CROP SCIENCE & ENVIRONMENT

BAGI: 1301

Sub-Unit: Agro – Forestry

Outline

1. Introduction
2. Role of trees in agriculture
3. Different types of agro-forestry systems
4. Species selection for agro forestry
5. Raising tree seedlings in a nursery
6. Transplanting and management of tree seedlings.

Topic One

Introduction

What is agro –forestry?

It's the cultivation of crops together with trees on the same piece of land at the same time.

Definition: - Agro – forestry is the deliberate use of woody perennials such as shrubs, trees, bamboo on the same land unit as agriculture crops, pastures and animals. These may consist of a mixed spatial arrangement in the same place and time or a sequence over time. This definition implies that:- Agro – forestry normally involves two or more spp of plants and / or animals. An agro – forestry system always has two or more outputs. The cycle of an agro – forestry system is always more than one year and that even the simplest agro – forestry system is more complex ecologically and economically than a mono cropping system.

Aims of agro – forestry: - Aims at increasing productivity**,** sustainability and diversity

Agro-forestry can increase productivity in many different ways such as:- Increasing output of tree products, improving yields of associated crops, reducing inputs of cropping systems, increasing labour efficiency. Agro–forestry increases sustainability by conserving the production potential of the resource base (land); mainly through the beneficial effects of woody perennials on soil. Agro –forestry can achieve and indefinitely maintain fertility goals by: - Improving or maintaining organic matter, controlling soil erosion, adding and recycling nutrients. Agro – forestry increases

diversity by having more than one product. This is important because farmers are risk takers.

Topic Two

Role of trees in agriculture

Agro – forestry is usually looked at as a solution to problems of land and water degradation and as well as a solution to shortages of fuel wood, food, cash income, fodder and building materials. However, it should be noted that agro – forestry is one of several solutions to these problems. Often agro–forestry practices are designed to protect and improve quality of natural resources and provide a wide range of goods.

The services offered by trees in agriculture include:- Improve soil fertility for crops. Improve micro climate for crop growth. Control soil erosion. Control pests and diseases. Provide goods such as food and medicine and raw materials for building and energy

The effects of trees in the farming system vary widely from one climatic environment to another. In some cases, they compete directly with agriculture crops e.g when water supply is limited while in other cases trees help to enhance agricultural production.

Trees and soil fertility plus crop productivity

Trees can improve crop yields in many different ways such as:- N_2 fixing trees, soil stabilization, protect crops from effects of strong winds and improving micro climate.

Trees can be used as wind breaks or shelter belts to reclaim land especially in semi arid areas. They can: - Reduce wind velocity to a speed which is insufficient to move soil particles. This minimises wind erosion and seeds and seedlings are prevented from being blow away. It also reduces sand blast damage to growing crops and reduced wind speed also lowers evaporation rate from both open water and soil surface making more water available for crop's growth. Trees increase atmospheric humidity. They may improve crop quality by reducing lodging and bruising of vegetables and fruits. Trees improve soil quality by humus addition and soil structure stability. When leguminous trees are used, N_2 is fixed in the soil. They contribute to nutrient recycling. They increase water infiltration. Trees reduce water runoff and erosion. Trees reduce frost damage in form of belts of shelter. They provide products like fruits, fuel wood. N_2 fixing trees provide foliage for organic mulch manure. Tree roots bind soil particles and create spaces which assist in water percolation. Tree shades lower ground surface temperature which may

reduce loss of organic matter by oxidation. Trees provide fuel wood which is substituted for dung and crop residue. Fuel so that the dung and the crop residue can be used to increase soil fertility.

Trees and livestock production

Trees increase livestock productivity by improving nutrition, management and animal welfare. They improve animal nutrition by: - Utilizing above ground space to produce more biomass. By providing more nutritious fodder e.g dry Lucerne contains four times more proteins as Napier grass, providing fodder during the dry season when other farm fodder is in short supply, proving a higher volume of production of Lucerne can produce 20 tons of dry matter per hec per year in a pure stand. Some trees provide foliage for honey bees and leaves of some trees of Lucerne are used to feed fish.

Trees contribute to improved animal management thorough

Use of trees on live fences or as live posts for fencing allowing controlled grazing. The use of timber for construction of farm structures such as crushes animal housing units. The use of timber to make fish traps, food troughs, bee hives and other inputs that may be required in animal management. They provide shade from extreme heat. Protect animals from cold winds and rain. Providing fuel for heating e.g. brooders and provide trees/shrub spp provide medicine for livestock.

Tree products for on farm consumption or for sale

The range of products from trees is enormous but they can broadly be grouped as follows:

a) Products for house hold needs
b) Products for house farm sale.
c) " " farm input
d) " " house hold needs

They include; timber & poles for construction and furniture, fuel for warmth and cooking, medicines, tanning and dyes and honey

Farm inputs; poles for staking growing crops e.g. beans and bananas, shading light sensitive field crops**,** fuel for processes such as curing tobacco, brick making and sugar processing. Timber for hand tools and implements, carts, product storage etc. Materials for produce handling e.g. bark of some trees used for binding and the foliage for rapping.

Basket making, crate making, plates etc.

Products for off farm sale; timber, poles, fuel wood, folders, bark for tanning, gums, oils, honey and bee works and fruits etc.

Trees and land reclamation for agricultural production

Land that has been out of crop production can be reclaimed by trees. Afforestation has been used to reclaim saline and alkaline soils. Saline tolerant trees include:- Albizzia laberck (timber, fodder), Prosopis guliflora (fuel wood), Pingelmia pinnata (oil from seeds) and Terminalia arjuna (foliage for silk worms). In this type of reclamation, the improvement in the soil's chemical properties is aided by leaching/drainage which can be achieved by constructing ditches which leads to better leaching.

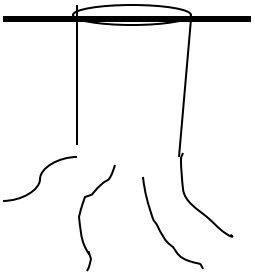
Adverse effects of trees

Trees can have adverse effects to both crops and soils and these include:-

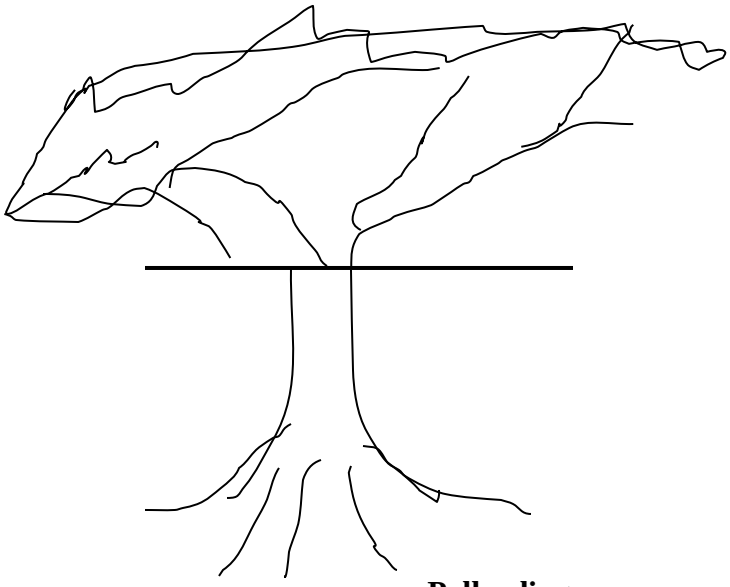
Compete with crops for water and essential nutrients. Competition for water is more pronounced where moisture availability is limited. On the other hand competition for nutrients is more severe in soils with low fertility. Some trees produce substances which inhibit germination a growth of other plants e.g some spp of eucalyptus. They use space that would otherwise be used for crop production. There is loss of organic matter (OM) and nutrients in tree harvests. Trees accumulate large quantities of nutrients in their bio-mass, part of which is removed in harvesting. Trees can provide a habitant for pests and disease causing organisms. Agro forestry can lead to reduced overall family income since it increases the demand for labour. It's possible for trees to increase soil erosion if the trees canopies are high, rain drops falling on the leaves coalese into larger drops which then fall with greater velocity than small drops, and when there is little under growth, the impact can be higher causing more erosion.

The above effects can be reduced by:-

Planting trees in rows with good spacing, selecting spp that have rooting and ground characteristics that do not impair crop growth, ideally rooting system for trees for agro forestry should be deep penetrating but have limited lateral spread. Following appropriate trees management practices such as pruning, coppicing and pollarding where coppicing is cutting down the tree up to its stamp and pollarding refers to cutting the tree up its branches.



Coppicing



Pollarding

Where crops are planted near a wood lot, ground cover should be clear. In summary trees can benefit crop and livestock production. Therefore, they have implications for food security and rural income.

Constraints to the practice of growing of trees on the farm

Antipathy (strong dislike) which results from cultural practices and contemporary reasoning e.g. control of tsetse flies, lowering of the water table plus taboos, lack of incentives or other priorities, unfavourable land tenure system, tree ownership (government or private) and shortage of land

Time / labour shortages

Agro-forestry systems and component interactions

These component interactions refer to the influence of one component in the system with the performance of the other component as well as the system as a whole. Since woody perennials (trees) are important components of all agro-forestry components, for practical purposes all interactions are referred to as tree-crop and tree-animal interactions. The component interactions are known as positive (beneficial) or negative (harmful). The balance between positive and negative effects determines the overall interactions on a given agro-forestry combination.

Positive or production enhancing interactions at the tree-crop interface

The main positive or complementary interactions are those related to micro climate amelioration (make something better). Micro climate amelioration involves soil moisture and soil temperature relations resulting primarily from the use of trees for shade or live fences or life support or wind breaks and shelter belts. Temperature, humidity and movement of air as well as moisture of the soil directly affect photosynthesis, transpiration and energy balance of associated crops which may translate into increased yields. Shading reduces temperature, temperature fluctuation as well as vapour pressure deficit (V.P.D.). This reduces transpiration hence shaded plants are less likely to suffer water stress. This is especially beneficial during short periods of draught and may result in increased production. Trees in crops may have both positive and negative effects on the water budget of the soil and the crops growing between them. Tree mulch or litter increases water infiltration and reduces evaporation of water (moisture) from the soil, however in situations where water supply is limited e.g. semi-arid areas, trees may increase water stress to the associated crops since they lose a lot of water by transpiration.

Trees also reduce or control light demanding weeds and also the mulch from trees pruning suppress weeds. Trees recycle nutrients and they also add nutrients when their litter decomposes and leguminous trees have non-fixing capacity. Trees also hold nutrients that would be lost through leaching.

Positive interaction at the tree-animal interface (T–A)

The positive interaction at T-A interface can affect the overall system's productivity in the following ways:- Trees provide fodder (foliage) which is of no direct use to the farmer but is transformed into animal biomass with high nutritional and monetary value.

Trees provide shade which results into better production and higher reproduction in animals. It's also believed that shade increases weight gain. Fodder form trees and shrubs especially legumes are highly nutritious leading to increased yields. Animals which gather under the trees shade fertilize the trees through their manure and also control weeds around it.

Negative or production reducing interaction at the tree-crop interface

The major yield reducing effects arise from competition for water, nutrients and light. Yields can also be reduced through Allelopathy (trees produce chemicals that affect crops). Availability of light that affect crops is most limiting in situations like relatively fertile soils and where water is adequate.

Competition for nutrients is most severe where there is low soil fertility and competition for water greatly affects agro-forestry systems particularly in arid areas. Allelopathy which refers to inhibition of growth of one plant by chemical compounds which are released into the soil by a neighboring plant depends on spp interactions.

Examples:-

Tree species	**Effect on**
Casuarin equisetifolia	Cow peas, sorghum, sun flower
Eucalyptus tereticornis	Cow peas, sorghum, sunflower, potato
Gliricidia sepium	Maize, rice seedlings tropical grasses
Grevillea robusta	Grevillea seedlings
Luecaena leucophala	Maize, rice seedlings, cowpeas, sorghum, sunflower

Modification of micro climate by trees increases incidences of some diseases especially fungal, while reducing the occurrence of others e.g. witches broom.

