## AGRICULTURE

The word agriculture originated from two Latin words i.e;

- Ager which means soil, land or field;
- Cultural which means tillage or cultivation.

The word agriculture means cultivating/ tilling or management of the field, soil and land.

**Definition**;

Agriculture is the science and art of growing crops and rearing of animals for human benefit Agriculture is a science because;

- Modern crop and animal production requires knowledge of other science subjects such as Chemistry, Physics, Biology, Zoology, Botany, Pedology, Geography and Economic, Math.
- It requires application of knowledge from experiments and observations.

Agriculture is an art because it involves adopting specific skills for doing certain activities like construction.

## AIMS OF TEACHING AGRICULTURE IN SECONDARY SCHOOLS

- To stimulate an interest and create awareness of existing problems and opportunities in Agriculture and rural development.
- To provide a background for advanced studies in agriculture in A-level,colleges and universities
- To promote an appreciation of agriculture as an applied science.
- To teach in a practical manner the basic principles and skills in agriculture.
- To ensure that schools take up an active role in rural development by intergrating agricultural activities in the school curriculum
- To demonstrate that farming is a respectable occupation that is both profitable and honorable.

- To show how improved griculture will contribute towards worldwide freedom from famine

**BRANCHES OF AGRICULTURE**

- Soil science (pedology); this deals with the study of soil, how it is formed, how it works to sustain life and how it is kept alive for many years.
- Crop production / husbandry; this deals with the study of crops i.e. plant life cycles, their health conditions (diseases and pests); plant breeding and genetics.
- Animal production / husbandry; this deals with the science of rearing animals of different types e.g. cattle, sheep, poultry, pigs etc.
- Agricultural engineering and mechanization concerned with the study and use of different types of agricultural machines and tools used to simplify and make work more efficient on the form e.g. tractors, Ox ploughs, combine harvesters etc.
- Agricultural Economies; Deals with the basic principles of economics such as accounting, record keeping, organization of farm activities, advertisement and marketing agricultural products.

**IMPORTANCE OF AGRICULTURE TO THE ECONOMY AND FARMERS**

- Source of food; Agriculture provided food to the farmer and his family e.g. meat, banana, maize which reduces malnutrition and improve health of farmer.
- Source of income to the farmer. After the farmer selling crops, animals and their products, they earn money which is used to acquire other necessities of life.

- Provision of market; Agriculture provides market for agricultural in put e.g. hoes, feeds, chemicals, fertilizer produced by various industries.
- Source of raw materials for agro based industries that use agricultural products like tobacco, coffee, and sunflower, cocoa get their raw materials from agriculture.
- Source of employment; about 80% of Ugandan are employed either directly or indirectly in agriculture as farmers, veterinary doctors, transporters, engineers etc.
- Source of government revenue; through taxation and collection of market dues. This revenue is used to run other government sectors.
- Source of fuel to the farm e.g. biogas, firewood and charcoal.
- Agriculture is a source of power e.g. animals can be used to transport items and people, or can be used for ploughing e.g. camels, donkeys.
- Provides medicine / herbs for treating sickness in both animals and human beings e.g. Black jack, moringa, Neem tree.
- Cultural values or traditional values and ceremonies are done using animals like cows, goats, sheep and birds.
- Influx development.

**PROBLEMS FACING AGRICULTURE**

- Shortage of capital to fund the activities of Agriculture e.g. buying inputs like fertilizer, seeds etc.
- Pest and diseases that attack both c.rops and animals; pests include maize stalk borers, termites; diseases like Nagana, anthrax, CMD, reduce yield.
- Shortage of enough land for farming due to increasing population thus keeping agriculture at a subsistence level.
- Poor market conditions due to lack of market information hence farmers are cheated by middlemen.

- Poor animal breeds and crop varieties that give low levels of output / poor quality products.
- Price change / unstable prices; this makes it hard for the farmers to plan for their incomes.
- Poor storage facilities; most agricultural products are perishable e.g meat, milk, fruits and therefore get spoilt quickly.
- Unpredictable climatic conditions i.e. prolonged drought and unreliable rainfall.
- High costs of agricultural inputs.
- Low level of technology in agricultural production.
- Poor transport and communication network.
- Shortage of labour especially the skilled man power. This is common in rural areas.
- Shortage of farm inputs e.g. fertilizers, seeds, tools and machines.
- Inadequate extension services.
- Corruption / mismanagement of agricultural sector / funds by government officials.
- Ignorance and illiteracy. The farmers lack knowledge in modern methods of farming.
- Poor land tenure system / ownership that discourage long term investments on the land e.g. communal ownership.
- Inadequate feeds / pastures and water for the animals.

**POSSIBLE SOLUTIONS TO THE PROBLEMS FACING AGRICULTURE**

- Provision of low interest loans or grants to the farmers to reduce the problem of shortage of capital.
- Construction of valley dams to harvest water which can be used in irrigating crops and watering animals during prolonged dry seasons.
- By encouraging co – operatives and collective ownership of machines to solve the problem of low technology.
- Encouraging mass education to reduce ignorance and illiteracy among farmers.
- Government should construct proper storage facilities e.g. silos to store excess produce in time of harvest and for during scarcity.
- Developing an appropriate land tenure system to reduce on the problem of land shortage and poor tenure system.
- Rehabilitation of the existing roads and railways to improve on transport.
- Developing a proper pest and disease control programme in order to control pests and diseases.
- Government should promote good governance to avoid political instabilities and insecurity.
- Investing in agro – processing industries to improve on the value of agricultural products for sale.
- Training more extension workers so that they can be employed even in rural areas to enable farmers to carryout appropriate farming methods / practices.
- Encouraging more research to develop better crop varieties and good animal breeds.
- Subsidizing on inputs like fertilizers, seeds etc.

**FACTORS WHICH AFFECT THE DITRIBUTION OF CROPS AND ANIMALS IN E.AFRICA**

1. Climate;

The major elments here which affect agriculture are rainfall,temperature and humidity.Climate varies from place to place which varies crops grown in such areas

**2** Altitude

This refers to the height of the placeabove sea level.some crops do well above sea level/high altitude e.g arabicca coffee give best yield on high altitude while sorghum does well onlower altitude with high tempratures.

**3**Topography

This refers to the nature oflandsurfce i.e flatness or steepness of an area,crops dont do well in hilly areas due to soil erosion.Animalgrazing is not easy on steep slopes and this affect agriculture

**4** Edaphic factors(soil factors)

Growth of some crops and pastures for animals is greatly affected by the natural fertility of the soil.

**5** Pests and diseases

This affects the growth and distribution of some crops and animals e.g cassava mosaic greatly affects cassava growth,tsetse flies on the other hand affect the distribution of animals

**6** Biotic factors

The relationship between interraction of plants and animals.Man and their activities can affect the distribution of crops and animals e.g In high populated areas,farmers tend to groew more food crops than cashcrops and rear a few animals due to lack of land

**7** Religious beiefs E.g muslims dont rear pigs because the religion prohibits it,However they rear other animals like goats,cattle,sheep etc

**8** Vegetation E.g areas with alot of vegetation can favour animal grazing

## LAND USE IN UGANDA

Land refers to all materials of the earth which are freely given by nature. They include soil, water bodies, minerals resources, air, light, heat forests etc.

## WAYS OF ACQUIRING LAND

- Inheritance from the parents.
- Buying a piece of land with / without a land title.
- Through borrowing from friends who have a plenty of it.
- Through settlement and resettlement schemes e.g. Mobuku settlement scheme.
- Through leasing: An individual applies to the state to lease land for a specified period of time (e.g. 9,99,999yrs)
- Receiving land as a gift from a well wisher or sympathizer.
- Through renting or hiring land for a season or a year from individuals or families who have plenty of it.
- Allocation of land to an indiviual by parents

## FORMS OF LAND USE IN UGANDA

- Agriculture; cultivation of crops and rearing of animals.
- Forestry; both natural and planted forests.
- Wildlife conservation; for national parks and game reserves e.g. Lake Mburo, Mt. Elgon, Kidepo valley etc.
- Mining; Land is used to provide minerals e.g. Copper, oil, Gold, silver e.g. in Kilembe Copper mines.
- Mortgage for loan; it is a security before getting money from a money lending institution e.g. banks.
- Transport and communication; e.g. roads, railways, airports are constructed on land.
- Recreation e.g. playgrounds, swimming pools, beaches etc.

- Industrialization; for establishment of industries in industrial areas e.g. Namanve.
- Fishing from lakes, rivers, streams.
- Residential land for constructing houses estates.
- Urban centres e.g. towns, cities, shops are built on land.
- Wetlands.

**FACTORS THAT DETERMINE THE FORM OF LAND USE**

- Topography; steep slopes cannot be used for settlement or planting crops; but is used for recreation or wildlife conservation compared to gentle slopes.
- Soil types / fertility; fertile well drained loam soils are used for agriculture, rocky infertile soils for settlement or mining.
- Climate; Areas with well distributed rainfall seasons are condusive for farming and settlement, while hot areas are for wildlife conservation and mining.
- Vegetation; thick vegetation is used for forestry, for wildlife conservation while light vegetation is used for farming.
- Culture of the people; some people prefer rearing animals; growing specific crops like coffee, or fishing especially around water bodies.
- Land tenure systems; Government owned land is used for wildlife conservation, forestry or mining while individuals prefer agriculture, industrialization or settlement.
- Religious factors; Religions dictate the type of animals kept by the people.
- Population pressure; densely populated areas like cities and towns encourage industrialization, recreation and settlement while sparsely populated area are used for wildlife conservation and farming.
- Education levels; areas with access to skilled labour engage in commercial agriculture compared to other areas.

- Capital availability for the various activities e.g. industries require a lot of capital compared to agriculture.
- Market forces.
- Power supply (electricity)
- Transport and communication availability.

**USES OF FORESTS IN UGANDA**

- They help in the formation of both relief and convectional rainfall
- They provide poles and timber used for furniture and housing construction
- It is used as a sorce of fuel i.e charcoal and firewod
- It is also a surce of employment opportunities e.g fores officers
- They promote tourism since thy are homes forwild aimals
- Trees act as wind breakers protecting farm buildings and farm grown crops
- Leaves of trees that fall down form organic matter which influences soil fertility
- Trees act as a source of revenue to the ugandan government through issuing of licences to timber dealers
- It is a source of medicinal herbs which are used to cure diseases to humans
- It is a source of food like wild fruits

## FARM LAYOUT

Farm layout refers to the designed arrangement and structural features on the farm.

It shows the set up of buildings, road network, water sources and systems, soil conservation structures, crop fields, fences, paddocks etc that are mapped and positioned on the ground in relation to each other.

A simple farm layout:

## FACTORS TO CONSIDER WHEN PLANNING A FARM LAYOUT

- Size of the farm; Bigger farms can have more enterprises than smaller farm.
- Topography of the area; this will help the farmer to identify the area that are suitable for different activities.
- Type and size of the enterprise; this is necessary because some enterprises require more land or area than others.

- Type and fertility of the soil; this will help the farms to decide correctly on which part of the farm to establish different enterprises and to erect different farm structures.
- Accessibility; different farm structures should be located in such a way that they are easily accessible.
- Water source: the farm layout should put more emphasis on the source of water for the farm use; therefore, there should be nearby water source.
- Climatic factors; factors e.g. rainfall, wind direction etc that can affect activities and structures on the farm.
- Security: There should be good security in terms of supervision and protection against theft, wild animals, pests and diseases.
- The government policies and regulations about land utilization should also be put into consideration.
- The farmer's objectives or interests.

## PRINCIPLES / FACTORS TO CONSIDER WHEN ESTABLISHING A GOOD FARM LAYOUT

- The land should be surveyed and mapped to establish the actual perimeter and acreage.
- Soil should be sampled and tested to determine its properties.
- Field boundaries should be marked out for proper management of the farm.
- The field should be divided into suitable sizes for maximum management and utilization.
- Fencing of the farm: the fences demarcate the farm (perimeter fence) and separate different areas of the farm.
- Location and construction of farm roads; these should be wide enough to easy transportation.
- Water supply; clean and permanent water supply.

- Electricity / power supply; this is necessary to run the machines, light and provide heat on the farm.
- Buildings should be constructed according to the purpose of the building, nature of the soil and accessibility.
- The plan should be flexible to cater for introduction of new enterprises.

## FARM ENTERPRISES

These are projects that are carried out/ practiced on the farm.

In a mixed farm, crops are grown and animals are kept on the same farm so that the whole farm land can be utilized sufficiently.

***Common enterprises on a mixed farm include;***

- Crop production
- Dairy production
- Apiculture (Bee keeping)
- Aqua culture (fish farming)
- Goat and sheep rearing.
- Agro forestry
- Poultry
- Piggery

*Other aspects of the farm may include;*

- Pasture land for animal grazing.
- Arable or cultivated land.
- Soil and water conservation measures.
- Manure sites.
- Farm tools and machinery.
- Agricultural chemicals.
- Farm feeds.
- Farm labour.
- Animal husbandry routines e.g. drenching.

- Farm records.

*For crop sector to have optimum production, the following should be done;*

- Proper seedbed preparation.
- Timely planting of crops.
- Use of clean and disease free seed. (planting materials)
- Proper spacing of crops.
- Keeping the crops free of weeds.
- Proper application of fertilizers and manures.
- Proper control of pests and diseases.
- Harvesting the crops when they are mature and ripe.
- Proper storage of crops.
- Growing crops in a rotation.
- Giving a rest period to the land to regain its fertility.

*For livestock sector to have optimum production, the following should be done;*

- Control of disease and parasites in animals.
- Proper feeding and management of animals.
- Controlled feeding.
- Proper housing of animals.

**FACTORS AFFECTING CROP AND LIVESTOCK DISTRIBUTION**

- Climate; Arabica coffee grown at low temperatures whereas Robusta coffee likes high temperatures; Exotic cattle rearing needs wet areas which local cattle can be reared in hot conditions / dry conditions.
- Altitude; this is the height above sea level. Indigenous animals are reared at low altitude areas while exotic animals do well in high altitude areas; different crops at different altitudes of coffee.
- Relief / topography; this is the nature of the landscape (i.e. flat, gentle sloping or valley). Certain crops grow well in valleys where there is poor

drainage e.g. rice; others e.g. tea do well along sloping land where drainage is good.

- Soil factors / edaphic factors; soil aspects like drainage, soil fertility, soil temperature, soil pH, aeration affect the type of crops grown or pastures growing.
- Biotic factors; these are factors concerning relationships between living organisms e.g. animals and plants; man and environment etc.
- Pests and diseases; presence of pests and diseases in a given area discourages the rearing of animals and growing of crops.
- Social and religious factors; some tribes don't allow the keeping of certain animals e.g. Bahima don't keep sheep, northern and easterners take millet as their staple food; Adventists and Muslims do not take pork.
- Land tenure systems; this refers to the possession of rights to own and use land; Bad land tenure systems bring about land scarcity and discourage rearing of animals and growing of crops.
- Government policy; the government can encourage the growing of certain crops and rearing of animals in some areas through incentives and discourage the practices.
- Political factors; political instabilities discourage investment as some of the infrastructure is damaged.
- Economic factors; e.g. capital needed to invest in exotic cattle is high compared to local cattle or growing of crops.

## FARMING SYSTEMS AND PRACTICES

Farming systems refer to the decisions that farmers make to utilize their land in rearing crops and animals in order to produce food and other necessities for their benefit.

Farming systems are divided into 2 groups;

- Traditional / Local farming systems
- Commercial farming systems.

## TRADITIONAL / LOCAL FARMING SYSTEMS

The local farming systems in Uganda include;

### TESO SYSTEM;

- Practice in Teso in the districts of Soroti, Kumi, Katakwi.
- The land is generally flat and soils light / sandy.
- Ox cultivation is used
- The area receives a monomodal rainfall pattern.
- Major food crop is millet, cotton is the main cash crop grown.

### BANANA ROBUSTA COFFEE SYSTEM

- Practiced around the fertile Lake Victoria cresent in districts of Mukono, Mpigi, Luwero, Wakiso, Kiboga etc.
- It has a bi-modal rainfall pattern (2rainfall seasons).
- Major cash crop grown in coffee; others include tea, cocoa and sugarcanes.
- There is a gradual change into modern dairy farming.
- Tractors and hoes are mainly used for cultivation.
- Land tenure system is individual with registered land title deeds.

### BANANA MILLET COTTON SYSTEM

- Practiced in districts of Tororo, Masindi, Ntungamo, hoima, Nakasongola, Kamuli.
- The area experiences a bimodal rainfall distribution which favours cotton as the main cash crop.
- The soils are silt clay loams of medium fertility.

- The system has more livestock compared to banana robusta coffee system.

**NORTHERN SYSTEM**

- Practiced in districts of Lira, Gulu, Kitgum, Pader, Apac, Pakwach.
- It experiences a mono modal rainfall distribution pattern which favours annual crops.
- Main cash crops grown are cotton and tobacco, main food crop is finger millet.
- Land tenure system is communal.
- Food storage structures are common where the food is stored during the dry season.
- Inter cropping is commonly practiced.

**WEST NILE SYSTEM**

- Is practiced in Moyo, Arua, Yumbe, Adjumani, Nebbi.
- Rainfall pattern received is monomodal.
- Cash crops include tobacco, cotton and Arabic coffee in the highlands.
- Food crops include cassava, finger millet, simsim, cowpeas, maize, beans etc.
- Some cattle and goats and sheep are managed at a subsistence level.

**MONTANE SYSTEM**

- Is practiced in mountaneous areas / districts of Mbale, Kapchorwa, Kisoro, Kabale, Bundibugyo, Kasese with fertile volcanic soils.
- Population pressure is high in these areas.
- Major food crops grown are banana, Irish and sorghum (mainly in Kigezi).
- Major cash crop is Arabica coffee, some tea is also grown.

- Contour ploughing is commonly practiced to reduce soil erosion.
- Livestock rearing is intensive / zero grazing due to high population pressure.
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**PASTORAL SYSTEM**

- Practiced in Kotido, Moroto, Rakai, Mbarara by the Bahima, Banyankole and Karimajong.
- Farmers live a nomadic way of life.
- Large number of animals are kept.
- Drought resistant crops e.g. sorghum, millet are grown.
- Overgrazing and bush burning are common.

**TRADITIONAL FARMING SYSTEMS**

These include the following;

- Shifting cultivation
- Bush fallowing
- Crop rotation
- Ley farming
- Pastoralism
- Intercropping
- Agro forestry
- **Bush fallowing**;- is a system of growing crops on a piece of land until the soil is exhausted and crop yields decline after which the land is rested in bush form to regain fertility while cultivation continues on alternative pieces.
- **Arable farming**;- this is the growing of short term crops on arable land (cultivable land)

  A well planned crop rotation programme should be followed to mantain the productivity of the arable land.

**Ley farming**; - is a system of alternating temporarily planted pasture with crop production.

**Advantages of ley farming**;

- Rested land is fertilized by humus from the grass dug into the soil.
- Land is utilized all the time instead of leaving it to rest.
- Infertile areas are fertilized by dung and urine.
- The planted grasses reduce on soil erosion.
- Helps to break pests and diseases life cycle.
- Leys provide cheap feeds for livestock

**Disadvantages**;

- Requires fencing and paddocking which increases costs.
- Requires water points in each paddock.
- More labour is required in management and establishment of pastures.

**Shifting cultivation**;- is a farming system where a farmer clears a piece of land and grows crops in it for a number of seasons until the soil is exhausted and crop yields decline; he then moves / shifts to a fresh land.

**Characteristics of shifting cultivation**

- It is subsistence oriented.
- Family members are the major source of labour.
- Simple tools e.g. hand hoes, Pangas are used.
- Settlement by farmers is not permanent.
- Farming plots / fields are usually small.

- Food crops are mainly grown.
- Mainly practiced in sparsely populated areas.
- Quick maturing crops are grown and no perennial crops are grown.
- Forests are usually cleared by fire.

**Advantages**:

- Fire destroys pests and disease causing organisms.
- Constant movement by farmers ensures fresh soils thus ensuring high crop yields.
- Easy and cheap to carry out.
- There is enough time given to the land to regain its fertility.
- Burning also controls weeds.
- Enables other activities e.g. hunting to go on well.
- Communal ownership of land does not allow land disputes.
- Plant nutrients e.g. potash are released quickly from the ash.

**Disadvantages:**

- Regular movement hinders land development.
- Burning of vegetation always destroys organic matter and useful living organisms.
- The system requires a lot of land and is not suitable for densely populated areas.
- A lot of timber will be destroyed due to destruction of trees by fire.
- Carbon, Sulphur and Nitrogen are lost by volatilization.
- Soil erosion and desertification may result.
- No soil conservation because people own the land communally and therefore, they do not care.

