AGRICULTURE FORM II NOTES

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Soil Fertility II

(Inorganic Fertilizers)

Introduction

- Plant nutrients occur in the soil in form of soluble substances.
- These substances are taken in by the plants in different quantities depending on their roles in the plant tissues.

Essential Elements

- These are nutrients needed by plants for various uses.
- They are divided into two broad categories namely:
  - Macronutrients
  - micronutrients.

Macro-nutrients

- These are also referred to as major nutrients.
- They are required by the plant in large quantities.

They include;

- carbon,
- hydrogen,
- oxygen,
- nitrogen,
- phophorus,
- potassium,
- sulphur,
- calcium
- magnesium.

- Nitrogen, phosphorus and potassium are referred to as **fertilizer elements,**
- Calcium, magnesium and sulphur, are referred to as **liming elements.**

Role of Macronutrients in Plants

Nitrogen (NO_3,$NH4^{++}$)

Sources:

- Artificial fertilizers
- Organic matter
- Atmospheric fixation by lightning
- Nitrogen fixing bacteria.

Role of Nitrogen in Plants

- Vegetative growth
- Chlorophyll formation
- Build up of protoplasm.
- Improves leaf quality in leafy crops such as tea and cabbages.

Deficiency Symptoms

- Yellowing of the leaves/chlorosis.
- Stunted growth.
- Premature ripening.
- Premature shedding of the leaves.
- Light seeds.

Effect of Excess Nitrogen

- Scorching of the leaves.
- Delayed maturity.

Loss of Nitrogen From the Soil:

- Soil erosion.
- Leaching.
- Volatilization.
- Crop removal.
- Used by microorganisms.

Phosphorus ($H_2 Po_4$, HPO^{2-}_4 P_2O_5)

Sources:

- Organic manures
- Commercial fertilizers
- Phosphate rocks

Role of Phosphorus

- Encourages fast growth of the roots.
- Improves the quality of the plant.
- Hastens maturity of the crops.
- Influences cell division.
- Stimulates nodule formation in legumes.

Deficiency symptoms

- Growth of the plant is slow.
- Maturity is delayed.
- Leaves become grey, purple in colour.
- Yield of grains, fruits and seed is lowered.

Loss of Phosphorus From the Soil

- Soil erosion.
- Leaching
- Crop removal
- Fixation by iron and aluminium oxide.

Potasium (K^+, K_2O)

Sources;

- Crop residue and organic manures.
- Commercial fertilizers
- Potassium bearing minerals e.g. feldspar and mica.

Role of Potassium in Plants

- Increases plant vigour and disease resistance.
- Increases the size of grains and seeds.
- Reduces the ill-effects due to excess nitrogen.
- Prevents too rapid maturation due to phosphorus.

Deficiency Symptoms

- Plants have short joints and poor growth.
- Plants lodge before maturing.
- Leaves develop a burnt appearance on the margin.
- Leaves at the lower end of the plant become mottled, spotted or streaked.
- In maize, grains and grasses firing starts at the tip of the leaf and proceeds from the edge usually leaving the midrib green.

Loss of Potassium From the Soil

- Crop removal.
- Leaching.
- Soil erosion.
- Fixation in the soil.

Calcium ($Ca^{2}+$)

Source:

- Crop residues and organic manures.
- Commercial fertilizers.
- weathering of soil minerals.
- Agricultural limes for example ***dolomite, limestone***.

Role of Calcium in Plants

- Improves the vigour and stiffness of straw.
- Neutralizes the poisonous secretions of the plants.
- Helps in grain and seed formation.
- Improves the soil structure.
- Promotes bacterial activity in the soil.
- Corrects the soil acidity.

Deficiency symptoms

- Young leaves remain closed.
- There are light green bands along the margins of the leaves.
- Leaves in the terminal bud become hooked in appearance there is a die-back at the tip and along the margins.

Loss of Calcium

- Crop removal
- Leaching
- Soil erosion

Magnesium (Mg2+)

Sources:

- Crop residues and organic manures
- Commercial fertilizers
- Weathering of soil minerals.
- Agricultural limes.

Role of Magnesium in Plants

- Forms part of chlorophyll.
- Promotes the growth of the soil bacteria and enhances the nitrogen fixing power of the legumes.
- Activates the production and transport of carbohydrates and proteins in the growing plant.

Deficiency symptoms

- Loss in green colour which starts from the bottom leaves and gradually moves upwards.
- The veins remain green.
- Leaves curve upwards along the margins.
- Stalks become weak and the plant develops long branched roots.
- The leaves become streaked.

Sulphur (So_4^{2-}, SO_2)

Sources:

- Commercial fertilizers.
- Soil mineral containing sulphides
- Atmospheric sulphur from industries.
- Rain water

Role of Sulphur in Plants

- Formation and activation of coenzyme-A.
- Sulphur is a constituent of amino acids.
- Influence plant physiological processes.

Deficiency Symptoms

- Small plants/stunted growth.
- Poor nodulation in legumes.
- Light green to yellowish leaves/ chlorosis.
- Delayed maturity.

Micro-nutrients

- Also referred to as trace or minor nutrients.
- They are required in small quantities/traces.
- They are essential for proper growth and development of plants.

They include;

- Iron,
- Manganese,
- Copper,
- Boron,
- Molybdenum
- Chlorine.

Role of Micronutrients and Their Deficiency Symptoms

- ***Copper***
  - Role in oxidation-reduction reactions.
  - Respiration and utilization of iron
  - Deficiency symptoms-**yellowing of young leaves**.
- ***Iron***
  - Synthesis of proteins.
  - Takes part in oxidation-reduction reactions.
  - Deficiency symptoms - **leaf chlorosis**

- ***Molybdenum***
  - Nitrogen transformation in plants.
  - Metabolization of nitrates to amino acids and proteins
  - Deficiency symptoms -**leaf curl and scathing.**
- ***Manganese -*** Same as molybdenum.
- ***Zinc***
  - Formation of growth hormone.
  - Reproduction process
  - Deficiency symptoms - **white bud formation.**
- **Boron –**
  - Absorption of water.
  - Translocation of sugar

Inorganic Fertilizers

- These are chemically produced substances added to the soil to improve fertility.

Classification According to:

- **Nutrients contained**
  - ***Straight -*** contain only one macronutrient.
  - ***Compound fertilizers*** - contain more than one macronutrient
- ***Time of application***
  - Some applied when planting.
  - Top dressing after crop emergence
- ***Effects on the soil pH.***
  - Acidic fertilizers.
  - Neutral fertilizers.
  - Basic fertilizers.

Properties and Identification of Fertilizers

Nitrogenous Fertilizers

Characteristics

- Highly soluble in water.
- Highly mobile in the soil hence it is applied as a top dress.
- Easily leached because of the high solubility hence does not have residual effect on the soil.
- Has scorching effect on young crops during wet seasons.
- Easy to volatilize during hot season.
- They have a tendency to cake under moist conditions.
- They are hygroscopic hence should be stored in dry conditions.

Examples:

- ***Sulphate of Ammonia (NH_4) 2 SO_4·***

  Physical appearance:
  - white crystals,
  - Has acidic effect,
  - Contains 20% N.

- ***Ammonium Sulphate Nitrate [$(NH_4)_2 SO_4$+ $NH_4 NO_3$]***
  - Colour: granules which appear yellow orange,
  - less acidic,
  - contains 26% N.
- ***Calcium Ammonium Nitrate (CAN)***
  - Colour: greyish granules,
  - neutral in nature,
  - contains 21 % N.
- ***Urea***
  - Colour: small whitish granules
  - Easily leached or volatilized,
  - contains 45- 46%N.

Phosphate Fertilizers

- Has low solubility and immobile.
- Non-scorching.
- Has a high residual effect hence benefit the next season's crop.
- Easy to store because they are not hygroscopic.

Examples;

- ***Single super-phosphate***
  - Appearance: whitish, creamy white granules,
  - contains **20-21 % P_2O_5**
- ***Double super-phosphate***
  - Appearance: dark greyish granules,
  - Contains ***40-42% P_2O_5***
- ***Triple super-phosphate***
  - Appearance: small greyish granules,
  - Contain ***44-48% P2O5***

Potassic Fertilizers

Characteristics:

- Has moderate scorching effect.
- Moderately soluble in water.
- Most Kenyan soils have sufficient potassium.

Examples;

- ***Muriate of Potash (KCl)***
  - Contain 60 - 62% K_2O
  - Slightly hygroscopic.
  - Appearance amorphous white.
- ***Sulphate of Potash (50% K_2O)***

Compound or Mixed Fertilizers

- These are fertilizers which supply 2 or more of the macronutrients.

Examples;

- ***Mono ammonium phosphate.***
- ***Di-ammonium phosphate***
- ***20:20:20, 23:23:23***

Advantages of application of compound fertilizers

- Saves time and money.
- Mixture gives improved storage properties and better handling.

Disadvantages of compound fertilizers application

- Expensive.
- Wasteful.
- Mixing may not be thorough.
- Incompatibility of the individual fertilizers.

Methods of fertilizer application

- ***Broadcasting*** - random scattering of the fertilizers on the ground.
- **Placement method** - application of fertilizers in the planting holes.
- ***Side dressing*** - fertilizer is placed at the side of the plant within the root zone, in bands or spot-rings.
- ***Foliar spraying*** - specially formulated fertilizer solution applied on the foliage in spray form.
- ***Drip method*** - applied through irrigation water.

Determination of Fertilizer Rates

Contents of fertilizers are expressed as fertilizer grade or fertilizer analysis.

- Fertilizer grade indicate the guaranteed minimum of the active ingredients (N, P_2O_5, K_2O) in the mixture.
- It is expressed as a percentage on a weight to weight basis or percentage by weigh

Example 10:20:0 means for every 10kg of the mixture there are 10kg of nitrogen, 20kg of P_2O_5 and 0kg of K_2O.

Example

A farmer was asked to apply fertilizers as follows:

- 60 kg/ha nitrogen (top dressing)
- 60 kg/ha P_2O_5 (in planting hole).
- 60 kg/ha K_2O.