Tree-animal interaction

Low quality tree spp can adversely affect livestock production, on the other hand, mechanical damage of trees, or deterioration of soil properties through animal feet can have a negative impact on the woody perennial components.

Component management

The magnitude of interactive effects between trees and other components of agro forestry systems depends on the characteristics of the spp, their planting density, spatial arrangement and management of trees.

Manipulating densities and arrangements is one of the most important ways of capitalizing on the most beneficial effects while reducing on the negative effects. The

different manipulations can be grouped as growth enhancing or growth reducing, depending on their effects on the targeted components.

Management options to achieve increased growth include: - Application of fertilizers / manure, Irrigation, Mulching, Soil tillage, Plant adapted spp, Micro climate amelioration (MCA), Supplemental feeding of animals

Management options to achieve decreased growth includes; Pruning, Flooding, Root pruning, Trenching, Extensive shading, Use of herbicides and Grazing / browsing. The goals of management practices should be to increase the production of the desired products and to decrease growth and hence competition of undesirable components.

Topic Three

Agro-forestry systems

There are several ways of classifying agro-forestry systems, the most common are:-

a) Spatial (space) and temporal (time) ways.
b) The importance and role of the component.
c) Production aims or outputs from the system.
d) The socio-economic features of the system.

However, we often use more than one. These correspond through the system structure, function, socio economic, major or ecological spread. According to these criteria, agro-forestry systems can be categorized as follows:-

1. On structural basis:-

   Refer to the composition of the components, spatial arrangement of the woody component, and vertical stratification of all the components and temporal arrangements of the different arrangements.

2. Function basis:

   Refers to the major functions of the system usually provided by the woody components, It can be service or protective in major e.g. wind breaks, shelter belts, soil conservation and others.

3. Socio-economic basis:

   Refers to the level of inputs or management or intensity of skill of the level of management and commercial goals

4. Ecological basis: Refers to the environmental condition and ecological suitability of the systems. Note: the broad basis of classification of agro-forestry are not independent or mutually exclusive,

According to the structure of the system

Three main categories are identified:-

a**). Agri-silvo-culture**: Is a combination of herbaceous crops and trees plus shrubs in the same land use system through natural regeneration. The practice is usually a combination of multi-purpose trees and common agriculture crops. Trees are grown for their valuable products and sometimes to increase production of surrounding crops by improving soil and water conditions for growth. This system is adaptable in all ecological regions especially in subsistence farming. Multipurpose tree spp suitable in this system include:- Acacia albida, Acacia eliator, Anacardium occidentalis (cashew nuts), Azadirachta indica (Neem tree), Callitris glauca, Cassia siamea (Iron wood or yellow cassia), Tamarindus indica (Indian date tree), Cassia spectabilis, Grivellea robusta (silver oak), Jacaranda mimosifolia (Jacaranda) and Leucaena leucocephala.

b**) Home gardens**

These are a complex collection of various trees and crops around the homestead. They are often associated with the production of home animals. They have 3 – 4 storeys:

- Very high trees
- Shorter trees
- Crops

Each system has wood for fuel, fodder, timber, spices, herbs and vegetable crops. This system is adapted to all ecological zones.

c). **Silvo-pastoralism**: Is a combination of the pastures, woody perennials and livestock production in the same land use system.

d). **Agri-silvo-pastoralism**: Is a combination of crops, pastures, animals plus woody perennials in the same land use system

Agri-silvo-cultural:

These are agro forestry systems with trees on cropland. They are the most widely practiced in Africa. Choice of trees or shrubs spp suitable for the various agro-forestry

systems vary according to the environment and the interest of the farmer. When selecting spp for an agro forestry system, consider the following:-

a) Compatibility of the spp with the cropping system.
b) Appropriateness of the spp with the soil conditions of the site.
c) Usefulness of the spp for production of valuable products, otherwise difficult to find or grow in the vicinity.

Agri-silvo-cultural systems include:-

(a) Trees dispersed in crop land.

Trees are usually permanent and may be scattered haphazardly or according to some systematic pattern. The practice of raising trees dispersed in cropland may be based on protection and management of selected mature trees already on the site or may involve planting new trees or may depend on careful management of selected seedlings established on site of high population, where land is in short supply. None the less even farmers with access to large pieces of land may adapt and develop home gardens, however the most frequently used spp are:- Guava trees, Pawpaw, Citrus, Avocado, Cassava, Several types of leguminous shrubs. Herbaceous plants e.g. Okra, bananas, g. nuts plus many others. Medicinal plants plus spices

(b) Improved fallows:

It's a rotational system that uses preferred woody spp to replace crops on the fallow fields in sequence overtime. Improved fallow have become important because fallow periods are becoming shorter due to an increasingly acute shortage of land. The shorter fallow periods may fail to restore soil fertility sufficiently to sustain later crop productions.

Introducing woody spp can help to speed up soil recovery and to control soil erosion as well as producing economic products. Improved fallows also help to control pests, diseases and weeds associated with certain crops. An ideal fallow spp is one that grows fast and efficiently takes up and recycles available nutrients within the system thus shortening the time required to restore fertility.

Species; should be compatible with future crops and not in competition with crops to be planted later. The degree of land pressure and the extent to which the local economy is commercialized will determine the farmer's priorities concerning soil fertility enhancements verses cash crop production.

Soil improving species include: Acacia mearsii (black wattle trees), Acacia auriculiforms, Acacia albida, Flemingia macrophylla, Leucaena leucocephala, Leucaena diveriflora Sesbania, Gliricidia spp and Calliandra calathyrsus (Calliandra)

Timber species: Markhamia platycaly, Cedrela spp (Burmese cedar) and Podocarpus henkelii. The practice of improved fallows may involve selective cutting and weeding of vegetation or replacement of natural vegetation with trees or herbaceous plants. Permanent tree and shrubs to be maintained through future cycles of cropping and fallows can also be introduced. Thus the fallow can lead into a more intimate mixture of trees and crops during the next crop rotation.

c) Alley cropping (hedgerow inter cropping)

Entails growing of food crops between hedge rows of planted crops and / or planted trees preferably leguminous spp. The hedge rows are pruned periodically to provide mulch and when returned to the soil enhances the soils nutrient status and physical properties, and it prevents shading of the growing crops. Farmers may also obtain tree products from hedge rows and on sloping land hedges help to control soil erosion. The primary purpose of alley cropping is to maintain and increase crop yields by improving soil and controlling winds and weeds.

Species:

Trees / shrubs spp for alley cropping are usually leguminous. An ideal alley cropping shrubs / tree should have the following characteristics.

Sparse small crown to permit sunlight penetration, should respond rapidly after pruning, coppicing, pollarding or ripping. Deep tap root system with few lateral roots near the surface so as not to compete with crop roots. Alternatively the tree / shrubs should have shallow lateral roots that can be pruned by ploughing along the hedge without serious damage to the plant, should have leaf litter that decomposes fast so that nutrients are made available when needed in the cropping cycle. Should fix nitrogen and also produce wood, food, fodder, medicine or other products used by the farmer or community and should grow well under specific conditions of the site.

Note: The criteria above only serves as a guideline for selection of tree at a specific site.

Species include: Leucaena leucocephala, Gliricidia sepium, Cassia siamea, Calliandra calothyrsus, Sesbania Sesban, Alchornea cordifolia

d) Contour vegetation strips

Are erosion control measures for sloping farm land and in addition providing useful products and enriching the soil. The establishment and maintenance of horizontal strips of vegetation on sloping land is one of the most direct, cost effective and ecologically sound erosion control intervention. The tree and shrub spp for this system should be compatible with the surrounding crops and cultivation practices. Tree spp for the upper and middle storeys should be fast growing, produce minimum of shade and root competition and should provide useful products. A dense mixture of small shrubs and herbaceous plants in the under storey is very important. Fodder crops such as lab-lab, stylo, elephant grass star grass and others may also be included. Contours strips may be established by intensive planting or simply by maintaining strips of vegetation when new fields are prepared particularly where natural vegetation consists of bush thickets and thickly wooded savannah woodlands.

e) Taungya:

Consists of growing annual agriculture crops along with forest spp during the earlier establishment of the forest system. Wood production is the ultimate objective in the taungya system but the immediate motivation for practicing it is food production.

The greatest disadvantage of this system is the erosion hazard caused by preparation for the agriculture crops; however, this can be reduced by adding crop residues. The land for such a system belongs to the forestry department but the farmers use for 2 – 3 years as the trees establish themselves. The system exploits the farmers labour to tend the tree seedlings in exchange for land to produce the much needed food. Suitable tree spp will depend on the purpose for which the plant is established.

f) Multi storey / Multi layer

These gardens refer to mixed tree gardens or plantations consisting of conventional forest spp and other commercial tree crops. The common characteristics of tree garden systems include:- Have a variety of mostly multipurpose plants in various vegetation layers. Are usually dominated by perennial rather than annual crops. Most tree gardens form a part of a whole farm system which also comprises of annually cultivated field crops. The latter are for producing staple food stuff while the tree gardens are for producing highly nutritious supplementary products, medicinal plants and spices, fuel wood, fodder and

wood for construction. Most tree gardens are used to produce a small continuous flow of these supplementary products for subsistence and if possible a small surplus for sale. Tree gardens vary with climate and soil conditions as well as socio economic conditions. However, the general cultivation practices are standardized. The role of tree gardens in food production depends on their spp combination. It's less significant in home gardens. An important value of tree gardens is their contribution to the cash economy of Uganda through the sale of various commercial products and various fruits and spices. Tree gardens can be an efficient buffer zone around the protected forests.

Trees in soil conservation:

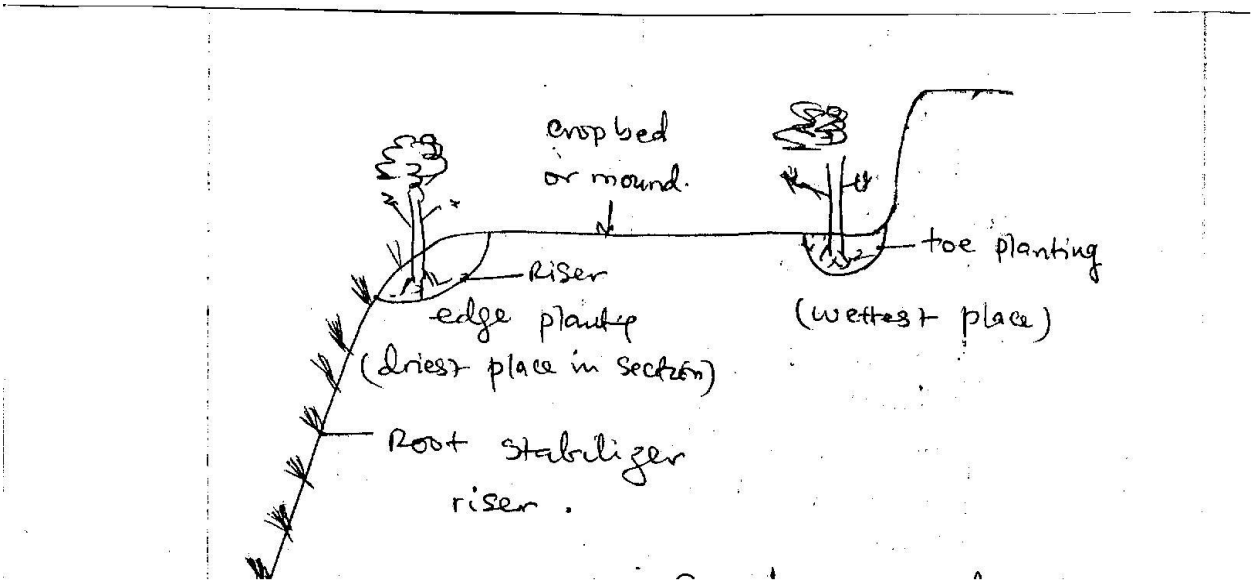
Trees and shrubs are grown on earth work structures, terraces, along water ways and gullies with or without grass strips.

i) Trees and shrubs on small earth work structures

Trees, shrubs and grasses can be used with several types of earth work structures e.g. micro catchments, contour ridges, contour furrows, infiltration gullies and barriers placed along contour lines. Small earth works intercept and slow down the flow or runoff water and prevent both sheet and rill erosion and in some cases also conserve water for plant growth, in crop lands pastures and degraded sites under rehabilitation. Trees and shrubs protect ridges and cut all field slopes of newly constructed structures especially in loose sandy soils. Woody plants and grasses also make lost cropping space productive by using the surface of structures where other crops cannot be grown. The choice of spp to plant is wider than any other agro forestry practice. Proper spp section depends on mainly soil / site conditions spp selection, also is a matter of farm management i.e. people select spp that are most likely to meet their needs and priorities.

ii. Trees, shrubs on terraces.