**Conditions that favor shifting cultivation**;

- Abundance of land

- Sparse population.
- Few crops grown for domestic use only.
- Communal ownership of land.
- When there is lack of modern farming techniques and facilities to improve the exhausted land.
- Pastoralism and Nomadism; Pastoralism is the keeping of herds of cattle, sheep and goats on practices (graze at random) OR

  Pastoralism is a system of farming where the farmers look after livestock as their main occupation.

  **Types of pastoralism**

  - Sedentary pastoralism / sendentarism; is the grazing of animals near permanent established homesteads and neighbouring marginal land. At night farmers keep their animals in enclosure or pans for security reasons e.g. the Bahima.
  - Nomadic pastoralism / Nomadism; Is the type of herding in which owners of livestock move from place to place in search of water and pastures for their livestock e.g. the Turkana, Pokot, Samburu, Boran and Somari.
  - Transhumant pastoralists / Transhumance; Refers to the movement of farmers with their animals looking for water and pastures when their areas are hit drought (scarcity of water and pasture) but go back to settle in their homeland when the weather is favourable e.g. Karamajongs.

**Characteristics / features of nomadic pastoralism**

- Very large number of animals are kept.
- Local indigenous breeds are normally kept.
- Owners do not have permanent settlements.
- Quantity of animals is more important to the owners than the quality.
- There is communal ownership of land i.e. grazing is done communally.

- Animals are reared for subsistence purposes.
- Overstocking and overgrazing are common.
- Most nomads are characterized by low education.
- No controlled breeding so mating is random.
- Normally practiced in areas with low rainfall and poor soils.
- Parasites and diseases are common.

**Problems faced by pastoralists:**

- Parasites, diseases and wild animals attack animals.
- Harsh climatic conditions e.g. low rainfall.
- Poor veterinary services which led to low quality of animals.
- Lack of inputs e.g. drugs, chemicals and equipment.
- Lack of capital to establish animal structures and purchase equipment.
- Poor quality breeds of livestock.
- Random mating leading to inbreeding.
- Overgrazing and overstocking hence erosion.
- Movement of long distances makes animal lose weights.
- Cattle rustling in some places.
- Poor market facilities characterized by unstable prices for animal products.
- Poor management of livestock due to low levels of education.
- Lack of transport facilities to transport products cheaply.
- Poor pastures that are coarse and fibrous hence difficult for the animals to digest and utilize.
- Fire outbreaks especially during clearing vegetation hence exposing the land to erosion.

**Measures to improve nomadic herding**:

- Restricting numbers of animals per unit area to avoid over grazing.

- There should be parasites and disease control e.g. mass vaccination, dipping, regular spraying and fencing.
- Selective breeding should be carried out to improve on live stock quality.
- Introduction of better breeds of animals which are high yielding to enable nomads reduce number of animals kept.
- Provision of better transport and communication for pastoralists to access markets for their animals and products.
- The government should provide loans to farmers to enable them construct farm structures, purchase improved breeds of cattle.
- Provision of processing facilities for livestock products in order to add value to them.
- Provision of general education to pastoralists to equip them with skills and modern livestock management techniques.
- Establishment of demonstration farms where farmers can learn modern techniques of livestock management.
- Provision and construction of water reservoirs, valley dams, boreholes and wells.
- Improvement of veterinary services e.g. A.I, disease and pest control.
- Introduction of new and improved varieties of pastures species that are palatable to animals and highly nutritious.

**SUBSISTENCE FARMING**

This is the growing of crops and rearing of animals purposely for home consumption and the surplus is sold to meet other domestic needs e.g. clothes, medical care, shelter, education etc.

Characteristics of subsistence farming:

- It depends mainly on family labor for cultivation, planting, harvesting etc.
- Simple tools e.g. hoes, pangas are used.
- The fields / plots are often small (less than 5ha family)

- The standard of living is low.
- Intercropping of crops is a common practice.
- Modern methods of farming e.g. fertilizer application are not commonly practiced.
- Gardens are normally fragmented / scattered.
- Products are mainly for domestic consumption e.g. cereals, root crops, legumes and bananas.

**Advantages of subsistence farming:**

- A variety of crops can be grown of the same time; this safe guards against hunger.
- It requires less capital.
- Growing many different types of crops protects the soil fertility.
- Price fluctuations do not affect the farmers.
- Meets the domestic and local demand for food.
- Production for home consumption saves transport and marketing costs.

**Disadvantages of subsistence farming:**

- Small scale farming tends to keep farmers poor.
- Small scale production does not encourage mechanization.
- Land fragmentation is common which hinders mechanization.
- The rate of economic development is slow.
- Labourers are redundant (idle) between harvesting and the next planting season.
- As more inputs are added, farmers operate at a loss because of the law of diminishing returns.
- Purchasing power of other goods in the market in low due of poverty.

**COMMERCIAL FARMING SYSTEMS**

This refers to the farming systems where farmers grow crops and rear animals mainly on large scale to get profit.

*Examples include;*

- Mixed farming
- Ranching
- Plantation farming
- Dairy farming

**MIXED FARMING**

This is the growing of crops and rearing of animals on the same farm land at the same time.

**Advantages:**

- The farmer gets double income from both animals and crops.
- Animals provide manure which is used in crop production.
- Remains of crops e.g. banana peelings, maize stalks can be fed to the animals instead of being wasted.
- Labour is well distributed or utilized throughout the year.
- In case of crop failure due to pests and diseases, the farmers still gets some income from animals.
- Land is better utilized (land unsuitable for crop production can be used for animal production).
- The farmer and his family get a balanced diet.

**Disadvantages:**

- It needs more capital to start.
- Animals may destroy crops especially of fencing is not well done.
- It requires more labour to manage both crops and animals.
- It requires a lot of land.
- It requires the farmer to have skills of managing crops and animals which is always not easy.
- Generally the system lacks specialisation.

- Individual projects take up a small portion of the land because much of it is shared by many enterprises.

## COMMERCIAL RANCHING

Large scale animal rearing is known as ranching and it comprises products for sale

This may be dairy or beef production of a large well managed livestock farm.

**Characteristics of ranching**:

- Large numbers of animals are kept.
- There is a lot of capital investment needed.
- Animals are kept especially for sale.
- Only highly productive breeds are kept.
- There is specialisation.
- Pastures are well established and managed.
- Selective breeding of livestock is done to get high quality breeds of livestock / products.
- There is less movement of animals than in nomadic pastoralism.
- Large areas of land are used.
- Land is often individually owned and thus no communal grazing on the land.
- More scientific methods of management are used.
- Often carried out in drier parts of the country where there is little or no crop cultivation.
- A few breeds of animals are kept.

**Factors that influence success of Ranching / factors necessary for success of Ranching:**

- Availability of adequate pasture.
- Efficient transport to ensure quick movement of animals to slaughter houses; and milk transportation.

- Availability of ready market for animal products.
- Ready access to facilities like cold storage plants to avoid spoilage of milk and meat.
- Presence of well trained veterinary personnel.
- Availability of extension services.
- Security in the area to make farmers stable.

**PLANTATION FARMING / ESTATE FARMING**

This is the type of farming where farmers grow mainly one type of crop on a large scale mainly for commercial purposes and year after year E.g. Sugar Estates (Kakira, Kinyara, Lugazi), Tea Plantations (Kasaku), Sisal (Kagera in Tanzania).

**Characteristics / features of plantation farming**:

- It is highly specialized (i.e. a single type of crop is grown).
- There is a high level of mechanization like use of tractors
- There is a high output.
- It employs many people from the communities
- Products are normally grown and processed for export.
- Products are normally processed on the farm to increase their value and profit.
- They mainly concentrate on perrenial crops only
- High quality products are produced due to improved methods of farming e.g use of fertilizers

**Advantages of plantation farming**:

- Many labourers are employed and this reduces unemployment.
- Governments get a lot of revenue through taxation of the product and labour force.
- On spot processing increases the value of produce and hence higher profits.
- Governments earn foreign exchange due to export of the products.

- Machines are economically used due to large sizes of farms.
- There is regular supply of produce because management is centralized and efficient.
- Workers become skilled as they specialize in the production of one commodity.
- It promotes growth of industries because they act as a source of raw materials.
- Stimulates the development of infrastructure in an area e.g. roads, schools, hospitals etc.
- Wastes / By – products are used for other purposes e.g. feeding cattle, manufacture of alcohol etc.
- The owner benefits from large scale production (economies of scale) e.g. reduced transport costs).
- High quality products is produced because processing is carried out on the farm.

**Disadvantages of plantation farming**

- Plantations require a lot of capital to establish and operate.
- Most plantations are foreign owned and the owners send nearly all the profits to the countries of the expense of the host country.
- Pests and diseases can cause serious damage.
- It may result in heavy losses as they crop prices fluctuate; so earnings are not predictable.
- It requires a lot of land which is not easy to get.
- Monoculture destroys the soil structure and exhausts the soil.
- Growing one crop accumulates pests and diseases which necessitates use of expensive chemicals to control them.
- It has a negative effect on food production since it emphasizes cash crop production.

- The many jobs created increase congestion of workers and social problems e.g. prostitution, illegitimate children etc.
- At times owners get a challenge of getting enough skilled and unskilled labour.
- Any slight mismanagement may cause heavy losses.
- Owners take some time to earn money due to long gestation period of most plantation crops.

## CROPPING SYSTEMS

### MONOCROPPING / SOLE CROPPING

This is the growing of a single / individual crop in a pure stand in the field / garden e.g. maize alone.

NB: Monoculture is the growing of one type of crop on the same piece of land season after season.

**Advantages of mono cropping**

- Weeding is easy
- Harvesting is easy
- It is easy to estimate the yields.
- It is easy to establish the correct plant population per unit area.
- It is easy to mechanise the field.
- Spraying against pests and diseases is easy.

**Disadvantages**

- Pests and diseases may spread very fast and destroy the whole crops.
- Soil erosion is encouraged if the crop does not offer good soil cover
- In widely spaced crops, the land is not fully utilized.
- In case of crop failure or drop in the market, the farmers suffer loss of income.

## INTER CROPPING/MIXED CROPPING

This is the planting of a minor crop (quick growing crop) alongside a major crop e.g. beans in bananas.

NB: Mixed cropping is the growing of many crops intercropped or in different plots of pure stands on the same piece of land at the same time.

**Advantages of intercropping**

- Total yields per unit area are higher than in mono cropping.
- There is better and full utilization of labour.
- It controls weeds since little space is left.
- Safe guards against famine since the crops mature at different times.
- There is maximum utilization of soil nutrients.
- Legumes in the mixture fix nitrogen into the soil.
- Interrupts the spread of pests and diseases.
- The risk of having total crop failure is reduced.
- Farmers get a balanced diet.
- Some crops act as nurse crops to the other crops.

**Disadvantages of intercropping**

- Too close spacing leads to entiolation and poor growth of crops.
- There is competition for water, nutrients, light, space.
- It hinders use of machines in operations e.g. weeding, harvesting etc.
- Late maturing crops are damaged while harvesting the early maturing crops.
- There may be build up of pests and diseases.
- Sometimes, fertilizers may be wasted on the crops in the mixture which are less profitable.
- Chemical control of pests and diseases is difficult.
- There is wastage of fertilizers especially when one of the crop is uneconomical.

## CROP ROTATION

This is the growing of different types of crops on the same piece of land in an orderly sequence / definite order.

It is done in order to preserve and maintain soil fertility and productivity.

## Factors to consider / principles to follow when designing a good crop rotation.

- Heavy feeders such as maize, cotton or sweet potatoes should be planted first in the newly opened land to taka advantage of the so much available nutrients
- The deep rooted crops should follow shallow rooted crops. This will allow efficient use of nutrients at different soil layers.
- Crops with similar pests and diseases should not follow one another in a rotation.
- Crops of the same family should not follow one another in the rotation because they have similar feeding requirements, pests and diseases.
- Crops that do not provide good soil surface cover should alternate with those that provide good surface cover to control soil erosion.
- The rotation should have a resting phase/fallow period planted with a grass ley to restore soil fertility.
- Crops which are easy to weed should alternate with those which are difficult to weed.
- Legumes such as G. nuts, beans, peas should be included in the rotation to provide nitrogen in the soil.

**Advantages of crop rotation.**

- It breaks the life cycle of crop pests and diseases.
- The legumes included add nitrogen to the soil.
- It controls weeds which are specific to particular crops e.g. striga in cereals.
- It checks on soil erosion by using cover crops.
- There is maximum use of environmental resources by growing crops of different growth habits.
- It improves the soil structure due to fallowing.
- It helps to even out labour requirements over the year.
- It spreads financial risks over several crops.

**Designing crop rotation programmes.**

Qn. 1. Design a crop rotation programme for maize, beans and cassava.

2nd Year BEANS

1st Year MAIZE

3rd year CASSAVA

OR

| | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| Plot 1 | Maize | Beans | Cassava |
| Plot 2 | Beans | Cassava | Maize |

Plot 3 Cassava Maize Beans

2. Design a crop rotation programme for G.nuts, cotton, cabbage.

## POPULATION

Population is the total number of people living in a particular area in a given period of time.

## COMMON TERMS USED IN POPULATION

- Population density; This is the number of people per unit area (e.g. per square kilometer)

$$\textit{Population density} = \frac{\text{Number of people}}{\text{Total area}}$$

e.g. The population of a given city is 28,000,000 people.

If the land area of that city is 560,000km$^2$

What is the population density of the city?

$$\textit{Population density} = \frac{\text{No. of people}}{\text{Total area}}$$

$$= \frac{28{,}000{,}000}{560{,}000}$$

$$= 50 \text{ people / Km}^2$$

- Population structure and composition; This refers to the way the population of a country is distributed in terms of sex, age, literacy rates, marriage, occupation, distribution etc.

  In terms of age distribution, there are 3 basic age groups used in description of the population.

  (i) the young

(ii) the working class / age

(iii) the old

- Population growth: This refers to the rate at which population size grows over time.

$$Population\ growth\ rate = \frac{No.of\ births}{1000\ of\ population} - \frac{No.of\ deaths}{1000\ of\ population} x\ 100$$

- Over population; this refers to a situation where there are too many people in an area / country for the available resources.
- Under population: this refers to a situation where there are too few people in an area / country for the resources available.

OR When the available resources are more than the available people.

- Optimum population; This refers to a situation where the resources of a country are fully exploited and can optimally sustain the population without excess or shortage.
- Birth rate; This refers to the number of live children born each year and is expressed per thousand.
- Death rate; this refers to the number of people who die each year and is expressed as per thousand.
- Infant mortality rate: Refers to the deaths among children who die between birth and one year of age.

## CAUSES OF HIGH POPULATION

- Early marriages due to inadequate education.
- Polygamy among young African families.
- Cultural factors; some cultures see children as a source of wealth and prestige.
- High fertility rates in women.

- Idleness in rural areas and some urban areas. This makes some people to view sex as a form of recreation.
- Absence of family planning.
- Improved medical services that have reduced death rates and increased birth rates.
- Ignorance of women who believe that their key role is to produce children.
- The need to provide cheap family labour in the peasantry life.
- Unchecked immigration into the country like Uganda.
- Promiscuous sexual relationships e.g. indiscriminate sexual relationship among men and women.
- Existence of cheap and abundant food plus accommodation in rural areas.

## EFFECTS OF POPULATION INCREASE ON AGRICULTURE

### Negative effects

- Leads to land fragmentation i.e. subdivision of land into many plots.
- Leads to over use of land which results into loss of fertility.
- It leads to shortage of food for the population.
- It leads to unemployment and under employment.
- There will be wide spread poverty because resources are shared by too many people.
- High population widens income disputes and causes social, political and economic discontent.
- There is always low standard of living due to low per capital income.
- Many social services will be run down.
- It calls for more expenditure on education, housing, food, medical care, clothing etc. This reduces investment in more directly productive sectors e.g. Agriculture, tourism etc.
- There will be congestion, famine, diseases and high crime rates.

- There is heavy dependence burden especially where there is increasing number of children.
- There will be inflation.
- Poor housing facilities and development of slums.
- High rates of illiteracy.
- Overgrazing on the existing small agricultural land.

**POSITIVE EFFECTS**

- Creation of wealth; large population is able to utilize the resources available for creation of wealth.
- It increases the market size.
- It increases the size of the labour force and so makes the labour cheap.
- High population justifies the establishment of infrastructure in an area.
- It leads to increases in government revenue through taxes paid by the citizens.
- High population boasts the growth of industries because there will be many people to work in the industries.
- It also leads to increase in the GDP (Gross Domestic Product).
- High population enhances the status if a country in international affairs e.g. China is a super power because of its high population.
- Efforts to work hard are stimulated and this promotes innovation and invention to cope with the challenges.

**WAYS OF LOWERING HIGH POPULATION**

- Family planning
- Legalizing abortion
- Education of women to delay them in school to avoid early marriages.
- Encouraging migration to areas with sparse population.
- Taxing those with large families.
- Denying bursaries for the extra children.
- Setting the minimum marriage age.

- Encouraging celibacy to reduce the number of breeding humans.
- Sex education to prevent early undesired births.

## CLIMATE

Climate refers to the average weather conditions of a place recorded for a long period of time say

25 – 35 years.

Weather is the atmospheric conditions of a place for a short period of time e.g. an hour, a day, a week or a month.

## ELEMENTS OF WEATHER

These are the conditions that make up the weather. They include;

- Temperature - cloud cover
- Wind - Pressure
- Rainfall - Sunshine and Mist / fog

## TEMPERATURE

This refers to the degree of hotness or coldness of a given place / object.

Atmospheric temperature is measured and recorded using an instrument called maximum and minimum thermometer or six's thermometer.

### Importance of temperature

**To crops**:

- It influences ripening of fruits.
- It helps in drying harvested crops.
- It influences the rate of transpiration.
- It influences distribution of crops.
- Influences sugar content of some crops e.g. oranges, pineapples, sugar.

**To animals**:

- Influences the rate of egg laying in birds.
- It influences the feeding rate of animals.
- It affects milk composition in animals.
- It affects livestock distribution.
- Affects grazing in animals graze in morning and late in evening.

Temperature is usually expressed in 2 scales i.e.

- Centigrade ($^0$C)

The freezing and boiling points of water are taken as the standards in centigrade and are defined as $0^0$C and $100^0$C respectively.

- Fahrenheight / Frahrenheit ($^0$f)

On this scale the freezing point of water is $32^0$F and the boiling point is $212^0$F.

Conversion from one scale to another;

- To convert $^0$C to $^0$F; we use the formula;

  $^9/_5 x o_C + 32$

  OR

  5 x $\frac{9}{5} x\, o_C + 32^{x5} = o_{F\ x\ 5}$

  = 9°C + $160^0$ = $5^0$f

*Example;*

Convert $10^0$C to $^0$F

$\frac{9}{5} x\ ^0C + 32$

$\frac{9}{5} x\ 10\ + 32$

$= 50^0F$

- To convert $^0F$ to $^0C$ we use the formula

$[F - 32]x\frac{5}{9}$

*Example:*

Convert $77^0F$ to $^0C$

$(F - 32)x\frac{5}{9}$

$(77 - 32)x\frac{5}{9}$

$45\ x\frac{5}{9}$

$25^0C$

Exercise

Convert the following

From $^0C$ to $^0F$

$40^0C$

$25^0C$

$30^0C$

From $^0F$ to $^0C$

$59^0F$

$86^0F$

$122^0F$

**WIND**

Wind is defined as moving air. Wind normally blows or moves from centre of high pressure to centres of low pressure.

## Importance of wind

***Positive effects***

- It helps in seed dispersal.
- It is an agent of pollination (wind pollination)
- It helps in the formation of rainfall and its distribution.
- It helps in drying crops.
- It drives wind mills used in processing agricultural produce.
- It is used as a source of power to pump water on the farm.

**Negative effects**

- It destroys farm structures
- It results into erosion (wind erosion)
- It destroys crops.
- It promotes high rate of transpiration leading to wilting.
- It spreads pests and disease causing organisms.
- Helps in dispersal of weed seeds.

Negative effects of wind can be overcome by planting wind breakers, ensuring that land is always covered by vegetation.

## RAINFALL

This is the form of precipitation formed as a result of evaporation and condensation.

*OR* It refers to the water droplets falling from above (sky) to the earth's surface with in a given area in a given time.

The amount of rainfall received in a given area at a given time is recorded and measured using an instrument called rain gauge.

**TERMS RELATED TO RAINFALL**

- Rainfall distribution; this refers to how many times or seasons rain is received in a area.

*OR* The spread of rainfall through the rainy season.