How much sulphate of ammonia (20%) would be required per hectare?
How much double super-phosphate (40%) P_2O_5would be required per hectare?
How much muriate of potash (50% K_2O) would be required per hectare?

Answer/Solution

- Sulphate of ammonia (SA) which gives 60kg/ha N
  $= \frac{60}{}$

$\frac{20}{100}$ x 100 =300kg SA

- Double super phosphate (40% P_2O_5)which gives 60kg/ha P_2O_5

$= \frac{60}{40}$x 100 =150kg DSP

- Muriate of potash (60% K_2O) which gives 60kg/hK_2O

$= \frac{60}{60}$ x 100=100kg muriate of potash

Example

A farmer was asked to apply fertilizers as follows:

- 200kg/ha of DSP (40% P_2O_5
- 150kg/ha of muriate of potash (60% K_2O)
- 150kg/ha of sulphate of ammonia (20% N)

How much P_2O_5 did the farmer apply per acre?
How much K_2O did the farmer apply per hectare?
How much N did the farmer apply per hectare?

Solution/Answer

- P_2O_5 applied per hectare from 200kg of DSP

$= \frac{40}{100}$x 200= 80kg/ha P_2O_5

- K_2O_5 applied per hectare from 150kg of muriate of potash

$= \frac{60}{100}$x150=90kg/ha K_2O

- ***N*** applied per hectare from 150kg/ha sulphate of ammonia

$= \frac{20}{100}$ x 150= 30kg/ha N

Soil Sampling

- Refers to obtaining of small quantity of soil that is representative in all aspects of the entire farm.

Soil Sampling Procedures

- Clear the vegetation over the site.
- Dig out soil at depths of 15-25cm.
- Place the dug out soil in a clean container.
- Mix thoroughly the soil in the container.
- Take a sample and send it to National Agricultural Laboratory for analysis.
- The container carrying the sample should be properly labeled as follows:
  - Name of the farmer,
  - Location,
  - District
  - Address of the farmer.

Sites to Avoid

- Dead furrows, ditches.
- Swamps

- Near manure heaps.
- Recently fertilized fields
- Ant hills.
- Under big trees.
- Near fence lines or foot paths.
- Do not put them in containers which are contaminated with fertilizers or other chemical containers.

Methods Of Soil Sampling:

- Zigzag method
- Traverse method

Soil Testing

- Soil testing is the analyzing of the soil sample to determine certain qualities of the soil.

Importance of Soil testing:

- To determine the value of the soil hence determine the crop to grow.
- To determine the nutrient content hence find out the type of fertilizer to apply.
- To determine whether it is necessary to modify the soil pH for a crop.

How Soil pH affects Crop Production

- Influences the physical and chemical properties of the soil.
- Affects the availability of nutrients.
- Influences the incidences of soil borne diseases.
- Determine the type of crop to be grown at a given area.

Methods of pH Testing

- Universal indicator solution
- pH meter

  -
  - Know the course of action to be taken in the event of a disease and maintenance of good health.
  - Know the prevalent diseases.
  - Calculate the cost of treatment.
- **Marketing Records** show commodities sold, quantities and value of all the sales.

Labour Records - show labour utilization and labour costs.

Crop production II (Planting)

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- Planting is the placement of the planting material in the soil for the purpose of regeneration in order to produce more of the plant species.

Types of planting materials

Seeds

- Seeds are produced by flowering after pollination and fertilization. They contain the part of the plant that germinates and subsequently grows in to new plants.

Advantages of using seeds as planting materials.

- Seeds are easily treated against soil borne pests and diseases.
- They are not bulky therefore storage is easy.
- They are easy to handle during planting making operation easy.
- When planting seeds, it is easy to use machines like seed planters and drillers.
- It is easy to apply manures and fertilizers together with seeds during planting.
- Fertilizers and manures application can be easily mechanized.
- It is possible to develop new crop varieties due to cross pollination.

Disantivantages of using seeds as planting materials.

- Some seeds have long dormancy and they may need special treatment in order to germinate.
- Plants raised from seeds have variations from the mother plant due to cross pollination, This may introduce undesirable characteristics.
- Soil borne pests may damage seeds if left for sometime in the soil before rain falls.
- Some seeds may lose viability if stored for a long time. This leads to gaps in the farm.

1. **Vegetative materials.**

- These are plant parts which have the ability to produce roots, they grow and develop in to new plants.
- Plant parts such as leaves, roots or stems can be used for planting as long as they are capable of rooting.

Advantages of using vegetative materials for planting.

- Crops originating from vegetative materials matures faster than those from seeds.
- The crops shows uniformity in such qualities as disease resistance, seed size, colour, keeping or storing quality and chemical composition.

- It is possible to produce many varieties of compatible crops on the same root stock.
- Use of the vegetative materials is easier and faster, especially where seeds show prolonged dormancy.
- The resulting plant has desired shape and size for ease of harvesting and spraying.
- It facilitates the propagation of crops which are seedless or those that produce seeds which are not viable or have a long dormancy period.
- Such crops include sugar-cane, bananas, Napier grass and others.

Disadvantages.

- Vegetative propagation does not result in new crop varieties.
- Keeping the materials free of diseases is difficult.
- Materials cannot be stored for long.
- The materials are bulky and there fore difficult to store and transport.

Plant parts used for vegetative propagation.

i) Bulbils.

- These are tiny sisal plants produced in the inflorescence almost at the end of the plant growth cycle.
- They resemble the mother plant except that they are smaller in size.
- They are produced by the branches of the sisal pole.
- When manure they mature they develop rudimentary roots and fall off to the ground just below the pole.
- They are the collected and raised in the nurseries before they are transplanted t\o the main field.
- One sisal pole may produce as many as 3,000 bulbils. They are usually 10cm long. They make good planting materials and are better than sucke

ii) Splits

- These are plantlets divided from the existing mother plant with complete with complete leaves and rooting system.
- They are used to propagate most pasture grasses and pyrethrum.
- Pyrethrum splits are raised first in nursery and then transplanted to the field.

iii) Crowns and slips

- These are materials used to propagate pineapples
- Crowns are born on top of the fruits and are broken off and prepared for planting.
- They are more preferred to suckers because they give uniform growth and take two years to reach maturity.
- Slips are borne to the base of the pineapple fruits.
- They are cut and prepared for plantings.
- Their growth rate is faster than for crowns giving average uniformity.
- They take 22 months from planting to maturity.

- Crowns and slips are planted in the nurseries first before transplanting to the main seed bed.

iv) Suckers

- These are small plants that grow from the base of the main stem.
- They have adventitious roots which grow quickly when planted to form a new plant.
- They are used to propagate bananas, sisal, and pineapples.
- When planted, suckers give uneven growth leading to maturity at different times. T
- hey should be planted when they are young.

v) Tubers

- These are underground food storage organs which are short and thick.
- They are used as vegetative propagation materials because they sprout and produce roots for growth.
- There are mainly two types of tubers, the stem and root tubers.
- Root tubers develop from the thickening of the adventitious roots.
- Root tubers are not commonly used for propagation since they produce weak stems.
- A good example of a root tuber is the sweet potato.
- On the other hand stem tubers have some auxiliary buds which are sometimes referred to as 'eyes'.
- These eyes sprout to produce stems which grow into plants. Stem tubers are therefore swollen stems with scales leaves.
- A good example of a stem tuber is Irish potato.

vi) Vines.

- These are soft wood cuttings which produce roots easily upon planting to give rise to new plants.
- They are cut from the mother plants and planted directly into the field.
- Soft wood cuttings (vines) are taken from rapidly growing shoots.
- The soft upper parts of the shoots are preferred.
- When preparing the cuttings, some leaves and nodes are included.
- Roots are produced from the nodes.

vii) Cuttings and setts

- Cuttings are portion of plants parts which are cut and then planted.
- They may be from stems, roots or leaves.
- A stem cutting must have a bud which develops into shoot.
- The root cutting must have an eye. Cutting must have an eye.
- Cuttings must produce leaves as soon as possible so that they can start making their own food.
- Sometimes cuttings are induced to produce roots by use of rooting hormones.
- Once the cuttings have developed roots, they give rise to new plants.

- In some crops, the cuttings are big enough to be planted directly to the main seedbed whereas there are some plants whose cuttings are first raised in special nurseries before they are transplanted to the seedbed.
- The cuttings of Napier grass and sugar-cane are planted directly on the seedbed but those of tea; have to be raised in special nursery before they are transferred to the seed bed.
- Examples of crops which are propagated by use of stem cuttings include: tea, cassava, and sugar-cane and Napier grass.
- The stem cuttings used to propagate sugar-cane are known as 'setts'. Setts are stem cuttings which have 3-5 nodes are usually 30-45 cm long.

Factors affecting rooting of cuttings.

- **Temperature:** for the cuttings to produce roots warm temperatures are required around the root zone while cool temperatures are important for the aerial part of the cuttings. For most species optimum day and light temperatures for rooting are 22 -27°c and 15-21° c respectively.

a) **Relative humidity:** Proper rooting of cuttings requires high humidity which lower the transpiration rate. It also increases and maintains leaf turgidity all the time. As such, cuttings should be rooted in green houses or under shady conditions, where relative humidity can be regulated. Sometimes the propagation area can be sprayed with water to keep it moist.

b) **Light intensity:** soft wood cuttings need high intensity light to produce roots. This is because light promotes the production of roots since it affects the rate of photosynthesis. Hard wood cuttings do well in dark conditions since they have high amount of stored carbohydrates and therefore rooting is excellent in darkness.

c) **Oxygen supply:** plentiful supply of oxygen is required for root formation. The rooting medium used must therefore be capable of allowing proper aeration.

d) **Chemical treatment**: these rooting hormones which promote the production of roots in cuttings. The common ones include IAA (Indoleacetic acid).

e) **Leaf area:** Soft woods cuttings require a lot of leaves for photosynthesis while hardwood cuttings will produce roots better without leaves.

