the ground) and a shoot system (structures above the ground). The shoot system consists of the stem, leaves and flowers.

Diagram of a typical

Flowering plant

Root systems

There are two general types of root system in flowering plants: These are: Tap root and Fibrous root system

a) Tap root system.

- In crops with a tap root, there is a clearly identifiable main root (also called primary root) Secondary roots (lateral roots) develop from the primary root and tertiary roots develop from the secondary roots.
- Examples of tap-rooted crops, tobacco, cotton, tomatoes, cabbages, carrots and legumes (peas, groundnuts, beans)

b) Fibrous root system

- This root system does not have a main root.
- All roots grow from the base of the stem.
- All grasses, including cereals (rice, sorghum, millet, maize) have a fibrous root system.

Diagram of taproot and fibrous root system

The internal structure of a root

Root cap :	is a layer of cells at the tip of the root. It protects the apical meristem.
Apical meristem:	is a bundle of meristematic tissue in the root tip. It is the growing point in the root which gives rise to all the other parts of the root.
Epidermis:	is the outer layer of cells, which is protective coat for the root.
Root hairs:	are very small hair-like structures found near the tip of all roots. They are elongations (extensions) of epidermal cells - they grow from the epidermis - they absorb water and mineral salts from the soil.
Cortex:	is a group of cells for food storage.
Endodermis:	Is a layer of cells separating the cortex and the vascular bundles (vascular bundles consists of the phloem and xylem)
Phloem:	Are cells or tubes which transport products of photosynthesis (food manufactured in the leaves) for root respiration and storage (in the roots)
Xylem:	Are cells or tubes which transport mineral salts and water absorbed by root hairs upwards (to the stems 15

Functions of roots

- To anchor (support) the plant.
- To absorb mineral salts and water.
- To store food.
- To manufacture food (green stems).

Stems

i) **External structure of stems**

- A stem has nodes and internodes. Nodes are slightly enlarged or swollen areas of a stem.
- Buds are formed at the nodes. The space between two successive nodes is referred to as "internode" Branches, leaves or flowers arise from the buds.

Diagram of the External structure of stems.

ii) **Internal structure of stems**

- Epidermis forms the outer surface of the stem. It surrounds the cortex, which surrounds the vascular tissue or phloem and xylem.
- Phloem and xylem are separated by cambium cells. Cambium cells produce secondary phloem and xylem through cell division, which increases the diameter of the stem Phloem vessel (sieve tubes) transport food manufactured in the leaves downwards to different parts of the plant.
- Xylem vessels conduct water and mineral salts from the roots to the branches, leaves or flowers.
- Endodermis is not present in stems.

Diagrams of **Internal structure of** a **stem. 10** page 33 (strides)

- As in the root the epidermis forms the outer surface of the stem (it surrounds the cortex which surrounds the vascular tissue or phloem and xylem.
- The phloem and xylem are separated by cambium cells (cambium cells produce secondary phloem and xylem through cell division, which increases, the diameter of the stem)
- Phloem vessels (sieve tubes) transport food manufactured in the leaves downwards to different parts of the plant)
- Xylem vessels conduct water and mineral salts from the roots to the branches leaves or flowers
- The endodermis is not present in stems.

Functions of stem

- To conduct food, water and mineral salts upwards and downwards
- To support and protect the upper pans
- To display leaves to sunlight, flowers to insects for pollination.
- To store food
- To manufacture plant food (young stems contain chlorophyll)

Leaves

External structure.

Leaves arise from buds. Atypical leaf consists of:

- The blade or lamina
- The stalk or Petiole which holds the blade
- The basal sheath, which connects the leaf to the stem in a cereal crop

The lamina or blade has a mid - rib (main vein) and other smaller veins.

Dicotyledonous plants, like legumes, have net veins. These net veins branch off from the mid-rib, on either side. These side veins may branch into smaller and smaller veins.

Monocotyledonous plants have leaf blades with parallel veins. All the minor veins run parallel to the main vein or mid rib.

Internal Structure

- Upper and Lower epidermis
The upper and lower layers on the leaf blade may be smooth or hairy (this can effect palatability to livestock)

- **Guard cells**
Pair of special cells found in both the upper and lower epidermis which control openings into the leaf.

- **Stomata**
These are the gates or openings into the leaf found between a pair of guard cells (stomata open up when guard cells are turgid or filled with water, to allow in carbon dioxide necessary for photosynthesis. They also release water into the atmosphere through transpiration. When guard cells have little water as in drought, the stomata close. This closing reduces water loss from the plant. Guard cells are the only cells in the epidermis that have chloroplasts and carry out photosynthesis)

- Palisade cells
These form a layer of cells (palisade layer) where most of the chloroplasts are found to trap sunlight. Palisade cells are long narrow and closely packed.

- Spongy layer
These cells are loosely packed and irregularly shaped. The products of photosynthesis are first stored here

- **Vascular tissue**
The mid - rib and veins are the vascular tubes for transporting water and mineral salts to the rest of the leaf.

Functions of leaves

- Photosynthesis
- Transpiration
- Respiration
- Storage of plant food

Flowers

The flower is the reproductive part of the plant
Parts of the flower include:

- The calyx
- Sepals
- Receptacle
- Corolla
- Stamens
- Anthers
- Pistil
- **Calyx:** is a ring of greenish leaves at the bottom of the flower, made up individual sepals (the calyx protects the upper of the flower)
- **The receptacle**: is the section which carries all the other upper parts of the flower
- **Corolla**: is made up of petals which attract insects to visit the flower and collect nectar. In cereals (grasses) the calyx and corolla are replaced by the glumes, lemma and Palea.
- **Stamens:** are arranged in a ring and form the male part of the flower. Each stamen has a filament or stalk with a swollen tip called the anther
- **Pistil:** The highest part of the receptacle holds the pistil. The pistil is the female part of the flower. The swollen base of the flower. The swollen base of the pistil is the:

- **Ovary:** Which contains the ovules. In grasses each ovary ha only one ovule. A stalk called the style extends from the ovary to the flat tip called the stigma flower

Pollination and Fertilisation

- Pollen grains (male gametes can be transferred from the anthers to the stigma by wind or insects. The transfer of the pollen grain from anther to the stigma is called pollination
- When this occurs between different plants, it is called cross pollination.
- In some plants the anther and stigma are on the same plant and they pollinate themselves this is known as self- pollination.
- The pollen grain on the stigma travels down to the ovary through a tube in the style.
- When the pollen grain reaches the ovary, it unites with the ovule (female gamete). This is called fertilization
- The fertilized ovule is the seed. The ovary containing a fertilized ovule or ovules is the fruit
- In legumes, a pod is a fruit (mature ovary) containing many seeds. In grasses or cereals, there is only one seed in each fruit (or ovary). These fruits are so closely fused (united) that they cannot be separated. Each grain in cereals is therefore a fruit.

Functions of flower

To enable pollination and fertilization to occur in order to produce seeds and fruits.

UNIT 5

ESSENTIAL PLANT NUTRIENTS

A plant nutrient is a mineral element needed by a plant to grow and complete its life cycle. For a plant nutrient to be essential, it must satisfy the following three conditions:

- The nutrient must be directly involved in metabolic processes in plants.
- Its deficiency must cause specific deficiency symptoms in plants.
- The deficiency symptoms can be corrected only by supplying (lie plant with that nutrient

i. Nitrogen

Nitrogen is absorbed by plants as nitrate ions (NO_3) or as ammonium ions (NH_4)

Functions

- For deep green colour (chlorophyll)
- Major component of proteins
- Increases leaf area and vegetative growth in crops
- Regulates the a availability and utilization of phosphorous and potassium
- Makes plants and their fruits succulent e.g. in cabbage, carrots lettuce, melons
- Increases grain yield by increasing grain size in both cereals and grain legumes

Source

- Fixation by symbiotic Rhizobium
- Application of CAN and Urea fertilizers to the soil
- Application of organic manures e.g. compost
- Nitrification of atmospheric nitrogen through lighting.

Reasons for depletion from the soil

- Volatisation (nitrogen is released into the atmosphere as gas through the activities of denitrifying

bacteria)
- Used by microorganisms to build up their bodies (known) as immobilization)
- Absorption by plants and the consequent removal of the crop from the land through harvest
- Soil erosion
- Leaching e.g. nitrate form N03 (The nutrients are washed down the soil profile to the water table beyond the root zone)

Deficiency Signs
- Leaves lose chlorophyll (chlorosis) and become yellow (starts at the leaf tips of the lower leaves and spreads a long the mid-rib until the entire leaf is yellow. Later the lower leaves may become brown or die.
- Slow plant growth, which results in stunted plants (dwarfism)
- Premature leaf fall

ii. **Phosphorous**

- Absorbed as H_2PO_4 especially at lower pH and $HPO4^{3-}$ at higher pH values. The dehydrogenated phosphate form is better absorbed.

Functions
- Increase root development, especially of secondary roots
- Strengthens straw of cereal crops, so lodging is reduced.
- Speeds up the maturity of crops by stimulating flowering and seed formation.
- Improves the quality of fruits, vegetables, forages and cereal crops
- Increases disease resistance
- It is a component of Adenosine Triphosphate (ATP), Adenosine Diphosphate (ADP) and Adenosine Monophosphate (AMP) (which are important in photosynthesis and various metabolic processes, such as carbohydrate metabolism, amino acid metabolism, fat metabolism etc)
- Is a component of nucleic acids, which makes it essential for reprodUCtion and seed.