**FORMS / TYPES OF RAINFALL DISTRIBUTION**

- **Monomodal / Unimodal**: this is a type of rainfall distribution where there is a single long rainy season in the middle of the year.It is suitable for drought resistant crops e.g. millet, sorghum etc.
- **Bi-modal rainfall distribution**: this is the type of rainfall distribution where the rainfall seasons are received over the year e.g. March – June, August- December. It is suitable for perennial crops e.g. coffee, tea, bananas etc.

**Effects of rainfall distribution**

- It determines the types of crops to be grown.
- It influences the time of planting.
- It affects the availability of water for pasture growth and water for livestock.

**Rainfall reliability**: it refers to the chances of receiving an amount of rainfall for a given period of time adequate for plant growth.

*OR* It refers to how sure one can be that the rains will come when they are expected to.

**Effects if rainfall reliability**

- It helps the farmer to plant crops at the right time.
- It determines when to irrigate the crops.

- Reliable rainfall ensures high yields since crops are not destroyed by drought.
- Rainfall intensity; this refers to the heaviness of rainfall received in an area for given period of time.
- Rainfall effectiveness; this is the ability of rainfall received to satisfy the crop needs.

  It is the amount of rainfall which is enough to support or sustain the crop from planting to harvesting.

**Formation of rainfall**

Rainfall is formed when air containing moisture cools.

Cooling occurs when the moistened air rises and reaches the cool layers of the atmosphere.

When the air cools, it becomes saturated with water vapour. Tiny droplets coalesce or join together to form larger drops; which become heavy and fall to the earth as rain. The amount of rain formed depends on the relative humidity and cooling extent of the air.

**TYPES OF RAINFALL**

- Relief rainfall (orographic rainfall)
- Convectional rainfall
- Frontal rainfall (cyclonic rainfall)

**THE HYDROLOGICAL / WATER CYCLE**

This is a presentation of the process which shows the movement or circulation of water from the water bodies, earth or land, vegetation and living organisms through the atmosphere and back to those different sources.

- Rainfall from the clouds falls to the ground after condensation.

- The rain water runs into the rivers, swamps and lakes some of the water sinks into the ground.
- Evaporation of water from the soil and open water bodies, animal excreta (urine, sweat, dug) and transpiration from plants occur.
- The water vapour rises and reaches the condensation level and condenses into clouds.

**THE WATER/HYDROLOGICAL CYCLE**

**EXPLANATION**

When it rains,water collects in water bodies and other water sink into the soil through percolation to form springs and wells.This water by capillary pull moves upwards and used up by plants.When the sun heats the earth,evaporation takes place from water bodies and vegetation.

Water vapour in the atmosphere rises upwards and meets the cold air region which condense to form clouds.Clouds descend due to weght and form rainfall which result into water runoff and percolation

## HUMIDITY

Humidity refers to the amount of water vapour in the atmosphere

The total quantity of water vapour that a given volume of air can hold is limited and varies with temperature; warm air can hold more water than cold air.

### Relative humidity

This refers to the amount of water vapour in a given volume of air compared to the amount of water vapour required to saturate the volume of air at the same temperature.

**Effects of relative humidity;**

- Relative humidity affects the rates of transpiration and evaporation.
- Affects the type of crops grown i.e. areas with low relative humidities can support crops that are able to tolerate high rates of evapotranspiration e.g. Banana and cocoa are adapted to high humidity conditions.
- Relative humidity affects prevalence of pests and disease causing organisms i.e. High relative humidity encourages the multiplication of many pests and fungal diseases.
- Affects the ease of drying crops i.e. high relative humidity makes it hard for drying crops.
- Affects the level of feed in take; High relative humidity causes a reduction in feed intake which in turn results in reduced animal production.

- High humidity depresses evaporative heat loss leading to an increase in heat load of the animal.

**TERMS USED**

- Evaporation; This is the loss of water from the soil and other surrounding water sources or change of liquid water into vapour.
- Evapotranspiration; this refers to the loss of water from the soil, water surface and leaf surfaces in plants.

**It is affected by**;

- Temperature of the water; the higher the temperature of water, the more rapid the rate of evapotranspiration.
- The dryness of the air; the drier the area the more rapid the rate of evapotranspiration.
- Air movement; evaporation increases with wind velocity because the wind removes the air that has become moist and replaces it with dries air.
- Humidity; the higher the humidity, the lower the rate of evapotranspiration.

- Transpiration; this refers to the loss of water from plants in form of vapour especially through the leaves.

**LIGHT**

- Light duration; this refers to the relative lengths of light and dark periods within a day. Day length on the equator is always 12hrs, while in the temperate countries day length varies with the season; up to 16 hours during summer and only 8hours in winter.

- Temperate plants; e.g. wheat, barley and roses can only grow and give high yields when they are grown in temperate regions where day lengths are longer.

  Crops, such as soybean and rice varieties that perform well in the tropics cannot flower when planted in the temperate regions.

- Light intensity; Light intensity has a direct influence on photosynthesis i.e. some plants such as sugar cane, maize, rice and sorghum grow well under high light intensities while barley, wheat and soybean grow well under low light intensities.

  This affects the production of chlorophyll thus affecting the colour of the leaves, etiolating.

## SOIL SCIENCE

Soil is a mixture of weathered rocks, air, water, organic matter and living organisms.

OR It is a medium in which plants grow and from which they derive their nutrients and anchorage.

### Importance of soil

- It is a medium with in which plants grow.
- It supplies mineral nutrients to plants.
- It provides water to the plant.
- It is a medium for microbial activities.
- It provided air for respiration of plant roots.
- It is a medium for anchorage/support of plant roots.
- Soil filters water as it passes through it, thus protects the quality of water.
- Soil absorbs and decomposes waste material, thus keeping our environment clean.

- Source of minerals.
- Soil acts as a foundation for structures like roads buildings and airports.

## SOIL FORMATION

Soil formation is the process by which soil comes into existence or is made.
Soil is formed by the breakdown of rocks in a process called weathering.

*Soil genesis;-* the weathering of rocks and the conversion of weathered rock material into soil.

Weathering; is the breakdown or disintegration of rocks into smaller particles to form soil.

**NB**: Soil formation occurs in the following four (4) processes;

- Weathering
- Decoposition
- Translocation
- Deposition

## TYPES OF WEATHERING

- Chemical weathering
- Biological weathering
- Physical weathering

- **PHYSICAL WEATHERING**

This is the mechanical breakdown of rocks into small fragments (particles) with no change in their chemical composition.

Processes of physical weathering

- Differential expansion and contraction of rocks; when the sun heats up the rocks during day, the rock expand and when they cool at night they contract.

  This alternate expansion and contraction cracks the rocks and eventually they breakdown.
- *Exfoliation;* during day, upper layers of the rock expand faster than the lower layer. This brings about separation and disintegration of the upper layer to the lower layer.
- *Frost action/freeze and thaw;* In cold region when the water in the crack freezes, it expands. This increases the size of the cracks and eventually the rocks break off.
- *Break down by living organisms;* As plants extend their roots, the pressure they exert leads to breakdown of rocks. The burrowing animals also breakdown the rocks through their weight and their activities.
- *Pressure release;* hard old rocks may be covered with softer recent sedimentary material making them to experience a lot of pressure due to the weight of the overlying blanket of sedimentary materials when their material is removed by erosion or glaciations, the underlying rock expands rapidly hence cracking.

- **CHEMICAL WEATHERING**

This is the breakdown of rocks with a change in their chemical composition.

It is mainly because of the reaction of minerals in the rocks with atmospheric gases e.g. Oxygen, carbon dioxide and water vapour.

**Processes of chemical weathering**

- **Oxidation;** this involves addition of oxygen to the rock minerals to form metallic oxides weaker than original minerals e.g. in tropical areas with high temperatures and high humidity.

*E.g.* Iron (II) carbonate + Oxygen → Iron oxide + carbon dioxide

$4\ FeC0_3 + 0_2 \rightarrow 2Fe_20_3 + 4C0_2$

(haemite)

- **Hydration;** this involves the combination of water with minerals to form hydrated compounds which are weaker than the original minerals.

  Iron (II) oxide + water → hydrated iron oxide (goethite)

  $Fe_20_3 + H_20 \rightarrow Fe_20_3.H_20$

- **Carbonation***;* this involves the reaction of $C0_2$ with bases in rocks to form carbonates and hydrogen carbonates e.g.

  Calcium hydroxide + Carbon dioxide → Calcium hydrogen carbonate + water

  $Ca\ (0H)_2 + C0_2 \rightarrow CaHC0_3 + H_20$

  Potassium hydroxide + carbon dioxide → Potassium carbonate + water

  $2K0H + C02 \rightarrow K_2C0_3 + H_20$

The carbonates formed are soluble in water and are easily washed away.

- **Reduction***;* this involves removal of oxygen molecules from mineral compounds. This leads to decomposition and crumbling of the mineral compounds especially in poorly drained conditions.

- **Hydrolysis;** This occurs when metallic cations of many compounds are replaced by hydrogen ions ($H^+$ ions) from water.

  E.g. Calcium silicate + water → Silisic acid + calcium hydroxide.

  $CaSi0_3 + 2H20 \rightarrow H_2Si0_3 + Ca(0H)_2$

- **Acidification;** Acids e.g. carbonic acid formed between atmospheric $C0_2$ and rain water reacts with rocks.

  $H_20 + C0_2 \rightarrow H_2C0_3$

  Carbonic acid

- **<u>BIOLOGICAL WEATHERING</u>**

  This is the type of weathering where the rocks are broken down by living organisms e.g.

  - Micro organisms e.g. fungi and bacteria decompose organic materials to form humus.
  - Termites, earth worms and rodents feed on organic materials and add humus to the soil when they die and decompose.
  - Lichens, fungi, bacteria colonise the rocks and produce organic acids which breakdown the rocks.
  - Roots of huge trees force their way into rocks forcing them to split.
  - Animals' hooves break the rocks by movement on the rocks.
  - Accumulation of calcium carbonate from shells of molluscs (e.g. snails) and fish to form rocks e.g. limestone.
  - Some roots produce organic substance at the root caps and their dissolve rock particles.
  - Man's activities e.g. cultivation break rock particles.

## FACTORS WHICH INFLUENCE SOIL FORMATION / WEATHERING

These are responsible for the type and nature of soil formed in an area;They are mainly five and they include;

- Time
- Topography
- Living organisms
- Climate
- Nature of the parent rock

**Nature of the parent rock***;* This refers to the materials from which soil is formed.

The type of rock determines the type of soil formed e.g. Sand stones give rise to sandy soils, volcanic ash rocks give rise to very fine soils.

- Parent material affects the colour of the soil formed.
- Parent material determines the ease of weathering i.e. soft rocks e.g. igneous rocks are easier to break down.
- Parent material determines the depth of the soil formed e.g. soft igneous rocks produces deeper and more fertile soils than hard sedimentary rocks.

**Climate;** Climatic factors that influence soil formation includes temperature, rainfall, wind.

**Effect of temperature**

- Alternate expansion and contraction of rock surfaces due to temperature changes of day and night causes cracking of rocks to form soil.

- Increase in soil temperature results in evaporation of soil moisture to form rain which is a weathering agent.
- Temperature affects the rate physical and chemical weathering.
- Temperature affects the rate of activities of soil living organisms (increase with increase in temperature within a given range).
- High temperatures cause peeling of the rock surfaces (exfoliation).
- At higher altitude in rock crevices, when temperatures are low, water changes into ice that exerts pressure and causes rocks to crack.

**Effect of rainfall**

Direct impact of rain drops on rocks dislodges small particles which are later weathered to form soil.

- As rain water flows down the stream and rivers, it carries rock particles which knock each other to form soil.
- Rain dissolves carbon oxide in the atmosphere to form weak carbonic acid which dissolves rocks.
- Rain water provides moisture needed by micro organisms to decompose organic matter.
- Running water helps to remove accumulated materials from the rock surface hence exposing the soil to more agents of weathering.

**Effect of wind**

- Wind blows sand particles against rocks causing abrasion of the rock surface.
- Wind carries away rock materials and deposits them else where to form soil.

**Living organisms**

- Roots of trees grow in the cracks widen the cracks causing the rocks to split.

- Burrowing animals e.g. rodents break down soft rocks and help in soil profile mixing.
- Earthworms and termites feed on dead organic matter and decompose it.
- They mix organic matter with top soil hence forming a little crumby structure.
- Animal hooves break the rock surfaces that they walk on.
- When living organisms die, they decompose and form organic matter that improves on soil fertility.
- The tips of plant roots secrete chemicals at their tips that help to dissolve rocks.
- Fungi and algae colonize the rocks and secrete chemicals which dissolve the rocks.
- Man's activities e.g. mining, digging, quarrying etc influence soil formation in various ways.

**Topography**

This is the nature of the surface of the land.

- This affects the rate of weathering, soil depth and nature of the soil formed.
- Topography affects local rainfall distribution through creation of rain shadow areas.
- Up the mountain, there is decreased temperature and hence reduction in the rate of weathering.
- Topography influences the depth of soil formed in the valleys where the weathered materials are deposited
- Topography influences the rate of water infiltration into the soil i.e. lower infiltration on steep slopes affects chemical weathering.
- A steep area does not encourage accumulation of weathered materials but encourages transportation and deposition occurs down the slope.
- Topography influences rate of erosion i.e. less erosion on gentle slopes and more erosion on steep slopes.

**Time**

- Soil formation is a very slow process that takes a lot of time to take place.
- The longer the time the rock is exposed to agents of weathering, the deeper and fertile the soil will be.
- The clay content of the soil increases with time.

## SOIL FORMATION PROCESSES

These include the following:

- **Disintegration**: this is the breaking down of rocks into smaller particles.
- **Decomposition**: the further breakdown of rocks into very small soil particles it makes the soils to release nutrients to the plants.
- **Translocation**: this refers to the removal of the soil. The soil is carried away by running water and wind.
- **Deposition**: the soil particles carried away by water and wind are deposited to another area.

## SOIL CONSTITUENTS

Soil constituents refer to the composition of the soil or the components of the soil.

Soil is composed of the following

- Air
- Water
- Mineral matter
- Organic matter
- Living organisms

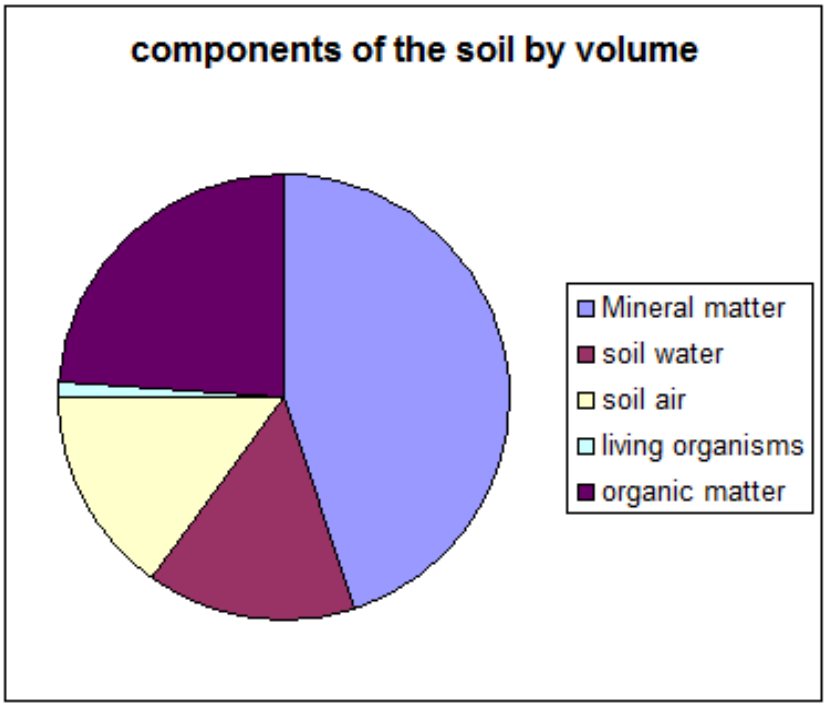
### PHASES OF THE SOIL

Soil consists of three phases i.e.

- Solid phase: this consists of solid particles e.g. small stones, organic matter.

- Liquid phase: this consists of soil water
- Gaseous phase: this consists of air i.e. oxygen and carbon dioxide.

The different components of soil vary from one another in percentage, composition and volume as seen below:




- Mineral matter: this forms the inorganic portion of the soil. It comprises fragments of rock materials that are broken down.

  The mineral particles form 45% of the volume of the soil. It includes minerals like iron, aluminum, zinc, copper etc.

  Importance of mineral matter
  - They supply the necessary plant nutrients for nutrition.
  - They hold plant roots in place.
  - The elements provide surfaces on which soil water is held.
  - They form the air spaces for both air and water.
  - The make the skeleton of the soil.
  - They influence the physical and chemical properties of the soil.
- Soil water: this is found in the micro and macro pores of the soil.

Importance of soil water

- Necessary for seed germination.
- It is an essential solvent for soil solution.
- Dissolves plant nutrients for plant absorption.
- Prevents desiccation of plant roots and micro organisms.
- Controls the amount of soil air present in the soil.
- Cools the plants through transpiration.
- Controls soil temperature i.e. soils with a lot of water are cool.
- Important in chemical weathering of rocks.
- Helps to remove toxic substances from the soil.
- Keeps the soil soft for easy cultivation.
- Necessary for photosynthesis in plants.

Types of soil water

- Gravitational water: This is excess water that can easily flood out of the soil. It is not available to crops.
- Hygroscopic water: This is the water that is held so tightly on the soil particles that it cannot be absorbed by the roots. It cannot be absorbed by plants.
- Capillarity water: This is the water that is held in the spaces between soil particles and can easily be absorbed by the plant roots.

**Experiment to determine amount of water in a soil sample**

Apparatus

- Soil
- Beaker
- Source of heat

- Stirring rod
- Tripod stand
- Dessicator

**Procedure**

- Weigh a clean, dry empty evaporating dish($a_g$)
- Half fill the dish with soil and weigh again ($b_g$)
- Find the weight of the soil alone by subtracting (a-b)=$C_g$
- Gently heat the evaporating from time to time
- Allow the dish and soil to cool in a dessicator so that it does not pick up moisture from the air.
- Continue heating till a constant weight is obtained
- Record the final weight of the dry soil sample and
- calculate the amount and percentage of water in the soil as below:
    - Weight of dry evaporating dish= $a_g$
    - Weight of evaporating dish + soil before heating = $b_g$
    - Weight of evaporating dish + soil after heating = $c_g$
    - Weight of soil alone before heating = (b – a) = $e_g$
    - Weight of dry soil alone after heating = (c – a) = $f_g$
    - Amount of water in the soil = ( e- f) $_g$
    - Percentage of water = $\frac{\text{Weight of water in soil sample}}{\text{Weight of soil before heating}}$

$$= \frac{(e - f)}{e} * 100$$

*Example*

- Soil air: soil air is found in the pores of the soil which are not occupied by water.

**Factors that determine amount of air in the soil**

- The amount of water in the soil: The more the water in the soil, the less the air in the soil.
- Soil structure: Granular and crumb structure encourage better aeration than a platy structure.
- Type of soil and texture: Sand soil is better aerated than clay soil.
- Organic matter content of the soil: Organic matter improves the soil structure and aeration.

- Soil depth: the deeper you go into the soil profile, the less the amount of air present in the soil.

**Components of soil air**

- Oxygen: for respiration of roots and microbes.
- Carbon dioxide
- Nitrogen for protein formation by microbes.
- Water vapor: helps to prevent desiccation of plant roots and microbes.

**Importance of soil air**

- Necessary for respiration of plant roots and microbes.
- Necessary for seed germination
- Good air circulation dissolves $C0_2$ which may be toxic to plants and other microbes.
- Expansion and development of plant roots.
- Supports existence of soil microbes.
- Some soil air is converted into plant nutrients that support the growth of plants e.g. nitrogen

**Effects of poor aeration**

- Reduced microbial activities
- Reduced root growth
- Wilting and yellowing of plants due to reduced energy absorption by plants
- Toxic substances are formed from organic substances
- Anaerobic conditions leading to formation of harmful acids.
- Increased denitrification

**Differences between soil air and atmospheric air**

| *Soil air* | *Atmospheric air* |
|---|---|

| | |
|---|---|
| • Not uniformly distributed | • Uniformly distributed |
| • Varies in composition from place to place | • Composition is the same |
| • Has higher moisture content | • Has low moisture content |
| • Has high carbon dioxide content | • Has low carbon dioxide content |
| • Has low oxygen content | • Has high oxygen content |

*.Experiment to determine volume of air in the soil*

Apparatus

- Measuring cylinder
- Water
- Stirring rod
- Soil sample

Procedure

- Place a measured amount of soil in a measuring cylinder.
- Add a measured amount of water to the soil in the measuring cylinder.
- Stir the contents well and leave to settle.