Selection of planting materials

When selecting materials for planting the following factors must be considered:

- **Suitability to the ecological conditions** – the selected planting materials should be well adapted to the soil conditions, temperatures and amount of rainfall in the area. There are many varieties of maize, for example, which are suitable to different ecological conditions. Hybrid 622f or example is mainly for the high altitudes areas of Kenya 513 for the medium altitudes and the Katumani composites for the low rainfall areas while the coast composites are suitable for the coastal conditions each variety will grow well and produce high yields if grown under the correct conditions
- **Purity of the materials** - planting materials should be pure and not mixed with other off types the percentage purity of planting materials will affect the seed while higher seeds rates are used for impure seeds.

- **Germination percentage** - This is a measure of the germination potential of seeds it is expressed as a percentage for example a germination percentage of 80 means that for every 10 seeds planted 80 of them are expected to germinate. Germination percentage helps to determine the seed rates of crops lower seed rates are used for crops with higher germination percentage while higher seed rates are used for those with lower germination percentage.
- **Certified seeds** - These are seeds which have been tested and proven to have 100 germination potential and free from diseases and pests they give high yields after the first planting but the subsequent yields decline if replaced therefore in this case it is always advisable to buy new seeds which are certified every time planting is done
  In Kenya certified seeds are produced by the Kenya seed company (KSC) and distributed by Kenya Farmers Association (KFA) and other agents.

PREPARATION OF PLANTING MATERIALS.

After the planting materials are selected they are prepared in different ways before they are planted. Some of the methods used to prepare planting materials include the following:

(a)Breaking the seed dormancy.

Some seeds undergo a dormancy period between maturity and the time they sprout. The dormancy period is the stage whereby a seed cannot germinate, the stage of inhibited growth of seed. It should be broken before the seed is planted.

Methods of breaking seed dormancy.

The following methods are used to break seed dormancy**:**

(I) ***Mechanical method:*** This is a method which aims at scratching the seed coat to make it permeable to water. Scarification is done by rubbing small sized seeds against hard surface such as sand paper, while filling or nicking the seed coat with a knife is done to large sized seeds such as croton seeds.

(ii) ***Heat treatment:*** this involves the use of hot water or burning the seeds lightly. It softens the seed coat making it permeable to water and thus is able to germinate. The seeds are soaked in hot water about 80'c for 3-4 minutes after which the water is allowed to drain off. Example of seeds treated in this way include: leucean $7a^2 + 3^2 = 2^2$ calliadra and acacia.

Light burning also serves the same purpose as hot water treatment. In this case trash is spread over the seeds which are already covered with a thin layer of soil. The trash is burned, after which the seeds are retrieved and planted. Examples include acacia and wattle tree seeds. Overheating should be avoided as this will cook the seeds.

(iii)Chemical treatment: seeds are dipped in specific chemicals such as concentrated sulphuric acid, for two minutes and then removed. The chemical wears off the seed coat making it permeable to water. Care should be taken not to leave the seeds in the chemicals for too long as this will kill the embryo. Cotton seeds are normally treated with chemicals to remove the lint or fibres.

iv) Soaking in water: seeds are soaked in water for a period of between 24 – 48 hours until they swell. They are then removed and planted immediately. The seeds treated thus germinate very fast. Pre-germinated seeds are used when raising rice in the nurseries.

b) Seed dressing

This is the coating of seeds with fungicides or an insecticide or a combination of the two chemicals. This is particularly common with cereals, sugar-cane and legumes.

The chemicals protect the seedlings from soil-borne diseases and pests. Certified seeds which are sold by seed merchants in Kenya have been dressed with these chemicals. Farmers can also buy the chemicals and dress their own seeds.

C) Seed inoculation

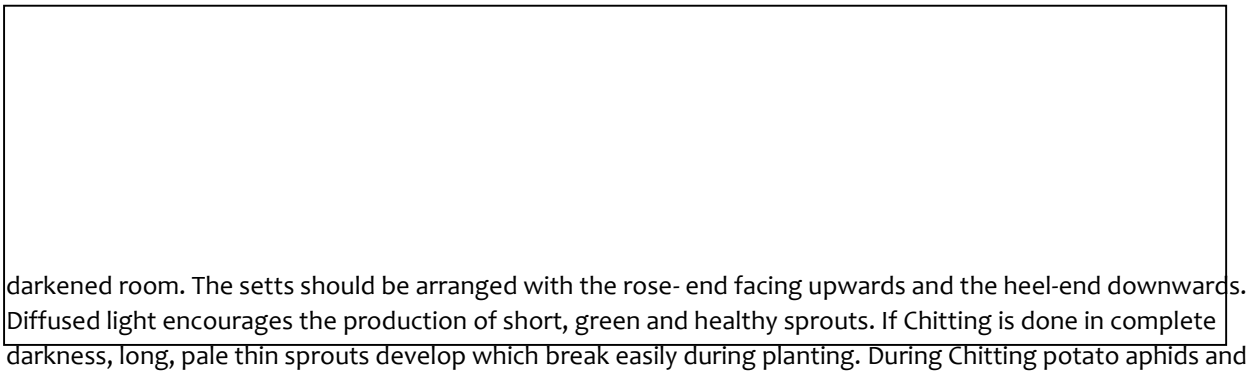
In areas where soils are deficient in nitrogen, legumes such as beans, clovers and peas should be coated with an inoculant. An innoculant is a preparation which contains the right strain of Rhizobium depending on the type of legume and encourages nodulation, hence nitrogen fixation. Below is a table showing different legume crops and their right strain of Rhizobium.

Crop inoculation group	Rhizobium Species
Lucerne	*R. melioti*
Clover	*R. trifoli*
Pea	*R. leguminosarum*
Bean	*R. phaseoli*
Lupin	*R. lupini*
soyabean	*R. japonicum*

When handling inoculated seeds, care should be taken to prevent them from coming in contact with chemicals. This means that inoculated seeds should not be dressed with chemicals as these will kill the bacterium. They should also be planted when the soil is moist to avoid dehydration which kills the bacterium.

d) Chitting

This practice is also referred to as sprouting. The selected seed potatoes 'setts' which are used as planting materials are sprouted before planting to break their dormancy. The setts of about 3-6 cm in diameter are arranged in layers of 2 or 3 tubers deep in a partially



darkened room. The setts should be arranged with the rose- end facing upwards and the heel-end downwards. Diffused light encourages the production of short, green and healthy sprouts. If Chitting is done in complete darkness, long, pale thin sprouts develop which break easily during planting. During Chitting potato aphids and tuber months should be controlled by dusting or spraying the sett with dimethoate. Sometimes a chemical

known as Rendite is used to break dormancy, thus inducing sprouting. Chitting is done mainly to make sure that growth commences immediately the seed is planted so as to make maximum use of rains for high yields.

Time of planting

The timing of planting or sowing is influenced by the type of crop to be planted and the environmental conditions of the area.

Factors to consider in timing planting.

- The rainfall pattern/moisture condition of the soil.
- Type of crop to be planted.
- Soil type.
- Market demand.
- Prevalence of pests and diseases.
- Weed control.

Timely planting is necessary and should be done at the onset of rains. In some areas where rainfall is scare dry planting is recommended.

Advantages of timely planting.

- Crops make maximum use of rainfall and suitable soil temperature, leading to vigorous growth.
- Crops usually escape serious pests and diseases attack.
- Crops benefit from nitrogen flush which is available at the beginning of the rain.
- For horticultural crops, proper timing ensures that the produce is marketed when prices are high.
- Crops establish earlier than the weeds, hence smothering them.

Methods of planting.

There are two main methods of planting :-

- Broadcasting.
- Row planting.

Broadcasting.

This method involves scattering the seeds all over the field in a random manner. It is commonly adapted for light tiny seeds such as those of pasture grasses. It is easier, quicker and cheaper than row planting. However, it uses more seeds than row planting and the seeds are spread unevenly leading to crowding of plants in some places. This results in poor performance due to competition. Broadcasting gives a good ground cover, but weeding cannot be mechanized. For good results, the seedbed should be weed-free, firm and have a fine tilth.

Row planting.

The seeds or other planting materials are placed in holes, drills or furrows in rows. The distance between one row to the other and from one hole to the other is known. In Kenya, both large and small – scale farmers practice row planting. It is practiced when planting many types of crops, especially perennial, annual and root crops.

Advantages of row planting.

- Machines can be used easily between the rows.
- It is easy to establish the correct plant population.
- Lower seed rate is used than if broadcasting is adopted.
- It is easy to carry out cultural practices such as weeding, spraying and harvesting.

Disadvantages of row planting.

- It does not provide an ample foliage cover. Thus the soil is liable to being eroded by wind and water.
- It is more expensive than broadcasting because of consuming a lot of labour and time.
- It requires some skill in measuring the distances between and within the rows.

Seeds can also be planted by dibbling where the planting holes are dug by use of pangas or jembe, or by a dibbling stick (dibbler). Most of the dibbling is done randomly although rows can also be used when using a planting line. Random dibbling is not popular in commercial farming due to low levels of production. It is only common among conservative farmers in planting of legumes such as beans, pigeon peas and cow peas.

Over-sowing.

This is the introduction of a pasture legume such as desmodium in an existing grass pasture. Some form of growth suppression of existing grass such as burning, slashing or hard grazing plus slight soil disturbance is recommended before over sowing. A heavy dose of superphosphate, preferably single supers at a rate of 200-400 kg/ha is applied. The grass must be kept short until the legume is fully established. Regardless of the method of establishment, the pastures and fodder stands should be ready for light grazing 4-5 months after planting if rainfall and soil fertility are not limiting.

Under-sowing.

This refers to the establishment of pasture under a cover crop, usually maize. Maize is planted as recommended and weeded 2-3 weeks after the onset of rains. Pasture seeds are then broadcasted with half the recommended basal fertilizer. No further weeding should be done and maize should be harvested early to expose the young pasture seedlings to sunlight. The benefits of under sowing include facilitating more intensive land utilization and encouraging an early establishment of pastures.

Fodder crops and vegetetively propagated pasture species may also be under sown as long as rainfall is adequate for their establishment. Timing is not very crucial in this case and planting can be done as late as 6-8 weeks after the onset of rains.