Sources
- Single super phosphate (P2 0_5 =21%) 20:20:0; 23:21:0+45 and double super phosphate and triple super phosphate.
- Organic manures e.g. Green manure Organic matter in the soil from crop residues through mineralization.
- Weathering of appetites (phosphatic rocks) in igneous rocks which causes phosphate salts such as calcium phosphate to be released.

Reasons for depletion from the soil
- Plant absorption and crop removal
- Fixation through adsorption into silicate clays
- Leaching
- Soil erosion

Deficiency Signs
- Reduce root development especially of secondary roots
- Leaves have purplish colour
- Slow and stunted growth
- Poor branching, since lateral buds remain dormant
- Dead spots on leaves and fruits and fruits
- Fewer and smaller tubers
- Delayed maturity
- Poor development of seeds, grains or fruits

iii. Potassium

- Absorbed in the form of potassium ions (K^+)

Functions

- Strengthens cellulose in cell walls to make systems strong and reduce stem lodging .
- Facilitates the translocation of sugars from leaves to other plant parts, especially tubers or seeds, so that they are well - filled (plump)
- Necessary in formation of starch and proteins
- Increases disease resistance such-as powdery mildew and root rot
- Acts as catalyst to activate enzymes necessary in metabolic processes (e.g. nitrogen metabolism. photosynthesis, respiration etc)
- Promotes the growth of meristematic tissue
- Regulates the opening and closing of the stomata by controlling the water content of plant cells (cell turgidity)
- Improves the qualities of crops e.g. fruits and vegetables

Sources

- Muriate of potash (KCL), potassium sulphate and potassium Nitrate, 20:20:0, 23:21:0+4S
- Organic manures and crop residues
- Potash rocks like mica and feldspar

Reason for depletion from the soil

- Absorption
- Soil erosion
- Leaching
- Absorption (fixation in soil particles of some clays)

Deficiency signs

- Scorched (burnt leaf margins from tips spreading backwards beginning with lower leaves)
- Weak stalks, resulting in high plant lodging (stalk breakage)
- Small fruits, seeds and tubers (shrivelled seeds)
- Small dots appearing on leaves

iv. Calcium

- Absorbed as calcium ions (Ca^{2+})

Functions

- For cell division (mitosis) so that elongation can take place in apical tips of the root system and shoot system
- Raise soil pH, which increases the availability of phosphorous and potassium, and the multiplication of nitrifying bacteria Is a component of cell wall structure Is useful in protein synthesis

Sources

- Inorganic fertilizers such as CAN
- Agricultural lime such as dolamite (Ca Mg (CO^-0_z) calcium carbonate (Ca ('O,) and quick lime (CaO)
- Weathering of calcium bearing rocks
- Organic manures

Reasons for Depletion from the Soil

- Absorption
- Erosion
- Leaching

Deficiency Symptoms
- Terminals buds and root tips fail to grow so that plant stops growing (it remains a dwarf)
- In maize the funnel (new leaves are rolled up)rnay fail to nnl-Old (opcn Lill) or even emerge
- Terminal buds (growing points) die
- Premature Shedding of flowers and buds
- Weak stems

v. Magnesium
- Absorbed as Mg^{2+} ions

Functions
- Is a component of chlorophyll molecule
- Activates enzymes in the metabolism of carbohydrates and nitrogen
- Increases the oil content in g/nuts and soya beans

Sources
- Inorganic fertiliser
- Organic mature
- Dolamitic lime
- Weathering of magnesium containing rocks

Reasons For Depletion From The Soil
- Plant absorption
- Soil erosion
- Leaching

Deficiency Signs
- Interveinal chlorosis on leaves where veins remain green while the rest of the leaf is yellow
- In some crops, like cotton lower leaves develop a reddish purple colour

vi. Sulphur
Is absorbed by plants as sulphate (SO_4^2)ions 20

Functions
- Increases the oil contents of oil crops such as sunflower, groundnuts and soya beans
- Is a constituent of three amino acids: cystine , cysteine and thiamine
- Activates some proteolytic enzymes, such as papain
- Is useful in Nodule formation on legume roots for nitrogen fixation
- Is needed in protein synthesis and improves the biological value of proteins

Sources
- Inorganic fertilizer such as Ammonium sulphate and 23:21:0+4S
- Oxidation of sulphides in soil minerals such as CuSOz and $FeSO_z$ to sulphatcs
- Rainwater
- Atmospheric sulphur from industries where coal is burnt to release sulphur dioxide (S'(

Reasons for depletion from soil
- Plant absorption and crop removal
- Volatisation in the form of hydrogen sulphide gas (H_2S)
- Soil erosion

- Leaching

Deficiency Symptoms

- Leaves turn light green (sometimes yellowish) starting with young leaves
- Small and short plants with thin (spindly) stems
- Reduced modulation in legumes

vii. Iron

Is absorbed by plant roots as ferrous (Fe^{2+})iron or ferric (Fe^{3+}) ions

Functions

- Necessary for the formation of chlorophyll
- Activities various respiratory

Sources

- Inorganic enriched NPK fertilizers and chelates
- Organic matter

Reasons for depletion from soil

- Soil erosion
- Leaching, especially of acidic soils, in which iron is very soluble
- Fixation into insoluble forms especially under high soil pH conditions

Deficiency signs

- Interveinal chlorosis of young leaves
- Young leaves can turn completely white in severe cases
- Twigs stop growing and die (the whole branch may die in severe cases

viii. Boron

Is absorbed mostly as borate (BO_3) ions

Functions

- Essential for cell division in meristematic tissue
- Regulates carbohydrate metabolism
- Important in the transfer (translocation) of sugars (starch) within the plant

Sources

- Inorganic enriched NPK fertilizer and borax
- Organic matter

Reasons for depletion from Soil

- Soil erosion
- Leaching

Deficiency signs

- Poor growth and sometimes terminal buds die
- Shorting of internodes
- Poor grain tilling on maize cobs
- Soft or necrotic spots on fruits or tubers

ix. Manganese

Is absorbed as Mn^{2+} ions

Function

- Activates enzymes and acts as catalyst in the formation of chlorophyll

Sources
- Fertilisers rich in manganese sulphate.
- Organic matter

Reasons for depletion from soil
- Soil erosion
- Leaching in acid soil condition
Fixation in alkaline soils

Deficiency signs
- Mottled interveinal chlorosis of young leaves
- Interveinal white / brown specks in some cereals

x. Molybdenum
Is absorbed as molybdate (MoO_4^{2-}) ions

Functions
- Promotes symbiotic nitrogen fixation in legumes
- Increases nitrogen utilization

Sources
- Enriched inorganic NPK fertilizers
- Organic matter

Reasons for depletions from the soil
- Soil erosion
- Leaching in alkaline soils in which it is very soluble
- Fixation into insoluble forms by ferrous oxides in acidic soil

Deficiency signs
- Whip tail in brassica crops such as cauli flower and broccoli (leaves curl into a whip like tail)
- Failure of legume (in severe cases)

Copper zinc and chlorine

The table below shows the roles and deficiency signs for the above trace elements.

Trace element	Available form	Roles	Deficiency signs
Copper	Cu^{2+} cupric ion	- Activates enzymes - Involved in chlorophyll	- Dying of back of terminal shoots - Wilting and death of leaf
Zinc	Zn^{2+} ions	- Chlorophyll formation - Stem elongation and root development	- Short stems - Formation of white buds - Failure of shoots to elongate - Uneven stripping of leaves - Chlorotic young leaves
Chlorine	Cl^- ions	- Produces a suitable burning quality in flue cured tobacco - Is needed in photosynthetic reactions	- Reducing root growth in tomatoes, tobacco potatoes, cotton, maize etc - Wilting of plants (leaf blade tips during the early stages of growth - Bronze discoloration of leaves

UNIT 6

WEEDS AND WEEDING

A weed is an unwanted plant. It is the plant which is growing at the wrong place at the wrong time. Weeds are harmful to crops.

Classification of Weeds

Classification is based on their shape, life span, feeding habits, preferred habit and seed type

1. Leaf Shape

a) Narrow - leaved weeds: e.g. all grasses panic maximum or (pokopoko) couch grass (Cynodon dactylon)
b) Broad - leaved weeds e.g. blackjack (Bidens pilosa) or chisoso, pig weed (Amaranthus) or bonongwe.

2. Life Span:

They can be grouped according to whether they can complete their life cycle in a year, two or several years. This classification groups weeds into annuals, biennials and perennials

Annuals: Their life cycle is completed in only one growing season. They can be broad - leaved or narrow - leaved

Biennials: These weeds require two growing seasons to complete their life cycle. They generally grow vegetatively in the first year (growing season) , storing l( )od in short fleshy roots. During the second year the plant uses the stored food to complete its vegetative growth, produces seeds and then dies, e.g. wild carrots and bull thistle

Perennials: These live longer than two years or indefinitely. Although some perennials weeds produce seeds, they generally depend on vegetative propagation. They normally have specialized underground f6od reserves in their tubers, corns, crowns, rhizomes, stolons or even fibrous roots. These produce new plants year after year. New shoots may also be produce by the basal portion vegetatively, whenever the aerial portion of the plant is cut.

3. Feeding Habits:

All weeds describe above absorb their own mineral nutrients
from the soil and manufacttire their own food through photosynthesis. Their only sin is plant. These are non- parasitic but there are others which obtain their food by parasitising on the host crop plant.

These are parasitic weeds see below for examples of some parasitic weeds.