Observation

- Bubbles are seen escaping from the soil indicating presence of air.
- After settling, the total volume of the two contents is less than the expected volume of the mixture.

To calculate the volume and percentage of air,

Volume of air = Expected volume – Actual volume

Percentage of air = $\frac{\text{volume of air in sample}}{} \times 100$

Volume of soil

*Example*

Calculate the volume and percentage of air in the soil using the following:

Amount of soil 100 $cm^3$

Amount of water 100 $cm^3$

Actual volume of the mixture 195 $cm^3$

- Soil living organisms

These are creatures that live or exist in the soil. They include the flora and fauna.

Types of soil living organisms

- *Micro organisms*: these are tinny organisms that can only be seen by a microscope e.g. viruses, fungi, bacteria, protozoan.
- *Macro organisms*: these are bigger in size and can be seen easily with naked eyes. E.g. termites, earthworms, millipedes, centipedes, rodents, etc.

The contribution of living organisms depends on their feeding habits i.e.

- Symbiosis: This occurs when two organisms live together and each benefits from the association. E.g. legumes and the nitrogen fixing bacteria in the root nodules of the legumes.
- Parasitism: occurs when an organism (parasite) feeds or lives on or in another (host) without the host benefiting from association. E.g. eel worms in roots of tomato plants.
- Saprophytes: these are organisms that feed on dead and decayed organic material.

## IMPORTANCE OF SOIL LIVING ORGANISMS

- Add humus to the soil when they die
- Help in decomposition of organic matter to release nutrients for plant use.
- Help in fixing nitrogen in the soil e.g. *Rhizobium* in root nodules of legumes.
- Burrowing animals help in mixing various layers of the soil profile with organic matter.
- Burrowing animals and earthworms help in improving soil aeration.
- Burrowing animals and earthworms make tunnels in the soil which help to improve drainage and water infiltration in the soil.
- Some bind soil particles together hence improving soil structure and stability. E.g., earth worms.
- Some produce antibiotics that can be used to control bacteria e.g *Aspergilus* and other penicillin producing fungi.
- Some carry out inorganic transformations of minerals e.g. in well drained soils, Iron and manganese are oxidized to higher oxidations.

## NEGATIVE EFFECTS

- Some cause disease to plants.
- Some transmit diseases to plants ( vectors)
- Some compete for nutrients with the plants ( immobilization)
- Some damage the plants physically

- Denitrifying bacteria cause loss of nitrogen from the soil.

## FACTORS THAT INFLUENCE ABUNDANCE OF SOIL LIVING ORGANISMS

- Tillage practices: Tillage of the soil directly kills soil living organisms leading to a reduction in their numbers.
- Soil depth: Deep soils favor abundance of soil living organisms because they provide space for soil living organisms. The deeper the soil down words, the less the number of soil living organisms.
- Type of crop grown: Some organisms are only abundant in number when certain crops are grown. E.g. Blue green algae in rice fields.
- Soil moisture content: Some organisms require some moisture to survive. However, high moisture favors less organisms
- Soil aeration: Most organisms require oxygen for survival and absence of oxygen will reduce their population.
- Soil temperature: Most organisms live with in a given temperature range.
- Soil pH: Most bacteria and earthworms do well in slightly alkaline soil while fungi do well in acidic conditions.
- Organic matter content: Many soil living organisms need organic matter for their nutrition. The higher the organic matter content, the higher the population of micro organisms.
- Pollution: Use of agricultural chemicals e.g. pesticides, industrial wastes reduce the population of soil living organisms.

**Experiment to investigate the presence of soil living organisms**

Apparatus

- Muslin bags
- Lime water

- Garden soil
- Conical flasks
- Cork

Procedure

- Put a handful of fresh garden soil in muslin bag A.
- Put garden soil that has been heated strongly to kill living organisms in muslin bag B.
- Suspend the muslin bags in different conical flasks containing lime water and cork the flasks.
- Leave the apparatus to stand for about 4 hours.

Observation:

The lime water in flask A will turn milky while that in flask B will remain clear.

Explanation:

- Carbon dioxide produced during respiration of living organisms in fresh soil (A) turned lime water milky.
- The lime water in flask B will remain clear since the organisms were killed by heating.

Conclusion:

- Fresh garden soil contains micro organisms which respire actively.

## ORGANIC MATTER

This is the non mineral portion of soil solids from decayed and partially decayed plant and animal residues.

It is composed of

- Carbohydrates

- Lignin
- Proteins
- Minerals
- Fats
- Pigments e.t.c

Organic matter is grouped into three main components,.

- *Litter*: This includes relatively un decomposed dead parts of plants and animals and their wastes that have just been deposited on the soil surface.
- *Residues*: These include the dead parts of plants and animals which are actively decomposing.
- *Humus*: This is the well decomposed and stable organic matter. It is the final product of organic matter decomposition.

## IMPORTANCE OF ORGANIC MATTER IN THE SOIL

- It provides food and shelter for soil living organisms.
- It is a source of plant nutrients.
- It buffers the soil pH i.e. controls pH.
- It improves the soil structure by binding soil particle together.
- It increases the soil CEC
- It reduces soil erosion because it holds soil particles together more firmly.
- Provides attachment sites for attachment of mineral ions.
- The organic acids released during the process of organic mater break down help in weathering
- It contains hormones and vitamins that stimulate plant growth e.g auxins.
- It improves air movement and water percolation because it improves the soil structure.

## FACTORS THAT AFFECT THE RATE OF DECOMPOSITION OF ORGANIC MATTER

- Plant factors
    - *Age*; young plants decompose faster than older ones because of high moisture content, they are less fibrous.
    - *Moisture content*: Succulent plants decompose faster than those which are less succulent.
    - *Carbon: nitrogen ratio*: legumes which have narrow C:N ratio decompose faster than cereals.
    - *pH of the material*: plants e.g. pine give acidic residues which are very difficult to break down.
- Climatic factors*:*
    - *Temperature:* with in a given temperature range, the higher the temperature, the faster the rate of organic matter decomposition.
    - *Rainfall:* this influences the activity o soil living organisms and speed of chemical reactions.
- Soil factors:
    - *Soil moisture:* influences activity of soil living organisms.
    - *Soil structure:* influences aeration.
    - *Soil temperature.*
    - *Mineral content:* Influences activities of soil living organisms that break down organic matter.
- Presence of living organisms*:*
    - The more the living organisms present, the higher the rate of organic matter decomposition.

**How organic matter level can be increased**

- Application of organic manures e.g. compost, FYM, green manure.
- Minimum tillage or zero tillage
- Mulching
- Ploughing back crop residues in the soil.
- Liming to increase the living organisms which decompose the organic materials.
- Proper drainage to encourage the soil micro organisms.

**EXPERIMENT TO DETERMINE THE PERCENTAGE OF HUMUS IN THE SOIL**

*Apparatus*

- Oven dried soil
- Evaporating dish
- Weighing scale
- Source of heat
- Stirring rod

*Procedure*

- Oven dried soil is weighed
- The soil is heated strongly in an evaporating dish upto a temperature of 105$^{o}$c
- Stir while heating the soil
- Note the colour change during heating
- Repeat the heating until a constant weight/mass is got
- Cool the dish and the contents in a desiccator

*Observation:*

- Smoke is given off
- The soil changes colour to brown

*Results*

- *Weight of oven dried soil = (a) g*
- *Weight of heated soil = (b )g*
- *Weight of humus = (a-b)g*
- *%age of humus = weight of humus * 100*

*Weight of oven dried soil*

$$= \frac{(a-b)}{a} * 100$$

*Example:*

## SOIL CLASSIFICATION

There are many ways of classifying soil. The major ones include:

- Classification based on colour
- Classification based on particle sizes
- Classification based on climatic region

- *Classification of soil based on colour*
    - Red clay soils: They are found on the northern and N. western parts of l. Victoria. These are deep, have stable structure and fairly high water holding capacity.
    - Brown soils: Mainly found in western and south western Uganda. They are shallow but fertile.
    - Reddish sandy soil: occupy large areas of central Uganda. Are acidic and of fairly low fertility.
    - Yellowish sandy soils: wide spread in eastern and northern Uganda. They are shallow, free draining, low in fertility and underlaid by murram.
- *Classification based on particle size*

| Soil separates | Diameter (mm) |
|---|---|
| Gravel | Above 2.0 |
| Coarse sand | 2.0 – 0.2 |
| Fine sand | 0.2- 0.02 |

| | |
|---|---|
| Silt | 0.02 – 0.002 |
| Clay | Below 0.002 |

These are further divided into sub-classes due to the %age of particle sizes present in each i.e.

- Silt loam has 20- 39%sand, 70% silt, 10% clay , 0.004% om.
- Clay loam has 20- 60% silt, 20- 30% clay, 20- 60% sand, 0.1- 0.6% om
- Sandy loam has 20 – 50%, silt clay 50- 80% sand, 0.13% om.
- Loam soil has 45%sand, 40% silt, 25% clay, 1-4% om.

- *Classification based on climatic region*
  - Zonal soils: are characterized and influenced by climate and world vegetation.
  - Intrazonal soils: are characterized and influenced by local conditions e.g. drainage, pH, mineral content etc.
  - Azonal soils: Have characterized by parent rocks of origin.

**TYPES OF SOIL**

There are majorly there types of soil. Namely,

- Sandy soil
- Clay soil
- Loam soil

**Sandy soil**

This type of soil contains more than 80% sand and are not more than 5% clay.

**Properties of sandy soil**

- Have large particles.
- Have large air spaces.
- Has a rough texture.
- Has poor water holdings capacity.
- Has good drainage.
- Has very low capillarity.
- Has low pH ( acidic).
- Has loose structure.
- It is light and easy to till or cultivate.
- Easily eroded and leached.
- Cannot be molded easily into shapes.
- The particles feel rough when dry and gritty when wet.
- It is usually single grained and the particles are loose.
- It is well aerated.

**Improvement of sandy soil to suit crop production**

- Addition of organic matter.
- Addition of artificial fertilizers.
- Irrigation to add water.
- Liming to control soil acidity.
- Addition of organic manures e.g. FYM, compost.
- Mixing with other types e.g. clay.

**Clay soil**

These contain 30% or more of clay particles.

**Properties of clay soil**

- Has a fine texture.
- Is poorly aerated.
- Poorly drained.
- Has high water retention capacity.
- Has very high capillarity.
- Is not easily eroded/ leached.
- It is sticky when wet.
- It can easily form a ribbon when molded.
- It is rich in plant nutrients.
- Expands when wet and cracks when dry.
- Its pH ranges from slightly acidic to slightly alkaline.
- Encourages water logging.
- Has small air spaces.
- It is heavy and not easy to cultivate.

**Improvement of clay soil for crop production**

- By draining i.e. removing excess water
- Adding organic matter
- Adding other types e.g sand to improve on its properties.

**Loam soil**

Loam soil contains almost equal proportions of sand, clay and silt.

**Properties of loam soil**

- It is well aerated.
- It is moderately drained.
- Moderately coarse textured.
- Has adequate plant nutrients
- Not easily leached.
- Has a high population of soil living organisms.
- It has high organic matter content.
- Has a moderate water holding capacity.
- Easy to till.
- Have loose particles that crumble when pressed.

## SOIL SAMPLING AND TESTING

Soil sampling refers to the act of taking or obtaining small quantities (samples) of soil from different parts of the field and taking to the laboratory for analysis.

### Aims of soil sampling

- To know the pH of the soil.
- To know the organic matter content of the soil.
- To know the moisture content of the soil.
- To know the type of fertilizer to apply to the soil.
- To know the type of crop to be grown in the soil.
- To know the amount of air in the soil.
- To determine the drainage and water retention capacity of the soil.
- To know the capillarity of the soil.
- To know the structure and texture of the soil.
- To know the nutrient level of the soil.

- To find out the presence of living organisms in the soil.
- To fairly estimate how much increase in crop yields expected after applying a certain fertilizer.

After analysis, appropriate recommendations are made as to how the farmer can improve his soil by either applying fertilizers or other good farming practices.

## METHODS OF SOIL SAMPLING

- Transverse method
- Zigzag/ random method

- **Transverse method**

  In this method, the samples are taken from sites that are selected to run diagonally from one corner to another as shown below.

- **Zigzag/ random method**

  In this method, the samples are taken from sites which are randomly chosen in a zig zag format.

**Procedure for obtaining a soil sample**

- Clear the vegetation around the area from which you are going to get the soil sample.
- Make a vertical cut into the soil to a depth of 15-25 cm for crop land and 5 cm for pasture land.
- Take a slice from the vertical cut made or use a soil auger to scoop out the soil.
- Collect the soil from many points or sites usually 15 to 20 on average.
- Mix the soil thoroughly to get a representative or composite sample.
- Put the representative sample in a container e.g. soil tube or bag.
- Label the container using a tag from both inside and outside with the following information:
    - Name and address of the sender.
    - Plot of field number.
    - Place of .location.
    - Date of sampling

***AREAS TO AVOID WHEN GETTING SOIL SAMPLES***

- Ant hills

- Old house sites
- Manure heaps
- Kraals
- Ditches
- Road embankments
- Furrows
- Where vegetation has been burnt
- Very wet areas
- Pig sties

*NB*: samples of soil from these areas give a misleading result therefore the areas should be avoided.

*Tools used in soil sampling*

- Hand trowel: to cut very thin slices of soil
- Soil auger: to tell the depth of sampling
- Hand hoe
- Shovel and spade: used as trowel
- Wheel barrow
- Panga or knife

*Diagrams of tools used in soil sampling*

## SOIL PROPERTIES

The soil properties can be classified into two i.e.

- Physical properties
- Chemical properties
- *Physical properties*

These include:

- Soil structure

- Soil texture
- Soil temperature
- Soil colour
- Bulk density
- Capillarity
- Drainage
- Water holding capacity
- Soil consistency/ stability
- Soil aeration
- Porosity

- *Soil structure*

Soil structure refers to the overall arrangement of soil particles. OR

The compactness or looseness of the soil particles.

The arrangement of soil particles results into the formation of different shapes of the soil.

The individual soil particles join together to form aggregates.

*Classes of soil structure*

Soil structure can be classified into three (3) major classes

- *Structureless* or single grained: these are single separate grains that do not stick together e.g. sand.
- *Massive:* This is found in very fine textured soil where soil particles unite with others. They are without pores almost and particles are more or less cemented.
- *Aggregated:* This is an ideal structure where particles stick together to form secondary and large particles. There are spaces between granules.

**Types of soil structure**

- *Crumb:* This is commonly found in top soil. It has a lot of organic matter that makes it good for growing crops especially vegetables. It is very porous and well drained.

- **Granular structure***:* here the particles are in form of granules but grouped together. It is common in top soil and is porous.

- **Blocky***:* These particles are arranged in form of cubes or blocks. They are hexagonal in appearance with sharp edges. Common in subsoil of some heavy clay soils (anthill).

- **Columnar***:* The aggregates are arranged in form of column – like structures. They are pillar – like with round tops.

- **Prismatic***:* the soil particles are arranged in form of prisms with leveled tops. It is found in sub soils of arid and semi arid regions.

- **Platy like structure** *:* These are arranged on top of each other to form thin horizontal plates. They are common at the soil surface or as surface crust. Water mostly moves laterally.

## Importance of soil structure

- It controls passage of water through the soil (soil drainage). Granular structure enables more rapid movement of water into the soil than platy.
- It controls the passage of air through the soil ( aeration)
- Controls soil temperature through its control on aeration.

- Controls the water holding capacity of the soil.
- Controls soil pH by controlling the passage of air and regulating the amount of carbon dioxide in the soil. High levels of carbon dioxide cause acidity.
- It controls the workability of the soil i.e. single loose grained soils are easily worked on and less sticky.
- It controls the ability of plant roots to penetrate into the soil.
- It influences the occurrence of soil erosion.
- It influences the availability of plant nutrients in the soil.

**Stability and consistency of soil structure**

Stability refers to the resistance of that soil to any changes caused by external forces such as rainfall, cultivation e.t.c.

Stability of the soil is influenced by:

- Soil texture i.e. soils rich in sand are less stable than those rich in clay.
- Organic matter content. The higher the amount of humus, the higher the stability of the soil.

*Consistency of soil structure:* is the degree of cohesion of individual soil particles and the resistance of these aggregates/ particles to breakage when they are handled.

**Factors that influence the formation of soil structure ( aggregation)**

- *Organic matter content:* organic matter is sticky and brings soil particles together hence increasing stability.

- *Soil water:* moist soils are plastic than dry soils and so are easy to bind together. Too much moisture causes dispersion of the particles.
- *Living organisms:* some living organisms produce substances that cement soil particles together. E.g earthworms.
- *Compaction:* this leads to the formation of a platy structure which comes as a result of destruction of other structures.
- *Soil texture:* soils with large particles e.g. sandy soils are not plastic enough and so their particles do not easily bind together.
- *Liming:* liming encourages formation of soil aggregates due to the favorable effect of Ca on the soil.

**Ways in which soil structure is destroyed**

- Continuous tillage: this breaks and separates the soil aggregates.
- Mining that breaks the soil particles.
- Soil erosion that washes away the top soil.
- Water logging: this leads to dispersion of soil particles.
- Lack of cover crops: This exposes the soil to erosion.
- Poor harvesting practices that do not add organic matter to the soil.
- Overgrazing: this creates a bare surface exposed to the effect of soil erosion.
- Leaching: this leads to loss of Ca which binds soil particles together.
- Pollution: This kills the soil living organisms.

**How soil structure is maintained**

- Minimum tillage
- Growing cover crops to reduce rate of erosion.
- Application of organic manures to bind soil particles together.
- Mulching to control soil erosion and add organic matter.

- Bush fallowing involving grass leys to bind soil particles.
- Aforestation to control soil erosion and add organic matter.
- Draining to remove excess water that causes dispersion.
- Liming to bind soil particles together.
- Controlled irrigation to provide soil moisture.
- Controlled grazing to prevent overgrazing and soil erosion.

**ii) Soil texture**

Soil texture refers to the roughness or smoothness of the soil.

OR

It is the measure of the proportion of sand, silt and clay in the soil.

**Methods of determining soil texture**

- Sedimentation/ mechanical method
- Finger feel method
- Rolling experiment/ cylinder method

**Experiment to show that soil is made up of particles of different sizes/ determination of soil texture by sedimentation method (mechanical method)**

*Apparatus:*

- Garden soil, water, Sodium carbonate, measuring cylinder

*Procedure*

- 50g of soil is put in a measuring cylinder.
- Add 4x its volume of water containing sodium carbonate.
- Cover the mouth of the cylinder with your palm.
- Shake vigorously for about 2 minutes.

- Place the cylinder on a table and allow the contents to settle for about 20 minutes.

*NB:* Sodium carbonate helps in dispersion of soil particles.

Diagram

Observation:

The soil particles settle according to their sizes in different layers. i.e. heavy coarse gravel, sand, silt, clay, humus/ organic matter in that order.

*Conclusion*

Soil is made of different sized particles which when subjected to the experiment sediment according to size.

- *Determination of soil texture by finger feel method*

This is mainly a field method where soil is felt by rubbing the soil between the first finger and the thumb when it is dry and when it is moist.

- Clay feels smooth when dry and sticky when wet.
- Sand feels rough when dry and gritty when wet.
- Silt feels floury/ powdery when dry and slightly sticky when wet.

- *Determination of soil texture by cylinder method/ rolling experiment*

Soil samples are wetted with water.

The soil is then rolled between palms into cylinders.

*Observation:*

- Sandy soil doesn't roll into a cylinder.
- Loam soil moulds into a cylinder but cylinder breaks when bent into a ring.
- Clay soil moulds easily into a cylinder which is easily bent into a complete ring without breaking.

*Importance of soil texture*

- It influences soil aeration.
- It influences the water holding capacity of the soil
- It influences soil drainage.
- It influences root penetration into the soil.
- It affects soil temperature
- It influences the workability of the soil i.e. sand soil is easier to till.
- It influences soil capillarity.
- It influences soil's susceptibility to erosion i.e. sand is easily eroded.
- It influences the ability of the soil to hold soil nutrients i.e. sand soil is easily leached.

iii) *Soil temperature*

This refers to the measure of the hotness or coldness of the soil.