Terraces are built mainly to conserve the soil and stabilize the slopes of steep lands while providing level areas for crop production. Trees can either be placed along the riser edge or at the toe. If the bench is wide enough, both sides can be used:



Spp suitable for home gardens can be used in this system. Fruit trees e.g pawpaws, guavas, olives and mangoes are commonly used but other spp such as Grevillea robusta, Ziziphus mauritiana, Chinese dates, Indian plum, and fodder spp can also be used.

iii) The trees and shrubs for protecting and stabilizing water ways and gullies.

Permanent vegetation particularly trees and shrubs can play an important role in stabilizing water ways and gullies as well as natural stream banks. The vegetation decreases the velocity of water along the channels edges and protects exposed soil from erosive forces of flowing water. Physical structures can be combined with vegetation to stabilize stream banks and gullies. The plant roots hold soil and rocks lining the channels and vegetation reduce the velocity of running water. In addition to soil conservation, trees and shrubs provide useful products.

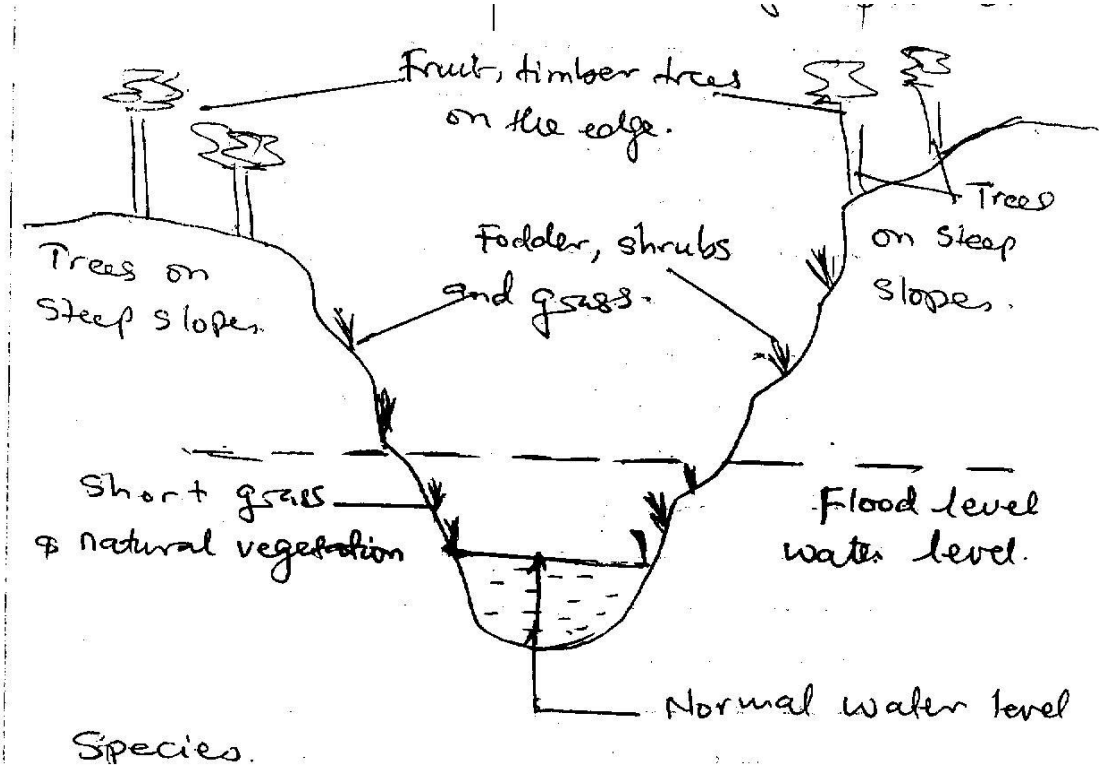
Species: Ficus (Bark cloth fig, Bush fig., Tamarix spp, Cedar tree). Mitragyna (Coe tree) Sesbania spp, Bambusa (bamboo)

g). Shelter belts and wind breaks

Live hedges:

Wind breaks are narrow strips of trees, shrubs and / or with grasses planted to protect the field / houses from wind and blowing sand. Shelter belts are types of wind breaks with long strips of trees. Wind breaks usually consist of multistorey strips of trees / shrubs and are planted in three or more rows, grass and herbaceous plants are often planted at the base of trees to prevent wind from scaring the soil. Live fences and hedge rows can

protect small sites such as home gardens and nurseries from wind. When properly designed and maintained, wind break reduces the velocity of wind and thus its ability to carry and deposit soil and sand. It also improves the micro-climate in a given protected area by decreasing evaporation from the soil and plants. It can protect crops from loss of flowers and it also reduces crop losses due to sand shear of seedlings. In addition to soil and water conservation effects, wind breaks also provide some useful products e.g. fibre, mulch, fodder, fruits, fuel wood and pawpaw.



Species:

Should consist of a central core of a double row of planting of fast growing and tall tree spp e.g. Eucalyptus, Casuarin, Azadichyta indica and two rows of shorter spreading spp e.g. cassia spp, Prosopis spp and Leucaena spp on both sides of the central core since the trees change their shape as they grow, it's necessary to mix several spp of different growth rates, shapes and sizes in multiple rows.

Mixing trees also extends the youthful life of the wind breaks, controls insect pest and diseases and yields wider variety of useful products. However, the choice of spp will depend on the farmer's priorities and site condition e.g. Eucalyptus trees are not good where water is a limiting factor because they use a lot of water, and the Neem tree is not good where the crops grown are sensitive to shade.

h).**Plantation crops combination:**

Tree-crop plantations do not necessarily include agro forestry practices, but they do so. Herbaceous ground cover crops can be introduced into stands of commercial tree crops along with upper storey trees used to produce shade, mulch or wood. This kind of combination or integration is only limited to the early phases of plantation establishment e.g. on modern plantations of crops like rubber, coffee or oil palm. This is because diversification would impede modernization and efficiency of traditional plantation management technology, however, under small holder farming where land and capital are limiting farmers usually integrates annual crops and animal production, with perennial crops e.g. citrus and coconut groves can be planted with pastures subjected to controlled grazing. In other cases, coffee and tea plantations benefit from these fast shade trees while in others coffee usually grown in association with crops such as bananas, beans and maize.

i).Trees for fuel wood production

Most developing countries use fuel wood and the gathering of wood is seen as the biggest cause of deforestation. Planting trees for fuel provision is one of the several measures to reduce deforestation. Fuel wood tree spp include: - Cobretum spp, Neem, Eucalyptus, Acacia nilotica, Tamarindus and Prosopis. But farmers prefer tree spp that produce multiple products rather than those that produce good quality fuel wood.

Silvo-pastoral systems

There are several and involve growing of large numbers of trees and shrubs, ranging from extensive nomadic systems to intensively managed systems of cut and carry system.

a).Trees on range lands and pastures.

Trees are scattered irregularly or are arranged in some form of systematic pattern on pastures. The trees / shrubs may be used primarily to produce fodder for livestock or for providing useful tree products or for providing pollen and nector for bees (fodder) or for

improving soil in the pasture. Extensive silvo-pastoral systems on range lands usually involve the selective protection and management of naturally occurring trees of particular value for animal fodder. In more intensive silvo-pastoral systems, naturally occurring trees are managed selectively or multipurpose trees and fodder shrubs are planted. In this case, trees are stretched more closely and managed more intensively than in the extensive system. In dry land Savannah zones silvo-pastoral systems help to maintain stability and fertility of the grazing land and to reverse trends towards land degradation and desertification. The woody spp in pastures meet wood and fodder animals throughout the year and maintain fodder reserves through dry periods. In addition fodder from trees /shrubs often have higher crude protein (CP) and mineral content and sometimes higher dry matter (DM) digestibility than associated grasses particularly during the dry season.

The main obstacle to the production of fodder trees in pastures and range lands is the need to restrict animal access and grazing till trees and shrubs are well established.

The choice of woody spp for agro forestry and pastures and range lands depends on:- Local priorities, Environmental conditions, Degree of grazing condition, The type of livestock, How to control access to the site, Ability of desirable spp to regenerate naturally. Acacia and Prosopis are suitable for fodder. Leucaena, leucocephala, Gliricidia sapium, combretum spp are suited for leaf fodder and fuel wood, other spp include; Pigeon peas, Yenels nut, Old man salt bush, Terminalia brownii and Acacia tortilis (for extensive system).

b). Home gardens involving animals.

This is an ultimate multi storey combination of various trees and crops and animals around the home stead. The woody spp should include some fodder spp. It's adapted to all ecological regions in a high population density.

c).Multipurpose hedge rows.

Woody hedges are grown for browse, mulch, green manure or soil conservation.

The tree / shrubs spp chosen should be fast growing and coppice well. This system is adapted to humid and sub-humid areas with sloppy or sloping terrain.

d). Multipurpose wood lots.

Trees are grown for various purposes such as, for wood, fodder, soil protection and land reclamation. Multipurpose spp are used e.g. Acacia spp, Albizzia, Alnus, Calliandra spp, etc. N**.B. Other agro-forestry systems may not fit in the above systems; examples**

a).Trees along water ways and flood plains

Trees and shrubs with grasses are grown along the banks of streams, lakes or seasonally flooded ponds / swamps when the natural vegetation has been removed or degraded. The main objective is to protect the fragile land along water ways and make it more productive.

Species; Flood plain management requires separate parallel strips of grass, shelter and trees rather than a combination of all the three in the same place. A strip of grass is especially important along the edges of fast flowing streams, spp commonly used include:- Dalbergia Sissoo (Si ssoo), Eucalyptus spp, Azadirachyta indica (Neem), Acacia Nilotica (Prickly thorn), Parkinsonia eculeata (Jerusalem thorn / hard bean) and Sometimes fruit spp e.g citrus, date palm, mangoes and spice trees are also included.

b).Trees along paths and roads.

In this system, they provide shade, shelter, reduce dust on adjacent land and when properly managed, they provide useful tree products e.g wood, fodder and fruits. Trees also greatly reduce soil erosion damage and siltation in rural water shades caused by road way drainage. The common spp include: - Jacaranda, Paper tree, Persian lilac and Cassia siamea.

Alley farming

Involves managing hedge rows of woody spp with annual crops planted within the rows of woody spp and some of the prunings from the hedge rows are used for fodder. Alley cropping has the potential to make many cropping systems more productive on a sustainable basis. The tree and shrub spp are periodically pruned to reduce shade and / or provide green mulch or fodder for livestock. Where prunings are continually removed for fodder, animal excreta must be returned to the field or else the soil will be impoverished. Where prunings are used as mulch, they reduce evaporation, suppress, weeds and add nutrients plus organic matter to the soil.

Although alley cropping focuses on soil improvement, the hedges also control soil erosion especially on steep slopes. When combined with mechanical erosion control methods, hedges reduce run off, makes productive use of land taken by conservation structures, strengthen and stabilize these structures through the binding action of their roots. Alley cropping is designed to be a sustainable alternative to shifting cultivation or expansion into unproductive land. Alley cropping combines the cropping and fallowing phases, reduces the requirements for external input and it's flexible enough for use by both small scale farmers and large scale producers.