Plant population

This refers to the ideal number of plants that can be comfortably accommodated in any given area, without overcrowding or too few to waste space. Agricultural research has arrived at the optimum number of various crop plants to be recommended to farmers. Plant population is determined by dividing the planting area by spacing of the crop. This may be simplified thus:

$$\textbf{Plant population} = \frac{\text{Area of land}}{\text{Pacing of crop}}$$

Example

Given that maize is planted at a spacing of 75 x25 cm, calculate the plant population in a plot of land measuring 4x3 m.

Working

$$\text{Plant population} = \frac{\text{Area of land}}{\text{Pacing of crop}}$$

Area of land = 400cm x 300 cm

Spacing of maize = 75 cm x 25 cm

Therefore, plant population $= \frac{400 \text{ cm} \times 300 \text{ cm}}{75 \text{ cm} \times 25 \text{ cm}}$

= 64 plants.

Spacing

It is the distance of plants between and within the rows. Correct spacing for each crop has been established as shown in table below.

crop	spacing
Maize (Kitale) hybrids	75 – 90 cm x 23 – 30 cm
Coffee (Arabica) tall varieties	2.75 cm x 2.75m
Tea	1.5 m by 0.75 m
Beans (erect type)	45 -60 m by 25 cm
Bananas	3.6 – 6.0 m by 3.6 – 4.5 m
Coconut	9 m x 9 m
Tomatoes (Money maker)	100 x 50 cm
kales	60 x 60 cm

Spacing determines plant population and the main aim of correct spacing is to obtain maximum number of plants per unit area which will make maximum use of environmental factors. Wider spacing leads to a reduced plant population which means lower yields, whereas closer spacing could lead to overcrowding of plants and competition for nutrients and other resources would occur. Correctly spaced crops produce yield of high quality that are acceptable in the market.

Spacing is determined by the following factors:

- **The type of machinery to be used.**

The space between the rows should allow free passage of the machinery which can be used in the field. For example, the spacing between rows of coffee is supposed to allow movement of tractor drawn implements.

- **Soil fertility**
  A fertile soil can support high plant population. Therefore closer spacing is possible.
- **The size of plant**
  Tall crop varieties require wider spacing while short varieties require closer spacing, for example, Kitale hybrid maize is widely spaced than Katumani maize.
- **Moisture availability.**
  Areas with higher rainfall are capable of supporting a large number of plants hence closer spacing than areas of low rainfall.
- **Use of crop.**
  Crop grown for the supply of forage or silage material is planted at a closer spacing than for grain production.
- **Pest and diseases control.**
  When crops are properly spaced, pests might find it difficult to move from one place to the other, for example, aphids in groundnuts.
- **Growth habit.**
  Spreading and tillering crop varieties require wider spacing than erect type.

Seed rate.

Seed rate is the amount of seeds to be planted in a given unit area governed by ultimate crop stand which is desired. The objective of correct spacing of crop is to obtain the maximum yields from a unit area without sacrificing quality. Most crops are seeded at lighter rates under drier conditions than under wet or irrigated conditions. Seeds with low germination percentage are planted at higher rates than those which have about 100% germination percentage. There is an optimal seed rate for various crops. For example, the seed rate for maize is 22 kg per hectare, wheat is 110 kg per hectare and cotton is between 17 to 45 kg per hectare.

Factors to consider in choosing seed rates.

- **Seed purity.**
  When planting seed which is pure or with a high germination percentage, less seed is required. On the contrary, more seeds are required when using impure or mixed seeds.
- **Germination percentage.**
  Less seed is used when its germination percentage is higher. Seed of lower germination percentage is required in large amounts.
- **Spacing.**
  At closer spacing, more seeds are used than in a wider spacing.
- **Number of seeds per hole.**
  When two or more seeds are planted per hole, higher seed rate is required than when only one seed is planted per hole.
- **The purpose of the crop.**
  A crop to be used for silage making is spaced more closely than one meant for grain production. This would require use of more seeds. Maize to be used for silage making, for example, requires more seeds than that meant for production of grain.

Depth of planting.

This is the distance from the soil surface to where the seed is placed. The correct depth of planting is determined by:

- **Soil type:** seeds will emerge from grater depths in sandy soil that are lighter than in clay soils.

- **Soil moisture content:** It is recommended that one plants deep in dry soils in order to place the seeds in a zone with moist soil.
- **Size of the seed:** Larger seeds are planted deeper in the soil because they have enough food reserves to make them shoot and emerge through the soil to the surface.
- **Type of germination:** seeds with epigeal type of germination (carry cotyledons above the soil surface) such as beans, should be planted shallower than those with hypogeal type of germination (leave cotyledons under the soil) such as maize.

Suggested Activities.

1. Learners to carry out planting using broadcasting method and planting rows.
2. Learners to identify different vegetative propagation materials displayed by the teacher.
3. Learners to determine the correct plant population for a given area by mathematical calculations.
4. Learners to collect samples of different tree seeds and prepare them for planting by various methods of breaking seed dormancy.
5. Learners to determine the germination percentage of different samples of cereals and legume seeds.

Crop Production III

(Nursery Practices)

Introduction

- Planting materials are either planted directly in a seedbed or indirectly through a nursery bed.
- A seedbed is a piece of land which could be small or large and prepared to receive planting materials.
- A nursery bed on the other hand is a small plot of land specially prepared for raising seedlings or planting materials before transplanting.
- It is usually 1m wide and any convenient length depending on the quantity of seedlings to be raised.
- A seedling bed is a special type of nursery bed used for raising seedlings pricked out from the nursery bed due to overcrowding before they are ready for transplanting.
- Pricking out refers to the removal of seedlings from a nursery bed to a seedling bed.
- Nursery practices refer to all the activities carried out throughout a nursery life to raise seedlings. .

Importance of Nursery Bed in Crop Production

- To facilitate the production of many seedlings in a small area.
- It is easy to carry out management practices in a nursery than in the seedbed.

- It facilitates the planting of small seeds which develop into strong seedlings that are easily transplanted.
- It ensures transplanting of only healthy and vigorous growing seedlings.
- It reduces the period taken by the crop in the field.
- Excess seedlings from the nursery may be sold to earn income.

Selection of a Nursery Site

Factors to consider;

- Nearness to the water source.
- Type of soil.-should be well drained, deep and fertile, preferably loam soil.
- Topography.-it should be situated on a gentle slope to prevent flooding and erosion through surface run-off.
- Previous cropping.-to avoid build up of pests and diseases associated with particular plant families, consider the preceding crops.
- Security.-select a site that is protected from theft and destruction by animals.
- Protection against strong winds and heat of the sun.-select a sheltered place. i.e. to avoid excessive evapotranspiration and uprooting seedlings.

Types of Nurseries

Categories of nurseries:

- ***Vegetable Nursery****:*
  - They are used for raising the seedlings of vegetable crops.
  - **Tomatoes, cabbages, kale, onions, brinjals and peppers.**
- ***Vegetable Propagation Nurseries:***
  - They are used for inducing root production in cuttings before they are transplanted,
  - The cuttings can be planted directly in the soil and hence called ***bare root nurseries.***
  - Or planted into containers such as pots, polythene bags and others, hence called ***containerized nurseries***.
- ***Tree Nurseries:***
  - These are used for raising tree seedlings.
  - The seedlings can be raised in bare root nurseries or in containerized nurseries.

Nursery Management Practices:

- These are the practices carried out in the nursery while the planting materials are growing.

They include:

- Mulching. –light mulch should be applied on thenursery bed.It be should be removed on the 4^{th} day
- Weed control.

- Shading.
- Pricking out.
- Pests and disease control.
- Hardening off
- Watering.

Preparation of vegetative materials for planting:

- ***Cuttings*** -These are plant parts such as stems, leaves and roots induced to produce roots and used as planting materials.
- ***Grafting –***
  - It is the practice of uniting two separate woody stems.
  - The part bearing the roots is referred to as ***root stock*** while the part which is grafted onto the rootstock is known as ***scion.***
  - The scion has buds which develop into the future plant.
  - The ability of the rootstock and the scion to form a successful union is termed as ***compatibility.***

Methods of Grafting

- ***Whip or tongue grafting:***
  - In this case the diameter of the rootstock and the scion are the same.
  - It is carried out when the diameter of the scion and the rootstock is 'pencil' thick.
- ***Side grafting****:* In this case the diameter of the rootstock is bigger than that of the scion.

Other types of grafting include ;

- ***Approach grafting,***
- ***Notch grafting***
- ***Bark grafting***.

Budding:

- It is the practice of uniting a vegetative bud to a seedling of another plant.
- The scion has only one bud and some bark with or without wood.
- The bud is inserted in a slit made on the bark of the stock.
- It is held tightly on the stock by tying with a budding tape until it produces a shoot.

Methods of Budding:

- T-budding
- Top budding
- Patch budding.

Importance of Budding and Grafting:

- Plants with desirable root characteristics but with undesirable products may be used to produce desirable products for example lemon-orange graft.
- They facilitate the changing of the top of the tree from being undesirable to desirable

- They make it possible to grow more than one type of fruit or flower on the same plant.
- They help to propagate clones that cannot be propagated in any other way.
- They help to shorten the maturity period.

Layering

- It is the process by which a part of a plant is induced to produce roots while still attached to the mother plant.
- Once the roots have been produced, the stem is then cut off and planted.

Types of layering;

- Marcotting or aerial layering.
- Tip layering.
- Trench layering.
- Compound or serpentine.

Tissue Culture for Crop Propagation

- Tissue culture is a biotechnology used in cloning vegetatively propagated plants.
- It is based on the ability of plant tissue (or cells) to regenerate other parts of the plant.
- The tissues are derived from shoot tips where cells are undergoing rapid cell division and are not differentiated.
- The cells are then provided with the right conditions which enable them to multiply and develop roots.

The Right Conditions for tissue culture:

- Culture medium.
- Correct temperature.
- Correct light intensity and
- Correct relative humidity.

Importance of Tissue Culture in Crop Propagation

- It is used to recover and establish pathogen-free plants especially in the control of viral diseases.
- It is used in mass production of plantlets or propagules.
- It is fast and requires less space than the cultural methods of using cutting which requires a bigger space.