*Importance of soil temperature*

- It controls the moisture content of the soil by affecting the rate of evaporation.
- It affects the aeration of the soil by influencing the moisture content of the soil.
- It controls the germination of seeds. All seeds require a certain critical temperature for activation of their enzymes before germination can occur.
- It controls root development and expansion. Roots need warmth to grow and indirectly by affecting aeration and moisture content.
- Increasing soil temperature increases cell wall permeability.
- It affects microbial activity. With in a given temperature range, increase in temperature increases microbial activity.
- It indirectly affects the availability of plant nutrients by affecting the rate of breakdown of organic matter.
- It affects the rate of weathering by influencing by influencing the rate of chemical reactions and microbial activity.
- It indirectly affects soil pH by affecting microbial activity, aeration and break down of organic matter.
- It controls uptake of water and mineral salts through its control on root extension, water movement and solubility.

*How to maintain soil temperature*

- Mulching; this keeps the soil cool during hot days.
- Shading. This cools the soil surface.
- Irrigation; this cools the soil from excessive external heat.

- Planting of cover crops.
- Application of organic matter.
- Drainage to remove excess water.

iv) *Soil colour*

Soil colour is determined by the colour of the parent material, iron and organic matter in the soil.

*Significance of soil colour*

- It can be used to determine the age of the soil.
- It indicates the presence of organic matter in the soil i.e. dark colour indicates the presence of organic matter.
- It can be used to reveal the soil profile horizon.
- White to grey colour indicates the presence of certain minerals e.g. White for carbonate lime deposits.
- It indicates the extent of mineral loss through leaching.

*Effects of soil colour on soil properties*

- Affects soil temperature: black colour absorbs more heat causing a rise in soil temperature.
- Affects soil nutrient levels: black colour absorbs more heat causing moisture loss through evaporation.
- Microbial activities: black colour indicates OM content hence improving microbial activities.

v) *Bulk density and Particle density*

Bulk density is the ratio of the weight of the soil to the volume of the soil.

$$\text{Bulk density} = \frac{\text{Weight of soil (g)}}{\text{Volume of soil (cm3)}}$$

Bulk density is also defined as the mass of dry soil per unit volume.

It is calculated for dry soil and takes into account mass or volume of particles and spaces. It excludes water.

*Factors that influence soil bulk density*

- Pore space size: soils that are loose and porous have lower bulk density than compacted ones.
- Number of pore spaces: the fewer the pore spaces, the greater the bulk density e.g. in sand.
- Particle sizes: clay soils with tiny particles have lower bulk density than sand with large particles.
- Organic matter content: increase in organic matter decreases the bulk density of the soil.
- Soil structure: the more compacted the soil structure, the higher the bulk density.
- Tillage/ cultivation: Ploughing of a piece of land decreases the bulk density since it increases the pore space.
- Cropping: cropped soils have generally a higher bulk density than un cropped soil.
- Machinery movement over the land: use of heavy machines e.g. tractors on a wet land compacts the soil and increases the soil bulk density.

*Particle density*

Particle density is the ratio of weight of solids to the volume of the solid soil sample.

i.e. particle density = $\frac{\text{Weight of solid (g)}}{\text{Volume of solids (cm}^3\text{)}}$

It is a measurement for solid particles and does not include water weight and pore spaces.

Particle density generally increases with soil depth due to decrease in organic matter.

- *Aeration*

Soil aeration is the circulation or movement of air with in the soil.

Soil living organisms require gaseous exchange for survival.

*The factors that influence the rate of gaseous exchange are:*

- Soil pore space sizes
- Soil temperature.
- Soil depth
- Amount of moisture in the soil
- Mulching / covering of the soil

*Causes of poor aeration*

- Water logging.
- Presence of clay
- Compaction of the soil by use of heavy machines.
- Deep soils.

- *Capillarity*

Soil capillarity is the ability of water to rise through the small pores of the soil.

The rise of water is brought about by the forces of adhesion and cohesion.

*Importance of soil capillarity*

- It helps to make water available to plants.
- It enables the plant to have access to plant nutrients the dissolve in water.

*Experiment to investigate soil capillarity*

*Procedure*

- Get a tube that is open on both ends ( capillary tube)
- Plug the bottom end of the tube with cork or cotton wool as shown below.
- Fill the tube with dry soil samples
- Place the plugged end of the tube in a water bath and leave it to stand for some time.
- Note the speed of water movement in the soil. That represents the capillarity of the soil.

*Diagram*

Note :

- Water rises fastest in sand and highest in clay

This is because sand has bigger particles with larger pore spaces that allow easy movement of water.

*Conclusion:*

- Clay has the highest capillarity
- Sandy has the lowest capillarity
- *Drainage and water retention*

*Experiment to determine porosity/ drainage/water retention capacity of the soil*

- Set a measuring cylinder and place a funnel at the mouth of the cylinder.
- Plug the funnel with cotton wool or filter paper.
- Measure a given quantity of dry soil and place it in a funnel.
- Allow the water to drip through the funnel into the measuring cylinder until it stops dropping,

*NB*:

The amount of water collected in a measuring cylinder is the water that drained through the soil.

- *Amount of water retained*

= Amount of water added to the soil – volume of water collected in the cylinder

- *Percentage of water retained*

  = Amount of water retained x100

  Amount of water added

- *Percentage of water drained*

  = Amount of water collected x 100

  Amount of water added

Drainage and water retention are inversely proportional i.e. a soil with good drainage has poor water holding capacity/ retention.

*Arrangement of the experiment*

*Example*

| *Soil types* | *Volume of water used* | *Volume of water drained* | *Volume of water* |
|---|---|---|---|

| | | | |
|---|---|---|---|
| | | | *retained* |
| Sand | 100 | 70 | |
| Loam | 100 | | 40 |
| Clay | 100 | 10 | |

Fill in the blank spaces in the table

Calculate the percentage of water drained and retained in each sample

*b) Chemical properties of the soil*

The chemical properties of the soil deal mainly with the chemical composition of the soil. They include:

- Soil pH
- Cation Exchange Capacity
- Anion Exchange Capacity
- Mineral content

*SOIL pH*

Soil pH is the degree of acidity or alkalinity of the soil.

pH stands for potential of Hydrogen i.e. the concentration of hydrogen ions in the soil. It is calculated using the formula,

$pH = - log\ H^+$ OR $pH = \log [1/H^+\}$

The degree of acidity depends on the concentration of hydrogen ions,

- When the soil is acidic; hydrogen ion concentration exceeds hydroxyl ion concentration.

- When the soil is neutral, hydrogen ion concentration equals hydroxyl ion concentration.
- When the soil is alkaline or basic, hydroxyl ion concentration is greater than hydrogen ion concentration.

*The pH scale*

- pH ranges from 1 to 14
- pH 7 is neutral
- Above pH 7, the soil is alkaline or basic.
- Below 7, the soil is acidic.

*Causes of soil acidity*

- Presence of acidic soluble salts which may arise from fertilizers, weathering of minerals etc.
- Leaching of bases which are later replaced by hydrogen ions.
- Presence of acidic organic matter.
- Water logging
- Acidification due to rain water
- Biological activities in the soil
- Artificial fertilizers e.g sulphate of ammonia
- Uptake of bases by plants
- The soil may have been formed from acidic parent material e.g granite

*Causes of soil alkalinity*

- Weathering of limestone.
- Addition of bases e.g lime.
- Irrigation
- Drought conditions

- Ground water

*Ways of adjusting soil pH*

a) *Changing pH from alkaline to acidity (Lowering soil pH)*

- Addition of acidic organic matter e.g. organic matter from pine needles.
- Addition of acidic fertilizers e.g. sulphate of ammonia

- *Changing pH from acidic to alkaline (Increasing pH)*
  - Lower pH can be corrected by addition of agricultural lime, in a process called liming.

*Examples of lime include:*

- Calcium carbonate ( calcite)
- Calcium Magnesium carbonate ( dolomite)
- Calcium Oxide ( Quick lime)
- Wood ash
- Paper mill

*Qualities of a good liming material*

- It should be cheap
- It should be easy to handle, store and apply
- It should have a mild effect on pH
- It should last long in the soil
- It should be able to improve the soil structure

- It should easily dissolve in the soil solution.
- It should contain desirable cations e.g. Calcium

*Factors to consider before liming*

- The pH of the soil
- Type of crop to be grown
- Economic returns in relation to the cost of lime.
- Percentage base saturation.
- Fineness of limestone or carbonate used.
- Amount of manganese present

*Loss of lime from the soil*

- Soil erosion
- Crop rotation
- Leaching

*Importance of lime*

- It improves the soil structure
- It prevents certain fungal diseases which are common in acidic conditions.
- It fastens decomposition of organic mater.
- It neutralizes acidity in the soil
- It supplies calcium in the soil.
- It improves root nodulation and hence nitrogen fixation.
- It makes nitrogen and phosphorus available to plants.

*Methods of determining soil pH*

There are mainly three methods of determining soil pH:

- Use of Universal indicator solution.
- Use of litmus paper
- Use of the pH meter

- *Use of universal indicator solution*

*Apparatus*

- Test tube
- Spatula
- Barium sulphate
- Dry soil sample
- Water
- pH meter

*Procedure*

- Put a small quantity of soil in a test tube using a spatula
- Add to it an equal volume of Barium sulphate. This will help to break soil particles and settle them at the bottom of the test tube.
- Shake the test tube end to end to mix the two thoroughly well.
- Add distilled water and shake vigorously.
- After a few minutes, compare the colour in the test tube with the colours on the pH chart.
- Read off the pH value of the colour that corresponds to the colour of the clear solution in the test tube.

*Observation /deduction*

- Red colour indicates acidic pH ( 1-2)
- Pink colour indicates moderately acidic pH ( 3-4)
- Yellow colour indicates weakly acidic (5-6)
- Green colour indicates neutral (7)
- Deep blue/ Violet/ indigo colour indicates ( 9-14)

- *Determination of pH using litmus paper*

*Apparatus*

- Test tube
- Litmus paper
- Distilled water
- Dry soil sample
- Spatula

*Procedure*

- Fill a test tube up to ¼ with soil sample and distilled water.
- Cover the open end of the test tube with your thumb and shake vigorously.
- Place the test tube in a rack and allow the contents to settle.
- Obtain a strip of litmus paper (blue and red) and dip them into the soil solution. Make sure they don't touch each other.
- Observe the colour changes on the litmus paper

*Conclusion and deduction*

- Acidic soil turns blue litmus paper red.
- Red litmus paper remain red if the soil is acidic
- Red litmus paper turns blue if the soil is alkaline
- Blue litmus paper remains blue if the soil is alkaline

- No colour change on both blue and red litmus papers if soil is neutral

*Importance of soil pH*

- It affects availability of soil nutrients. Some nutrients are available in very acidic or alkaline soils e.g P, Mn, Bo, Fe, Zn become less available at pH above 8.5.
- It controls the presence of living organisms in the soil. Most living organisms do not prefer very high or very low pH conditions.
- It influences the type of crop to be grown. E.g. tea does best in acidic soils while oats and vegetables prefer slightly alkaline soils, cotton grows best between pH 5 and 6.
- It controls the prevalence of disease causing organisms e.g fungal diseases are common in acidic soils while bacterial diseases are common in alkaline conditions.
- It influences the type of fertilizer to be applied e.g. sulphate of ammonia should not be applied to acidic soils because it increases acidity of the soil.

THE SOL PROFILE

Soil profile is the vertical cross section of layers (horizons) from top to bottom.

The soil profile shows layers in different stages of development.

Each layer differs from the others in colour, structure, thickness, composition etc.

The typical soil profile is easily distinguishable into four (4) layers or horizons. i.e. A, B, C, D.

*Diagram showing the soil profile*

*Horizon A*

- It is also called zone of eluviation where soluble nutrients are washed and deposited to the lower layers.
- It contains adequate plant nutrients.
- It contains high amounts of humus (organic matter)
- It is loose and facilitates easy penetration of plant roots.
- It is well aerated
- It is dark in colour due to the high amount of humus.
- It has more active living organisms.

*Horizon B*

- It is called the illuviation zone since it is where nutrients from top soil accumulate or get deposited.

- It contains less living organisms.
- It has more compacted soils.
- It is light brown or reddish yellow in colour.
- A hard pan may be formed which is an impermeable layer below the top soil that resists water movement.
- It resists root penetration.

*Horizon C*

- It consists of parent materials that have just started undergoing weathering.
- It is a very compacted layer.
- It does not contain humus
- It does not contain living organisms
- It is poorly aerated
- Plant roots cannot penetrate easily through it.

*Horizon D*

- It is called horizon of un
- weathered rocks
- Under ground water may accumulate on top of the bedrock to form ponds.
- Trees with excessively deep roots can obtain water from this horizon.

The soil profile may be described as:

- *Mature:* when it has clear horizons.
- *Trancated*: when the horizons are not clear due to erosion.

*Influence of soil profile on crop production*

- Soil profile influences nutrient availability.
- Soil profile influences soil aeration.
- It influences the water holding capacity of the soil.
- It influences the drainage of the soil.
- It influences availability of soil living organisms which break down organic matter.

*SOIL CATENA*

This is the horizontal sequential arrangement of different types of soil along a slope.

The types of soil differ from the bottom of a hill along the slope to the valley bottom due to weather, drainage, vegetation, topography, etc.

SOIL FERTILITY AND PRODUCTIVITY

*Soil fertility* is the ability of the soil to supply the required type and amount of nutrients for optimum plant growth.

*Soil productivity* is the ability of the soil to produce high crop yield for longer period of time.

*Factors contributing to soil fertility*

- *Good soil depth*: deep soils give plant roots a greater area for nutrient absorption.

- *Proper drainage*: well drained soils are aerated and aeration promotes healthy root development.
- *Good water holding capacity*: this ensures that enough water is retained in the soil for plant use.
- *Adequate nutrient supply*: A good soil should have correct amount of plant nutrients.
- *Good soil structure*: good soil structure ensures aeration and respiration of plant roots and soil living organisms.
- *Correct soil pH*: different plant nutrients are available 0at specific pH values.
- *Good soil texture*: a good soil texture encourages aeration, drainage, root penetration and ability to retain nutrients.
- *Good soil colour:* soil colour influences soil temperature e.g. dark colour absorbs heat.
- *Freedom from pests and diseases*: weeds compete with crops for plant nutrients and other growth factors. Pests make utilisation of nutrients by plants ineffective.
- *Presence of organic matter*: a fertile soil should have large amounts of humus because humus improves soil structure and adds plant nutrients into the soil.

*Loss of soil fertility*

- *Leaching*: this refers to the loss of nutrients from the upper to the lower layers of the soil where plant roots may not access them.
- *Soil erosion*: the washing away of top fertile soil by running water, wind e.t.c. It ends in loss of nutrients as well.
- *Mono cropping*: this leads to exhaustion of a particular nutrient from the soil.

- *Continuous cultivation of the soil*: this destroys the soil structure making the soil loose and easily eroded.
- *Presence of weeds:* These compete for growth factors with the crops.
- *Water logging:* This encourages acidity and leaching of nutrients, and poor aeration.
- *Build up of pests and diseases.*
- *Soil capping*: this refers to the development of impervious layers on the soil surface as a result of use heavy machines.
- *Change in soil pH*: this makes some nutrients and living organisms un available.
- *Development of hard pans*: these are impervious layers below the soil surface. They form as a result of Ploughing at the same depth for a long time.
- *Burning of vegetation*: this destroys soil living organisms, organic matter and causes evaporation of nutrients.
- *Accumulation of salts*: these may make the soil saline and toxic and hinder absorption of water into the plant roots.
- *Pollution* of the environment with materials like polythene paper, plastic materials, toxic chemicals, etc.
- *Excessive irrigation*: this leads to loss of soil particles and nutrients.
- *Excessive drainage*: This leads to loss of soluble nutrients which are drained off with water.

*Maintenance of soil fertility/ ways of improving soil fertility*

- Addition of organic matter.
- Use of minimum tillage to conserve soil structure.

- Application of inorganic fertilizers.
- Mulching to conserve soil moisture.
- Weed control.
- Erosion control by afforestation, terracing e.t.c.
- Control of pests and diseases using chemicals and cultural methods
- Controlled irrigation in areas with limited water supply.
- Crop rotation with grass brakes to help the soil regain its fertility.
- Improving on drainage by planting deep rooted crops or constructing surface drains.
- Controlling pH e.g. through liming to ensure availability of nutrients and living organisms in the soil.
- Proper disposal of wastes to avoid pollution.

**PLANT NUTRIENTS**

These are elements required for proper plant growth and develpment.These elements are absorbed by plant roots in an ionic form which may be positively charged like $NH_4^+$,Ca2+ or negatively charged like $CL^-$,$NO3^-$etc.

**CATEGORIES OF PLANT NUTRIENTS**

Plant nutrients are divided into two major groups namely;

i. Major/macro/Essential plant nutrients

ii. Minor/micro/trace elements

**Macro Plant Nutrients**

These are elements required by plants in large quantities(amounts) and if they are missing,the plants suffer serious effects

**Micro Plant Nutrients**

These are plant nutrients required by plants in very small quantities but should be present to enable plants grow well.

**Examples of macro plant nutrients**

*i.* Hydrogen

*ii.* Carbon

*iii.* Oxygen

**From soil**

*i.* Nitrogen

*ii.* phosphorous

*iii.* Potassium

*iv.* Calcium

*v.* Magnesium

*vi.* Sulphur

**Examples of Micro plant Nutrients**

*i.* Iron

*ii.* Manganese

*iii.* boron

*iv.* Molybdenum

*v.* Zinc

*vi.* Chlorine

*vii.* Copper

*viii.* Cobalt

**SOURCE OF NUTRIENTS IN THE SOIL**

*i.* From the soil solutions e.g nitrogen,phosphorous etc

*ii.* From already decomposed materials

*iii.* From chemical or inorganic fertilizers e.g sulphate of ammonia

*iv.* From organic manure such as FYM,Compost etc

*v.* From exchangeable ions

**WAYS THROUGH WHICH NUTRIENTS ARE LOST FROM THE SOIL**

*i.* Throug the removal of crop residues especially during harvesting e.g beans harvest

*ii.* Through soil erosion where topsoils with much nutrients are washed away

*iii.* Through Denitrification process where by nitrogen in the soil is converted into gaseous form and taken back to the atmosphere.

*iv.* Through leaching i.e downward movement of nutrients to layers where plant roots can not easily reach.

*v.* Excessive drainage of land causing nutrient loss in solution

*vi.* Through burning of vegetative materials that cause loss of nitrogen from the soil

*vii.* Excessive irrigation leading to leaching of nutrients

*viii.* Through immobilization i.e build up of nitrogen into microbial tisues during decomposition rendering it unavailable for plant use.

## MAJOR PLANT NUTRIENTS

1. **Carbon,ydrogen and oxygen**

**C**arbon and oxygen are derived from air through photosynthesis,Hydrogen is got from soil water.

**Functions**

- They help in the frmation of cellwalls of plants
- They enable plants to carryout photosynthesis being raw materials

**Deficiency symptoms**

- Yelloe colour between the veins of the leaves
- Wilting,drying and finally death of the plant

## NITROGEN

This is the most important plant nutrient in the soil needed for crops growth and development

Sources of nitrogen in the soil

- Nitrogenous artificial fertilizers e.g urea,CAN etc
- Application of organic manure/matter

- From atmospheric by rhizobia bacteria and free living bacteria(azotobacter)
- Through lightening
- Ammonification i.e conversion of amino acids into ammonia

Absorption of nitrogen in the soil

It is absorbed by plants in form of Nitrates($NO3^-$) and ammonium ions($NH4^+$)

**IMPORTANCE OF NITROGEN TO PLANTS**

- It is used in the formation of chlorophyll
- It heps in cell division which brings about growth in plants
- It is a constituent of protein formation in plants
- It is necessary for quality of vgetative cropslike cabbages,amaranthus etc
- It controlsthe availability and use of other nutrients by plants e.g phosphorous and potassium
- It controls the/increases the succulence of fruits and quality needed e.g pineapples,water melons etc
- It increases the size of grains among cereal crops like rice

**DEFICIENCY SYMPTOMS OF NITROGEN**

- Chlorosis i.e leaves lose their green colour(chlorophyll) and become yellowish
- Stunted growth(dwarfness) because of limited cell division
- Restricted root growth and development
- Pre-mature loss of leaves

- pre-mature ripening of fruits/seeds or pods
- Production of pigments other than chlorophyll e.g anthrocyanin in tomatoes
- High susceptibility of crops to diseases hence leading to poor quality crops.

**EFFECTS OF EXCESSIVE APPLICATION OF NITROGEN IN THE SOIL**

- Lodging of stems i.e stems become weak and bend down because of excessive succulency(alot of water)
- Prolification of the plant i.e development of so many branches and leaves
- Etiolation i.e plants become thin and tall
- Delayed maturity due to stunted growth
- Excessive veetative growth especially in tomatoes and vegetables
- Weakening of the roots e.g in cotton the fibre weakens hence poor root growth and development
- Scorching i.edrying of some leaves
- Poor crop production interms of yield due to stunted growth and excessive production of leaves.