Design of alley cropping:

The woody plant spp are introduced as hedge rows in farm fields to maximize the positive effects and minimize the negative effects of trees on crop management and yields. The position and spacing of hedge rows and crop plants in an alley cropping system depends on:- Plant spp, Climate, Slope, Soil conditions and Space required for movement of people and tillage equipment. Ideally hedge rows should be positioned in an E-W direction.

Management:

Management practices vary widely in specific areas. Once established, trees and shrubs are left to grow for the first 6 – 15 months before the first cutting. The period depends on:- Growth vigour, Root development, The type of hedgerow plants and the cutting schedule required

Alley cropping if well managed; It arrests degradation of land, Enhances biological….., Raises / improves efficiency of labour use, Stabilizes favourable environmental conditions for crop production and Sustains production for longer periods. This agro-forestry system is suitable for humid and semi-humid regions but less feasible in areas with high labour costs, low rainfall and / or long dry periods.

Note: The alley cropping technique is still under experiment; therefore all promotion should be through an implemental approach.

Protein banks / cut and carry:

Tree and shrub spp are grown in block configuration or along plots boundaries or other designated places. The foliage is periodically pruned providing protein rich fodder to feed

animals kept in stalls. The woody spp should be leguminous such as Calliandra, Sesbania and Leucaena.

Live fence posts and live fences

The fodder trees are left to grow to develop sufficient root so that they serve as fencing posts around plots. The trees are pruned periodically for fodder and pole. Living fences are common in many farm land use systems. They are mainly used in the control of movement of wild and domestic animals. Plant spp used for living fences are usually low, rarely over 2m high. The plants are trimmed and for some spp, the branches are woven around the stems to form a dense barrier.

Topic Six

Raising tree seedlings in a nursery bed:

Trees are propagated either from seeds or vegetative materials such as cuttings or buddings. These require special attention involving frequent watering and shading therefore the need for a nursery.

Choosing a site for a nursery

The site for a nursery should be:- near a source of water, near the site of field for planting. In an area that is not subject to flooding, with a leveled or terraced ground. Trees seedling can be raided in either polythene bags or directly planted in the soil.

Containers for seedlings

Polythene bags are the most commonly used, although woven baskets and plastics containers can be used. Polythene is cheap and durable; it also makes handling of seedlings at planting out very easy. 5mm holes should be perforated into the polythene at about 5cm apart. The bags should be filled with good loamy soil or mixed sand and clay (1:2) respectively. The size of the bag depends on the size of the seedlings.

Ground nurseries:

Raising seedlings in ground nurseries leads to considerable damage to the seedlings on extraction, thus delaying their development. It also leads to more seedlings being lost.

Preparation of a nursery bed:

All roots and grass should be removed from the area to be used for the nursery bed. Soil should be deeply cultivated into a fine tilth and the bed should

be sterilized before planting. The top of the bed is made firm by gently ramming it. After preparation of a nursery bed, allow the vegetation to rot and soil to weather before planting.

Nursery management:

Watering, once or twice daily at a rate of 50,000l/ha on rainless days (in the humid tropics)

Shading and spacing:

Provide partial shade at early stages, shade should gradually be removed as seedlings grow. The spacing of the seedlings depends on the time they are to be kept in the nursery. Seedlings should be hardened off before being transplanted.

Fertilizers

Usually nursery seedlings grow faster if fertilized such as N.P.K. and those containing Magnesium. Apply fertilizers once a week but if the soils are fertile, reduce the frequency of application.

Transplanting:

Transplant when the seedling first fill the bag (Leaves of adjacent seedlings just). Transplant during sufficient wet season, only strong ones, and carry out weed, pest and disease control.

END OF SUB-UNIT

Sub-Unit: Environment Management

Course outline

- Introduction
- Environment Management & Systems
- Man's activities & Environment degradation
- Environment policy issues in Uganda
- Environment Impact Assessment
- Forestry

Introduction

This course is an introduction to ecological, economic, political and socio-cultural perspectives on relationships between humans and the rest of the natural world. EM is concerned not only with the impact of human kind on the planet but also with pattern and human behavior necessary to preserve and manage the environment in a self sustaining way. As human activity has increased its scale and coverage, its impact on the global environment has become so serious that it may even endanger human survival. Human activity is the accumulation of each of our daily activities. Accordingly each and every one of us is required to grapple with environmental problems in earnest and take specific actions to alleviate the loads on the environment. In planning and implementing corporate (business) activities, we should always be conscious of environmental problems and make minimization of environmental load a prerequisite for corporate activities. At the same time, we should also share the fundamental belief that efforts for the environment carry the same weight as safety and quality management.

Concept of environment

The word environment is very broad referring to: Lithosphere-which covers soils and rocks, Biosphere-which deals with plants and animals, Hydrosphere-which deals with water resources, Atmosphere – is the envelope of air that surrounds the earth. Therefore in short, environment therefore is man and his surroundings.

Environmental management (EM)

What is EM? The word environment is used in different ways. We talk of home, work, social etc environment; we use the word to describe our physical surrounding made up of air, trees, soil water etc. By EM we mean keeping control of our activities so that we do

what we can to conserve these physical resources and to avoid polluting them. We can apply these controls in our life domestically in what we throw away, but it is usually in our work where the environment impact of what we is greatest. Such has been the impact of industrial activity that resources are becoming depleted and environmental damage is increasing. EM is a subject that combines science, policy and socioeconomic applications. It primarily stresses on finding solutions to practical problems that people face in cohabitation with nature, resource exploitation and waste production. In a purely anthropocentric sense, EM is all about dealing with the fundamental issues of how to innovate technology to evolve continuously while limiting the degree to which this process alters natural environment. Environment managers therefore fall within a broad spectrum that extends from conservationists to technocrats, from those who would limit human interference in nature to those who would increase it in order to guide natural processes along benign paths. Both conservationists and developers therefore need to com and work together over the need to make economic development sustainable, without it being under mined by long term damage to natural resources and vital habitats. This is the intention of the United Nations Conservation on Environment and Development (the process that began at the earth summit in Rio de Janeiro in 1992)

Environmental Management System (EMS)

A system can be thought of as a number of interrelated elements functioning together to achieve a clearly defined objective. We therefore say that EMS consists of a number of interrelated elements that function together to achieve the objective of effective EM.

What are the elements that make up an EMS?

Different countries, businesses or entities have widely differed combination of elements to meet their particular needs, however a common model for an EMS has been formulated by the ISO which standardizes the elements that an EMS should contain. The model has been designed to be applicable worldwide and to organizations of all types and sizes and is set out in the standard ISO 14001 EMS. The elements of ISO 14001 are organized around five steps; Environment policy, Planning, Implementation & Operation, Checking & Correction action and Management Review.

3. Make brief notes on Environmental Impact Assessment (EIA)

Meaning of Environmental conservation and management:

This may take on several meanings;

Environmental conservation and management refers to the skillful and wise utilization of the natural resources. Environmental conservation refers to the preservation of the natural resources such as soils, forests, and wildlife among others. Management and conservation of resources involves: - The protection of the natural resources from over exploitation in order to prolong their use for example, protection of the oil fields, water and land. Restoration of natural resources which had been abused earlier, for example over exploitation/utilization of land can be restored through addition of manure so that its productivity is maintained. Recreation-man should plant trees, flowers which provide beauty. The scenery provided through the planting of trees, retaining as much genetic diversity as possible so as to protect different plants from disease, which may wipe them out. This helps man to survive given that man depends entirely on the environment.

Rationale for Environmental Conservation;

The environment offers four broad functions; resource/raw material production, food production, provision of habitat and waste accumulation. Therefore the overall rationale for environmental conservation is to ensure that the environment is able to carry out the above functions effectively. Through the environmental conservation, there is constant food supply. For example, soil conservation helps in providing soil texture, which provides essential plant nutrient. It helps in maintaining constant water supply, for example if the water catchments areas are protected, it will help everyone to constantly receives water. Helps in the provision of raw materials to the industries. Through the conservation of resources, there will be high productivity in crops and plants. This will provide raw materials to the industries. Helps in the control of natural hazards like floods, drought, and storms and helps in the provision of beautiful scenery for example, through the planting of trees and flowers

Ways of conserving and managing the Environment

The environment can be conserved and managed in the following ways:-

Control of floods; this can be done through the creation of multi-purpose river schemes which will have the purposes which will have the purpose of controlling floods, creating hydro-electric power and the water created can be used for irrigation. Control of desertification; this can be done through regulated grazing which is associated with

nomadic. It can also be controlled through afforestation in semi-arid and arid areas. Control of pollution; this can be done through using pesticides very carefully and disposing the containers well. Through the use of smokeless energy and electricity which will not interfere with the atmosphere. Pollution can also be controlled through building taller chimneys so that smoke does not diffuse in the environmental atmosphere next to man. It can also be done by first treating the effluent from industries before disposing it into the lake or river system. Pollution can as well as be controlled by controlling carbon monoxide emission from old vehicles. Control of pests and diseases; pests such as tsetse flies, locusts are very destructive. This can be controlled by use of insecticides and monitoring their breeding grounds in case of locust invasion. Diseases can also be controlled through hygiene and intensification of the medical sector to cater for dangerous diseases. Deforestation can be controlled by afforestation programmes to replenish stocks. Soil erosion can be controlled by forming terraces in hilly areas, encourage Contour Ploughing and also controlling nomadic grazing and overgrazing which leave the land bear. Proper disposal of waste; industrial waste and human waste should be controlled and directed in their rightful places. Latrines and pits should be prepared where these wastes are directed so that they don't appear in the home surroundings. Health homes; the houses should be ventilated and cleaned by sweeping the floor, cleaning the utensils and storing them away from pests and dust. These help in cleaning and maintaining the environment in the home for human survival.

Wetland resources of Uganda

Wetlands are places that are partially or constantly under water which inhabit aquatic life for example, a swamp eco-system. Wetlands are solid parts of each surface, which are socked or saturated with water, for example, swamp eco-system. Wetlands cover about 30,105Km, representing 13% of the total area of Uganda. The area under permanent wetlands is currently estimated at 7,296Kmsq and seasonal wetlands 22,809Kmsq.

At least 69% of the total area is under wetlands comprising of impeded drainage, while swamps constitute 30% and swamp forests 1%. There are two broad categories of wetland, namely those that are associated with lakes (lacustrine) and river (riverine). The lacustrine type include, the Kyoga/Kwania complex, L.George, Edward and Albert, Bunyonyi, Bisinia and Opeta, Wamala and other minor lakes. The riverine swamps

include; the Okole and Kafu swamps. The wetlands can further be differentiated based on altitudinal variations as follows:

i. Above1, 900-3,000m; valley swamps (poet) of Kabaale, as well as upland swamps in Bwindi forest, papyrus swamps, sedge-dominated (including papyrus swamps, and syzygium swamp forest.
ii. Above 3000m; swamps, bags and miles of mountainous areas like Ruwenzori and Elgon mountains.
iii. Permanent swamps; Cyperus papyrus, sedges, typha, swamp grasses and swamp forests.
iv. Seasonal wetlands and temporary pools.

Values/Uses of wetlands

Provide water in the dry season which is sold to generate income for the people. Being spongy, wetlands control floods by carrying away excess rainwater, used to control soil erosion, source of crafts, palm leaves and materials to make mats, chairs, tables, clay soil is used to make pots, cups and bowels. They are productive places (very fertile) and therefore can be used to grow rice, yams and sugarcanes. This is true with Kibimba rice scheme and Kakira sugar works. Provide food to the natives in form of fruits, rice, yams and fish. Purify water by removing chemicals and nutrients from sewage and waste waters. Modify the climate, water evaporates and convectional rainfall is formed. This type of rainfall is common in river lake region, Provide water for both human and animals. Water is used for drinking, cooking and washing. They act as source of building materials like roofing grass, clay for bricks and timber. Wetlands act as natural habitats for birds and animals. They are centres for tourist attraction for example, Bujagali falls in Jinja. They are used as research areas for an environmental management. They provide herbal medicine. They provide employment to fishermen and transporters. They are used as a form of transport which is sometimes quicker. They provide local and international boundaries for example, R> Nile defines the boundaries of Busoga and Buganda while Lake Albert defines the boundaries of Uganda and DRC and they are source of hydro-electric power, for example, at Jinja Owen Falls Dam, hydro electric power is generated. Another dam to generate hydro electric power is being constructed at Bujagali falls.