Parasitic Weed	Host Crop
Witch weed (striga asiatica)	Maize, Sorghum, Millet
Dodder (cuscutu species)	plantation tree crops (eg coffee, Tee,) and herbaceous plants (vegetables)
Mistletoe (Tipinanthus bangwensis)	Orange, Tangerine, lemon, Coffee, Rubber, and Guava

Witch weed is an annual parasitic plant. Germinating seedlings develop thread-like roots (haustoria) which penetrate the roots of crops to suck sap or plant food. This happens even before the shoot system of weed appears above the soil surface.
By the time the witch weed emerges above the soil surface, it will already have caused a lot of damage. The dodder weed produces seedlings which grow until they find a host plant. The seedlings then coil around the host plant. The **haustoria** of the dodder enters the stem of the host plant and takes up nutrients. Then the lower part of the stein of the dodder dies while the rest of the weed

continues to live off the host crop.
The dodder is firmly attached to host by the haustoria or suckers and it looks as if the dodder is suspended from the host.

4. Preferred Habitat

- Weeds may be grouped into aquatic and non- aquatic, depending on whether they are adapted or not to live and grow in water or waterlogged soils
- Non- aquatic weeds cannot complete their life cycle in water or water logged soils - Aquatic weeds e.g. water hyacinth grows and lives in water and waterlogged soils

5. Seed type

- Weeds are also classified according to their botanical characteristics. In this classification all flowering plants (angiosperms) are grouped into monocotyledons and dicotyledons
- Monocotyledonous weeds have only one cotyledon (embryonic leaf) - Dicotyledonous weeds have two cotyledons

Importance of classifying weeds

- To easily identify weeds in a crop field.
- To chose appropriate methods of controlling the weed.

The impact (importance) of weeds

The economic importance of weeds stems from their destructive power. Weeds are known to cause greater loss to agriculture than insect pests and disease combined. At certain times their effect is so serious that there is no harvestable crop at all from the field Weeds cause a lot of damage in some of the following ways:

- **Decreasing the quantity of crop yield due to competition.**
- **Reducing the quality of crop yield**

Weeds, their seeds or dry leaves can spoil the quality of the crop through contamination or adulteration. This lowers the grade and value of the produce.
For example, during harvesting of cereals, weed seeds mix with the grains. Similarly, during the harvesting of cotton, debris from dead weeds plants, especially dry leaves may mix with the cotton lint.

Harbouring pests and diseases of crop plants

Weeds act as alternate host plants for various pests and diseases of crop plants.
For instance quinea grass harbors stalk borer and rout knot nematodes, while rapoko grass harbours blast pathogens.

Smothering crop plants

Weeds suppress the growth of crop plants because they become established faster and more aggressively than crop plants.
Weeds like commelina benghalensis (khovani) spread rapidly over a crop like groundnuts. The weed shades the crop plant so that very little light will reach the crop. Some weeds grow taller or higher than crop plants e.g. grasses)

Increasing Production Costs

Weed increase weeding and harvesting costs i.e. weedy crop field require more labour to carry out the above operations.

Reducing the value of agricultural land:

Weeds are generally heavy feeders. This lowers tile nutrients status of the soil. Some weeds, like thristles, can reduce the grazing area and the feeding value of the pasture, such as wild onion, taint the colour and flavour of milk if eaten by lactating cows.

Poisoning Livestock

Some weeds, for example thorn apple (dosa) fireball (katupe) and lantan, are poisonous to farm animals if eaten. These cause severe illness or even death.

Increasing the cost of water management:
Aquatic weeds interfere with the use of water for irrigation, transportation and fish farming and should therefore be controlled in time.
Water hyacinth is an example of an aquatic weed.
Aquatic weeds can:

- Block the flow of irrigation of water in channels
- Cover the surface of a fish pond completely
- Choke rivers if not controlled

METHODS OF CONTROLLING WEEDS

a. Physical control

This involves uprooting weeds by hand. For effective control ensure

- Weed are uprooted before the flowering stage to prevent seed multiplication, which would increase the weed population in the next growing season
- Weeds are uprooted before their roots interfere with those of crop plants
- The uprooted weeds are effectively disposed off, so that there is no chance for regeneration.
- The soil is moist enough to enable the uprooting of the entire weed (including roots)
- The weather is sunny, so quickly dry out and die. Physical weeding is common in gardens of runner crops such as groundnuts, pumpkins and melon. It is also used where plant are close together as in vegetable beds or where plants are established by scattering (broadcasting) seeds, as in rice fields and pastures.

b. Cultural control

It involves the use of crop husbandry practices which help the plant to grow faster than, or kill, the weeds. Such crop husbandry practices include:

- Burning as a land --clearing practice (destroys weed seeds)
- Deep tillage as a land preparation practice (buries weed seeds to kill them or prevent them from germinating before crops are established.
- Flooding in rice fields (controls non - aquatic weeds)
- Crop rotation (controls parasitic weeds which are associated with specific crops)
- Early planting (crops are established before weeds become a serious problem)
- Correct spacing (ensures adequate ground cover by the leaves to suppress the growth of weeds)
- Correct fertilizer placement (ensures that crop plants grow faster than weeds so that they can smoother weed growth).
- Mulching (covers the soil and denies weeds light)

Advantages

- Easy to use.
- Cheap.
- Does not require extra effort since it only makes use of the normal husbandry practices for the crop.

Disadvantages

- Does not control all the weeds.

c. Mechanical control

Involves the use of farm machinery, including farm tools and implements to directly remove or kill

weeds.

Examples:
- Slashing to cut down weeds.
- Hoeing out weeds.
- Using sickles and lawn mowers.
- Using ox-drawn or tractor drawn-implements like cultivators to dig out weeds and bury them or expose them for drying.

Advantages:
- Faster.
- Less tiring.
- Reduces drudgery, especially when tractor-mounted cultivators are used.

Disadvantages
- Expensive.
- May not completely eliminate the weeds.
- May require skill to use some of the equipment.
- Some crops may be cut down.
- Cannot control weeds within the row of crops.

d. Biological control

This uses natural enemies of weeds to keep the weed population in check.
Insect pests and plant pathogens are used to eat out weeds, kill them or give them diseases.

Advantages:
- Makes use of natural enemies.
- Does require any labour other than that for introducing the pest into the field.

Disadvantages:
- Requires careful attention to maintain a balance between the pest and the wced.
- Its difficult to breed host-specific pests for weed control.
- Cannot be used to eradicate weeds.

c. Chemical control

Herbicides are used to kill weeds. Herbicides are available as sprays, powders or granules. There are different types of herbicides and these may be classified based on their use, mode of action or time of application.

(i) Mode of action.

There are three main groups, namely:

- **Contact Herbicides**
  These kill weeds only when they are in direct contact with them, they need to be applied to the leaves. For instance, Bentazone and Propanil kill weeds in rice fields.

- **Translocated or systemic herbicides.**
  Are absorbed by the plant through leaves or roots and are translocated to other plant parts through the vascular system - phloem and xylem - to kill the weed. For instance Atrazine, simazine, Alachlor and Diuron.

- **Soil Sterilants**
  Are applied to soil to prevent growth of' weeds e.g. }3romacil is a sterilant.

(ii) use

There are two types of herbicides in this type of classification.

- **Selective Herbicides**

  They destroy plants of particular group without harming other plants in the mixed population. For example: Dafapon kills monocots (grasses), 2,4 dichloroacetic acid (2-4-D and 2,4,5, trichloro acetic (2,4,5-T) kill only dicotyledunous p;ants, which include mainly broad-leaved weeds

- **Non -Selective herbicides**

  These kill any plant, including monocot and dicot weeds, for instance, paraquat.

(iii) Time of application

Herbicides classified in this way include:

- **Pre-planting herbicides**
  Are applied before planting the crop e.g. soil sterilants like methyl bromide.
- **Pre-emergence herbicides**
  Are applied after the crop is planted, but before the emergence of the crop or weeds in the maize fields.
- **Post-emergence herbicides**
  Are applied after the emergence of the crop and the weed. Translocated and contact herbicides are applied to the plants to kill them.

Advantages

- Reduces early weed competition through the use of pre-emergence herbicides
- Reduces labour demand for weeding
- Enables the cultivation of a large hectrage possible, without any fear of' weeds.
- Ensures the timely control of weeds the operation can be completed before weeds become a serious problem.

Disadvantages

- A high concentration of herbicide can damage crops.
- Expensive to buy
- Some herbicides are harmful to people, they need careful handling and protective clothing should be worn
- Herbicide may be too diluted (by rain water)to be effective
- Require proper training in handling and application

9. Legislative weed control

- Involves passing laws to control weed and their spreads. New weed enter a country through imported plants or crop products. Weed seeds can be carried into a weed free country very easily by people who cross border; new weeds thrive in a new environment which may not have their natural enemies (like insect pests) to keep them under control.
- Fortunately there are laws in every country to prevent the introduction of specific noxious weeds in clean areas. Such laws provide for:
  - **Inspection** measures at entry points like airports, harbours to ensure those entering the country do not carry weed seeds or any good that may contain weeds.
  - **Quarantines** to ensure that suspicious goods that may contain weed seeds can be observed for a reasonable period of time to check that they are free from weeds or weed seeds,
  - **Mechanism for reporting** and controlling noxious weeds.

Advantages

- Prevent strange weeds from being introduced into the country

- Is free to the farmer (of course farmers contribute through normal taxes)

Disadvantages

- Is not very effective, since smuggling of goods is common.
- Is difficult to enforce
- Does not control weeds on individual farms
- Only covers a few specified noxious weeds.