## *PRINCIPLES OF CULTIVATION*

Land clearing: before land is cultivated, it must be cleared of natural vegetation e.g. bush and forests.

A piece of land that has been cleared and made ready to receive planting materials is called a *seedbed.*

*Objectives/ importance of seedbed preparation/ land clearing*

- To kill weeds by either burying them or exposing them to sunlight.
- To improve o soil aeration.
- To break the impervious layers of the soil so as to facilitate good water drainage.
- To destroy the pests by interfering with their life cycle.
- To get the right tilth for crops to be grown.
- To level the ground so as to ensure uniformity of the level of the seedbed.
- To incorporate fertilizers and manures into the soil.
- To burry crop residues of the previous season for easy planting.
- To loosen up the soil surface so as to facilitate water infiltration and planting.
- To control soil erosion by preventing surface runoff especially where ridges are used.
- To bring the leached minerals to the top soil by turning the soil.

*NB: There are a number of operations carried out on virgin land. These include:*

- Bush and tree clearing.

- Burning of stamps.
- Stamping i.e. removal of stamps and roots.
- Burning of stamps.
- Arranging and removing trash.
- Draining the land when it is swampy.
- Leveling of the land and filling up the stump holes.
- Laying out of contours in fields.
- Ploughing and digging to remove weeds.
- Pulverizing and digging to remove weeds.
- Ridging and raking.
- Removal of stones.
- Making garden edges straight.

METHODS OF LAND PREPARATION

- Hand/manual method.
- Ox- cultivation.
- Mechanical method

- Hand/ manual method

This involves use of hand tools e.g. hoes, pangas, slashes, axes e.t.c. and the source of power is man.

*Advantages*

- Creates employment
- Cheap for small scale farmers.
- Can be used in stony and hilly areas with less difficulty.
- Requires no specific kills.

*Disadvantages*

- Very slow method.
- It only operates to a limited depth.
- It is expensive for large scale farmers.
- It is inefficient in hard soils/ thick vegetation.
- Does not thoughly bury the vegetation.
- Operations may be delayed until the ground is softened by rain and this delays the time of planting.
- It is tiresome on a large scale.

- Ox cultivation method

This involves the use of ox- drawn implements e.g. ox- plough. The main source of power in this method is farm animals e.g. bulls (oxen), donkeys.

*Advantages*

- It is faster than the manual method.
- It is cheaper on large scale farms.
- It buries the vegetation better than the manual method.
- Requires little skills.
- More work can be done in a short time.
- Land is ploughed at uniform depth.
- Maintenance of the implements and their accusation is cheap.

*Disadvantages*

- Cannot be used in hilly, stony or densely vegetated areas.
- Requires enough pastures land for grazing the animals.
- The areas used are limited by tsetse fly infection.

- Animals are prone to epidemics/ diseases.
- It takes time to train the animals and it is also risky.
- The work output of the animal is affected by the health conditions of the animals.
- The animals require soft light soils in order for them to work well.

- Mechanical method

This involves the use of categorized machines e.g. tractors, bull dozers and their implements e.g. disc ploughs. The main source of power is fuel.

*Advantages*

- It is quick/fast.
- There is better burring of vegetation.
- Cheap in the long run.
- Efficient in its operations.
- Land preparation is easily done on time.
- It releases labor for other operations.

*Disadvantages*

- Machines are expensive to buy.
- Requires skilled labour to operate the machines.
- Creates unemployment.
- The use of machines especially the heavy ones can lead to compaction of the soil which interferes with water infiltration.
- The machines ant their implements used are also expensive.
- It is only economical on large scale farms.
- The fume produced by machines pollutes the environment.

*TYPES OF LAND PREPARATION/ SEEDBED PREPARATION*

Al the activities in land preparation can be generally divided into two (2) categories;

- Primary cultivation.
- Secondary cultivation.

*Primary cultivation*

This includes the first activities done when opening up a piece of land or after removing the previous crop.

It involves activities like cutting trees, stamping, slashing and first Ploughing. It is a heavy job which uses heavy implements e.g. disc ploughs, moldboard plough, disc plough, chisel plough.

*Importance/ objectives of primary cultivation*

- To break the hard soil surface.
- To improve the aeration of the soil.
- To burry the weeds and weed seeds.
- To improve water infiltration.
- To incorporate organic matter into the soil.
- To prepare big lumps of soil for galvanization during secondary tillage.
- To bring the leached minerals to the top soil.
- To provide enough depth in the soil for root penetration and expansion.
- To invert top soil and bring a fresh layer to the surface for further weathering.

*Secondary cultivation*

It is usually done atleast 2 weeks after primary cultivation. It involves second Ploughing, leveling and harrowing of the seedbed.

The time of two weeks is to allow the weeds and the vegetation that were buried in primary cultivation to decompose/ germinate and grow such that they can be destroyed during secondary cultivation.

*Objectives of secondary cultivation*

- To level the land/ ground in preparation for planting.
- To incorporate/ mix manures and fertilizers in the soil.
- To kill the weeds that have germinated after primary tillage.
- To create the right tilth for the crop.
- To break up the large lumps of soil after primary tillage.
- To improve aeration, drainage and soil structure.
- To control pests and diseases as they desiccate due to exposure to the sunshine.
- To increase on the water infiltration.

NB: Tools used in secondary cultivation include: disc harrows, tine harrows, tined cultivators.

FACTORS THAT DETERMINE THE NUMBER OF TILLAGE OPERATIONS CARRIED OUT

- *Initial condition of the land:* densely vegetated land requires more operations than lightly vegetated land.
- *Types of soil:* sandy and other lighter soils require few operations than clay.
- *Type of equipment used:* a disc plough leaves the land in a very untidy state that necessitates several other operations.

- *The type and size of seeds to be planted:* small size seeds require more operations than big sized seeds.
- *Financial stand of the farmer:* richer farmers can afford to carryout more operations than poor ones.
- *Moisture content of the soil:* Very dry soils are hard and require more operations but moist soils are soft and easy to till and so require fewer operations.
- *Liability to erosion:* if the soil is liable to erosion e.g. sandy soils, less operations should be done to avoid soil erosion.
- *Topography:* very steep land requires rough Ploughing to avoid erosion and hence less cultivation preparations than gentle slopes.

*Disadvantages/ limitations of cultivation*

- It leads to destruction of soil structure.
- Encourages germination of formerly buried weeds.
- Ploughing at the same depth may also lead to soil capping.
- It increases the rate of leaching of nutrients by increasing the passage of water into the soil.
- It leads to destruction/ killing of soil living organisms especially through mechanical damage.
- It increases the rate of oxidation of soil nutrients and organic matter.
- Increases the loss of soil moisture through evaporation.
- It may result into soil erosion due to destruction of soil structure.

## MINIMUM TILLAGE

This is the practice of preparing land and having crops planted but with minimum disturbance of the soil.

*Advantages of minimum tillage*

- Helps to conserve soil moisture.
- Reduces the death/ killing of soil living organisms.
- Saves the farmers' money.
- Maintains the soil moisture.
- It saves time and requires less labor.
- It reduces soil erosion by providing soil cover and good soil structure.
- It reduces over decomposition of organic matter.

*Disadvantages*

- Weeds with underground structures e.g. rhizomes, bulbs are not killed or destroyed.
- There is incomplete decomposition of organic matter.

## AGRONOMIC PRACTICES

These refer to the activities/ practices that are carried out in the cultivation of crops to ensure proper growth and high yield of crops. These include:

- Early/ timely planting.
- Correct spacing of crops.
- Poor seedbed preparation.
- Use of recommended planting depth.

- Seed selection and seed dressing.
- Application of fertilizers and manures.
- Gapping.
- Pruning.
- Pest and disease control.
- Timely harvesting and drying of produce.
- Mulching
- Irrigation.
- Earthing/ digging around the plant.
- Sorting and grading.

- *TIMELY/ EARLY PLANTING*

  Planting of crops should be done at the beginning of the rainy season.

  *Advantages of timely planting*

  - Plants/ crops benefit from the nitrogen flush releases during the dry weather.
  - Crops also get enough moisture from the soil at critical stages of growth.
  - Plants also escape damage/ attack by pests and diseases especially those that come late in the season.
  - Crops get a good start against weeds.
  - Crops grow and mature when conditions are suitable for harvesting.
  - Harvesting of crops reaches when market conditions are good and prices are high.

- The farmer carries out his farming activities on programme without delay.

- *TIMELY SEED PREPARATION*

Land should be opened atleast six (6) weeks before planting. Land that is prepared hurriedly and seeds sown immediately make the plants stunted due to competition with the microbes.

- CORRECT SPACING
  - Helps to suppress the Weeds.
  - Each crop gets enough nutrients for proper growth.
  - Reduces competition for light between crops.
  - Provides optimum plant population per unit area and this leads to high yields.
  - Lowers the seed rates i.e. less seeds are used for planting.
  - It controls pests e.g. close spacing in g.nuts controls the aphids.
  - Mechanization is also possible.
  - It is easy to carryout other agronomic practices e.g. weeding, spraying, pruning, harvesting e.t.c.

FACTORS THAT DETERMINE THE SPACING OF CROPS

- *Growth habit of the crop*: Crops that spread widely require wider spacing than those with erect growth.
- *Planting method*: close spacing is used in broadcasting and wider spacing in row planting.
- *Amount of moisture/ rainfall*: close spacing is possible for areas with high moisture content and vice versa.
- *Level of fertility of the soil:* close spacing is recommended for more fertile soils than less fertile soils.
- *Purpose for which the crop is grown:* maize crop grown for silage making is closely spaced than that for grains.

- *Type of machinery to be used:* wide spacing allows use of machines during weeding and spraying.
- *Life span of the crop:* short term crops are closely spaced than long term crops.
- *Whether the crop is pure stand or intercropped (cropping system).*
- *Disease control measures e.g.:* close spacing in g. nuts for control of g. nut rosette disease.

- SEED SELECTION AND DRESSING

Seed selection is the choosing of the best seeds to be planted so that they are able to grow into mature crops and give high yields.

The seeds should be dressed to prevent attack and damage by soil and storage pests.

Seed dressing means mixing the seeds with chemical and pesticides to prevent the pests from attacking them.

- USE OF CORRECT PLANTING DEPTH
  - This ensures quick and uniform germination of seeds.
  - It also protects the seeds from drying due to too much heat.
  - It also prevents the birds and other animals from eating up or destroying the seeds.

NB:

- Small seeds are planted in shallow holes to avoid exhaustion of food reserves before they germinate.
- Seeds planted during dry weather are planted deeper than normal so thy can germinate only after rains have fallen.
- Deep planting ensures good supply of moisture for germination than planting seeds near to the surface.

- Planting depth is determined by the size of seeds and moisture ( i.e. planting depth = size of seeds * 3/4).

- GAPPING / GAP FILLING

  This is the filling of empty spaces where some seeds did not germinate. It is done by replanting fresh seeds in these gaps.

- DIGGING AROUND THE PLANT

  This is usually done for the following reasons:

  - To remove the weeds.
  - To loosen the soil so that underground stems can grow properly.
  - To encourage anchorage of the roots.
  - To cover the plant roots and tubers that are exposed to sunshine.
  - To improve the aeration around the plant roots.
  - To incorporate the fertilizers and manures into the soil.
  - To improve water infiltration around the plant.

- EARTHING UP

  This is the placement of a heap of soil around the base of the plant.

  This helps to retain/ maintain enough moisture for plant growth.

9. IRRIGATION

Crops should be irrigated to supplement soil moisture especially during the dry season.

10. MULCHING

This helps to conserve moisture and modify soil temperature.

11. WEED CONTROL:

Weeding should be done early to avoid competition with crops. Delayed weeding reduces crop growth and yields.

12. THINNING

This is the removal of weak and unhealthy seedlings to allow enough space for the remaining plants.

*Reasons:*

- To enable crops grow laterally.
- To prevent over crowding and reduce competition.
- Reduces the occurrence and spread of diseases.

13. APPLICATION OF FERTILIZERS

Artificial fertilizers e.g. phosphatic fertilizers, nitrogenous, potasic fertilizers should be applied to boost growth and production of crops.

When the artificial fertilizers are not there, natural/ organic manures can be used.

14. PRUNNING:

This is the removal of excess, diseased or injured branches or leaves or excess suckers from the plant.

*Reasons/ importance*

- Facilitates easy spraying/ harvesting of crops.
- Gives the plant a proper shape.
- Gives a convenient height for workers to ease harvesting.
- To control pests and diseases e.g. Antestia burgs in coffee.
- It economizes chemical use e.g. pesticides.
- It allows more air and light for photosynthesis thus encouraging healthy growth.

- Controls overbearing in coffee.
- Regulates the quantity and quality of the fruits.

15 PEST AND DISEASE CONTROL

Pests and diseases should be controlled effectively because the lower the quality and the yield of the crop.

16. TIMELY HARVESTING

Crops should be harvested in time to reduce field losses caused by insect pests, birds, thieves, rain, rodents, shattering and germination of seeds.

*Too early harvesting may lead to the following:*

- Inadequate drying of produce due to high moisture content.
- Difficulty in shelling and threshing.
- Small sunken seeds of poor quality.
- Susceptibility of seeds to pests and diseases.
- Low germination capacity of the seeds.

*Effects of delayed harvesting*:

- High loss due to shattering of crops, rotting of fruits and seeds in the garden
- Increased number of volunteer plants which harbor pests and diseases.
- Attraction of pests in the fields.

17. DRYING OF CROPS

This practice is carried out especially on grains to obtain the correct moisture content for storage.

*Reasons for drying grains/crops*

- To prevent the produce from rotting and decaying.
- To reduce insect damage.

- To prevent fungal growth.
- To maintain seed quality and viability.
- To prevent germination of seeds in the store.
- To reduce bulkiness of crops for easy transportation.
- To allow easy processing of the produce into other forms e.g. maize grains into flour.
- To minimize wet heating problems.
- To prolong the storage period of the grains/ produce.

18. PROPER STORAGE

This prevents spoilage of the seeds caused by storage pests. It also makes the produce available for future use.

19. PROCESSING

This is the transformation of raw materials into final utilizable products. It includes activities like threshing, winnowing, sorting and grading/packaging.

*Reasons for processing*

- To reduce the bulkiness and make transportation easy.
- Reduces wastage due to spoilage.
- Adds value to the product by improving its quality.
- Converts the product to an easy and utilizable form.
- Eases packaging.
- It extends the availability of he product in the market and prevents shortage of he products.
- It enables getting two (2) or more products from one crop e.g. maize bran and flour from maize grains.

## 20. SORTING AND GRADING

Crop products are sorted and graded to increase their value and price. Products are sorted and grades according to:

- Uniformity
- Size
- Shape
- Degree of contamination.
- Spoilage
- Maturity.

## PLANT PROPAGATION

Plant propagation refers to the way in which new plants are obtained.

There are two major Methods of plant propagation i.e;

- Seed propagation (sexual method)
- Vegetative propagation (A sexual method)

### SEXUAL METHOD

This is the method of obtaining new plants using seeds.

The seeds to be used must be fertilized containing embryo, food reserves and protective cover (testa)

On order to use the seeds as a mean of propagation, the seeds must be selected such that only those which are viable (able to germinate) are used for propagation .

### SEED SELECTION

This is the process of choosing seeds to be used in planting.

The selected seeds should have desirable qualities i.e.

- Free from pests and diseases
- Free from mechanical damages because these reduce their viability.
- Should have the correct moisture content.
- Should be fertilized i.e. it must have gone through pollination process.
- High germinability.
- Should be of good size to have a good food reserve.
- Should be mature
- Should be clean i.e free from contamination by weed, soil
- Should have a long self life.
- Should be of a desired genetic makeup i.e from high yielding, early maturing plant.
- Should be plump i.e well filled and not wrinkled.
- Should have a good vigour i.e should be able to germinate over a wide range of conditions.

SEED TREATING

Seed can be treated by

Drying
Seed dressing
Fumigations of seeds
Seed inoculation

SEED FUMIGATION

This is the use of chemicals which produce gases that fill the room, cracks on the wall, sacks e.t.c to prevent the soil land storage pests that attack the seeds.

SEED INNOCULATION

Seed inoculation is the treating of the legume seed with the correct strain of NfB.

IMPORTANCE

Promote formation of root nodules.
Increase nitrogen fixation in the soil.
Economics the use of nitrogenous fertilizers.

SEED VIABILITY

This refers to the ability of a seed to germinate when planted.
The viability of the seeds is tested before seeds are planted to establish their percentage germinability.

METHODS OF SEED VIABILITY

There are mainly 3 methods;

- The germination test method

- The lackon of technique
- Using potassium Permanganate solution.

***GERMINATION TEST METHOD***

***Materials required:***

- Seed lot
- Cotton wool /filter paper
- Water
- Petri dish /plate

PROCEDURE

- Put the cotton wool on the plate/ petri dish.
- Pick a counted number of seeds from a seed lot at random.
- Place the seeds in the cotton wool.
- Water the seeds and cover them.
- Provide all the conditions necessary for germination.
- Continue watering the seeds.
- After 5- 7 days, open the seeds and count those that have germinated and express them as a percentage of total seeds planted.

Note:

If the germination percentage is above 80% then the seeds are good for planting.

***example***

- Given that 45 seeds were tested and 36 of them germinated.

- Calculate the germination percentage
- Comment on the suitability of the seeds for planting.

Soln

= ~~36~~ 4 x ~~100%~~ 20

~~45~~ 9

= 4 x 20

= 80%

ii) The seeds are able to germinate so they are suitable for planting.

- 65 seeds tested germinated.

  48 did not germinate

  Seeds tested = 65 + 48

  113 seeds

  65 X100%

  113

  = 57.5%

***The lackon technique / Tetrazolium salt method***

***Materials***

- Seed lot
- Petridish
- tetrazolium salt solution

***Procedure***

- Accounted number of seeds are soaked in a tetrazolium salt solution
- Allow the seeds to stay in the solution over night
- Cut the seeds open to expose the embryo.
- Count the number o f seeds that have acquired pink/ reddish embryo. Thee will be the viable ones.

Express their number as a percentage of the total seeds soaked / tested.

***OBSERVATION AND CONCLUSION.***

When the viable seeds respire they produce carbon dioxide that turns tetrazolium salt solution pink or reddish.

N.B

If the percentage of the seeds with pink/ reddish embryo is 80% and above, then the seeds are good for planting.

USE OF POTASSIUM PERMANGANATE

***Materials used***

- Seed lot
- Potassium permanganate solution
- Beaker
- Heat source

***PROCEDURE***

- Put a counted number of seeds in a beaker containing potassium permangate solution.
- Heat the seeds in the beaker for some time to break the testa so that they can release the liquid in them.

- Potassium permanganate solution is usually purple in colour and will get discoloured if the seeds are vaiable.

NB

In this method, calculation of the germination percentage is impossible because it is difficult to identify the seeds that release the liquid and those that have not.

ADVANTAGES OF USING SEEDS FOR PROPAGATION

- Seeds can be stored for a longer time and they remain available.
- Seeds are easy to handle and transport because they are less bulky.
- It is generally cheaper than vegetative propagation
- It controls the spread of parent diseases in the seeds
- Plants established from seeds have longer life span than those established vegetatively.
- Ensures variation among plants since it involves crossing over pollination.
- Seeds are easy and possible to plant with machines.
- Some plants cannot be propagated vegetativley so; the only way to propagate them is by seed e.g maize, beans.
- Easy to apply fertilizers during planting time together with the seeds

DISADVANTAGES

Use of seeds encourage the spread of seedling or seed – borne diseases

It takes longer for the plant to teach maturity.

There is low uniformity among the off spring and the parents

Requires proper land preparation and nursery bed preparation which makes it tiresome.

Some seeds have prolonged dorminacy period that makes them take long to germinate.

The use of seeds encourages quick spread of undesirable characteristics of the plant.

Some plants do not have valiable seeds to be planted.

Seeds of some plants have low germinability.

## SEED DORMANCY

Seed dormancy refers to the condition/ period when the variable seeds donot germinate when planted even when provide with favourble condition of germination.

## CAUSES OF SEED DORMANCY

- Hard seed coats

  This prevents the entry of water and oxygen between the seeds. It also prevents the emergency of the plumule and radical.
- Immature seeds.

  Immature seeds have immature embryo which cannot germinate when planted.
- Presence of used coat hair which prevents the absorption of oxygen by the seeds e.g barley seeds.
- Presence of germination inhabitants that prevents the germination of sees e.g Absicic acid.
- Death of the embryo due to over storage.
- Shortage of growth stimulating hormones e.g gibberellins
- Physical factors e.g light and temperature.