Encroachment on the wetlands:

Wetlands in Uganda have been encroached in the following ways:
Conversion of wetlands for agricultural purposes; wetlands particularly those with shallower water have been put under intensive cultivation of crops such as rice, sugarcane yams and Eucalyptus. These wetlands have been poorly managed for example wetlands in Iganga, Namutumba, Kaliro, Budaka and Tororo districts.

Dumping of waste (solid garbage); some isolated wetlands, some of which are close water bodies as is the case at Gaba market and the dumping site near Luzira prisons, Masese swamp in Jinja, Namatala in Mbale, Lumolo in Pallisa and Walugogo near Iganga town are other examples of wetlands affected by illegal dumping of Garbage.

Deforestation of swampy forests; this is done for wood and other crafts products. It is particularly a serious problem in the wetlands of Iganga, Tororo, Butalejja, Namutumba, Ssango bay in Rakai district.

Excavation in the form sand mining and extraction of clay for brick making, the pits accumulate stagnant water, which has created habitats for disease carrying vectors such as mosquitoes and snails. This has led to wide spread of malaria and some pockets of Bilharzia. The above activities are closely linked with developments in urban center where there is high demand for bricks as a result of the current construction boom.
Rampant swamp fires; swamp fibres are common in Butalejja, Budaka Soroti, Apac, Pallisa and lira districts where they are mainly started deliberately by hunters or to encourage regeneration of new papyrus swamp fibres pose a threat to the bio diversity in these areas.

The wetlands of Jinja districts are the most degraded in Uganda. Most of the encroached areas where originally allocated to private developers and have since been reclaimed for industrial development, therefore the loss of wetlands in the district has had a significant environmental cost. For example the reclamation of Walukuba-Babu Patel wetlands in Jinja has led to siltation of streams in Walukuba, Makenke and Magamaga.

In Iganga and Pallisa districts, an extensive area of the seasonal wetlands is also under intensive cultivation. It is estimated that, 64% of the total seasonal wetlands in Iganga and 68% in Pallisa have been reclaimed for rice growing. The impact of massive reclamation of wetlands in the two districts has been as a reduction in the number of permanent streams, disappearance of permanent springs and a low ground water yield in the wells

The encroachment on the wetlands in Iganga has led to the shift from the growing of perennial crops such as bananas, to annual crops such as maize and rice.

The outstanding environmental issue concerning wetlands is the increasing level of degradation. Related to this are the pressures, which include ownership of wetlands as a common property and government institutional Policies. Other threats to the stability of wetlands are agricultural conversion, industrial pollution, drainage activities and over harvesting of wetland resources.

Factors for encroachment on wetlands

There are a number of factors that have contributed to encroachment on the wetlands in Uganda. They include:-

Where individuals own wetlands; plots in them are usually sold cheaply compared to upland areas. The enforcement capacity is very limited amongst the various institutions charged with the environmental management planning of the country. The wetland inspection division has limited staffing required to cover the whole country. Similarly, NEMA's monitoring department is small yet it has the task for the whole country.

Political interference; in many cases of wetland abuse in the country, the offenders are prominent individuals. In many cases where enforcement agents try to stop encroachment, such individuals help to overrule the decision and thus encroachment continues. According to NWCP (2000), lack of knowledge and understanding amongst wetlands users, law enforcement officers and legislators about the functions of the wetlands, the laws and regulations in place, the mechanisms of law enforcement is a

contributory factor. Lack of coordination and planning in the allocation and development of plots. The various players like city, municipal and town councils, Uganda investment Authority, Uganda Manufacturers Association and individuals allocate or develop plots in wetlands in disregard of any infrastructure plan, including works for drainage. Wetlands are free in most parts of the country. Ownership is either not very clear or not seriously pursued. The poorer section of the population moves into such areas, where they can open up gardens of rice, yams in rural areas while in urban areas put up structures more or less free of charge. Wetlands lease procedures were started long before the coming into place of the National environment statute and other pieces of legislation on wetlands. Although no new leases are supposed to be given, the issuing of leases continues for those, which are already being considered. Therefore, many of the developments, which are emerging presently, are because of bureaucratic procedures started some years back. Such encroachment although dangerous cannot easily be stopped.

Impact of swamp reclamation on the environment in Uganda

Swamp reclamation is the making of land that is naturally wet suitable for farming, settlement, transport and industry. It affects weather cycle by increasing temperature and making area dry. It deprives the area of water sources necessary for plants and animals including man. It leads to destruction of natural vegetation. It destroys beautiful scenery (aesthetic value). Swamps which act as natural sieve for water are destroyed. Flood destruction is enhanced as reservoir is destroyed, leads to destruction of natural habitat for some creatures. They die and thus ecological imbalance. Water tables are allowed leading to dryness/drier soil. Leads to loss of raw materials for craft industry. For example, papyrus for mats, clay for pottery and leads to loss of food for example, fish and medicinal plants.

Protection of wetlands:

Wetlands can be protected in the following ways:-

Sensitizing people on the use of wetlands, enacting laws and byelaws on the wetlands management and use, gazetting some of the useful wetland areas to become protected areas, building dams to trap/retain water that would be wasted as wetlands dry up, developing varieties of crops like upland rice and yams that don’t require a lot of water to

grow as opposed to paddy rice, developing alternative materials for wetland functions like other forms for bricks, for timber , treating effluents from industries and before being dumped into wetlands, establishing overseeing agencies like National Environmental Management Authority (NEMA) and reducing population pressure through resettlement and family planning methods.

4. Read about the following; Uganda Wetlands Policy, Uganda Environment report (2015), Environment Impact Assessment regulations, Uganda hand book on Environment, Noises standards & Control and Waste management regulations

Environment degradation and environment management in Uganda

Environmental degradation refers to the decline in the productive value of man's surrounding or environment. It is the deterioration in the quality and characteristics of the natural surrounding that's land, water, flora and fauna through deforestation, pollution and many others. It may also refer to activities, which destroy or have a negative impact on the natural environment, for example, cutting of trees, dumping of wastes, and pollution among others. Environment degradation can also be looked at as incapacitating the environment from carrying out its broad functions i.e. waste accumulation, food production, provision of habitat and raw material production, therefore environmental degradation results from both natural and manmade causes. In Uganda when you look at environment, we see an element of degradation and are associated with farming systems, through the use of poor and environmentally unfriendly methods and techniques. However, the size of this differs from region to region. There are few things we should have to look at. African farming systems which we see today go back to pre-colonial periods when a variety of systems were developed by different ethnic groups e.g. shifting cultivation. The past trend of farming in a sustainable way seems to be disappearing in much of Africa and this can be seen in the frequency of draughts, abject poverty (rampant) lack of resting of land under bush fallowing and frequent deforestation. Increase in agriculture production in much of African countries is as a result of putting more land into cultivation rather than intensifying farming methods, this affects environment. There is crisis for arable land due to population increase, because of

increase in population; it means increased use of various resources available and intensified use of agro-chemicals.

Common forms of environment degradation:

Soil degradation: Through soil erosion. This lowers the grade of soil which is important to farming, soil fertility is lowered and thus productivity goes down. Several kilograms of soils are lost every year per hectare through this type especially the mountainous areas lose 4,000 Kg /ha/year of top soil.

Deforestation: In clearing land for cultivation, we cut trees/ vegetation or for charcoal and this is increased by this population increase. Burning also causes land degradation.

Excessive drainage of wetlands: This is brought about by rice growing and this disturbs the water balance. It also destroys the bio-diversity and forests.

Loss of bio-diversity; Bio- diversity is lost by excessive cutting, fires and by interference of other plants e.g. the water hyacinths.

Water pollution: Pollution of water especially through siltation, chemicals from farm wastes, people and industries, agro-chemicals from farms e.g. acaricides, herbicides, and pesticides e.t.c. This will result in radioactive substances emission from such polluted water.

Poor sanitation practices: Waste disposed; waste management should be encouraged. All these wastes are very difficult to manage.

Global warming: This tends to have some problems with temperature as temperatures do rise and no rain. This does come about as a result of industry gas which eats up the ozone layer which would prevent or filter the solar radiation leading to our animals being affected by such radiation.

High population problem: 3.5% increase of population growth rate leads to high population densities which result in increase of provision of food, money e.t.c. These are more of concern to us because we want to use land more sustainably

Activities of man responsible for environmental degradation:

i. Deforestation; this is the depletion of the forest cover in many parts of the world. One fourth of land in the world is covered by forests among which 50% is located in the tropics. The tropical rainforests are disappearing quickly. The annual average rate of destruction is over0.8%, whose number indicates that all tropical rainforests would be

lost in the 21st century. Yet forests play an important role in maintaining soil fertility, protecting water catchments areas (ref. to R. Amazon forest, Brazil, River Ssezibwa, R. Nile, L. Kyoga and Victoria-Mabira forests in Uganda R. Congo-Congo forest in DRC), minimizing soil erosion and many other roles.

Deforestation will thus result into:-Reduced rainfall**,** increased soil erosion and hence, soil deterioration**,** unreliable water supply due to reduced rainfall**,** creation of high temperatures on earth due to the creation of the carbon dioxide layer in the atmosphere, which keeps heat on earth. Remember plants are the consumers of carbon dioxide.

ii. Swamp reclamation (Depletion of wetlands)

Land shortages as in Kigezi and the desire to grow certain crops that require a lot of water such as rice in South East Asia and Eastern Uganda have led man into swamps. Swamps drainage results into serious water shortages, wells and streams dry up and there's insufficient water for both man and livestock, the drainage areas soon become arid and unproductive. Many birds and animals lose their habitat hence, affecting the eco-tourism industry.

iii. Desertification

This is the process whereby desert fringes are encroaching on potential agricultural land as a result of increased soil loss. It is also a process, by which areas, which were not formerly classified as deserts are turned into desert, land mainly by man's activities. The process of desertification leads to the decline of agricultural productivity in the affected regions. The problem of desertification has been aggravated by the rural energy crisis, firewood is still the main source of energy in many developing countries and many people in rural areas still depend on firewood for cooking and heating purposes.

vi. Over grazing

This is common in regions where domesticated animals exceed the carrying capacity of the land. The carrying capacity of the land is the ability of the land support a certain number of animals comfortably without exhausting the grass completely. Overgrazing in the semi arid regions and on the fingers of the Savannah may expose the soil to agents of soil erosion. For example, in some parts of southern Kenya, (Masai land), Northeastern Uganda (Karamoja), Northern Nigeria (Fulani), where nomadic Pastoralism communities keep large herds of cattle, sheep and goats, large hectares of land have been overgrazed.

The large number of animals nibble the grass to the roots and expose dusty top soil is detached by wind and carried away hence, soil erosion which results into loss of soil fertility, deterioration of underground water resources and increased drought.

v. Pollution: this refers to the addition of certain substances into the soil, atmosphere and water thereby contaminating them. The causes and effects of pollution can be seen in the following cases:-

Dumping of industrial and domestic wastes in lakes and rivers, thus contaminating urban water supplies, endangering the life of fish and other aquatic life through the disposal of chemical impurities from industrial plants into lakes and rivers, car washing at river and lakes banks that pollutes the water resulting into death of fish and land pollution through the dumping of polythene papers, which reduce productivity of land Polluted water used for irrigation may lead to the transmission of diseases and acid rain especially in Europe and North America.

vi. Bush burning: This is mainly done by shifting cultivation, sedentary farmers and nomadic pastoralists for various reasons such as clearing land for farming, securing fresh pastures at the beginning of the wet season and others burning of vegetation results into:- Exposure of top soil to wind and running water hence, erosion of soil, destruction of useful worms and other living organisms which contribute to soil formation, destruction of humus hence, reduced soil fertility and development of fire resistant vegetation which is not nutritious for the livestock.

vii. Overfishing: this is the most pronounced in the international waters. The demand for fish is growing year which results into over fishing. This has resulted into disappearance of certain fish species, barren waters and migration of fish to new safer areas.

viii. Cultivation: Agricultural practices may induce environmental degradation in several ways; Traditional monoculture of growing perennial crops such as bananas, coffee and tea year after year leads to soil depletion if manures or fertilizers are not used. Over use of land for cultivation without giving it enough time for the soil to regenerate. For example, in densely populated regions like Ruanda and Burundi lead to soil deterioration and poor farming methods that accelerate soil erosion such as cultivation of crops in areas, which do not receive a reliable rainfall and others.