Transplanting Seedlings

- Transplanting of vegetable and tree seedlings are generally the same.
- Generally, vegetable seedlings are ready for transplanting when they are one month old or have 4 -6 leaves or are about 10-15cm in height.
- Before transplanting, the nursery bed is adequately watered 3 - 4 hours before lifting the seedlings.
- This ensures the seedlings are lifted easily with a ball of earth around the roots to minimize root damage.
- Tree seedlings take a little longer to reach transplanting age compared to vegetable crop seedlings.
- The roots are trimmed before lifting the seedlings.

- Transplanting should be done at the onset of the long rains to give the young trees a good start.
- After transplanting the young trees should be protected from damage by animals for a period of about one year.

Crop production IV (Field Practices I)

Introduction

- Field practices are activities carried out on the field to facilitate proper growth and maximum yield of the various crops grown.

They include the following:

- Crop Rotation
- Mulching
- Routing field practices
- Crop protection
- Harvesting

Crop Rotation

- This is the growing of different types on the same piece of land in different seasons, in an orderly sequence.

Importance of Crop Rotation

- Maximizes use of nutrients and moisture.
- Breaks the life cycle of pests and disease agents.
- Maintains good soil structure.
- Reduces soil erosion due to adequate soil cover.
- Controls weeds that are specific to certain crops e.g. striga on cereals
- Improves soil fertility when legumes are included in crop rotation.

Factors Influencing Rotational Programme

- Growth habits and nutrient req uirements.
- Liability to soil erosion.
- Crops attacked by the same pests and diseases should not follow one another in the programme.
- Availability of capital and market for example beans or peas in legumes.

Mulching

- This is the placement of materials such as banana leaves or polythene sheets on the ground next to the growing crop.
- These materials should not come into contact with the base of the crop as they may encourage pest attack.

Importance of Mulching

- Reduction of evaporation rate.
- Smothers weeds.
- Moderation of soil temperature.
- Reduction of speed of run offs.

Types of Mulching Materials

- ***Organic mulching*** materials such as;
  - Sawdust, wood shavings, coffee pulps, rice husks,
  - Dry grass, banana leaves, dry maize stalk, napier grass.
- ***Inorganic or synthetic materials*** commonly used are either black or transparent polythene sheets.

Advantages of Mulching

- Prevents water evaporation thus maintaining moisture in the soil for crop use.
- Acts as an insulator thus modifying the soil temperature.
- It helps to control soil erosion.
- It controls weeds by suppressing them.
- After decomposition organic mulch add nutrients to the soil thus improving its fertility.
- Humus produced after the decomposition of organic mulch improves soil structure and the water holding capacity of the soil.

Disadvantages of Mulching

- It is a fire risk.
- Provides a breeding ground as well as a hiding place for pests that finally may attack the crops.
- Traps the light showers of rainfall thus lowering the chances of rain drops reaching the soil.
- It is expensive to acquire, transport and apply.

Routine Field Practices

Thinning

- Removal of excess, weak, damaged or diseased seedlings.
- Allows the remaining seedlings to get enough nutrients and moisture.
- It is aimed at obtaining optimum plant population.

Gapping

- Filling the gaps so as to maintain proper plant population.
- Gaps occur as a result of failure of seeds to germinate or dying of seedlings.

- It should be done early enough for the seedlings to catch up with the other plants

Rogueing

- This is the removal and destruction of a diseased part of a plant or the whole plant.
- The destruction can be achieved through burning of the uprooted plant.

Pruning

- Removal of extra unwanted parts of the plant.

Reasons for pruning are:

- To remove old, unproductive or diseased, damaged parts of the plant.
- To train plants to take a desirable shape for example formative pruning in tea.
- To control crop leave ratio hence avoiding overbearing.
- To control diseases and pests for example antestia bugs in coffee.
- To facilitate other operations such as spraying, picking and seeding.
- To reduce wastage of chemicals applied on the crop.
- To remove branches that interfere with traffic, telephone lines and view.
- Open up the plant to allow free air circulation and exposure of leaves to sunlight.

Note**:* Tools used are ***secateur, pruning saw and pruning knife.

Earthing-up

- This is the placement of soil in form of a heap around the base of the plant.
- It is mostly carried out in tuber crops such as Irish and sweet potatoes to improve tuber formation.
- It is also carried out in groundnuts and maize.
- In groundnuts it promotes production of pods while in maize it provides support to prevent lodging.

Crop Protection

Weed Control

- Weeds are plants growing where they are not wanted, that is a plant out of place.
- Such plants include blackjack, couch grass, thorn apple and Mcdonald's eye.
- Such plants should be eradicated or controlled using recommended methods.

Pest Control

- Crop pests are living organisms that are harmful to the crops.
- They include; insects, nematodes, rodents, thrips and mites.
- They cause great damage to crops in the field and stored produce.

Control of Crop Diseases

- A disease is any alteration in the state of an organism and functions of a plant or its parts.
- Disease causing organisms are known as pathogens.

- They include **fungi, viruses and bacteria.**
- Diseases caused by fungi are referred to as fungal diseases while those caused by viruses and bacteria are referred to as viral and bacterial respectively.

Harvesting

- It is the gathering or of the farm produce after maturity.

Time of harvesting depends on:

- Stage of maturity of the crops.
- Use of the crop.
- Tastes and preferences of consumers.
- Weather conditions, hence liability to spoilage.
- Moisture.

Methods of harvesting is determined by:

- Scale of farming for example large scale farming machines are used.
- Type of crop for example pyrethrum is harvested by hand.
- Uniformity in ripening of the crop for example wheat is harvested by use of combined harvester while coffee is harvested by hand.
- Uniformity in height of the crop and size of seed, fruits and flowers.
- Financial status of the farmer.
- Part of the plant to be harvested.

Post-Harvest Practices

- These are the preparations carried out on crop produce before it gets to the consumer. **They include;**
- Threshing/shelling.
- Drying.
- Cleaning.
- Sorting and grading.
- Dusting.
- Processing.
- Packaging.

Storage

Purpose of storage is to;

- Prevent spoilage
- Make the produce available for future use
- To await good market prices.

Requirements for proper store are:

- It should be clean.
- It should be well ventilated.
- It should be raised from the ground to prevent damp conditions.
- It should be dry.
- It should be strong to hold crop produce.
- It should be easy to clean.

- It should be vermin-proof.
- It should be secure from theft.
- It should be treated against pests such as weevils.

Types of Storage
- Traditional storage structures.
- Modern storage structures.

Preparation of the Store
- Cleaning the store.
- Maintenance
- Dusting the store with appropriate chemicals.
- Clearing the vegetation around the store to keep off vermin.

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Crop Production V: (Vegetables)

Introduction
- A vegetable is any crop that is grown and eaten fresh.
- Vegetables are important both for nutritional and commercial reasons.
- They are categorized on the basis of the part used as food.
- Such parts include;
    - Leaves,
    - Stems,
    - Roots,
    - Fruits,
    - Flowers,
    - Pods
    - Bulbs.

Vegetables are grouped into the following categories:
- ***Leaf vegetables*** for example kales and cabbages.
- ***Root vegetables*** for example carrots, beets, radishes and turnips.
- ***Fruit vegetables*** for example French beans and okra.
- ***Stem vegetables*** for example asparagus, leeks and spring onions.
- ***Bulb vegetables*** for example bulbed onions and garlic.

Tomatoes (Lycopersicon esculentum)
- Tomatoes are fruit vegetables widely grown in Kenya.
- The ripe fruit may be eaten raw cooked or processed to make tomato sauces, juices and pastes.

Ecological Requirements
- Altitude: 0-2100m above sea level.

- Rainfall: 7S0-1300mm per annum.
- Soils: deep, fertile and well drained.

Varieties

- ***Fresh market varieties***:
  - Money maker,
  - Marglobe, hundred fold,
  - Beef eater,
  - Hot set,
  - Super marmande
  - Ponderosa.
- ***Processing varieties***:
  - Kenya beauty,
  - San -marzano,
  - Roma,
  - Heinz 13S0,
  - Primabel,
  - Rutgers hybrid
  - **Cal- J.**

Nursery Practices

- Choose a site which has not been grown ***Solanaceae*** crop in the last three years.
- Nursery beds are raised about 15cm above the ground level.
- Make drills of 20cm apart and 1cm deep drill and cover the seeds.
- Provide shade or mulch material.
- Water twice a day.
- Apply phosphatic fertilizers during planting.

Seedbed Preparation

- The land should be dug deeply to control weeds.

Transplanting

- Seedlings are ready for transplanting when they are 10-15cmhigh after about one month.
- Holes are made at a spacing of 60cm x 90cm.
- Apply 20gm of DSP in the planting hole.
- Transplant with a ball of soil around the roots.
- Apply mulch around each seedling.
- Transplanting is normally in the evening or on a cloudy day.

Field Maintenance

- Early control of weeds is necessary.
- Top dressing is done after crop establishes.
- Pruning and staking are done to train the plants to grow vertically.

Pests Controls

- ***American Bollworm***
  - ***Nature of damage:*** boring holes on the fruits.
  - ***Control:*** spraying insecticides.

- ***Tobacco White Fly***
  - ***Nature of damage:*** suck plant sap from the underside of the leaf, hence may transmit viral diseases.
  - ***Control:*** Destroy infected plant and spray insecticides.

Disease Control

- ***Late Blight***
  - ***Cause:*** Fungus
  - ***Symptoms:*** dry patches on the leaves and fruits.
  - ***Control:*** use of fungicides, crop rotation and destruction of affected materials.
- ***Blossom-end Rot***

  Caused by;
  - Too much nitrogen in early stages.
  - Irregular or infrequent watering.
  - Calcium deficiency.
  - ***Control:*** Apply calcium ammonium nitrate and correction of the above problems.

Harvesting

- For canning, fruits should be fully ripe.
- For fresh market, fruits should be partially ripe and packed in crates to avoid damage.
- The fruits should be graded according to;
  - Size,
  - Colour,
  - Ripeness
  - Freedom from blemishes.