  Some seeds are negatively photo plastic and their germination is inhabited by presence of light e.g onions, tobacco seeds donot germinate unless there is enough light and they are said to be positively photoplastic.

METHODS OF BREAKING SEED DORMANCY

- By soaking the seeds in growth stimulating hardness.
- By pre- chilling i.e seeds are exposed to very low temperatures for a short period of time before planting in normal conditions.
- Soaking seeds in cold water overnight to soften the testa before planting in normal conditions.
- Mechanical breaking of the seed coat (scarification) here the seeds are cracked or pricked with some paper or with pin to break the testa so that water and oxygen can go through the seeds.

  Heat treatment

  The seeds are soaked in hot water at about 80oc for 3 – 5 minutes before taken for planting.

  Chemical treatment

  Here the seeds are soaked in chemicals e.g sulhpuric acid, potassium Nitrate urea. They are then washed in water before planting.

  Teaming off the brush covering the seed coats. This will allow the entry of oxygen into the seed.

ADVANTAGES OF SEED DORMANCY

- It enables the seeds to wait for favourable conditions before germination
- Allow sufficient time for dispersal of seeds to enable them colonize new areas.
- Prevents death of the entire population in bad times since some would not have germinated

- Prevents pre- harvest germination especially of cereal crops
- Facilitates proper storage of crop produce (seeds).

DISADVANTAGES

It increases the chances of seed destruction by pts because of their prolonged stage in the dormant phase.

It leads to the decrease in the food reserves in the seed.

TYPES OF SEED DORMANCY

Primary dormancy

This occurs if seed cannot germinate immediately after their dispersal

Secondary dormancy

This usually occurs when seeds enter dormancy after failing to get favourable conditions

Questions

Write down the condition necessary for germination of seeds.

METHODS OF PLANTING

There are mainly 2 methods of planting. These include:

Broad casting

This is the scattering of seeds all over the field in a random manner.

It is usually used for seeds which are very small that cannot be easily put in the holes.

ADVANTAGES

- It is a quick method
- It is easy and simple to perform
- Requires less labour
- Helps to control of soil erosion due to good crop cover
- Good for small seeds e.g millet. Simsim

DISADVANTAGES

- Machines or mechanization cannot be used easily
- It is very difficult to cultivate or estimate the plant population
- There is uneven germination of seeds
- Requires a higher seed beds i.e water seeds
- Sometimes some areas of the seeds are overcrowded with the seeds while some parts are empty.
- Some seeds are lost to the birds and surface runoff.

ROW PLANTING

This is the method where the seeds are planted in holes, drills or fallow that are in rows/lines

ADVANTAGES

- Uses fewer seeds i.e low seed rate
- Gives optimum plant population per unit area.
- Use of machines is also easy to carryout
- There is uniform germination due to uniform planting rates
- It is easy to carry out other field practices like weeding, spraying harvesting
- Plants also get enough space.
- Easy to achieve uniform spacing.

DISADVANTAGES

- Requires a lot of labour
- Takes a lot of time
- Does not provides total crop cover for the soil.
- Requires some skill to measure the correct distance between and within the rows
- Not suitable for small seeds.

NURSERYBED

A nursery bed is a small portion of land prepared for raising seedlings before transplanting them.

A seed bed on the other hand is a piece of land which has been prepared and is ready to receive the planting materials where they can grow up.

N.B. A nursery bed is always one meter wide and of any length.

IMPORTANCE OF A NURSEY BED

- Many seedlings can be prepared in a small area.
- Makes it easy to carryout routine management practices
- Provides the best conditions for growth i.e fine till
- Small seeds can be planted to develop into strong seedlings that are easy to plant
- Ensures transplanting of healthy and vigorous seedlings
- Excess seedling may also provide a source of income for the farmer when sold.
- It reduces time period of growing the seeds so marketing happens earlier at higher prices.

FACTORS TO CONSIDER WHEN SELECTING A SITE FOR A NUSERY BED

- Water source:

  Nearness to water sources makes watering easy.

- Type of soil

  The soil should be deep, fertile and well drained.

- Topography

  Gentle slopes are preferred to avoid erosion and flooding.

- Security

  The site should be well protected from wild animals, birds and thieves.

- Sheltering / shelter

  But the place of the site should be sheltered well with wind brakes in order to prevent the strong wind from causing damages to the seedling.

Previous cropping

A nursery bed should not be made a site where the previous crop grown belonged to the same family.

ESTABLISHEMNT OF NURSERY BED

a) VEGETABLE NURSERIES

Vegetation is cleared and trash is removed

- Digging is done to remove perenial weeds
- The size of the nursery bed should be 1m wide by nay length leaving path 60cm wide between individual beds.
- Harrowing is fine to provided a fine tilth.
- Phosphatic fertilizers are added in the organic matter.
- The ground is leveled using a rake to remove any trash.
- Shallow drills are made (10 – 20cm) apart.
- The seeds are drilled uniformly
- Cover lightly with soil and water immediately
- Erect the shade.

b) TREE NURSERIES

- Vegetation is cleared and trash removed.
- Digging is done to remove perennial weeds
- Size of the nursery bed, should be 1m wide by any length leaving paths 60cm wide between individual beds.
- Add phosphatic fertilizers to organic manures
- The ground is leveled using a rake.
- Trees are established in polythene sleeves
- Pre – germinating seeds that for have been put in water 24 – 48 hrs are used.
- Plants in polythene sleeves half – filled with soil and phosphetic ferilisers.
- Fill the sleeves to ¾ with soil. This makes transplanting easy.

NURSEY MANAGEMENT PRACTICES

While in the nursery, the following practices are carried out to the seedlings;

- Watering regulary in the morning and evening
- Weed control mainly by uprooting the weeks.
- Pricking out. This is the removal of weak and unhealthy seedlings and planting them in another nursery seedlings bed.
- Shading. This refers to erecting a shade for the seedlings
- Mulching. This is done after planting and should be removed after the seedlings emerge.
- Pest control by applying the recommended pesticides.
- Hardening off. The gradual reduction of shade and watering before transplanting to adapt the seedlings to the field conditions.
- Disease control by use of appropriate chemicals.

TYPES OF NURSERY BEDS

There are 2 types of Nursery beds.

- Sunken Nurseries
- Raised nurseries.

Sunken nurseries are prepared during the dry season and raised nurseries during rainy season.

N.B

- Seeds may be planted in nursery beds, seeds boxes or soil blocks
- Seeds boxes are wooden boxes filled with fertile soils in which seedlings are raised.
- Soil blocks are polythene sleeves filled with fertile soils to raise seedlings.

VEGETATIVE PROPAGATION

This is where new plants are produced without the use of seeds.

Vegetative planting materials are plant parts that contain or can develop buds and have the ability to produce roots resulting into development of new plants.

Plants that a rise from the same parent through vegetative propagation are referred to as Clones. Plants may be propagated vegetative include, sugarcane, bananas sweet potatoes, Irish, pineapples and ginger e.t.c.

## TYPES OF VEGETATIVE PROPAGATION

There are mainly 2 types of vegetative propagation

- Natural vegetative propagation
- Artificial vegetative propagation

## NATURAL VEGETATIVE PROPAGATION

This is the method of vegetative propagation in which plant parts i.e. roots or stems have been modified naturally for food storage

They include the following:

- Stem tubes

  Swollen underground stems that have buds (eye) that develop into new plants are used e.g Irish, sweet potatoes.
- Suckers

  These are plants that develop from the mother plant below the ground level and can be used for planting. It common in bananas, sisal, pineapples e.t.c.
- Splits

  These are individual shoots that develop in tillering plants especially grasses e.g guinea grass, pyrethrum, sorghum.
- Bulbs

These are underground stems with modified leaves to store food between the modified leaves are auxiliary buds which grow into new plants e.g. onion garlic and lilies.

- Rhizomes

  These are underground stems with nodes and internodes which store food and are able to germinate into new plants e.g Couch grass, spear grass e.t.c

- Runners

  These are horizontal stems growing above the ground surface producing and adventitious roots and new plants at their nodes e.g Wandering jew, sweet potatoes, straw berry, pumpkin e.t.c

- Corns

  These are vertical underground stems with short internodes and scaly leaves. They can be used as a planting materials e.g Cocoyam.

- Slips

  These are plants that develop externally from the stem or fruit of an old plant e.g pineapples

- Crowns

  These are vegetative structures which are particularly found on top of a pineapple plant and establishes slower than the suckers when planted.

- Bulbils

  These are tiny plants produced in the inflorescence at the end of the plant's life cycle e.g. sisal.

- Stolons

  These are horizontal digital creeping stems about the ground modified to store food e.g. star grass.

- Root tubers

  These are swollen underground roots that can also be used for planting e.g. Sweet potatoes

ARTIFICIAL VEGETATIVE PROPAGATION

- CUTTING

These are portion or parts of the plant that may be cut and used for multiplying plants.

There are 3 types of cutting i.e

- Stem cutting e.g. cassava, sugarcane, and elephant grass.
- Root cutting e.g. guavas, apples pears e.t.c
- Leaf cutting e.g. African violet

Some cuttings are planted directly into the soil. E.g cassava, sweet potatoes while others are delicate and first need to be raised in the bed to root and then later planted in the field. They are usually in the rooting medium to encourage rapid rooting. The medium may include, sand, peat, saw dust and soil. The medium should be well aerated for easy development of the roots. The rooting medium is first sterilized to avoid infection by soil pathogens. This is done by heating the soil using steam or chemically using fumigants.

FACTORS THAT AFFECT ROOTING OF CUTTING

- OXYGEN SUPPPLY

  The root forming process requires ample supply of oxygen.

- LIGHT INTENSITY

  Soft wood cuttings and herbaceous cuttings used more light for synthesis of carbohydrates while for hard wood cuttings enough carbohydrates darkness encourage rooting.

- TEMPERATURE

Cool to warm temperatures around the roots promote rooting because they reduce transpiration rate.

- RELATIVE HUMIDITY

  High relative humidity prevents desiccation and encourages rooting.

- LEAF AREA

  Some cuttings require leaves to root while others don't.

- CHEMICAL TREATMENT

  Rooting hormones applied at the basal end of the cutting quicken the rooting process.

COMMON ROOTING HORMONES INCLUDE;
IAA (Indole Acetic Acid)
IBA (Indole Bytric Acid)
NAA (Naphthalene Acetic Acid)

- LAYERING

This is a method of vegetative production which involves inducing parts of the stem to produce roots while still on the plant before they are cut off to be planted elsewhere.

The part of the plant is wounded to expose the stem cambium to give rise to roots.

The wounding or bending of the stem blocks downwards movements of photosynthesis which accumulate at the wounded or bent part to provide rooting.

TYPES / FORMS OF LAYERING

- Tip layering.

  The branch tip is bent to the ground and covered with soil to produce roots.

  It's held in position by pegging.

- Simple layering

  This is done when a branch is buried in the soil at only one point reasonably away from the tip and then held in position by pegging.

- Compound / serpentine layering.

  The branch is bent and buried in the ground at several points and pegged to provide roots called serpentine because the branch is in a serpent – like shape.

- Air layering / marcotting

  This method is mainly used for plants which cannot be bent to the ground.

  The bark is removed from a small section of the branch, moist fertile soil or moist sawdust in a polythene bag wrapped around the wounded section.

- Mound or stool layering

  Soil is heaped around the base of the stem which gives rise to new shoots.

- Trench layering

  The shoot is bent and laid in a trench and covered with moist soil.

- Grafting

  This is the process of uniting two separate woody plant parts to rise new plants. The two plants are normally of the same species or closely related species.

  The lower part ( the part of the root system) is called the Root stock. While the upper part that is grafted onto the root stock is called the Scion. The Scion must have one or more buds to give to a new plant.

  If a bud is completely used, the method is called <u>buddy or bud grafting</u>

  N.B.

  For successful grafting the cambium of the root stock must be in contact with the scion Cambium.

  Only dicots are grafted because they undergo secondary thickening unlike monocots.

METHODS OF GRAFTING

- Whip/ tongue grafting

  In this method, a straight slunting cut is made on both the Scion and root stock.

  They are then joined together and wrapped with a grafting tape.

It is used for materials of the same diameters.

- Wedge /cleft grafting

  This is used when the stock diameter is bigger than that of the Scion.

  The root stock is cut to form a V- shape and the scion to form a wedge shape. The Scion is then inserted in the stock. Wax is put over the cut surface to prevent drying.

- Side Grafting

  This is the grafting of a scion of a small diameter into an already growing tree.

  A cut is made into the stock at an angle of $20^{o} – 30^{o}$ and the scion is inserted to ensure firm contact between the cambium of the stock and the scion.

- Saddle Grafting

  A Scion with a deep V – cut is fitted onto the stock.

Other types of grafting include:

Approach grafting

Notch grafting

Bridge grafting

Budding (bud grafting)

BUDDING / BUD GRAFTING

This is a special form of grafing where a vegetative bud of one plant is grafted onto another plant (root stock). The bud is inserted into a slit made on the bark of the stock and held tight with a budding tape.

After the bud has started to grow, the part of the stock above the bud should be cut off.

**Procedure**

- Budding starts when the stocks are pencil thick.
- Select the suitable tree species and get their buds and stocks.

- Make a T- cut on the stock and the bark gently separated from the wood.
- Insert the bud into the T- cut.
- The bud is bound to the stock with poltythene papers or tape to prevent water entry.
- Apply wax or Vaseline on the outside of the wrapping to reduce bacteria or fungal entry.
- After 2 weeks remove the wrapping.
- If the bud is green , then the process is successful and if the bud is brown the process is not successful.
- When the green bud produces the shoot, the end part of the root stock (Stub) is cut off to reduce transpiration.
- The budding are then transplanted to the field.

**FACTORS TO CONSIDER WHEN GRAFTING./ factors for successful grafting**

1. Compatibility. This is the ability of the scion and stock to form a union.
2. The scion and the stock should be disease free.
3. The two plant parts should belong to the same family or species.
4. Use suitable equipment or tools when grafting.
5. The scion should have buds.
6. The cambium layer of the scion and stock must touch each other.
7. Use sharp cutting knieves or blades.
8. Both the scion and the stock should be woody.
9. The scion should be from a good quality plant.
10. the technique of grafting i.e the quality of cut, joint made should be standard and care should be taken to protect the union.
11. Availability of grafting tape and wax.

12. Graft quickly.
13. The stage of growth of scion and stock i.e. They should not be too old.
14. The stock should also have desirable qualities.

ADVANTAGES /AIMS /REASONS FOR GRAFTING

- Helps to propagate the clones which cannot be propagated by other means.
- Helps to obtain new varieties or produce more than one type of fruits / trees.
- Can be used to repair damaged trees E.g Bridge grafting.
- It helps to produce plants that mature and produce fruits at an early stage i.e shorten maturity age.
- It helps to test disease resistance in crops.
- It facilitates improvement of fruit trees in terms of quality and quantity.
- Helps to import disease resistance e.g by grafting the resistant crop with susceptitable one to improve the susceptitable crop.
- It enhances vigour of defective trees.
- To develop branches that are lacking on the tree.

DISADVANTAGES

1. Certain undesirable characteristics by the stock are transferred to the offspring.
2. Requires skilled man power to carry out.
3. Expensive especially in buying some materials that are required e.g the wax and grafting tape.
4. It is labour intensity i.e requires a lot of attention.

5. Only plants of the same family are used.
6. Absence of genetic variation.
7. Encourages pre- mature aging of the plants.

PROCESS OF GRAFTING A CROP e.g Mangoes, Oranges

1. Select a suitable scion and stalk.
2. Remove the leaves from the scion.
3. Make a slanting cut, using a sharp knife.
4. Fit the scion and the stock together with the cambium of the stock touching that of the scion.
5. Wrap the joint with a grafting tape.
6. Apply wax on the tape.
7. Cover the graft union with a transparent Polythene paper to provide a shade againt dessication.

ADVANTAGE OF VEGETABLE PROPAGATION.

- There is less risk of seedling diseases.
- Off springs are genetically similar uniform to the parents.
- Plants propagated vegetatively mature faster or earlier
- The offsprings are stronger and hardy.
- Disease resistance is passed onto the off springs by parents.
- The vegetative parts have better chances of growing up.
- It helps to overcome prolonged dormancy of some seeds
- Doesn't require a well prepared seedbed like when seeds are used.
- Some plants do not produce viable seeds or produce seeds with low germinabilty so vegetative propagation is the way to go.
- Some vegetatively propagated crops have better characteristics than those created by seeds e.g oranges that have fewer thorns can produce many fruits.

- When fully established plants require less care and attention.

DISADVANTAGES OF VEGETATIVE PROPAGATION

1. It is generally more expensive than use of seeds.
2. Vegetative planting materials are bulky and not easy to handle and store.
3. Easy spread of diseases from the parents to off spring
4. The materials are bulky and difficult to transport.
5. Difficult to mechanize vegetative propagation.
6. There is little chance of variation of the crop since there is no crossing over and fertilization.
7. Some methods of vegetative propagation require skilled manpower e.g grafting and budding.
8. The planting materials have high moisture content and a low keeping quality compared to the seeds.
9. Plants may be overcrowded in the area because they grow and establish themselves quickly.

CROP PROTECTION

Crop protection is an activity or practice aimed at providing conditions that will enable the crops to grow without pest destruction, disease infestation and weed infestation.

WEEDS

A weed may be defined as a plant growing where it is not wanted or a plant out of place.

Therefore the above definition means that a bean plant in the cassava garden can be considered as a weed.

If weeds are not controlled ,they have adverse effect on the crop plants as well as the quality of the plant and the produce.

ECONOMIC IMPORTANCE OF WEEDS

- After weeding , the weeds provide organic matter and plant nutrients when they have decomposed.
- Some are also used as vegetables for human consumption e.g pig weed (dodo) Solanum nigrum.
- Weeds also provide a good soil surface cover hence minimizing waterless or evaporation of the $H_2O$ from the soil.
- Provide a good surface soil cover that helps to control soil erosion.
- Some weeds are also a source of food for animals, both domestic and wild.
- Some are used as local medicine (herbs) for people and animals to cure some diseases e.g Aloevera (Kigaji), Sodom Apple, Mululuza, Molinga tree.
- Some are used to construct temporary houses e.g. Spear grass.
- Some weeds are also used in mulching the garden.
- Some also help in fixing Nitrogen in the soil hence improving the soil nutrients.
- They also help in preventing /controlling leaching in plant nutrients by taking them up. These are then recycled and returned to the soil when weeds die and decay.

DISADVANTAGES

- Lead to loss /reduction in crop yields because of competing with the the crops for crop nutrients.

- They reduce the plant size and height which leads to less photosynthesis area for the plant.
- Some are altenate hosts for some crop pests.
- They lower the quality of crop produce especially when their seeds mix up the crop products.
- Weeds also lower the quality of the pastures making them to become unpalatable to the animals.
- Some weeds are poisonous to man and livestock when eaten tick berry fruits.
- They also increase the cost of production.
- Some weeds also block irrigation, navigation and drainage channels especially the water weeds.
- Reduce the value of land on selling.
- Lead to extra work during seedbed preparation and weeding.
- Reduce market value of crops.
- Aquatic weeds e.g. Water hyacinth and mile cabbage endanger the life of fish and other animals in water by suffocating them depleting $O_2$ supply in water.
- Some weeds are irritating to workers thus reducing efficiency strongly e.g. Love grass, thorn apple.
- Weeds also lead to extra work during seedbed preparation.
- Some weeds limit i.e choice of crops to grow in some areas.

CHARACTERISITCS /FACTORS THAT MAKE WEEDS MORE SUCCESSFUL THAN CROP PLANTS

1. Weeds are more aggressive /vigorous than the crops and they are able to outcompete the crops.
2. They produce a lot of seeds that ensure their survival always.

3. Weeds also have a faster rate of growth than normal plants; therefore they are able to complete their lifecycle within short time.
4. They are able to grow more harder (difficult) conditions than the plants e.g. poor soils, drought. e.t.c.
5. Weed seeds undergo dormancy that enables them to germinate at the right time and grow.
6. They are more resistant to crop pests and diseases than the crops.
7. Some weeds have perenating organs that can sprout and grow into new plants.
8. Weeds also have efficiently diverse dispersal mechanism e.g. the fruits and seeds that can be dispersed by the wind , water or animal and self.
9. Most of the weed plants are not palatable to livestock than the crop plants and therefore cannot be grazed upon or destroyed.
10. Some have protective structures e.g. Thorns that protect them from damage or being destroyed by animals.
11. Others are parasitic e.g witch weeds that obtain their nutrients from the crop.
12. Some of the weeds seeds can germinate even when they are immature.
13. Some weeds produce toxic substances that exclude other plants from growing around them.
14. Some are resistant to herbicides so cannot die when sprayed.