How poor farming methods have led to environmental degradation:

Overgrazing/overstocking removes the vegetation cover thus exposing the soil to erosion, Felling of trees/forests to create land for agriculture through slashing and burning of the cultivated trees contributes to environmental degradation. Monoculture that's the growing of crops for example, maize, tea, and many others exhaust the soil quickly. Wild bush burning to provide fresh pasture destroys the vital nitrogen fixing bacteria, in the soil and vital plant species. Mechanization of farming leads to distortion of the soil structure. Continuous application of artificial fertilizers, pesticides and herbicides lead to pollution of air and water. Reclamation of swamps and marginal land set up for farms leads to floods, flora and fauna killed, habitat destroyed thus leading to eco-system. Over cultivation of the same piece of land leads to soil exhaustion. Tilling/planting up/down slope leads to soil erosion and over harvesting of the natural resources for example, fish, timber and many others leads to depletion of such resources.

ix Mining and quarrying: The extraction of minerals ores and quarrying of stones leads to exhaustion of minerals for example, copper at Kirembe in Uganda and exposed coal in Ruhr region of Germany, destruction of scenic beauty, which may affect tourism, increased noise through blasting of rocks and pollution when ores are dissolved in rain water and run over to the fields and water bodies.

x. Poaching: This refers to the illegal hunting and killing of wild game especially in the national parks and game reserves. In Kenya for example, the elephant population has been seriously reduced due to the demands of elephant tasks. In Uganda, the white rhino is extinct. Poaching leads to the reduction of the tourist industry.

xi. Genetically modified (foods) organisms (GMO). The gene technology makes it possible to transplant the DNA of one species to another species. Now it is utilized to make new plants to feed people. In North America, genetically modified crops for example, soybeans, potatoes and cotton are now increasingly planted and sold. The problem of GMO food lies in the safety and potential toxicity, even if the acute toxicity is proved not to be evident. The gene technology is not yet proved safe for the environment hence; GM foods are not yet welcome in many nations.

xii The Ozone layer depletion: The earth is covered by the ozone layer that absorbs the harmful ultraviolet rays from the sun, protecting the living organism on earth 1%

decrease of ozone means 2% increase of the ultra violet on the surface of the earth and 5% to 7% increase skin cancer. In 1980s, scientists discovered a big hole in the ozone layer over the Antarctica. There a big hole appears in spring, whose size tends to increase each year. Scientists identified the chlorofluorocarbons CFC as the responsible matter for destroying the ozone layer. The CFC has been widely used since 1928 as a safe coolant (refrigeration Gas) and washing material.

Natural causes of environmental degradation

i. Biological causes: Weeds, pests and diseases are biological hazards which seriously pose a threat to production and man in the following way: Plant pets such as locusts, caterpillar, aphids and worms destroy crops and the natural vegetation. Plant diseases affect both crops and forests, weeds such as the water hyacinth, which leads to massive problems of fish breathing. Human diseases such as malaria, dysentery, TB, cholera and AIDS reduce the effectiveness of Labour. Live stock diseases such as Nagana in West Africa kill large numbers of domestic animals particularly cattle.

ii. Climatic hazards; these are numerous and affect the productive value of man's surrounding in the following ways:- Flooding which doesn't only destroy agricultural land but also leads to loss of property, life and contaminates safe drinking water. Drought, which is the abnormal insufficiency of water below usual requirements for plant growth, irrigation, domestic and industrial consumption. Drought may kill livestock, crops and people. It is one of the main causes of food shortage and famine in Africa. Hail storms causing extensive damage to crops.

iii. Other natural hazards:-

Volcanic eruptions which may introduce sulphurous gases like in Cameroon in early 1990s into the atmosphere thereby polluting it, Earthquakes, which are disastrous, for example, refer to the effect of Tsunami December 25, 2004 in the Far East. Landslides in highland areas such as S.E Asia, Latin America, Africa and Glacial and river erosion in highland areas that cause mass soil erosion

Measures to control environmental degradation:

Use of proper farming methods such as crop rotation, organic mulching, agro forestry and others so that the soil does not lose its fertility, environmental education in schools should be emphasized through wild life clubs and should also be integrated in the

syllabus, Afforestation and reafforestation programmes should be launched to provide fuel, timber, control soil erosion as well as modifying the climate and water supply. The public should be sensitized through mass media like radio, television, Newspapers on the dangers of misusing environment and also on good agricultural practices, which help to maintain soil fertility. Government should develop alternative sources of energy such as hydro-electric power, solar energy, biogas and the use of energy saving stoves to reduce the clearing of forests for fuel. Proper disposal of industrial wastes and proper treatment of sewage wastes before disposal. This will protect the life of fish and result in clear water for both domestic and industrial use. Reduction of excessive population pressure on land through birth control, cut migration and developing other sectors of the economy such as industry, mining, tourism where excess population can be employed rather than on land, control of overgrazing and overstocking through the introduction of scientific livestock management such as rotational grazing (paddocking) controlled grazing and others, banning important/manufacture and use of Polythene bags in the country, this is already in place only that enforcement machinery is still weak. Government policies on wetlands, forests, rivers, and lakes should be streamlined which protect them. There should be regulations on the importation of vehicles and related machinery, which are environmentally unfriendly, the use of swamps which should be controlled and planned by government to avoid misuse and excessive drainage. Enacting acts in parliaments for example, acts on clear air such that industrialists know that they are bound by law to treat their industrial wastes and not supposed to pollute it. Pass laws and encourage mass education against burning especially by pastoral communities. Government agencies like NEMA should be empowered to monitor environmental concerns of the country. Use of agricultural chemicals should be regulated. Stringent laws on those who destroy environment should be enforced and encourage research for example, in high yield/optimum crops for a type of soil/climate.

Impact of modernization of farming on the environment

Modernization of farming refers to the use of the improved methods in rearing animals and growing crops, for example, use of improved breeds, fertilizers, and machinery in a proper and organized way.

Positive Impact:

Leads increased productivity of animals and crops, leads to production of high quality products hence, improved nutritive status, leads to efficient use of available natural resources for example, land utilization, encourages use of marginal lands for example, desert, mountain slopes, wastelands and others, influences local weather for example, through, Afforestation, encourages the use of organic farming, which reduces on the use of chemicals for example fertilizers and pesticides and encourages agro forestry, mulching, and terracing which protects the environment from soil erosion agents.

Negative impacts:

Leads to destruction of natural vegetation, which leads to erosion, floods, drought, landslides and global warming, deep constant Ploughing leads to destruction of soil structure and profile, the constant use of chemicals pollutes the environment, it leads to distortion of the ecological balance. Dams, ponds and constant irrigation expose the animals to water borne diseases, continuous use of heavy machinery like tractors leads creation of a hard pan through which water can't easily percolate. Leaching plant nutrients/fertilizers leads to the creation of salt pan beyond the level which pants reach hence, result into poor yields. Mulching offers breeding places for germs, pests and fire risks.

Environment Management issues in Uganda

This is trying to contain the unwanted consequences of environment and this is done by;

NEMA which was created in 1996 to carry out all monitoring of environment management in Uganda

NEMA is supervised by two committees

i. Prime minister committee for environment - this committee is supported by a board of directors with representatives called line ministries (Seventeen ministries) and some NGOs. The work of these is to implement any recommendations that NEMA puts in place. Environment problems in Uganda are exacerbated by following problems:-

Abject poverty, Wars, Low literacy rate, Uncoordinated policies, Land fragmentation, Un appropriate farming methods, Over grazing , Land compaction, Agro-chemicals, Deforestation, Bush fire, Water weeds, Industrial gases, Effluents and Improper fishing methods and gear

Sub Unit: Pasture Management

Course outline

- Introduction
- Pasture classification
- Pasture establishment
- Grazing management & Practices
- Pasture conservation

Introduction

The term "grassland" refers to those areas where grasses are the main component of the vegetation.

Importance of grasslands

It's a cheaper source of livestock feed compared to commercial feeds. The grasses may be sold to earn income; Grasses protect the soil from erosion. Legume grasses may add N to the soil. Grasslands ensure proper land utility i.e. land is not left redundant. Grasses help in nutrient recycling i.e. bringing up nutrients from the lower layers of the soil to the surface. Grasslands help to maintain soil structure. They provide thatching materials

If established in a rotation, they help to break crop pest and diseases cycles. They add manure / humus into the soil. They provide a soil cover thus help to maintain soil moisture.

Types of grasslands

(i) Natural: These are grasslands that have evolved in an area without man's influence.

(ii) Improved: These grasses where originally found on the land but have been modified by man through weeding, fertilization and mixing with other grasses and legume.

(iii) Established: These are grasslands or pastures that have been purely planted by man.

Pastures

These are grasses or areas of grass suitable for grazing animals or a pasture is an area of domesticated grass and legume for animal feeding. It can also be defined as any plant that is suitable for feeding livestock.

Importance of pastures

They are the main source of livestock feeds. Improve and maintain soil fertility. The fibrous roots of grasses restore the crumbed soil structure by the binding action while legumes play a role in N_2 – fixation. Decomposition of pastures adds organic matter to the soil. They protect the soil from erosion. Grass: legume pastures offer proper land utilization because land is not left redundant. Pasture management forms an alternative husbandry in farming.

Classification of pastures

(i) According to composition

- **Pure:** This is where exclusively Grass or Legume only species are grown. They can also be termed as **single stand pastures**.

These contain exclusively grasses or legume species alone.

- **Mixed pastures:** These contain both legume and grass species.

(ii) According to establishment

Natural pastures, temporary (leys), improved pastures and Permanent

Permanent Pastures: Is a piece of land that is planted with a combination of grass and legume and is not ploughed for crop growing.

Temporary (Leys): These are pastures grown in rotation with arable crops.

(iii) According to growth period

Annual Pastures and Perennial Pastures

(iv) According to water needs

Xerophytic

Grow in dry conditions, in areas where there is seasonal water or areas with marked water deficiency. Plants are tufted, leaves are twisted or convulated, thin and hard. They have a well developed deep rooting system and a have a high nutritive value.

Mesophytic grasses

Grow in moderately wet areas / soils, are loosely tufted or stoloniferous, may be perennials or annuals the leaves are flat, broad and soft. They have a well developed rooting system. **NB:** Most good grasses for grazing livestock belong to this group.

Hygrophytic grasses

Grow in marshes and swamps, densely tufted and stolen ferrous, Perennials, stems are spongy, broad and flat and soft, low nutritive value.

Hydrophytic grass

Capable of growing in water, they may be densely tufted or stoloniferous, they may have floating and spongy stems and their leaves are flat and soft and their grazing value is very low.

Advantages of Natural Pastures

They contain a wide variety of forage plants from which livestock can graze. They are cheap to maintain since they do not require a lot of care. Forage plants found in natural pastures are well adapted and can persist under poor management. They are found in areas that are considered unproductive (marginal lands).They support a large population of local livestock spp e.g. sheep, goats and wild game and if improvement is to be done, fewer inputs e.g. fertilizers are required. However natural pastures are less productive in terms of herbage yield and nutritive value. The grasses / plants mature very fast becoming fibrous and woody which results into low palatability and disease spread is very common due to communal grazing and over grazing is high.

Single stand pastures compared with mixed pastures

Single stand pastures are easy to manage both at seedling and utilization stage. Germination is uniform and emergence and growth pattern are all the same hence easy to manage. However in mixed pastures; there is faster coverage of the land surface. Water and nutrients are evenly removed from the land. There is better yield both in forage quantity and quality. There is maximum use of soil as different crops have different nutrient needs. Better weed control is achieved. There are fewer cases of bloat in animals which graze on mixed pastures than on pure legume stand and there is economy in the use of N_2 fertilizers as legumes will fix N_2 from the air.