UNIT 7

PROTECTING CROPS AGAINST PESTS AND DISEASES

- **Crop protection** means keeping cultivated plants from organisms that could cause damage and a reduction in crop yields and the farmers' income.
- The best way to do this is by providing conditions which allow crops to grow in the fields with minimum disturbance from their enemies, insect pests, mites, nematodes, worms, birds rats, monkeys, pathogens (bacteria, fungi. virus) and parasitic weeds.
- A pest is an organism that causes damage to crops or animals. For instance grasshoppers, stalk borers are pests.
- A disease is a physiological or anatomical disorder or abnormality in a plant which can be identified through characteristic symptoms on the plant. Diseases reduce plant economic values. For instance, early leaf spot in g/nuts and rice blasts are plant diseases which disturb the normal functioning of the plant.

Common Pests

They can be divided into five groups:

Mammals: Monkeys and Rats

Birds: Guinea fowl, doves, weavers, red headed quelea

Nematodes: These are microscopic roundworms called eelworms, which cause knots on the roots of crops, causing a lot of damage.

Insects: Are the most common pests. The insect has three main segments. **The abdomen** which has spiracles (Air spaces) for breathing. The **thorax** to which wings (sometimes) and three pairs of jointed legs are attached. The **head,** which has antenna (feelers for sensing smell, heat objects etc) Single or compound eyes for sight and mouth parts (Study diagrams of insects)

Type of damage

The type of damage cause by insects depends on the kind of mouth parts they have. Insects have special mouth parts for:

- Biting, and chewing parts of plants and their products.
- Piercing and sucking sap from plants or fruits.
- Boring and entering the plant or fruits and seeds

(i) **Biting and Chewing insects pests:** These pests bite eat parts of roots, stems, leaves, flowers, fruits and seeds of plants. The mouth parts of such insect pest have a pair of powerful mandibles (sharp blades) for cutting and chewing the plant parts. Examples are grasshoppers, cutworm, termites, locusts army worms and bud worms.

(ii) **Piercing and** sucking insect pests: Their mouth parts have a sharp needle-like stylet (Proboscis) which penetrates plant tissues (leaves or fruits) to suck juices. Examples Aphids, fruit flies, cotton stainers and mealy bags.

(iii) **Boring insect pests:** e.g. Stalk borer and weevils. Their mouth parts are adapted for biting and chewing. The tunnel (drill holes) into stems, fruits or seeds and remain inside the tissue and eat it.

Common pests and the crop they attack

Pest	Mouth parts	Damage to crops	Affected crops
Army worm (Spodeptera exempta)	Biting/ Chewing	An armyworm (Spodoptera exempta) larvae invades and eats up entire young succulent crops	Grasses (Cereals)
Termites	Biting/chewing plants or timber	Workers eat up growing mangoes	Cereals, citrus
Bud worms	Biting/ chewing	Caterpillars eat up buds of plants	Tobacco, tomatoes
Locusts	Biting/chewing	The adult locusts (Zonocerus variegates) and nymphs eat up leaves	Cereals (grasses) Cassava vegetables
Cutworms	Biting/ Chewing	Caterpillars eat stems of young plants at ground level.	Vegetables, seedlings of maize
Aphids	Piercing/ sucking	Nymphs and adults suck sap from plant cells and transmit diseases	Groundnuts, beans
Fruit flies (moth)	Piercing/sucking	Adult moths pierce succulent fruits to suck juices	Mangoes, oranges, Bananas, pawpaw
Cotton Stainer	Piercing/ Sucking	Adults suck juices distort leaves and transmit diseases	Cotton
American bollworms	Biting	Larvae bores into fruits (bolls) or flowers	Cotton
Maize weevil	Boring	Adult bores into grain to lay eggs	Maize
Stalk borer	Boring	Caterpillar tunnels into stems	Maize, sugarcane, rice, millet, ground nuts
Birds	Break	Eat sown seeds and mature grains.	Maize, sugarcane, rice, millet, ground nuts
Rats	Gnawing	Eat grain in field and storage	Maize and ground nuts
Warthogs	Teeth for biting and chewing	Dig up and eat cassava	Cassava
Monkeys	Biting/ Chewing teeth	Eat up grain between milky stage and grain development.	Maize
Bean bettle	Biting/ Chewing	Feeds on leaves and flowers	Beans

The Harmful effects of pests

Pests harm crops by:

(i) **Transmitting diseases, because they:**

- Act as vectors (disease carriers)
- Inject poisonous/Toxic saliva and other substances into plant tissues which can kill or poison such tissues.
- Pierce plant parts, encouraging secondary infection.

(ii) **Lowering the quality of yield by:**

- Puncturing fruits or seeds, making them undesirable and unmarketable.
- Blemishing the produce (fruits or cotton lint) which reduces its quality.
- Contaminating the produce through their excreta or eggs.

(iii) **Reducing the quantity of yield by:**

- Eating roots or causing roots rot or root knot diseases
- Boring stems
- Eating plant leaves
- Consuming fruits or seeds

- Sucking sap
- Feeding on flowers
- Destroying apical buds resulting into stunted growth.

(iv) **Increase the cost of production by:**

- Causing farmer to buy pesticide and its equipment.
- Demanding time for crop inspection, planning how to and when to control the best note (time is money).

Common diseases

Common disease like nests, make an economic impact because they lower the quality and quantity of crop

Crop	Disease	Symptom	Control
Maize	Northern leaf bright caused by	• Papery (almost transparent) large brown spots on leaves. • Death spots on leaves	• Growing resistant varieties • Early planting since the disease appears late in the growing season
Maize	Maize streak caused by virus	Chlorotic areas appears parallel to the veins	• Rogeing infected plants • Planting early • Spray actellic 85wp at 85g per 14 litres to kill vectors leaf hoppers
Maize	Maize streak caused by virus (Puccinia Sorghi)	• Tinny brown or reddish circular spots with a raised appearance on leaves	• Early planting • Growing resistant varieties • Using certified seeds • Treating with fungicides
Maize	Cob rot caused by fungus Diplodia maydis	• Cob grains rot from the tips	• Planting resistant varieties with good tip cover • Timely harvesting • Proper drying of cobs before storage
Maize	Headsmut caused by fungus ustilago maydis or ustilago zea	• The cobs and tassels are substances (spores) covered by black substances (spores)	• Planting clean seeds • Planting resistant varieties • Treating seeds with suitable fungicides

Crop	**Disease**	**Symptom**	**Control**
Ground nuts	Early leaf spot caused by fungus cercospora arachicola	• Leaves have brown spots (each spot is surrounded by a yellow circle- band) • Defoliation occurs later	• Crop rotation • Early planting • Burying/burning crop residues • Destruction of volunteer ground nuts
Ground nuts	Rosette caused by virus and transmitted by aphids	• Curled tiny leaves • Variegated leaves green/yellow patches • Stunted plants or dwarfism	• Planting resistant varieties like RG1 • Close spacing • Early planting • Uprooting and burning infected plants
Cotton	Bacterial blight caused by bacteria	• Angular dark brown spots on leaves dead or brown/black branches giving the appearance of a black arm • Bolls rot	• Observing closed season • Uprooting and burning stalks after harvest • Growing resistant crops • Plants treated seeds
Bean	Anthracnose caused by fungus	• Brown spots on leaves, stems, pods or fruits	• Spraying dithane 45 80wp at 10g per 10 litre of water fortnightly • Spraying Daconil 278 75wp at 35g/10 litres of water
Bean	Angular leaf spot caused by fungus	• Dead brown spots which may join up to form large spots between mid-rib and net vein	• Spraying Daconil as above
Beans	Halo bright	• Brown spots • Each is surrounded by a	• Spraying copper • Oxychloride

		yellow circle	
Field peas	Powdery Mildew	• Leaves and stems are covered by masses of whitish patches of fungal moulds, Mycelia and spores of the fungus	• Spraying Dinocap (Karathane) at 10g/10 litres of water • Apply sulphur dust at 7 days interval
Cassava	Cassava mosaic virus disease (CMVD)	• Mottled and curled leaves • Stunted growth • Veins look clear	• Planting CMVI free materials • Uprooting and burn infected plants
Cassava	Bacterial blight	• Wilting tips leading to a die-back appearance	• Spray and burn infected plants • Plant clean materials
Cassava	Cassava brown streak virus disease	• Yellow mottling with green leaf backing round on bottom leaves	• Rogueing infected plants • Plant disease free materials
Rice	Rice blast caused by fungus pyricularia oryzae	• Oval brown spots on leaves and stem • Stems break	• Correct plant spacing • Burn infected crop residues • Proper water control
Rice	Leaf spot caused by fungus Helminthosporium oryzae	• Dead spots on leaves	• Plant disease free seeds • Use suitable fungicides

Harmful Effects of diseases.

Diseases can harm crops by:

- Damaging roots
- Injuring roots
- Disturbing the flow of nutrients and water through the stem.
- Reducing leaf area
- Interfering with pollination

General Methods of controlling pest and diseases

Physical Control

Is using direct human effort or mechanical devices to remove or destroy the pests and diseases; make the environment unsuitable for the; or provide a barrier against the pest.

The Physical control measures include:

a. Hand picking. For instance:

- Large caterpillars, Insects or eggs can be collected by hand and crushed.
- Bud worms are hand picked I tobacco field.
- African bollworms and Maize earworms are effectively controlled through Hand picking.

b. Fencing. For instance vegetable gardens.

c. Frightening off pests

- For instance, sound of firing devices (i.e. beating drums, firing gun) Can scare off monkeys, sight of human shape can scare birds.

d. Painting sticky bands

- Sticky substances are smeared at the base of fruit trees to prevent crawling insect pests.

e. Erecting concrete foundations

- This is to keep off termites from Grain stores.

f. Flooding fields

- Caterpillars and soil pests (Especially in crops like rice) are deprived of air and they are killed by suffocation (asphyxiation)

g. Using rat guards

h. Using air-tight Storage facilities: pests run out of air.

i. Chilling and heating.