Cabbage

- It is a leaf vegetable related to other brassica crops such as kales, cauliflower, Chinese cabbage and Brussels sprouts.
- Cabbage leaves may be eaten raw in salads, steamed, boiled or cooked in a variety of ways.
- The leaves can also be fed to livestock.

Ecological Requirements

- ***Altitude:***
  - Those with small heads: *900-1500m* above sea level
  - Those with Large heads: 1800-2700m above sea level.
- ***Temperature:*** require cool condition.
- ***Rainfall:***
  - ***750-2000mm*** per annum.
  - Should be well distributed throughout the growing period.
- ***Soils:***
  - Deep,

- Fertile
- Well drained.

Varieties

- ***Early maturing:***
  - Brunswick,
  - Sugar loaf,
  - Early jersey,
  - Copenhagen market,
  - Chinese cabbage,
  - Celery cabbage,
  - Cafe splits kool
  - Gloria, mukuki,
  - Golden acre .
- ***Late maturing***:
  - Drumhead,
  - Savoy,
  - Perfection,
  - Winningstadt.

Nursery Practices

- The beds should be raised, dimension 1 m wide and any convenient length (usually 2-3m in length).
- Make drills of *15-20cm* apart.
- Sow seeds by drilling and cover to a depth of 1 cm.
- Provide shade or mulch material.
- Apply phosphatic fertilizers and mix thoroughly with soil during planting.
- Water twice a day.

Seedbed Preparation

- Cultivation should be done during the dry season so that all the weeds are killed.
- Dig holes at the spacing of 60cm x 60cm.
- Incorporate farm yard manure in the soil.

Transplanting

- Water the seedlings before uprooting.
- Seedlings are ready for transplanting after one month that is when they are 10-15cm in height.
- Select healthy and vigorous seedlings.
- Transplant the seedlings with balls of soil to prevent root damage.
- Plant to the same depth as they were in the nursery.

Field Maintenance

- Apply fertilizers during planting and top dress later.
- Control weeds to reduce competition.

Pest Control

- ***Diamond Black Moth***
  - ***Damage:*** Eats the underside of the leaf making windows or holes in the leaf.
  - ***Control:*** Spray recommended insecticides.
- ***Cutworms***
  - ***Damage:*** Attacks the stem at the ground level causing he plant to fall.
  - ***Control:*** Spray recommended insecticides.

Disease Control

- ***Black Rot***
  - ***Cause:*** Bacteria
  - ***Symptoms:*** Leaves turn yellow and rotting of the stem giving an offensive odour,
  - ***Control:*** Closed season, crop rotation, use certified seeds and spray appropriate chemicals.
- ***Black Leg***
  - ***Cause:*** Fungus
  - ***Symptoms:*** Brown to black spots on seedlings and dark canker on the stem.
  - ***Control:*** crop rotation, destroy infected materials.

Harvesting

- Cabbages are ready for harvesting 3-4 months after transplanting.
- The heads are cut when they are solid and compact.
- Harvested cabbages are sold immediately.

Carrots (Daucus carota)

- It is a root vegetable grown in the cool areas of Kenya.
- It is commonly eaten raw in salads but can also be cooked.

Ecological Requirements

- ***Altitude:*** 0-2,900m above sea level.
- ***Rainfall:***
  - 750 - 1,000mm.
  - Well distributed throughout the growing period.
- ***Soils:***
  - It requires deep,
  - Fine tilth
  - Well drained soils that are free from obstacles to allow for root expansion.
- ***Temperatures:*** it requires cool to warm temperatures as very high temperatures result in the production of pale and short roots.

Varieties

- Fresh market varieties for example **Chantenay** and **Nantes.**
- Canning varieties for example **Nantes**
- Fodder varieties for example **Oxhast**.

Land Preparation

- The field should be well dug to a depth of about 20cm.

- The soil clods should be broken to give a fine tilth before planting.
- Manure should not be applied as it induces forking which reduces the crop quality.

Planting

- Carrots are planted directly into the main seedbed.
- Seeds are drilled into rows made 20-30cm apart.
- The seeds are then covered lightly and the soil pressed down.
- 90kg/ha of DSP should be applied at planting time in the drills.
- It should be mixed well with the soils before placing the seeds.

Field Practice

- ***Thinning*** -- it is done 2 weeks after germination.
- ***Weed control***- the field should be kept weed free.
- ***Earthing up*** should be done while weeding to encourage root expansion ..
- ***Topdressing:*** after weeding 60kg of nitrogen per hectare should be applied as top dress.
- ***Irrigation*** - this should be carried out where or when there is not enough rainfall.

Pest Control

- Carrots do not have many field pests except the green aphids.
- These can be controlled by use of the appropriate pesticides.

Disease Control

- Occasionally attached by the mildews especially in wet and humid environment.
- Thinning can be done to reduce humid conditions.

Harvesting and Marketing

- Carrots are ready for harvesting 3-5 months after planting depending on the variety.
- They are lifted from the soil and sold fresh or canned.

Onions (Allium cepa)

- Onions are bulb vegetables grown in the warm areas of Kenya.
- They are used as a vegetable in salads and for flavouring foods, soups and stews.

Ecological Requirements

- ***Altitude:*** 0-2, 100m above sea level.
- ***Rainfall:***
  - 1,000mm of rain per year
  - Irrigation in dry areas .
- ***Soils:***
  - Requires well drained fertile soils
  - ***pH*** of 6.0 - 7.0 .
- ***Temperatures:***
  - Onions are a warm climate crops.
  - However, some varieties prefer cool conditions.

- They require a fairly long dry period for ripening.

Varieties

- Red creole,
- Tropicana hybrid
- White creole.

Land Preparation

- The land should be well prepared leaving a fine tilth.
- Farm yard manure at 40 - 50 tonnes per hectare should be applied and mixed well with the soil.

Planting

- Direct: Seeds are drilled in rows 30cm apart and 8cm within the rows. 20kg/ha of DSP fertilizer is used.
- Indirect: Seeds are established in the nurseries before transplanting them in rows 30cm apart and 8 cm within the rows.
- Shallow planting is recommended for bulb expansion.

Field Management Practices

Thinning

- It is carried out only in the crop that has been directly planted so as to achieve spacing of 8cm between two plants within the row.
- The thinned plants referred to as spring onions are used as vegetables in salads.

Topdressing

- Calcium ammonium nitrate at the rate of 250kg per hectare is recommended for topdressing onions.
- This is done 3 months after planting.

Pest Control

Onion Thrips:

- These cause silvering and withering of leaves from the tips downwards.
- They are controlled by spraying with appropriate insecticides such as ***Diazinon*** or ***fenthion.***

Disease Control

Purple Blotch and Downey Mildew

- **Purple blotch;**
  - Characterized by oval greyish lesions with purple centres on leaves.
  - This causes leaf curling and die back.
- **Downey mildew;**
  - Characterized by brown spores covering the leaves leading to death of the whole plant.

- The two diseases are effectively controlled by crop rotation and application of appropriate fungicides.

Harvesting and Marketing

- Onions are ready for harvesting 5 months after planting.
- When leaves start drying the tops are broken or bent at the neck.
- This hastens the withering of the stems.
- The bulbs are then dug out and left to dry in a shade for a few days.
- Onions are graded according to size and marketed in nets of about 14 -16kgs.

Livestock Health I

(Introduction to Livestock Health)

Introduction

- Health is the state of the body in which all the organs and systems are normal and functioning normally.
- Disease is any deviation from the normal health of the animal.

Importance of Keeping Livestock Healthy:

- Healthy animals give high income due to low treatment costs.
- The productive life span of a healthy animal is longer.
- High production.
- Healthy animals can multiply regularly.
- Healthy animals give high quality products for example eggs.
- Safety of consumers of livestock products.

Predisposing Factors to Livestock Diseases

- These are conditions within or around the animal that make it easy for an animal to contract a disease.

They include:

- ***Animal factors such as;***
  - species,
  - breed,
  - age,
  - sex
  - colour of the animal.
- ***Environmental factors such as;***
  - chilling,

- being rained on,
- exposure to hot sun
- dampness.

- ***Management factors such as;***
  - poor feeding,
  - housing,
  - handling
  - hygiene,
  - overcrowding .

Signs of ILL-Health in Livestock

- **Abnormal behaviour** for example separation from the rest of the herd and restlessness.
- **Abnormal posture** for example limping and lameness.
- **Alimentary canal disfunction** such as blood stained faeces and abnormal defecation, diarrhoea and dysentery.
- **Urination:** high frequency or too low and having strange colour.
- **Skin:** rough with scaly skin, blisters on the skin and hair loss.

Causes of Diseases

- **Pathogenic causes ;**
  - viruses,
  - rickettsia,
  - bacteria,
  - protozoa
  - fungi.
- ***Physical causes;***
  - fractures,
  - dislocation,
  - sprains .
- Nutritional disorders for example milk fever.
- Chemical causes for example poisoning by agrochemicals.

Categories of Diseases

- ***Notifiable diseases ;***
  - These are diseases which cause high economic losses.
  - Any case should be reported to the Chiefs, D.O.s, veterinary officers or the police.
- ***Tick-borne diseases*** - Transmitted by ticks.
- ***Breeding diseases*** - Transmitted through mating.
- ***Nutritional diseases*** for example milk fever and bloat.
- ***Parasitic diseases*** for example ascariosis.

General Methods of Disease Control

- Quarantine.
- Vaccination.

- Control of vectors by use of acaricides and rotational grazing.
- Disinfecting the equipment and buildings.
- Use of preventive drugs.
- Proper feeding of livestock.
- Culling of the animals which are carriers/slaughtering the affected animals.
- Use of artificial insemination to control breeding diseases.
- Proper selection and breeding of animals.
- Proper housing and hygiene,
- Isolating sick animals.

Appropriate Methods of Handling Livestock

Animals are handled for the following reasons:

- When inspecting the animal to ascertain any abnormality or signs of diseases.
- When administering any form of treatment such as drenching, injection and mastitis control.
- When spraying or hand dressing the animal with chemicals to control external parasites.
- When milking the animal.
- When performing some of the management practices such as dehorning, disbudding, castration, hoof trimming .