Role of legumes in a mixed pasture

They are rich in protein and therefore supplement grasses which have less protein content. Most grasses are less palatable than legumes; therefore legumes increase the overall palatability of the pasture. They have high supply of Ca^{2+} and a lot of Vitamin A. They increase N_2 in the soil through N_2 – fixation. They increase / extend the grazing

period into the dry season as many legumes remain green throughout much of the dry period and because their roots are deeper than those of grasses, they help in re-circulation soil nutrients. The practice of growing pastures in rotation with arable crops is referred to as ***ley farming.*** This system has the following advantages; it provides herbage for animals during periods of no cropping, the legumes add Nitrogen to the soil while The grasses add humus to the soil. Controls soil erosion. Improve soil structure there is improved nutrient recycling and leys break pest and disease cycles.

Success of a mixed pasture

This depends on the selection of compatible legume + grass species, adaptability of species in the climate and soils of the area, palatability and nutritive value of the species to livestock, persistence of species to grazing and other environmental conditions and the ease of establishment of the Spp among other factors.

Problems of legumes in a mixed pasture

The total yield of a mixture is lowered because the energy content is lower and this yield is expressed in terms of DM (Dry Matter). They are more difficult to manage as compared to single stand pastures; this could be attributed to the fact that in a mixed pasture the grass: legume ration is always 1:2. The legumes are very susceptible to diseases and pests and are very sensitive to nutrient deficiencies i.e. iron, copper, zinc and manganese.

Characteristic features of a good forage Spp.

A good pasture grass or legume should have the following characteristics:

Remarkable drought resistance / tolerance, relatively high palatability and attractiveness, high in nutritive value, easy to manage at both establishment and maintenance stages, able to provide fodder all year round, has a suitable height to enable picking by livestock (at least 10-15cm), resistant to heavy grazing and produces large quantities of DM. In case of mixed pastures, the Spp should be compatible, Resistant to pests and diseases Able to produce large quantities of viable seeds or productive vegetative parts. Good competitive ability with weeds, highly digestible, should not contain toxins and should have the ability to recover quickly from heavy grazing

Activity 1

Identification of some common pastures

With the guidance of hand book on East African grasses and legumes, identify the following common pastures around your environment. Make brief notes on each of them as regards establishment and, nutritive value and most suitable method of utilisation

(a) Grasses: Elephant grass / Napier (Pennisetum purpureum), Kikuyu grass (Pennisetum clandestinum), Rhodes grass (Chloris gayana), Guinea grass (Penicum maximum), Signal grass / Congo grass (Brachiaria Spp), Jaragua grass / thatch (Hyparrhenia Spp), Nandi Setaria (Setaria anceps), Guatemala grass (Tripsacum laxum), Star grass (Cynodon dactylon) and Red-Oat grass (Themeda triandra).

(b) Legumes: Glycine (Glycine wightii)**,** Stylo (Stylosanthes gracilis)**,** Green leaf desmodium (D. intortum)**,** Silver leaf desmodium (D. uncinatum), Centro (Centrosema pubescens)**,** Siratro (Macroptilium atropurpureum)**,** Lablab (Dolichos purpureus)**,** Gliricidia (Gliridia sepium)**,** Calliandra (Calliandra callothrysus), Sesbania (Sesbania Sesban) and Leuceana (Leuceana leucocephala)

Establishment of pastures

Before you establish a pasture in any area, consider the following: Soil type, this should avail adequate nutrients, moisture and good structure. Topography, if hilly use contours to minimize soil erosion and loss of nutrients. Seed quality, Seeds should be viable, pure and should be free from physical damage, pest/disease free and must have passed the dormancy stage to allow quick germination. Economic factors, such as money spent on establishment should be justified by the price and gains from the undertaking and number of livestock or size of herd should match with the herbage supply.

Establishment of pure pastures

The type of seedbed required varies from place to place. However it should be a firm seedbed and free from weeds. The following simple steps can be followed; slashing the remains of the previous crop or existing vegetation, ploughing the garden, harrowing the land to break soil clods and make the soil fine, (a rough seed bed may also be desirable depending on the nature of the planting material), application of fertilizers if need be especially SSP at a rate of 150 – 250kg ha^{-1} yr^{-1} a day before planting. Carry out seed treatment e.g. by scarification and inoculation, this to hasten germination as these

techniques break seed dormancy. Planting may be by broadcast or drilling if the planting material is seed. For elephant grass and/ or other vegetative materials, open furrows where the cuttings are to be placed. Covering with light soils by dragging a branch of a tree over the seedbed or in case of vegetative materials the cutting may be fully covered under soil or half covered while left standing. Carry out light grazing after 1½ - 2 months to encourage tiller production full grazing may be done after 3 months. Apply Nitrogen fertilizers to improve quality and vegetative growth weeding by hand pulling or digging out the weeds to reduce nutrient competition and improve growth vigour.

Establishment of Mixed Pastures

The same procedure may be followed except the application of nitrogen fertilizers may not be done as the legumes can provide the required nitrogen. You may sow legume and grass seeds by broad casting and cover with light soils, however depending on the spp used legumes can be sown after the grasses have established, this is because most legumes have a faster growth rate than most grasses so this would avoid over showing of the grasses by the legumes. Firming of the seedbed with a roller after sowing may be done to reduce soil erosion and increase soil-seed contact. Carry out light grazing to check on the growth of grasses and give chance the legumes to establish and to stimulate tillering of the grasses.

NB: Alternatively a pasture can be established using the ***nurse*** crop or ***companion*** crop method. Crops like maize and sorghum are planted, after the last weed, pasture grasses and legumes are broadcast in between the line. The crops provide shelter against sunshine, too much rainfall and strong winds. By the time the crops are harvested, the pasture would have fully established itself. This is also called ***under sowing***.

Pasture Management / Improvement

To avoid any shortfalls from the pastures, there is need to properly care for them. The Objectives are:-

- To achieve efficient utilization of pasture for a long grazing period.
- To improve performance of pastures in both quality and quantity.
- To enable pastures plants persist for a long time / period.
- Maintain pastures in a vigorous state of growth. Pastures will often show certain signs

which will determine if there is need for improvement such as; evidence of erosion in pasture land; gullies and sheet erosion pavements, presence of dead and dying plants Presence of less valuable plants or unpalatable plants e.g. tick berry, Sodom apple, poor condition of the animals, selective grazing, presence of marshy areas / vegetation, lack of healthy and vigorous and plants, when valuable species fail to produce seeds and presence of pests, parasites etc.

Methods of pasture improvement

Removal of all unpalatable and poisonous weeds, Controlled burning to reduce the layer of dead materials, Carrying out controlled burning to reduce the decayed layer of grasses, Deep plough the spots where new pastures are to be planted and apply manure, Over sow, sow or spot sow with valuable grasses and legumes, Even distribution of watering points to minimize overgrazing at existing water points, Paddocking to allow controlled grazing, Irrigation during the dry season to encourage continuous growth, Draining to control water borne diseases and parasites, Fencing to ensure effective use of pastures, Applying lime to reduce soil acidity and encourage microbial decomposition of dead material, Spraying Urea or Molasses on pastures to make them more palatable, Allowing a section of good pasture to become standing hay. By over growing these will produce seeds which will be dispersed and germinate in the next season and ensuring close herding of livestock to have uniform grazing but avoid overgrazing.

Activity 2

Establishment of a pasture museum

Grazing management systems

These fall under the following two categories ***extensive*** and ***intensive.*** Extensive systems usually involve herding large numbers of stock on a large piece of land usually with limited control over the animals. The stock is that of mixed nature with goats and sheep as supplements. Such a system includes practices like; Communal grazing, Continuous grazing (Set stocking or free ranging) and nomadic herding. Continuous grazing system is practiced widely in East Africa and makes low cost use of large grazing lands. Furthermore the system is practiced in range where animals remain in their pasture grounds for a long time. The pastures are open and not fenced. In this system, the farmer does not incur fencing costs and individual animals are able to select what they graze.

However, due to under grazing in the growing season and over grazing in the dry season, it tends to lead to the disappearance of grasses of high feeding value. It also encourages the buildup of parasites such as ticks and worms because of repeated races of animals, the animals spend a lot of energy searching for suitable pastures and water and it permits selective grazing that leads to wastage of pasture.

In nomadic herding pastoralists make efficient use of distant grazing lands but because of increasing livestock population pressure and grazing concentration caused by drought, it can lead to soil erosion.

Communal grazing can be looked at as a subgroup of the continuous grazing the distinction lies in the fact that the livestock usually belong to different individuals. In this system herds belonging to different farmers are allowed to graze on a common pasture land. It is largely practiced where the land is communally owned. There is low productivity of both pastures and animals since no one is willing to improve the pastures. Soil erosion is common due to over stocking resulting from over grazing. It is difficult to control the spread of diseases and parasites as animals mix freely. Random mating is common so there chances of spreading reproduction diseases and undesirable characteristics. It is impossible or difficult to improve on pastures as no one cares.

Intensive grazing systems are characterized by high stocking rates and intensive pasture management practices and grazing control.

(a) Night pad docking:

This is a system of grazing cattle on an extensive area during the day and then confining them to small areas during the night. Animal production is greatly improved as animals carry out optimum grazing during the cool hours of the night. It may also reduce cases of theft and attack from wild animals as the animals graze near homes.

(b) Tethering:

The animal is tied with a rope around the neck or leg and the rope is pegged to the ground. The animal can only graze within the length of the rope. It is the commonest

method of grazing animals in E. Africa. Supplementary feeds and water are provided by the farmer.

(c) Strip grazing: (Hon heim)

It's an intensive system where movable electric fences are used to confine animals within a strip of grass. Any animal that tries to go beyond gets a mild electric shock which stops it from advancing. When a particular strip is optimally utilized (or grazed), the wire is shifted, this happens once or twice a day. It has limitations since fencing is expensive and adds to the total costs also animals will not select what they want to eat which may limit their level of production. However, animals get fresh grass every day; grass is eaten when it's at its greatest value or when it is still nutritious, allows for recovery of the grass. Dangers of overgrazing and soil erosion are minimized; it helps to control ticks and internal parasites and it gives the farmer a chance to carry out operations like topping, weeding and applying fertilizers within pastures.

(d) Differed grazing

Part of the pasture is set aside without grazing so that the pasture grows, matures and dries in the dry season thus making standing hay. This standing hay is then utilized during the periods of scarcity. The advantages of this system are it's a cheap way of making hay though it takes a lot of time. It provides fodder for livestock in the dry season. Enables the setting of seeds for re-growth of pastures and there is no risk of bloat caused to animals as the pasture is dry. However the palatability and nutritive values of the pasture is very low.

(e) Zero grazing (Cut and Carry)

Is where animals are confined in building or sheltered places from where they are fed. On a daily basis, the farmer cut forage and takes it to the animal, in addition to providing water. The system has limitations as animals lack enough exercise and this leads some of them to fail to take service. Collecting feeds, cleaning the stalls and replacing bedding materials makes it tedious. The costs of putting up the shelter and probably cementing the floor are high and discouraging. The system limits the size of the herd and accumulation of disease organisms can occur as animals are kept in one place. However the system requires a small area for the animals and permits keeping of animals even where the population pressure is high. Fencing costs are limited. It is impossible to cause

overgrazing as it's the stockman to provide the grass. It helps to control conditions like bloat since pasture is often allowed to wilt. It provides for good calf management. It is easier to control parasites and diseases because animals do not mix with others. The shelter protects animals from bad weather. Dung and urine are easy to collect and use for manuring and biogas production. There is effective use of herbage provided to the animals. Selective grazing and trampling of herbage are not experienced. Extensive walking by animals in search of food and water in avoided and grass from distant fields can be made use of.