Cultural control

This is the use of normal crop husbandry practices (agronomic practices) that prevent or reduce the

multiplication or spread of pests and diseases. They include the following:

i. **Tilling the soil**
- This either exposes pests and diseases to sun or buries them

(ii) **Rotating crops**
- This is more effective in controlling soil pests and disease such as root knot, nematodes in bananas as they are less mobile, so they may not move to attack their normal host crop in its new plot.

(iii) **Planting early**
- This ensures crops are well established before pests and diseases build up to dangerous level. It also ensures that the crop can escape late pests and diseases. For instance, Cassava scales and maize streak are controlled by early planting.

(iv) Planting clean healthy seeds

(v) Removing volunteer plants.
- These will encourage pests and diseases of the previous crop to remain on the plot by providing them with food. So remove them to starve the pests.

(vi) Weeding early.
- Weeds invite and keep pests and diseases in the field, so remove them early to control pests.

(vii) Maintaining a recommended plant population

This controls the groundnut aphid (Aphis Craccivora) which transmits the groundnut rosette virus. Rice blast is also reduced in this way.

(viii) Applying manure or fertilizer correctly
- This keeps crops healthy and strong so that it can resist pests and diseases. For instance organic manure in pepper reduces the incidence of root knot nematodes. Fertilizer application in rice reduces leaf spot and rice blast.

(ix) Destroying crop residues
- This reduces the carry-over of pests and diseases from one season to another.

(x) Intercropping or mixed cropping
- This reduces pest and diseases by one crop acting as a barrier (for the other) against pests or by acting as alternate hosts which divert the pest away from the susceptible crop.

Legislative control

Is the use of laws and regulations to prevent dangerous pests or diseases from being imported into the country or from colonising new areas and so restrict their spread such measures include:

Prohibition. Laws or regulations are made nation wide forbidding the introduction of specific agricultural materials that may be a source of infection in an area. This involves inspection at international Airports or any entry points (Immigration).

Quarantine. Suspicious materials are inspected closely, impounded or quarantined. Quarantine. Is a period of isolation and observation of products in sealed compartments, long enough for any disease symptoms to appear.

Notification order. This ensures that serious pests and diseases are promptly identified and dealt with e.g. Army worm, Red locusts are notifiable pests.

Closed season. This is the period during which there should be no plant growing in the field. The aim of closed season is to starve out certain pests so that they do not survive and multiply during the cold

dry season. Tobacco and cotton are such crops having closed season. One of the diseases controlled during closed season for tobacco is bushy top, which is caused by a virus transmitted by aphids (myzus persicae).
For cotton, stalks must be uprooted by 30th July and burned by 31st August (except in Karonga where uprooting and burning should be completed by 31st August and 15th September respectively) to reduce pink ball worms in the next season's crop.

Note that it is difficult to control this pest with pesticide.

Seed certification. Regulations are in place to ensure that seeds for certain crops are not sold to farmers by seed companies unless they have been inspected and certified free of pests and diseases e.g. tobacco seeds.

Biological Control

This is the use of living organisms such as predators parasites and pathogens to reduce the pest populations. The organisms used are:

- **Predators** e.g. ladybirds prey on aphids.

- **Parasites.** A parasite is an organism which lives in or on another organism (host) in order to obtain food or shelter e.g. diphtheria are parasites of grasshoppers.
- **Pathogens** For instance, bacteria like Bacillum popilliae is used to control the larvae of some beetles.
    - Biological control safe (unless the predator itself becomes a pest)
    - It is relatively cheap, it is effective for several years and it does not pollute the environment.

However it requires expertise and thorough knowledge of the ecosystem and the behaviour of both the pest and the controlling agent (predators, parasite or pathogen)

Chemical Control

This is the use of toxic substances that are lethal to kill crop pests, parasites or pathogen.

Types of chemicals (pesticides)

Type of pest	Type of pesticide
Insect	Insecticide
Mites	Arcaricide
Nematode	Nematicide
Snails molluses	Moluscicides
Rats or mice (rodents)	Rodenticides
Bacteria	Bactericides
Fungi	Fungicides
Viruses	Virucides
Parasites weeds	Herbicides

Methods of applying pesticides
Pesticides can be applied to crops as dusts, gases (fumes) granules or sprays.

- Dusting in form of powder e.g. Aldrin
- Fumigating in form of smoke or gas (fumes) in grain silos to control storage pests like weevils such pesticides include methyl bromide control nematodes on nursery beds.
- Sprays. Watering cans, hand sprayers, knapsack sprayers, aeroplane-mounted sprayers are used to spray.

Mode of action

a) Contact poisons: The pest is killed when it touches the pesticides. Contact herbicides can enter through the cuticle (skin).
b) Stomach poisons: kill pests by entering their stomachs via their mouths as they eat treated plants or seeds.
c) Respiratory poisons: are in vapour form and are inhaled.
d) Systemic poisons: are applied to soil or leaves and are absorbed by plants. The pesticides then enters in the cell sap and when any pest sucks the sap it gets killed.

Advantages of chemical control

- Faster to carry it out
- Quick results
- Individual farmers can effectively use it as opposed to legislative or biological.
- Is more dependable than legislative and biological.
- Is easy to use as instructions are always given.

Disadvantage of chemical control

- Expensive.
- Kills beneficial organisms (predators of pests, pollinators).
- Pollutes the environment.
- Requires repetitive application to larvae or adults in subsequent cycles.
- Some pests develop resistance.
- Is harmful to people.

UNIT 8

CROPPING SYSTEMS

Cropping system refers to the patterns, techniques, procedures or practices followed in cultivating and production of plants. It describes what crop or crops are grown in an area, as well as how and why they are grown.

1. Shifting cultivation

This is a cropping system where land is cultivated for several years until crop yields become too low due to soil exhaustion.
This forces the former the farmer to abandon the plot and moves on (shift) to farm cultivate another.

Land is cleared by cutting down trees and burning which adds potassium and calcium through the ash.

Advantages

- It is cheap, does not require fertilizers
- It is simple since operations are generally carried out using hand toois.
- It controls pests and weed seeds effectively through burning.

Disadvantages

- requires a lot of land
- results into low yields due to low inputs levels (no fertilizers etc)
- Burning destroys vegetation and some nutrients.
- Exposes land to erosion
- Encourages deforestation

2. Bush Fallowing (Land Rotation)

The word bush means uncleared, wild vegetation. `Fallow' is land left uncropped for one or more seasons to allow re-growth and the decomposition of plant remains
Bush Fallowing means farming a plot, then temporarily leaving it when exhausted so that it can regain fertility, before returning to it later. The fallow period may be as long as five to ten years.

Advantages
- It is cheap, it does not need fertilizers.
- It maintains soil fertility through the fallow period.

Disadvantages
- Encourages deforestation
- Increases soil erosion
- Requires a rot of land.

3. Mono Cropping

The whole farm has only one crop and this crop is grown every year for instance Estate commercial farming like sugarcane - Chikwawa, rice - Zomba, tea - Mulanje.

Advantages
- It produces highest possible profits since farmers grow only the most suitable crop for the most suitable crop for the environment
- It simplifies farm management.
- Easy to merchanise
- It saves costs. Monocropping is usually associated with large-scale estate farming, so large quantities of inputs (fertiliser, pesticides etc) can be bought in bulk at wholesale price or discount.
- It reduces the amount of starting capital.
- The farmer specialises, so he becomes an expert, thereby better management leading to higher profits.

Disadvantages
- Pest and diseases build up.
- High risk of loss or disappointment.
- Soil quickly becomes exhausted. So you need heavy fertiliser applications.

4. Monoculture

Monoculture means cultivating or growing only one crop on a piece of land. It is different from Monocropping in that in Monocropping the whole farm grows only one crop, whereas in Monoculture different crops may be grown on one farm, but they occupy separate plots. A plot which carries only one crop is known as "**pure stand".** A plot in which two or more crops are grown is known as "**mixed stand**" Cash crops like tobacco, groundnut and tea are normally grown in pure stand.

Advantages
- Mechanisation is easier
- Eliminates the possibility of any competition from other crops.
- Easy to carry out farm operations like spraying pesticides.

Disadvantage
- Pests and disease build up and they spread faster.

5. Mixed cropping

This is the practice of growing two or more crops on the same plot at the same time. Forms of mixed cropping are intercropping, **interplanting, multiculture or polyculture.**
Ways in which mixed cropping is practiced in Malawi include:

- **Intra-row mixed cropping**
  Two or more crops are planted within the same ridge (row). The crops may be sown on the same planting stations or on different stations along the ridge e.g. maize and beans.
- **Inter-row mixed cropping** One crop is grown between the rows of another crop. In other words, the two crops are grown o alternate rows or ridges.
- **Relay intercropping**

- A second crop is sown on the plot while the first one is still growing, established or eve maturing. This is also known as "phased planting" for instance, Rhodes grass pasture may undersown in a maize plot when the maize is almost mature.
- For instance pumpkin seeds are sown when tobacco is almost ready for harvesting. Cassava is also planted in an established maize field.

Advantages
- Saves labour since some operations (such as weeding) are done at once for all the crops in the mixture.
- Saves land.
- Increases total yields (although the yield for each crop might be lower than if it were in a pure stand, the combined yields is higher per unit area)
- Provides security i.e. reduces risk of crop failure.
- Enables crops to benefit from each other.
- Reduces spread of pests and diseases.
- The mixture provides adequate soil cover.

6. Continuous cropping
Is growing crops on a piece of land ever year without fallowing or resting the land. This is very common in Malawi.