When carrying out these activities animals should be restrained in a ***crush.***

Other methods of restraining animals include the use of;

- halters,
- ropes,
- bull ring
- lead stick.

Livestock Health II *(Parasites)*

Introduction

- A parasite is an organism which obtains its livelihood from another organism (host) which suffers damage.
- Parasitism is the association between a parasite and a host.

The effects of parasite on the host animal are:

- Depriving the host of its food.
- Sucking blood.

- Damaging the organs of the host.
- Cause irritation on the skin of the host.
- Destruction of hides and skins.
- Transmission of diseases.
- Cause obstruction in body passages.

General Symptoms of Parasites Infestation:

- Emaciation.
- Pot bellied condition.
- Swellings in the jaw or other areas.
- Rough hair or rough coat.
- Anaemia.
- Diarrhoea.
- Presence of worm segments and blood stains in the defecation.

Types of Parasites

There are two types of parasites:

- External (ecto-parasites)
- Internal (endo-parasites)

External parasites are;

- ticks,
- tsetse flies,
- mites,
- lice,
- fleas
- keds

Life Cycle of ticks

- Eggs are laid in cracks on the ground.
- They hatch in 4-6 weeks into larvae which climb on the grass waiting for a passing animal.

One-Host Tick

- This requires one host to complete its life cycle.
- *Example:* blue tick ***(Boophilus decoloratus)***.
- *Preferred sites:* face, neck, dewlap and side of the body.
- *Disease transmitted:* Redwater and anaplasmosis.

Two-Host Tick

- This requires two different hosts to complete its life cycle.
- ***Example:*** The red legged tick ***(Rhipicephalus everts)***
- *Preferred sites:* Ears, anus, udder and the tail.
- *Disease transmitted:* Redwater and east coast fever.
- *Example:* Bont legged tick ***(amblyomma spp.)***
- *Preferred sites:* Udder, scrotum and tail switch.
- *Disease transmitted:* Sweating sickness.

Three-Host Tick

- This requires three hosts to complete its life cycle.
- *Example:* The brown ear tick (***Rhipicephalus appendiculatus)***
- *Preferred sites:* Ears, tail switch and around the eyes.
- *Disease transmitted:* East coast fever and redwater.
- Bont tick transmit heartwater ***(amblyomma spp.)***

Control of Ticks

- Dipping/spraying/hand dressing with acaricides.
- Rotational grazing.
- Ploughing the land to break the life cycle.
- Hand picking and killing.
- Fencing of the grazing fields to keep off other animals including wild game.
- Burning of grass to kill them in various stages.

Endo-parasites (internal Parasites)

- Endoparasites are helminths.

They can be divided into:

- Platyhelminthes/flatworms which include;
  - Trematodes (flukes)
  - Cestodes (tapeworms).
- Nemato-helminthes/nematodes. E.g Roundworms.

General Symptoms of Helminthiasis

- Diarrhoea which foul the anal and tail region.
- Dullness.
- Anaemia.
- Big stomach (pot bellied condition).
- Presence of worm segments in faeces.
- Coughing.

Trematodes (Liver Fluke)

- There are two species of flukes:
  - ***Fasciola gigantica***
  - ***Fasciola hepatica.***
- *Fasciola hepatica* is more common.
- It is commonly found in the liver and bile duct of cattle, sheep and goats.
- Liver fluke is a problem in marshy and low lying wet areas.

Life Cycle of the Liver Fluke

- Adult fluke in the liver of the primary host lays eggs.
- Eggs pass through the bile duct into the small intestines and are passed out in faeces onto the pasture.
- Under moist conditions, they hatch into a **miracidium larva** which swims about in search of a secondary host (fresh **water snails**).
- In the snail, it develops through **sporocyst, redia and cercaria**.
- When it leaves the snail, the cercaria gets encysted on vegetation and becomes **metacercaria.**
- This is swallowed by the primary host with grass.
- The young fluke migrates into the liver through blood vessels when it matures.

Control of Liver Fluke

- Keep livestock off marshy areas near the rivers/streams/lakes and dams.
- Drench affected animals.
- Drainage of swampy areas.
- Eradicate the intermediate host by use of molluscicides.
- Provide water to livestock in elevated troughs.

Tapeworms

- There are many species of tapeworms

Eexample;

- ***Taenia solium***
- ***Taenia saginata.***

The adults live in the small intestines of man (the primary host).

- The intermediate host of ***Taenia solium*** is pig .
- The intermediate host of ***Taenia saginata*** is cattle.

Life Cycle of Tapeworm

- Adult tapeworms live in man's intestines where it lays eggs.
- Eggs are passed out with faeces,
- Then they develop an outer covering known as **onchosphere.**
- The eggs are swallowed by intermediate host.
- The outer covering is digested and the young worm emerges.
- This bores into the blood vessels and is carried to specific muscles such as the tongue, heart, thigh muscles.
- It develops into an encysted form called **bladder-worm.**
- When the animal is killed and meat is eaten raw or in an inadequately cooked form, man gets infected by the bladder-worm.
- In man, the bladder-worm evaginates and attaches itself onto the intestinal wall where it develops into an adult.

Control of Tapeworms

- Meat should be well cooked before eating.
- Use of drugs in primary host.
- Meat inspection by meat inspectors/ veterinary officers.
- Use of pit latrines by man.

Nematodes (Roundworms)

Common ones are;

- ***Ascaris suum*** (pig roundworms),
- ***Ascaris lumbricoides*** found in man and sheep
- ***Haemonchus contortus*** found in sheep, cattle and goats.
- Roundworms are common in warm areas especially in areas where the standards of hygiene and sanitation are low.

Nature of Damage

- Damage is done to the liver and lung tissues as they migrate in the body.
- Suck out blood.
- Deprive the host of food.

Control of Roundworms

- Use of drugs.
- Rotational grazing.
- Use of proper stocking rates to avoid overgrazing.
- Practicing high standards of cleanliness and hygiene such as use of latrines.

Livestock Production II *(Nutrition)*

Introduction

- Animals are fed for the purpose of production and body maintenance.
- The edible material given to animals is called food.
- It is digested, absorbed and utilized in the body.
- Nutrients are organic and inorganic substances contained in the food materials.

Components of Food material

- water,
- protein,
- carbohydrates,
- fats and oils,
- vitamins
- mineral salts.

Water

Sources

- Free water (through drinking)
- Bound water (contained in feeds).
- Metabolic water (obtained from oxidation of food).

Functions

- Regulates body temperature.
- Transport agent in the body.
- Universal solvent in the body.
- Gives shape to the cells (turgidity).

- Acts as a lubricant.
- Acts as constituent of body fluids.

Factors Determining the Requirements of Water by Livestock

- Production level.
- Amount of dry matter eaten.
- Temperature of the surrounding area.
- Type of animal.
- Type of food eaten.

Protein

Sources:

- Groundnut cakes,
- cotton seed cakes,
- fish meal,
- meat meal.

Functions:

- Growth of new tissues.
- Repair of worn out tissues (body building).
- Synthesis of antibodies.
- Synthesis of hormones and enzymes.
- Production of energy during starvation.

Digestion of Proteins

In non-ruminants, protein digestion takes placed in the stomach.

- Food is subjected to mechanical breakdown through chewing into small particles.
- Protein is acted on by enzymes to turn into amino acid which is assimilated into the bloodstream.

In ruminants, protein digestion initially takes place in the rumen.

- Food is acted on by micro-organisms into microbial protein.
- Later, enzymatic action takes place in the "true stomach" or **abomasum** where proteins are broken down into amino acids which are then assimilated into the bloodstream.

Carbohydrates

Sources:

- Cereals,
- tubers
- commercially mixed feeds.

Functions:

- Supply energy and heat to the body.
- Excess is stored in form of fat for insulation of the body.

Digestion of Carbohydrates

- In non-ruminants;
  - carbohydrate feeds are broken down by chewing into small particles.
  - Then enzymatic action further breaks down carbohydrates into glucose, fructose and galactose which are then assimilated into the bloodstream.
- In ruminants;
  - mechanical breakdown of carbohydrate feeds is followed by microbial activities which break down cellulose into **volatile fatty acids.**
  - These are absorbed through the rumen walls.
  - Some carbohydrates are broken down by enzymatic action in the "true stomach" or **abomasum.**

Fats and Oils

Sources:

- Cotton seeds,
- soya beans
- groundnuts.

Functions:

- Supply energy and heat to the body.
- Excess is stored as fat adipose tissues.
- Source of metabolic water in the body.
- Required for the development of neural system.
- Insulator in the body.

Digestion of lipids in Ruminants

- Fats are hydrolysed in the rumen into fatty acids and glycerol.
- Others are fermented into propionic acid,
- The shorter chains are passed to the true stomach where enzymatic action takes place.

Vitamins

Sources:

- Green materials,
- dried grass
- fish liver oil.

Functions:

- Protects the body against diseases.
- Regulate the functions of all parts of the body.
- It acts as a co-enzyme in the body.

Examples:

- Vitamin A,
- vitamin B_2
- vitamin C,

- vitamin E
- vitamin K.

Minerals

Sources:

- Salt licks,
- bone meal,
- legumes
- cereals.

Functions:

- Form part of the tissues such as bones and teeth.
- Work together with the enzymes.
- Act as acid -base balances.
- Act as electrolyte in the body.
- Regulate osmotic balance in the body.

Examples:

- Calcium,
- phosphorus,
- magnesium,
- iron,
- iodine,
- sodium
- chlorine.

➢ ***Calcium and phosphorus -***
- Needed for teeth and bone formation.
- Lack of these minerals leads to **rickets, osteomalacia**.

➢ Lack of iron leads to **anaemia.**

Classification of Animal Feeds

This is based on nutrient composition:

- Roughages.
- Concentrates.
- Feed additives.

Roughages

- Are feeds of low available nutrients per unit weight and high fibre content.

Examples:

- Dry roughages,
- succulent roughages,
- residues from agricultural by products and conserved materials.

Characteristics

- Low level of available nutrients.
- Have high level of calcium especially legumes.
- Good source of vitamin A.
- Have high fibre content.