## CLASSIFICATION OF WEEDS

The weeds are mainly classified into 2 ways i.e

- According to the lifecycle.
- According to the morphology

- ACCORDING TO THE LIFECYCLE

In this classification, weeds are classified according to the length of the lifecyle i.e the time they take to grow, mature and die.

Under this classification, the following groups of weeds existence.

- Annual weeds

  These weeds complete their lifecycle within a year or less e.g. black jack, goat weed, pig weed e.t.c

- Bi – Annual weeds

  These complete their lifecycle in more than one year but not more than 2 years. In the 1st year may exhibit vegetative growth and flowers and produce a seed in the second year.

- Perennial weeds

  They complete their lifecycle in more than 2 years e.g coach grass, tick berry oxalis. Perennial weeds are often very difficult to control because they possess perenating organs e.g. Rhizomes, bulbs, corns e.t.c.

- ACCORDING TO MORPHOLOGY
  - Broad leaved weeds.

    These weeds are usually dicots and they have net venation leaves e.g thorn apple, wandering jew, maxican mangled e.t.c

  - Narrow leaved weeds

    They have parallel veins and they are mainly monocots. They are subdivided into the following
    - Grasses e.g spear, star .coach grass.
    - Sedges.This group has a triangular stem e.g Cyperus species.
  - Woody weeds

    They have strong wood stems and they are mainly controlled mechanically by uprooting e.g Sodom apple, lantana camara e.t.c
  - Herbaceous weeds

These are the weeds with thick water filled / succulent stems e.g water hyacinth.

METHODS OF CONTROLLING WEEDS.

There are a number of methods that are used to control weeds by farmers and those include:-

- Cultural method
- Mechanical / physical method
- Biological method
- Chemical method
- Legislative method

vi) Integrated weed control.

The use of any , of the above methods keep on varying from one place to another depending on the type of weed, the type of plant grown, the economic status of the farmer and environmental conditions.

MECHANICAL / PHYSICAL

This method involves physical destruction of the growing weeds.

The main aim of this method is to encourage the germination of as many as possible so that they are destroyed at tender /young stage.

It is very effective for controlling annual weeds but for the case of perennial weeds , they must be weeded periodically because they continue to grow new shots from their perenating organs.

The methods used in mechanical weed control include the following.

- Hand pulling/ uprooting of individual weeds to expose their roots so that they eventually die.
- Hand hoeing using garden tools like hand hoe, forked hoe.

- Mechanical cultivation /tillage. This involves use of implements e.g ox- drawn implements, tractor, drawn e.g weeders, this buries the weeds before they produce the seeds.

PROBLEMS ASSOCIATED WITH FREQUENT TILLAGE TO CONTROL THE WEEDS.

- Too much cultivation may lead to destruction of soil structure.
- Encourages water loss from the soil through evaporation.
- It may improve the conditions that encourage the germination of weed seeds previously buried in the soil.
- In some cases, the implements and tools used cause damage to the root of crops or destroy the whole crop plant.

*Flaming:* This is the use of heat or fire to control the weeds among the grown crops. For it to be effective.

- The crop must be more resistant to the flame than the weeds.
- The crop must have grown higher than the weeds.

*Slashing /mowing*

This is done using cutlasses/ slashes/mowers to destroy the weeds. It is more effective in controlling tall and soft weeds than creeping weeds.

ADVANTAGES OF SLASHING

- It is effective to control tall annual weeds
- It is faster /quicker to use.
- Useful in tilling weeds in harsh or hard condition to cultivate.
- It can be fairly used in all top topography

DISADVANTAGES

- Can’t control the weeds that are below the ground
- It is not easily applicable where crops are not well spaced
- Does not encourage improved soil drainage and aeration.

ADVANTAGES OF MECHANICAL METHOD

- It is not toxic to crops and the animals.
- Its use requires little skills.
- It is cheap in the longrun i.e tools are used for long time.
- It is quicker, especially when machines are used.
- If the weeds are cultivated out, the cultivation promotes aeration, drainage and water percolation in the soil.
- It enables burying of the surface vegetation and crop residues for easy decomposition.

DISADVANTAGES OF MECHANICAL METHOD

- Destroys soil structure.
- The crops may also be damaged in the process of removing the weeds.
- It is also slow especially when hand tools are used.
- It may lead to the oxidation of nutrients in the soil.
- It encourages soil erosion.
- Its efficiency and effectiveness may be affected by wet weather.

BIOLOGICAL CONTROL

This involves use of natural enemies to control weeds. These natural enemies are commonly animals that feed on weeds. Other living organisms can also be used.

*Examples*

- Use of rabbits to control the Mc Donald’s eye in Banana plantation.
- Control of water hyacinth using beetles

- Control of lantana camara by lantana burgs and goats

ADVANTAGES

- Does not pollute the environment.
- Doesnot affect the soil structure.
- It is cheap once the biological agent has been identified.

DISADVANTAGES

- The biological agent of weed control may later become a pest especially when the weed is eaten up.
- It requires a lot of research in establishing the biological agent hence making it tiresome.
- It does not destroy the underground parts of the weed.
- It takes a long time for the weed to be eaten up from the garden thus becoming expensive.
- Some weeds donot have appropriate biological agents.
- The agents may destroy predators and pollinator at the same time.
- It cannot eradicate weeds with seeds that remained dormant in the soil.

CHEMICAL WEED CONTROL

This involves the use of chemicals known as herbicides (weed killers)

CLASSIFICATION OF HERBICIDES

- Classification according to time of application
  - Pre- emergency herbicides.

    These are applied to control weeds from the surface before crops emerge.

*ADVANTAGES*

- Crops emerge in a weed free environment.

- The crop grows vigourously and covers the ground before weeds recover.
- If rains water leaches , the herbicides to where the crop seed is, there may be delayed or incomplete germination.
    - Post – emergence herbicides

      These are applied after the crop seedlings have emerged out of the soil.
- Classification according to mode of action
    - Contact herbicides

      These will kill only the part of the weed with which they come into contact e.g paraquant (Gramaxone) . They are mainly used to kill the shoot system of the weeds.
    - Systemic herbicides

      These are absorbed and translocated into the plant and will kill the weeds by disrupting the physiology of the weed. They are also called translocated herbicides.
- Classification according to selectivity of the herbicides

  Selectivity of the herbicide refers to the capacity of a herbicide to be able to kill a given species of weeds and not another plant .
    - Selective herbicides

      These kill certain weeds in preference to another.
    - Non – selective herbicides

      These kill only weeds to which they have been applied.

EXAMPLES OF COMMON HERBICIDES

- 2, 4 – D, It is a selective translocated herbicides that controls broad - leaf weeds. It is applied as a post – emergency herbicides
- MCPA is selective herbicides that control broad - leaf weeds. it is applied as a past – emergence herbicides.
- Paraquant (Gramaxone)

It is a non- selective and non- systemic herbicide that controls broad leaf weeds and young grasses.

- Simazine; controls broad - leaf weeds and grasses.
- 2, 4, 5 – T. It is systemic and kills woody weeds.
- Atrazine, used for broad - leaf weeds and grasses. It can be applied both past - emergence and pre – emergency.

ADVANTAGES

- The method is quick and less tiresome.
- It's effective as it kills the weeds completely
- It's effective where mechanical tillage is imposed e.g. In area with less labour.
- It preserves the soil structure.
- There is minimum disturbance of the soil
- It is based in crops where the monohology doesn't favour mechanical cultivation.
- It is the best method where the topography doesn't favour use of machines to control the weeds.

8. more effective in controlling weeds in the rows of crops where tillage would injur the roots of the crops.
9. Controls weeds in good time before competition sets in e.g pre-emergency herbicides.
10. Effective in controlling problematic perennial weeds e.g Oxalis Latoforia, digitaria scalarum.
11. It requires less labour.

DISADVANTAGES OF CHEMICAL WEED CONTROL

- Chemicals pollute environment.
- Expensive since it involves purchasing of chemicals.
- Herbicides are poisonous to man either when absorbed through plants or by direct contact.
- Their application needs skills which are lacking in most local farmers.
- Chemicals affect PH of the soil.
- They are often hard to obtain in most areas.
- Some chemicals have long residual effects e.g Atrazine.
- If applied carelessly, they can spoil crops especially non- selective

PRECAUTIONS TO TAKE WHEN USING HERBICIDES

- Read the labels and instructions carefully before mixing the chemicals.
- Wear protective clothes e.g overalls, gloves, masks, rubber boots.
- Trouser with turn outs where granules / dust particles can collect avoid them.
- While in fields, avoid drinking , eating and smoking
- Do not keep chemicals in unlabeled container i.e avoid transferring chemicals to beer bottles, containers e.t.c
- Keep all chemicals in locked places out of children' reach.
- Dispose of empty container, safely by burning or burying the m to avoid them from being leaked by animals.
- Donot blow blocked with your mouth.
- Wash the protective clothes thoroughly with soap.
- Wash your hands thoroughly with soap after handling chemicals.
- In case a farmer in hales unknowingly drinks or comes in contact with chemicals , seek medical advice.

HOW TO ENSURE EFFECTIVENESS OF CHEMICALS

- Do not spray in windy conditions to avoid chemicals being blown to unintended fields.
- Dilute the chemical with the right amount of water.
- Use the chemicals for the intended crop.
- Allow the correct time to elapse between spraying and harvesting of the crop.

LEGISLATIVE CONTROL

This involves laws and regulations to control introduction of weeds into the country or from one country to another.

Question

Outline the conditions for effective legislative weed control.

INTERGRATED WEED MANAGEMENT

This involves the use of more than one method in a way that is friendly to the environment . It resorts to herbicide use as the last method.

## CROP PESTS

Pests are living organisms that cause damage to crops.

## CLASSIFICATION OF PESTS.

1. **According to plant parts they affect**
    - Root pest's e.g Rodents, nematodes, and termites.
    - Leaf eaters e.g locusts, grasshoppers, caterpillars, leaf miners,
    - Stem borer e.g Maize stalk borer.
    - Fruit eaters e.g birds , bean brunched

2) **According to level of damage**

a) Major pests

These cause a significant loss which guarantees control e.g those that attack flowers and fruits i.e. vital organs.

b) Minor pests

These cause relatively less damage e.g those that attack branches which are less vital.

c) Local pests

These are pests whose attack is not uniform.

- Occasional pests

  These attack in specific seasons and their attack is very serious e.g locusts. Grasshoppers.

**3 According to mode of feeding (mouth parts)**

- Piercing and sucling

  These have styles / probesis that they use to pierce the tissue and suck plant sap e.g aphids, cotton strainers.
- Rasping and scratching

  These scratch and suck e.g. thrips
- Biting and chewing

  These have strong mandible for biting and chewing of plant parts.

**4 According to where they attack crops**

- Field pests. Attack crops when they are still in the field e.g rats.
- Storage pests; attack the produce in stores e.g weevils, bean bruchids

5 **According to number of plants attacked**

- Polyphagus pests;These are pests that attack very many crops for survival e.g locusts,american bollwormetc
- Monophagus pests;These pests feed on only one crop for survival e.g maize weavils,bananaweavil,cofee mealy bugsetc

## TYPES OF PESTS

- **Insect pests.**

These are the commonest and most successful pests

**Reasons why insects are the major successful pests**

- They have high rate of reproduction to ensure survival
- They have short life cycles and so increase in numbers very fast.
- Presence of a cuticle that prevents water loss and protects insects against water chemicals.
- Small in size and therefore
  - Not easily detected by predators.
  - Require little space.
  - Require little food and produce energy.
- Have an exo skeleton that protects the inner organs against mechanical damage , maintains a small size, discourages predators from feeding on them, provides camouflage against predators.
- They secrete uric acid which requires little water for excretion hence preserving water in their bodies.
- Most of them feed on a wide range of materials.
- They are easily adaptable to the changing conditions i.e they have lived on this earth longer than any other organism.
- Have defensive mechanisms e.g stings, spines and their legs pungent chemicals against enemies.

2. **Nematodes**.

These are legless, tubular, with round un segmented bodies.

The parasitic nematodes have stylets for piercing and sucking of plant sap , e.g eel worms

SYMPTOMS OF ATTACKS BY NEMATODES

- Root knots
- Excessive branding of the root tips.
- Witting and whethering of leaves.
- Retarded growth
- Necrotic lesions

WAYS THROUGH WHICH NEMATODES ARE SPREAD

- Rain splash
- Irrigation water
- Infected plant materials
- Soil transfers

3. Rodents e.g. rats, squirrels, field mice, mole rats.

They have specialized teeth for gnawing and crushing.

They can grind hard materials e.g grains.

4. Birds

These mainly eat e.g quela quela

5. Mites

They lack wings. They attack citrus fruits, tea, and cotton.

When mites attack crops, the leaves turn yellow or brown and later fall off.

e.g moulds, yeast. They sometime cause diseases.

6. Bacteria

These attack crops and cause disease e.g. banana bacterial wilt.

7. Viruses

These are tiny and only capable of living when inside living tissues of hosts e.g cassava mosaic, g/nuts rosette.

8. Fungi

They are either parasitic or saprophytic

## DAMAGES CAUSED BY PESTS

- They destroy seeds hence interfering with germination e.g. bean, bruchids.
- Reduce seed production by attacking flowers.
- Destroy growing parts and cause distorted growing of crops.
- Tunnel inside crops and interfere with transport and nutrient absorption.
- Eat leaves and reduce the rate of photosynthesis.
- Biting pests attack roots and cause loss in water and nutrients absorption.
- Remove stored food in tubers, corns and other storage structures e.g rate.
- Suckling pests remove plant sap and cause loss in plan vigour e.g Aphids.
- Inject saliva which is toxic to plants.
- Cause crop loss by contaminating products with waste and hence poor quality output.
- Increase costs of production because their control is expensive.
- Transmit disease - causing organisms e.g fungi and bacteria.
- Make harvesting hard by destroying crops especially when mechanical harvesting is to be used.

## METHODS OF PEST CONTROL

- Cultural method.
- Biological control
- Mechanical / physical
- Legal control
- Integrated pest management (IPM)

## CULTURAL CONTROL

Thi involves the conrol of pests using agronoic practices that include the following;

i. Early planting of the crop;This makes the pest survive pest attack and icrease its resistance for the pest
ii. Use of closed season(dead season);This is a period during which the growing of a given crop is stopped so as to remove pests and disease build up.
iii. Croprotation;Crops which are susceptible to pest attack should be rotated with those that are not easily attacked
iv. Growing of resistant crop varieties which are able to withstand the effects of pests
v. Rogueing i.e the reoval of diseased plants or infected plant parts in the garden and consequently burning them
vi. Use of clean seeds where by oly certified seeds that are dressed against pests should be planted
vii. Mulching;some mulches like banana leaves used in the mulching of banana plantations help to trap banana weavils
viii. Trapcropping where by a minor crop that resembles the main crop but when it is planted for the purposes of preventing pests fro entering the main garden
ix. Destruction of the alternate host e.g weeds should be destroyed by weeding because they harbour pests

**MECHAICAL/PHYSICAL METHOD**

i. Physical destruction by picking and destroying of pests
ii. Use of physical barriers
iii. Suffocation i.e use of gas carbondioxide
iv. Use of extreme temperatures i.e vryhot or very cold
v. Use of scare crows

**BIOLOGICAL METHOD**

This involves introduction of other living organisms that are either parasites or predators ued to destroy pests by feeding on them

**Qualities of a good predator**

i. It should have a high ability to run after a pest with in plants so that all plant parts are protected
ii. It should have a high reproductive rate so as to out compete the pests population
iii. It should not be dangerous to the farmer or user in the field
iv. It should be harmless to crops being protected i.e should not inject poisonous substances to crops
v. It shouldnot eat other predators it comes int contact with
vi. It should be able to destroy more than one pest type in the field
vii. It should be resistant to the existing environmental conditions

CHEMICAL METHOD

This involves use of pesticides that are harmful to the targeted pests.It can be applied through spraying,dusting or fumigation of a crop using sprayers or dusters

QUALITIES OF A GOOD PESTICIDE

- It shouldnot be translocated in plant tissues i.e it shouldnot have a residual effect which affect human life e.g DDT
- It should be ozone friendly i.e should not pollute the environment
- It should be harmless to the crops being sprayed
- It should not be poisonous to human and other animals
- It should persist in the soil to avoid frequent applications
- It should not be toxic to predators,parasites and pollinators like bees that are more useful to the crop

ADVANTAGES OF CHEMICAL PEST CONTROL

- It is a faster method of controlling crop pests in the garden
- It is more effective than other methods of pest control
- It does not reqire alo of labour compared to either mechanical or cultural

- It only applies where mechanical and cultural methods are not possibly applicable e.g topography

DISADVANTAGES OF CHEMICAL PEST CONTROL

- Pesticides can pollute the environment since some are non bio degradable
- Pesticides may be toxic to plants if poorly applied
- Chemicals may kill non targeted and useful organisms e.g pollinators,predators
- some chemicals may leave their residues on the crop products which may affect the farmers
- Some pests require reistance to some pesticides if they are persistently used
- Some pesticides may be poisonous to man and must be handled properly
- Technical knowledge is needed when applying the pesticides
- Chemicals are expensive and may not be afforded by small scale farmers

WAYS THROUGH WHICH CHEMICALS AFFECT THE PESTS

1. By direct contact;This is when the chemical enters through the skin or the cuticle of a pest and then kills it
2. Breathing System;This is when the chemical passes through the insect breathing pores and then affect it
3. Ingestion;This is when pests eat some of the toxic or poisonous chemicals and die by poisoning
4. Sucking;pesticides which pass through the plant stream may be sucked in by insects obtining their food in this way.such pesticides are called systemic chemicals that are used to kill piercing and sucking insects like aphids

**Common insect pests and their effects on crop plants**

- Locusts(orthoptera)

Have biting and chewing mouth parts,Adults and nymphs defoliate the plants e.g yams,casava,cereals

- Termites(Isoptera)

Have biting and chewing mouth parts,eat up timber,cutdown growing plants e.g maize,citrusetc

- Weavils(coleoptera)

Larva and adults bore,pupate in and feed on seed reducing grain quality e.g maize,beans,sorghum,peas etc

- Maize stalk borer(lepidoptera)

Boring and chewing larva into stems,leaf sheaths and weaken the stems of maize,sugarcanes,rice etc

- Army worms(lepidoptera)

Bting and chewing larva which attack and destroy large hectares with in a short period of time

- Cotton stainers(hemiptera)

Have piercing and sucking mouth parts,destroy leaves and transmit viral diseases to cotton,tomatoes,maize and yams

- White flies(hemiptera)

Have piercing and sucking mouth parts,distortion of leaves transmitting viral diseases to cocoa,citrus,rubber and tobacco

- scale insects(hemiptera)

piercing and sucking mouth parts,feeding on cell content,folliage turns yellow and falling of young fruits

- Aphids(hemiptera)

Have piercing and sucking mouth parts

## PLANT DISEASES

A disease is a physiological disorder and structural abnormality which is dangerous to the plant or part of the plant.

## HOW DISEASES SPREAD FROM CROP TO CROP

1. Through wind or air currents that blow disease spores from infected plants to healthy ones
2. Through rain water or rain splash that disperses off infected soil from a diseased plant to a healthy crop
3. Through contact of plants i.e infected and healthy ones
4. Planting of the infected planting materials e.g seeds
5. Through use of garden tools that were used on infected crops e.g knives,pangas,hoes etc
6. Through sucking pests which inject infected saliva into a healthy plant e.g aphids
7. Through use of mulches that were previously infected
8. Through irrigation water that is infected by disease pathogens e.g bacteria,fungi and viruses
9. Use of organic manure e.g FYM,Green manure that is also infected by disease.

**General Methods that can be used to control crop Diseases**

- Planting of resistat or tolerant crop varieties that can withstand disease attacks.
- Legislation to restrict movement of infected planting materials from one place to another
- Weeding to remove plants tat can act as alternate hosts of disease causing organisms
- Carrying out a good crop rotation to prevent build up of diseases to crops
- Proper land drainage of the soil surface to prevent water borne diseases
- Spraying of crops with recommended chemicals to control crop diseases
- Seed dressing to destroy spores that may be hidden on seeds
- Rogueing i.e removal of diseased plants or plant parts and destroyed by burning
- Soil treatment/sterilization should be done to kill spores of diseases

- Early planting or timely planting in order to escape disease build up
- Use of diease free planting materials to prevent the spread of diseases