7. Crop rotation
is the growing different crops (changing crops) on a piece of land in a particular sequence (order) every year.

Disadvantages
- Mechanisation is difficult.
- Requires large starting capital.
- Difficult to carry out operations.
- Requires skill.
- Crops may shade one another from light.

Advantages
- Ensures 100% utilisation of the land and other resources.
- Conserves the soil. Since land is continuously under crop cover.
- Ensures food security or sufficient cash for the farmer.

Disadvantages
- Exhausts soil fertility since land does not rest.
- Results in overcultivation of overcropping which destroys structure;'so apply manure)
- Results in multiplication of diseases and pests and some parasite weeds.

Year	Plots					
1	Maize	Cassava	Cotton	G/beans	Millet	G/nuts
2	Cassava	Cotton	G/beans	Millet	G/nuts	Maize
3	Cotton	G/beans	Millet	G/nuts	Maize	Cassava
4	G/beans	Millets	G/nuts	Maize	Cassava	Cotton
5	Millet	G/nuts	Maize	Cassava	Cotton	G/beans
6	G/nuts	Maize	Cassava	Cotton	G/beans	Millet

Crop rotation sequence
- The above diagram illustrates a six-year crop rotation. In other words each crop returns to its original plot after six years.

Some principles farmers follow in allocating crops to plots are:
- Alternating tap (deep) rooted crops with fibrous (shallow) rooted crops.
- Alternating leguminous crops with non-legume crops.

- Alternating heavy feeders soil (exhausting crops) with light feeders.
- Alternating crops that are resistant to specific diseases / pests with susceptible crops to those diseases / pests.
- Alternating crops with good soil cover with those having little soil cover.

Advantages

- Full use of nutrients from all layers in the soil.
- Maintains / improves fertility when a legume is included.
- Controls pests and diseases.
- Control host-specific parasitic weeds.
- Reduces soil erosion.
- Ensures a more even distribution of labour hence reduces serious labour peak and work **trough.**
- Spreads out financial risks over several crops (i.e. security)

Disadvantage

- Loss income because some crops may have low commercial value. -
Requires more land.
- Requires more labour.
- Requires skill in management of the rotation and the various crops.
- May not be practical where the farmer needs to use for example up to 90% of land for a stapple food crop to meet family food requirements.

8. No-till cropping

The land is cleared but the soil is left undisturbed in that it is neither tilled nor ridged, except when making planting holes. It is also called **Zero tillage** or **minimum tillage.** Weeds are controlled by applying herbicides and weeding with cultivators.

Advantages

- Conserves soil since it is not loosened.
- Saves labour because there is no ploughing or ridging.
- Crop husbandry practices are conducted and completed on time.
- Maintain soil structure
- Saves money (i.e. no buying machinery for cultivation).
- Can be used effectively on hilly areas.

Disadvantage

- May not improve the productivity of clay soils, which require opening up.

9. **Biological farming**

Crops are grown using organic (rather than inorganic inputs: fertiliser, fungicides, pesticides, herbicides) as much as possible. Biological farming is also called organic farming or eco-farming. Weeds, pests and diseases are controlled physically, mechanically, culturally or biologically instead using chemical methods.

Advantages

- prevents pollution of rivers and lakes.
- Protects useful insects (like pollinators and predators of pests)
- Improves soil structure through use of manure.
- It is cheaper to make manures than fertiliser.
- Reduces chances of poisoning people (some pesticides do not decompose or breakdown fast enough)
- Keeps ecosystem is a state of balance since organic inputs tend to be environment friendly.

Disadvantage
Organic inputs may not be as quick as inorganic ones in producing results.

UNIT 9

FRUIT PRODUCTION: MANGOES

Importance of fruits
- Source of food nutrients e.g. carbohydrates, proteins, minerals for instance, see below:

Products	Fruits
Juices (drinks	Mangoes, oranges, guava, pineapple
Jams	Strawberries, peaches, plums, pawpaws, apples, guavas.
Marmalades	Lemons, limes, grape fruits, sour oranges, sweet oranges
Pickles	Green mangoes
Spiced preserves (such as mango a chaar)	Green mangoes

Fruits provide people with income people sell mangoes, guavas etc.
- They provide employment. The people are employed in orchards of tangerines (Mwanza), bananas (Nkhatabay and Mulanje and Thyolo) and mangoes in Mangochi) -
Provide foreign currency when exported e.g. macadamia nuts.

Mango (Mangifera Indica)
Is a tropical evergreen tree which can reach a height of over 15 metres. The foliage is dense, producing a heavy shade which suppresses weed growth underneath.
The fruit is a large drupe which ranges from 5 - 30 cm in length, depending on the variety. The flesh is orange and sweet when the fruit is mature.
Inside the fruit, there is a stone with a hard fibrous endocarp, which encloses a small brown or white seed.

Varieties of mangoes
Common varieties of mangoes include boloma, domasi and dodo which are sweet and big and small mangoes such as waka, kapantha and kambulutu which have a good flavour.

All these are fibrous (the flesh is stringy) and are therefore, not acceptable on the overseas m.jrl<ct. However, these varieties can still be exported for processing into juice and chutney.

Export variety
Mangoes varieties for export need to be well-coloured preferably with red or purple blush and completely fibreless.

Characteristics of some of the varieties

(i) **Haden:**
- is large (400 -- 700g) mature early in the season.
- Suitable for hot dry areas
- Well- coloured fruits with excellent flavour
- Susceptible to anthracnose.

(ii) **Zill:**
- Is medium (300 - 400g) and is and early season crop.
- Fruits are scarlet to dark red when ripe
- Is suitable for all tropical mango areas.
- Excellent internal quality
- It keeps well

(iii) **Irwin:**
- Weighs up to 450g and is 12 cm long.
- Matures early in the season.
- Is suitable for most areas
- Fruit is elongated and slightly flattish.
- Has excellent internal and external quality.

(iv) **Davis:**
- Haden: Is large (up to 900g).
- Is a mid-season variety.
- Is like Haden but resistant to anthracnose.

(v) **Palmer:**
- Is large (600 0 700g) is a late-season (matures late) variety.
- Produces elongated fruit.
- Is susceptible to bacterial black spot.

(vi) **Kent:**
-Is large (up to 900g) and is a late season variety.
- Is a high yielding variety - Is suitable for hot areas.

(vii) **Keitt:** Is large (up to 900g.
- Matures very late in the season.

(viii) **Anderson:**
-Is large (1 kg), 28 cm long.
- Is suitable for canning.

Selecting varieties.
Characterists to look for include;
- Yield
- Resistance to diseases and parasites
- Fibreless
- Early maturity and later maturity than existing varieties to extend the mango season.

Cultivating mangoes
Mangoes do best in deep, fertile, well-drained sandy loam soils.

They do well at altitudes below 600 m.
Mangoes are drought tolerant but they need a minimum rainfall of 650 mm and a dry period for flowering and fruiting.
Mangoes are a warm weather crop.

Land preparation
Planting holes should be made two months in advance 90 cm x 90 *cm* x 90 cm. Refill with top soil mixed with 5- 10 kg of decomposed manure.

Planting holes should be spaced at 9 m x 9 m or 10.5 m x 10.5 or 12 m x 12 m depending on the variety and fertility of the soil.

Planting
Sowing or transplanting should be done in December or January.
Use sub soil left from the planting holes to make basins around each tree to hold water.

Mulching
Should be done to conserve moisture.

Weeding
- Clear all weeds beneath the seedling or tree (within the basin area). The rest of the area should be slashed.

Fertiliser application
- mangoes are not heavy feeders
- Apply 5 - 10 kg manure per plant per year.

Age of tree (yrs)	CAN	Triple super phosphate	Muriate of potash
1	100	20	125
2	200	40	250
3	300	60	375
4	400	80	500
5	500	100	625
6	600	120	750
7	700	140	875
8	800	160	1000
10	1000	200	1250

Fertiliser application to fruit trees **grams/tree/year.**

Harvesting mangoes
Mangoes trees bear fruit 4 - 5 years after planting.
Harvest when the fruits are mature especially those which are improved varieties (e.g. Kuyezuka or kudengula)
Fruit are harvested by hand and collected in a bag.
Use a ladder or climb the tree to pick the fruit by hand, one by one - fruits should not fall to the ground, to avoid bruising.
- Improved varieties can yield 200 - 500 fruits per year.

Pest and control.

(i) **Mango stone weevil** (Sterinochetus Mangiferae)
The larvae is fleshy white grub. It enters the fruit during the early stages of fruits development, leaving no external sign of its entry. It damages the stone (seed) fruit may fall early or rot, or may have hard white areas inside.

Control
- Collecting and burying dropped fruits.

- Keep orchard clean.

(ii) **Mango scales** (coccus mangifera and coccus a cuminatus)

Damage:
These are small, flat, oval insects which attack the leaves, stems and fruit. They produce honey dew (a sticky liquid)

Control:
Spraying dimethoate 20 wp at 85g in 14 litres of water.

(iii) **Fruit flies** (ceratitis capitata)

Damage:
Flies lay eggs on the fruit. Shiny white maggots hatch and enter the fruits,. Fruits change colour before they are ripe. Parts of the flesh become liquid.

Control.
- Collecting and burying fallen fruits.
- Spraying fenthion (lacycid) 50 EC at 1 ml per litre of water.
- Harvesting fruits before ripening..

Diseases of mangoes

(i) **Anthracnose** (Glomerella cingulata)

Symptoms
- Discoloration of young !eaves (leaf spots)
- Premature ripening of fruits
- Black spots on fruits
- Rotting of fruits

Control
- Spraying Benoml (Benlate) 50 wp at 15 g in 10 litres of water.