Concentrates

- Are feeds of high available nutrients per unit weight.

Examples:

- Maize germ and bran,
- malt extract,
- milk products,
- soyabeans,
- oil seed cakes,
- meat meal,
- bonemeal
- bloodmeal.

Characteristics

- Low fibre content.
- Feed content is consistently high.
- High digestibility of the feed.
- High in nutrient content.

Feed Additives

These are substances added to the feed to increase;

- palatability,
- medication
- or hormones to make animals produce more.

There are two types:

- Nutritive additives, such as mineral licks (maclick).
- Non-nutritives additives, such as;
  - medicants (coccidiostats),
  - Stilboestrol (used in beef animals)
  - oxytocin (to increase milk let down).

Functions

- Stimulate growth and production.
- Improve feed efficiency.
- Prevent disease causing organisms.

Compounded Feeds

- These are the feeds prepared and mixed by use of machines.
- These feeds can be round, pelleted, pencils, cubes or mash.

Poultry feeds can be categorized as:

- Chick mash having 20% D.C.P. given to chicks.

- Growers mash having 16% D.C.P. given to growers.
- Layers mash having 12-15% D.C.P. given to layers.

Meaning of terms used to express feed values

- Nutritive ratio (NR):
  - Is the proportion of protein to carbohydrates and fats.
  - In young animals 1:3:6
  - In old animals 1:8.
- **Crude protein (C.P):** Is the total amount of protein contained in a feed.
- **Digestible Crude Protein (D.C.P):** Is the portion of crude protein which an animal is capable of digesting.
- **Crude Fibre (C.F.):**
  - Is the total amount of fibre contained in a feed.
  - It is mainly lignin and cellulose.
- **Digestible Fibre (D.F.)**: Is the portion of the total fibre contained in a feed which an animal is capable of digesting.
- **Dry Matter (D.M.):** Is the material left in a feed after water has been removed.
- **Starch equivalent (S.E.):** Is the amount of pure starch which has the same energy as 100kg of that feed.
- **Total Digestible Nutrients (T.D.N.):** Is the sum of all the digestible organic nutrients such as fats, proteins, carbohydrates and fibre.

Computation of Livestock Rations

- ***Ration:***
  - Is the amount of food that will provide essential nutrients to an animal in a 24 hour period
  - to enable that animal to meet its maintenance and production requirements.
- ***Balanced ration:***
  - Is the ration that contains all the essential nutrients in required amounts and in the right proportion.
- ***Maintenance ration:***
  - is the portion of a feed required by an animal to continue with the vital body processes with no loss or gain in weight.
- ***Production ration:***
  - Is the feed required by animals over and above maintenance ration to enable the animal to produce;
  - for example; milk, eggs, wool, grow in size, perform work, reproduce and fatten.

Steps in ration formulation

- Finding out the animal's feed requirement based on body weight.
- List all the available feeds, with their nutrient composition and their prices.
- Calculate the amount of ingredients required in the ration to meet the animals needs.

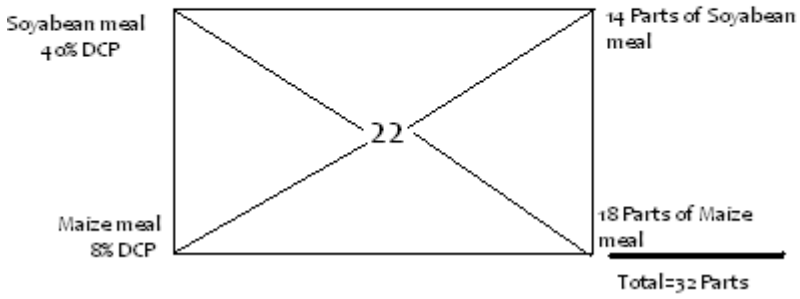
Methods used in ration formulation

- Trial and error method
- Pearson's square method
- Graphical method
- Linear programming(use of computers)

Examples;

Mix a Pigs ration 22% protein using soya bean meal 40% DCP and maize meal containing 8%DCP.

Pearson's square method



Soya bean meal (14 *100)=43.75kg
32

Maize meal (18*100=56.25kg
32

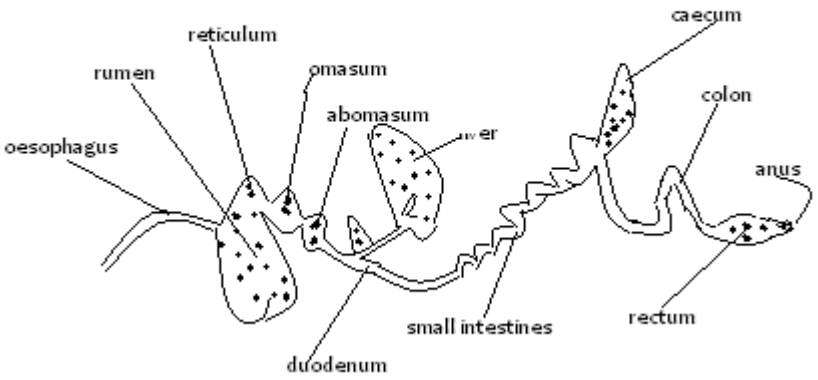
Digestion and digestive systems

- Digestion is the process through which food is broken down into small particles in the alimentary canal ready for absorption into the blood stream.

Digestion of food in livestock takes place in three stages;

- Mechanical breakdown and chewing
- Microbial breakdown by bacteria and protozoa in the rumen of ruminants
- Chemical breakdown by enzymes.

Digestive system of a Ruminant



Rumen-

- Breakdown of food by micro-organisms and also stores food.
- Synthesis of vitamin B-complex.
- Synthesis of amino acids from ammonia gas.
- Proteins are broken to peptides and amino acids.
- Carbohydrates are broken to volatile fatty acids.

Reticulum:

- Separates large food particles from the small particles.
- Retains foreign materials such as stones, hard wood and sand.

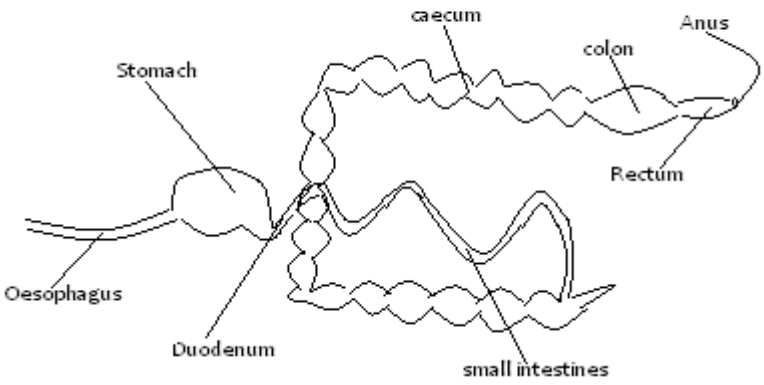
Omasum:

- Breaks up food by grinding.
- Reduction of water content from the feed stuff.

Abomasum:

- Enzymatic digestion takes place here ..
- Contains some microbes which digest cellulose.
- Breaks up food by grinding.
- It is also found in non-ruminants.

Digestive system of a non-ruminant e.g pig

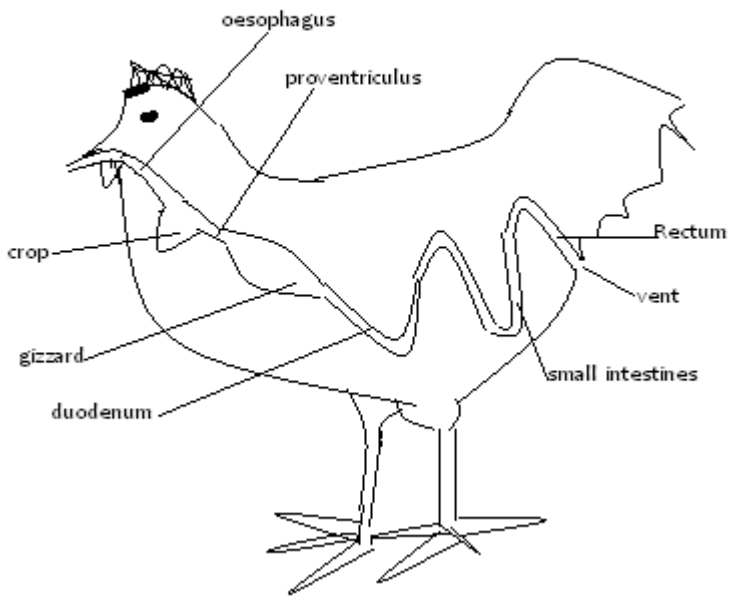


Comparison Between Digestion in Ruminant and Non-ruminants

- ***Differences***

Ruminants	*Non -ruminants*
• Chew the cud. • Have four stomach chambers-thus polygastric. • Regurgitate food. • Can digest cellulose. Have • micro-organisms in the rumen • that digest cellulose. • 5. Have no Ptyalin in saliva hence • no enzymatic digestion in the mouth. • Most digestion and absorption takes • place in the rumen. • Have alkaline saliva due to presence • of ammonia. •	• Do not chew the cud. • Have one stomach chamber - thus monogastric. • Cannot regurgitate food once swallowed. • Have no micro-organisms in the stomach hence cannot • digest cellulose except those • animals with micro-organisms in the caecum. • Have Ptyalin in the saliva hence enzymatic digestion starts in the mouth • Most digestion and absorption takes in the small intestines. • The saliva is neutral pH.

Digestion system of poultry



Functions of the Parts of Poultry

- **Crop:**
  - Storage of food.
  - Softening of food by secretions from small glands in the walls.
- **Proventriculus:** Enzymes start the breakdown of food.
- **Gizzard:**-Crushes and grinds the coarse food (has small grit and gravel).

Comparison Between Digestion In Ruminants and Non-Ruminants

Similarities Between Digestion In Ruminants and Non-Ruminants

- Digestion in young ruminants is similar to that in non-ruminants as they do not have a developed rumen-reticulum complex.
- Final protein digestion takes place in the small intestines in both cases.
- Water absorption takes place in the colon in both ruminants and non ruminants