(ii) **Powder mildew** (oidium mangifera)

Symptoms:
- Shedding of flower and immature fruits.
- Par nn flowers

Control
- Spraying Benomyl (Benlate) 50 wp at 1>> in 10 litres of water.

UNIT 10

LIVESTOCK: FEEDS AND FEEDING

V

Classes of food

There are two main classes namely:

a) **Roughage** (fresh grass or green fodder silage and hay)

(
- Are high in moisture and fibre and low in protein. They can be succulent or dry.

b) **Concentrates** (maize meal, madeya, fish meal, meat and bone meal, groundnuts and cotton seed cake, urea, soya meal, and blood meal)
They are high in protein, and carbohydrate but low in moisture and fibre.

Two types of concentrates are:

i) **Energy concentrates** eg.
Cereal grains and their by-products (maize, madea, wheat meal, sorghum and millet) and grain legumes and their by-products (groundnuts, soya meal)

ii) **Protein concentrates** eg.
meat and bone meal, fishmeal.
Note: In addition to roughage and concentrates, animals are given mineral and vitamins supplements. These are referred to as **additives.**

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The composition of feed and functions of nutrients

Nutrients	Function	Source
Carbohydrates (made up of starches and sugar)	- Provide energy - Excess carbohydrates are stored as fats	Cereal, (maize sorghum, millet) Potatoes and their vines Grass Root tuber
Fats and oils	- Provide energy twice as much energy as carbohydrates	Oil seeds (e.g. groundnuts) Soya, milk, eggs, meat, fish meal
Proteins (made of proteins)	Body building and repair Component of enzyme hormones, antibodies Excess proteins are converted into proteins, carbohydrates or glycogen	• Grains, legumes eg beans, ground nuts • Meat, liver, milk • Bone and fish meal
Minerals calcium and phosphorus	Bone formation For milk production Egg shell formation	Meat, milk, lime bone meal
Magnesium	For health bones and teeth Help to metabolise carbohydrates	Milk, cereal grains, leafy vegetables
Iron	Part of haemoglobin Prevents anaemia	Egg york
Iodine	Essential for the growth of thyroid gland which produces thyroxine Prevent goitre	Iodised salt
Copper and cobalt	Form part of haemoglobin and enzymes (cobalt) is part of vitamin B12 Improve appetite in ruminants Prevents anaemia Maintains blood pressure Essential for bile formation	Salt containing copper and cobalt Most vegetables contain copper and cobalt
Sodium	Maintain blood pressure For bile formation	Common salt and rock salt
Manganese	Helps in bone formation and enzymatic reactions.	Most foods

	For metabolism of proteins and carbohydrates	
Chlorine	Part of gastric juice Aids in digestion	Common salt and rock salt
Potassium	Helps in functioning of the muscles and heart Activates enzymes	Potassium Grass
Zinc	Helps in enzymatic reaction	Most feeds
Vitamin A(soluble in fat)	Needed for good eye sight and growth For prevention of diseases	Milk, fresh grass, yellow maize, fish cold liver.
Vitamin B (water soluble)	- Helps in metabolism of carbohydrates, proteins and (Water soluble) fats	- Green vegetables - G/nut meal - Cereals ruminants are able to synthesize vitamin B through the micro organism that is found in the rumen.
Vitamin C (water soluble)	Important for disease resistance	- Green leafy vegetables - Fruits
Vitamin D	- For bone formation - Prevents rickets in animals	- Sunlight, hay, - Fish liver oil yeast green grass
Vitamin E	- For proper functioning of the reproductive system - Prevent sterility	Grains, soya, grass green vegetables
Vitamin K - Fat soluble	For blood clotting, prevent breeding	
Water	- For body fluids and maintenance of shape of body, help transport of nutrients. - Helps transport nutrients.	- All feed, especially succulent leafy vegetables or roughages. - Drinking water - All feeds especially succulent feeds

Feed rations

- For animals to grow well they need to be well fed with a balanced ration.
- **A ration** is an amount of feed required by animal per day.
- A balanced ration is an amount of feed that contains all the nutrients and in the right proportion.

Types of rations

i) **Maintenance ration**: is an amount of feed that the animal needs per day to maintain its bodily processes without gaining or losing weight.

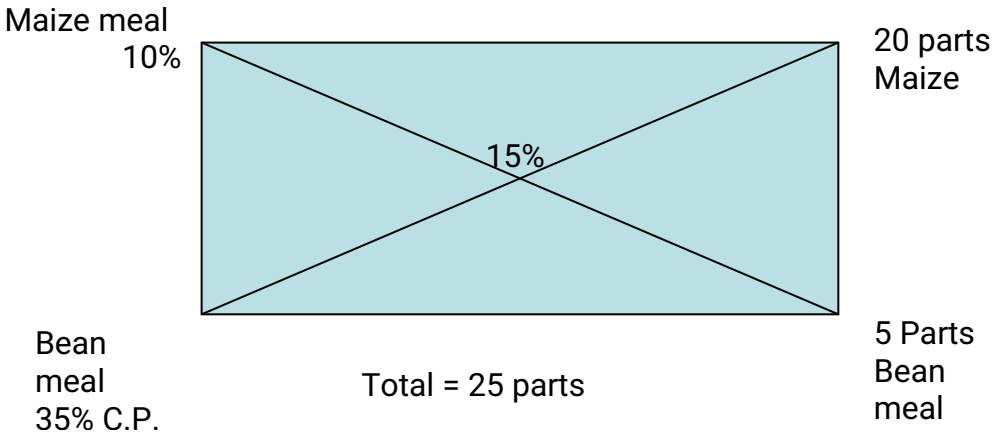
ii) **Production ration:** is feed given to animals over and above the maintenance ration - it is for animals to produce (e.g. layers eggs, broiler or beef cattle to produce meat)

Formulating Rations

- Farmers can make their own feed. For them to do this they need to know the nutrient requirement of the animals reared and the feed ingredients.
- For instance chicken feed can be- formulated using a **Pearson's square**

- Example: formulate a 15% protein feed using maize containing about 10% protein and bean meal containing 35% protein. The procedure is as follows:

Draw a square and place the desired percentage protein content of the mixed in the centre. See diagram below.



Note: CP = Crude protein

- Place the percentage of each feed stuff to be mixed at the left corner
- Subtract the figures diagonally across the square. Remember to subtract small number from bigger ones. Disregard the negatives.
- Place the numbers obtained on the right comers, giving the required parts of each feedstuff as shown in the above diagram.

As shown in the example of a person square calculation above, 20 parts of maize and five part of bean meal are mixed, the result will be 15% protein.

Factors to consider when feeding animals

- Age and size of animals.
- Type of animals: ruminant or non- ruminant
- Purpose for which animals are kept.
- The condition of the animal. Is it sick? Animals should not be allowed to starve.
- The quality of feed. Feed should be easy to ingest and digest.
- Palatability: Feed should be tasty, sweet smelling and appetizing.
- Digestibility: this refers to whether the animal is able to digest the feed. This will depend on the type of the animal.
- The amount of the feed. Although it is advisable that animals be fed ad lib (when and as much as, they like) the amount of feed to be given to animals will depend on its quality and type. Texture: this refers to coarseness or fineness of the feed. This is important, especially when feeding chickens as they prefer coarse feed.
- Cost of the feed. Because feed is expensive, give feed to animals which are productive.

UNIT 11

SHEEP AND GOAT PRODUCTION

Importance of sheep and goat

- Provide meat, skins, milk (goats), wool (sheep), mohair (goat)
- Prestige
- Manure

Note: Goats' milk is easily digestible and is thus suitable for babies and children.

Types of Breeds

a) Indigenous breeds

i) Malawi Goat
ii) Small East African goat

b) Exotic breeds
i) Sheep: Merino, karkul and Blackhead Persian
ii) Angora, Boer goat, Toggengliurg, British Saanen, British Alpine.

- Indigenous sheep and goats are small, grow slowly, mature slowly and their yield is low.
- Exotic sheep and goat are tend to be big, grow and mature faster and their yield is higher.

Methods of improving local sheep and goat

i) Selection
ii) Cross breeding local breeds with exotic ones. Some examples of exotic breeds which can be used for cross-breeding are below.

The two above are the methods by which livestock can be improved:

Type of animal	Examples of indigenous breeds	Use for they were intended
Sheep	Black Persian	Mutton
	Dorper	Mutton
	Merino	Wool
	Karkul	Skin (pelt)
Goat	Angola goat	Mohair
	British Saanen	Milk
	Anglo-Namibia goat	Milk, meat
	British Alpine	Milk
	Toggerburg	Milk
	Boer goat	Meat

Criteria used to select a breed of sheep

a) Primary use or product

Select a breed that will give you the highest production.
For instance if you want to produce more mutton, select dorper. Mutton sheep should have the following characteristics:

- Good mothering ability of ewes
- Should be fast growing and maturing
- Good body shaped
- Good body weight for instance dorper can weigh 50kg
- Good quality mutton

b) Adaptation to the climatic

Local environmental eonditions. The breed should be adapted to the local conditions.

Note:

- The local Malawi sheep is hardy.
- The black Persian is also hardy karkul is adapted to desert conditions, while the merino thrives in dry conditions
- The Hampshire Down can survive on poor pasture and is good for wool.

The management of sheep

- Activities involved in livestock management are **breeding, housing, feeding, disease** and **parasite control.**

- These four above are referred to as **principles** of livestock management.

Breeding
- Ewes can first be served (mated) at 18 months old but 2 years is best.
- Rams can mate first at 8 months old.
- Breeding ratio (sex ratio) is: 1 ram for 10 - 20 ewes but a ram can service up to 60 ewes. - **Castrate** rams not required for breeding.
- Castration: is the removal or destruction of male reproductive organs.

Reasons for castration
- Animal fatten quickly
- Prevents inheritance of undesirable genes.
- Animal become more docile, so easier to handle
- Reducing fighting and so injuries
- May check spread of sexually transmitted diseases.

Methods of castration

a) Open Method
- Using a sharp knife to cut open scrotum and remove the testicles or cut and tie sperm ducts.

b) Closed Method
- **Burdizzo** is used to crush the testis or spermatic cords
- **Elastrator** or strong rubber band is tied round the testes and above the testes to cut off blood supply to them.
- The scrotum and testes drop off after a few weeks.

Mate animals in November so that lambing (five months later) takes place when grass is in plentiful.

Oestrus (heat) is the recurring period of sexual receptivity in female mammals.
- Knowledge of heat helps farmer to plan for mating.
- The **oestrus (heat)** in sheep is between 18 - 24 hours and the oestrus cycle lasts between 15 - 18 days.
- **Flush** the ewes two weeks before mating them to improve their fertility and health (flush by feeding them with concentrates)
- **Gestation** lasts for 150 days
  - Feed ewes properly
  - Dose/ drench them against intestinal parasites.
  - Vaccinate against diseases.

- **Steam up** ewes two months before lambing. This ensures better development of foetus and smooth lambing. Steaming is feeding quality feed (cereal, grains or oil cakes, good silage or hay) to pregnant animals prior to giving birth.

Lambing and caring for lambs
- Signs of parturition (giving birth)
- Restlessness
- Ewe isolates itself to a quieter place.
- Vulva becomes swollen and red.
- Frequent bleating
- Udder swells

Giving birth
- Ewes rarely need help when giving birth.

- However be observant
- Normal birth is: forelegs come out first with head resting on them.
- Assist newly born lamb~ to suckle their mothers immediately.
- Provide supplementary feed to lambs as soon as milk yield starts to decline. - Vaccinate and drench lambs against diseases and parasites.
- Castrate lambs with 1 - 2 months of their birth.

Docking (cutting off the tail should be done about four or weeks old.

- This prevents dirt and dung from collecting under the tail, which could be source of infection.
- It is easier to remove external parasites such as ticks, from the anal area.
- Improve quality of mutton.
- Helps animals to mate easily.

Trimming (cutting back overgrowing hooves) to prevent lameness should be when animas are still young. Housing Sheep and Goats
- A simple pole and thatch house is constructed where sheep are kept under extensive system.
- Under intensive management system an elaborate khola is constructed.

Characteristics of a good khola

- Strong
- Specious (1.0m2 per animal)
- Well ventilated and well - lit
- Dry and warm
- Easy to clean
- Easy and cheap to construct

Feeding sheep.

- Provide supplementary feed (e.g. madeya, maize meal bean or pea meal) and mineral licks of bone meal, sulphur and salt.
- Provide quality pastures.
- Steam up and flush sheep.
- Lambs should depend on their mothers' milk because it is nutritious and contains antibodies.
- Help lambs to learn to eat grass after three weeks. This also helps to develop their digestive system in addition to solving the problem of declining milk production.
- Practice creep feeding (i.e. giving lambs extra feed to improve their growth.)
- Wean after four weeks.
- Note that sheep prefer to nibble young grass and shoots at ground level. Goats like to browse - eat leaves, young shoots and twigs from trees and herbs.

Disease and parasite control

Disease	Causal organisms	Symptoms	Treatment control
Pneumonia	Bacteria or Virus	- Loss of appetite - Coughing - Difficult breathing - Nasal discharge - Provide plenty water	- Treatment control - Treat with anti biotics - Keep clean kholas - Provide plenty water and palatable feed
Enterotoxaemia (pulpy kidney or lamb dysentery	Bacteria	- Staring eyes - Tiredness - Brownish and blood-stained diarrhoea - Convulsions and sudden death in severe cases	- Vaccinate the animals
Heart water	Protozoa transmitted by	- Loss of appetite - High fever - Nerviousness/tiredness	- Control ticks by dipping - Treat with antibiotics with tetracycline

	ticks	- Twitching of eyes - Animals tend to walk in circles of hit against objects - High mortality in exotic breeds	
Brucellosis contagious, (abortion)	Bacteria	- Uterus is infected and fetus die - Abortion	- Slaughter and burn infected animal - Vaccinate
Foot rot	Fungi bacteria	- Feet have pus and bad smell - Animals may become lame - Feet swell and animals have difficulty in walking	- Treat feet with anti biotics and disease infecting - Trimming hooves
Foot and mouth	Virus	- High fever - Animals become dull and stop grazing due to blisters - Excessive salivation - Lameness	- Restrict movement - Vaccination - Slaughter and burn infected animals
Mastitis	Bacteria	- Swollen udder - Blood clots and pus in milk	- Treat with antibiotics - Strict sanitation - Use disinfectants - Vaccinate
Sheep pox	Virus	- High fever - Dark red - Pimples/lesions - Some lambs die	-

Some external parasites of sheep and goats

Parasite	**Part of the** body is **attacked or damaged**	**Treatment control**
Ticks	- Ears, Tail, Udder. - Suck blood and transmit tick - borne diseases animal regularly like heart water and red	- Dipping the animal regularly (once every two weeksduring the dy season and weekly during the rainy season
Scaly mites	- Skin - Cause itching	Dipping
Lice	- Skin - Dipping	Dipping

Some internal parasites of sheep and goats

Parasite	**Part of the body attacked/ damaged**	**Control**
Roundworms	- Walls of the intestines - Animals have spot bellies	Dosing/ drenching the animals with drugs like phenothiazine.
Liver fluke	Mostly liver	- Kill snail with copper surphate. - Avoid dambo or marsh grazing
Tape worm	Muscles, lungs, liver, brains, intestines	- Rotational grazing. - Treat with drugs

The Management of Goats

There are two main systems of managing goats, namely:

(i) **Tethering:** where grazing land is scarce and to protect crops. The goat is tied. Goat is allowed to graze a limited area.

(ii) **Extensive system**. Goats are free to graze and browse natural pastures under the supervision of a herder.

Note that goats are more of browsers than grazers.

- A combination of sheep and goats makes the best use of pasture.
- But goats can also be managers under a semi-intensive system where there is controlled grazing which is coupled with stall feeding.
- Under intensive system animals are kept inside a house and feed is brought to them. Both intensive and semi-intensive are practiced only at research stations or agricultural colleges.

Selecting an appropriate breed of goat

a. Consider:

- Should grow fast and mature early
- Good body shape
- Nannies with good mothering ability
- Milk goats should have large well-developed udders.

b. Suitability of breed to local and economic conditions:

- It should suit the climatic and local conditions of the area.
- Note that the Malawi goat is hardly and disease resistant, it is also a good scavenger. However it is genetic - potential is low, therefore there is need to cross breed it with exotic breeds its milk and meet production. Remember the improved breed will require improved management,

c. Personal preference:

What breed will the farmer want -meat or milk from local or exotic breed.

Breeding goats

- Female goats (nannies/Does) should be served (mated) at 15-18 months old.
- Male goat (Bullies/bucks) should be used when they are two years.
- Breeding ratio (sex ratio) is: one billy to 25-30 nannies. However one billy can service up to 60 nannies.
- Billies have their puberty at 9 months, they can mate.

Oestrus cycle

In goats (nannies) it lasts 18 - 21 days while oestrum (heat) lasts 24 - 72 hours. Service nannies when they are on heat.

Signs of heat include:

- Signs of excitement/restlessness.
- Vulva becomes red and swollen t think)
- Mucous discharge from vulva.
- Undue noise - making

- Remember to mate animals in November
- Remember to isolate animal after noticing

Gestation

- Is 150 days long
- Practice proper feeding (concentrates)
- Steam up one month before kidding (giving birth in goats)
- Signs of parturition (giving birth) are the same as those of sheep.

How to care for kids

- Let the nanny lick mucous from the kid to clean it.
- Kid must suckle for up to four days to suckle colostrums.
- Wean when kids are 3 - 6 months but when nannies are kept for milk, production, remove kids from nannies 3 - 4 days after birth.
- The kids must from then own wards be fed milk a bottle or bucket observe hygiene rules, otherwise kids may develop diarrhoea. Milk should be warm.
- Introduce pasture and feed supplements to kids about 3 weeks after birth to help develop their digestive system.
- Castrate unwanted males at the same time (3wks)

Housing

- Is same as for sheep above remember to have separate pens for kids.

Feeding Goats

- Goats are more browsers than grazers can feed on pasture, herbs, shrub, leaves, crop refuse, tree barks, shoots, twigs from trees, shrubs and herbs.
- Goats can be destructive if not controlled and cause desert formation if allowed to over browse or overgraze.
- On the other hand goats are beneficial in a ranch because they help to check the growth of bushes.
- Goats will not eat soiled feed or drink dirty water.

3. **Parasite and Diseases Control**

The Malawi goat is quite hardy and resistant to diseases but can act as carriers of internal and external parasites for other animals. So dip them or dust them or drench them to control external parasites (fleas, lice, ticks and tsetse flies) and internal parasite, (roundworms, tapeworms and liver flukes)

- Practice rotational grazing
- Most of diseases that attack sheep also attack goats.
- For goats also watch for the following diseases: pneumonia, mastitis, foot rot, enterotoxaemia, rinderpest, foot and mouth.
- Good nutrition (feed) increase resistance.