(f) Rotational grazing

This is a system of where the pasture is divided into paddocks. The animals are grazed in the different paddocks in a sequence. After grazing each paddock is given a rest period during which the grass recovers and improvements on it are made. Each paddock must have a water trough and feed trough for supplementary feeding. The system has the following advantages; it provides a uniformly developed pasture due to uniform grazing or allows uniform pasture utilization, does not allow selective grazing, it minimizes build up of diseases and parasites the grass in grazed when it's at its highest value. Cow dung and urine are well distributed throughout the field. Grass is given time to recover and also the intervals between the rotations allows improvements to be done on the pastures. It reduces the amount of labour needed to look after the animals and soil erosion is avoided as over grazing does not take place. However, selectivity of pasture by grazing animals is prohibited, Paddocking costs are high**,** and it's only suitable for small and medium sized farms. The chances of bloat are increased since the lushy and fresh grass cannot be wilted before consumption.

Terms used in grazing

Stocking rates

Stocking rate is the number of animals per unit area of land and normally expressed as heads per hay. Stocking rate is a measure of the herbage output in pasture. If herbage production is under estimated or amount to be consumed is over estimated, the pasture will be under stocked and will be used to full capacity. If the pasture capacity is over estimated then the pasture will be over stocked and over grazed. Under stocking results in a waste of land herbage due to trampling and selective grazing and total production is low although production per animal is high. High stocking rates result in low animal production. It encourages soil erosion and overgrazing. It leads to encroachment of weeds on the pastures.

Recommendable stocking rates are:-

- Good fertilized ley 4 – 5 adults / ha
- Average ley 3 – 4 adults / ha
- Permanent rough grazing 1 – 2 adults / ha

Importance of stocking rate

Affects level of productivity of animals; Affects pasture production, Determines pasture duration and determines economic returns from livestock investments Several studies and models have been developed to look at stocking rate, productivity per animal and productivity per unit area of land. The relationship is in terms of live weight gain, milk production

PASTURE CONSERVATION

Forage conservation

This is an important management practice in pasture management since it ensures constant forage supply to the animals. This is particularly important in areas that have wide periods of dry spells; however areas that need forage conservation are the ones that do not carry out this practice. It's more associated with the stable agriculture economies. It provides a significant proportion of the energy needed to maintain productivity.

Herbage conservation is the practice of preserving grass that is plenty in the rainy season so that it can be used during periods of scarcity. The growth rhythm of pastures is affected by types of plant spp, season and climate. This results into two pasture growth patterns.

- Period of over production beyond the live stock needs.
- Period of under production; below the live stock needs.

The excess herbage production in the rainy season should be used in the dry season to meet livestock needs throughout the year. This is only possible through conserving it as hay or silage.

Importance of conserving fodder

To distribute available forage for livestock throughout the year, provide feed for the dry season, ensures better and full utilization of available land. Conserved forage can be sold for money; to avoid unnecessary waste of forage and to maintain continuity animal production.

There are various forms in which forage is conserved. It can be in a form of; hay, silage, standing hay. Standing hay is dry grass grazed in situ or is bushy forage i.e. standing hay of natural origin.

Hay

This is grass that is cut and given to animals in a dry form. It's mostly practiced in temperate regions though the climatic (temperature) conditions make it difficult, however they have developed techniques of curing it artificially in bundles under a shelter.

Stages

Cutting harvesting

Drying / curing

Baling

Storage

(a) Cutting / harvesting stages

The major decision is to decide at what stage to cut the forage. It's recommended that just at the beginning of flowering you get a good balance between nutritive quality and DM production. However this is exceptional to forage where even the seeds form part of the feed.

Methods of cutting

The method will depend on the size of the area and the amount of the bundles or material needed. In the temperate areas there are mowers specialized for forage harvesting and

these are usually unsuitable for the tropical coarser forage. Using hand tools e.g. pangas, slashers and sickle. Using mowers / tractors, using flail type harvesters which cut the forage and also chop it into finer pieces which increases drying rate. It also has the capacity to cut even the material that has dodged, however it requires more fuel than a mower

(b) Curing of hay

This determines the quality of hay harvested. The aim of hay preparation is to reduce the moisture content of the fresh material from the 60 – 80% to 25 – 28% in the shortest possible time to avoid loss of nutrients brought about by alternative wetting and drying, respiratory losses and exposure to sunshine.

After the material has been cut, it's heaped into wind rows; the aim is to reduce the surface area that is exposed to sunshine. The material is turned over to allow the underneath material to dry as well. The times of turning over will depend on the amount of sunshine, grass spp etc.

This is especially done to the stems which take longer to dry; this facilitates the synchronization of drying of both leaves and stems.

There is also chemical curing / drying it was developed in the temperate regions to overcome the short comings of weather. The material is sprayed with reglon before harvesting. This has two effects; stops the physiological process that could lead to nutrient loss and it also facilitates fast drying (2-4 days) the material is ready for storage and baling.

Barn curing

The material is harvested and partly cured in the field to 30 – 35% moisture content then it's taken to the barn with slated floors to allow air circulation. The limitation of barn curing is the cost of installation of the barn since it involves; shelter, heating facilities and shelves.

(c) Handling of hay

After curing, the next stage is baling. It's convenient to bale since the material is easier to store / handle since it's in pieces; so more material can be stored. There is specialized equipment for baling. Baling makes the transporting of the material easier to the feeding places. There are other forms of handling hay and the type chosen will depend on the spp of forage, the quantity of hay, the weather conditions and amount of labour and equipment you have.

(i). Chopping the material

When chopping is done will depend on the equipment used e.g. frail harvesters chop at harvesting while mowers you chop later. The moisture content of chopped hay should be (19 – 21% and that of hay is 15%. Chopping increases the rate and amount of hay intake by the animal and it also requires less space for storage than baled hay.

(ii). Making of pellets or wafers

Here the chopped hay is compressed into pellets or wafers and there is specialized equipment for this. The advantage is that they require much less spaces than bales or chopped hay (40% less space). The system subjects itself to automated feeding systems. It also increases feed intake by the animals. It reduces the bulk of the roughage and it has a true physiological effect on lactating animal.

Losses that occur during the making of hay

At every stage of hay making there is an element of loss that occur, and losses of up to 10 – 15% are inevitable so the aim is to control losses above that threshold level. Most losses occur in leaves since they are more fragile, they dry faster than the stems. You may lose ~25% of the nutrients if the curing process is not fast enough (this could be due to leaf loss) A loss of 25% in DM = 40% loss in protein content)

Losses of nutrients from the curing materials are due to:

Biological losses:

Due to the continuation of the physiological process after cutting e.g. respiration e.g. Carbohydrate break down, degradation of fats, proteins. When the physiological process stop but the material still has moisture, microbial activity and fermentation also lead to loss of ~ 10%; microbial activity causes 5-10% loss. The extent of loss will depend on temperature, humidity, moisture content, and the quality of forage handled and the method of curing.

Losses due to sunshine (heat)

Due to long exposure there are losses in the palatability and digestibility. Losses in amount of carotene (Vit. A). But at the same time this extended (long) exposure increases Vit. D content. Prolonged exposure also causes increases heat in the materials which can lead to wet heating and loss of nutrients; thus control the rate of curing.

iii. Losses due to rainfall

This is due to re-wetting of dry hay. A process of decay can start in wetted hay. The material in contact with the soil can;

- Also suffer leaching of the nutrients
- De-coloration of the material
- Direct loss of nutrients
- Bleaching and loss of palatability wetted material can lead to loss of up to 35% of carbohydrates

iv. Mechanical losses These occur especially during cutting e.g. the lodged material may be destroyed. There can be losses during baling, transporting, chopping. The mechanical losses are mainly due to loss of leaves. It's recommended that in order to reduce mechanical losses the frequency of handling the hay should be minimal.

v. Losses after baling

Baling is normally done at a moisture content that is higher than the recommended moisture content for storage and the reason is to reduce the loss of leaves. Because of high moisture content, a certain amount of fermentation occurs which leads to loss of nutrients, however within limits the fermentation process may improve palatability

If the fermentation process is increased, you may have an increase in temperature, this will lead to nutritional losses especially protein and digestibility would be reduced. Excessive moisture within bales can lead to moulding:

The biological component or composition of the forage would also influence loss at baling e.g. legumes dry at a lower rate than the grasses.

vi. Losses during storage

These are mainly determined by the moisture content of the material at the time of storage. If the hay is stored at a moisture content of above 25% there would be losses due to:-moulding, fermentation, wet heating. (This could even cause spontaneous fires within the hay). Heat development may also be as a result of microbial activity.

The quality of hay

There are several characteristics or factors used to measure the quality of hay.

The main determinants are the:- Energy value per weight consumed. The amount of hay the animals would consume voluntarily. There are other visual characteristics of estimating the quality of hay. Leafiness of hay: More leaves more nutrients. The leafiness may vary between 10 – 70% and is determined by; hay making process, type of crop, stage of crop. The leaves contain twice as much protein than the stems; they are more digestible; they are richer in Vit. E, they are more palatable. Colour of the hay; there is a correlation between the amount of chlorophyll and the amount of carotene and the green colour. The green colour is an indicator that the material was cured properly, timely harvesting and carotene content.

Time of harvesting

The green colour fades as the material matures and also loss of colour can be due to fermentation and improper storage

Aroma of the material

Properly cured hay has a pleasant aroma. Improperly cured hay has a musty smell (chocking feeling)

Amount of foreign matter within the material

E.g. stones, weeds, residues of crops reduce the quality of hay. However soil is the worst contaminant as it leads to digestion upsets.

Growth of moulds

Mouldy hay is extremely dangerous to animals and should not be fed to animals.

Factors affecting the quality of hay

This is determined by; Type of grass and legume used, Stage at which the grass is cut Degree of turning, Exposure to sunlight (avoid direct sunlight). Handling manner for-example miss handling leads to loss of leaves. Moisture content at baling and how well the hay is stored.

Signs of good hay

Good hay is usually highly leafy. Green-brown colour (Brown colour is due to over drying and loss of carotene). Has a pleasant aroma and is free from foreign materials and Non-mouldy.

Standing hay

This is herbage of sown pasture left to mature in the field. Because of the decline in nutrient quality as the forage matures, it does not meet the maintenance requirements of the animals and so requires supplementation of other feeds. To improve the quality, standing hay is mixed with legumes. Animals grazing on this kind of material will show weight gain at the dry period but as the dry season progresses there occurs a decline in animals' performance

Several attempts have been made to improve hay quality e.g. fertilizer application during growth at the end of the wet season especially nitrogen supplementation is required e.g. with G.nuts, cotton, seed cake. Stocking rates and factors determine

Silage

This is a green fodder preserved in succulent form. It is herbage cut usually before flowering or during podding and converted into a succulent feed through the process of fermentation. This succulent roughage is prepared by fermentation of fresh or partially wilted forage under anaerobic conditions. It is a vital source of energy, carotene, and minerals and has a positive physiological effect on animals

Advantages of silage

Is a good method of preserving forage in a succulent form, Silage increases animal appetite and feed intake. Good quality silage is consumed without wastage. Many plants may be ensiled and fed to animals which would not be fed in original form; it's an efficient method of storing many valuable products from industrial processes e.g. sugar by products. Economical in storage space as compared to hay, fire risks are eliminated since the preservation method keeps it fresh, incurs less nutrients loss is incurred than other methods of preservation like hay. Carotene losses are also minimal and if properly prepared and stored silage can keep for several years. However it's more costly when making it than in hay making. Silage cannot be fed by itself as a sole supplier of energy but requires supplementation. Mistakes in the preparation methods may lead to total loss of the material. To reduce top surface spoilage, the material can be covered by a sheet of plastic and weights added.

Method of ensiling

- Prepare a silo of adequate size.
- Identify top quality grasses and legumes of young maize, sunflower, sweet potato vines, elephant grass, clover and Leuceana.
- Cut these materials just before flowering or at podding in case of legumes.
- Allow the material to wilt in case it has a high moisture content (60-70 %.)
- Chop the material into convenient pieces 2-5cm in length.
- Take the material to the silo, in case of a pit silo; it should be laid with a layer of polythene.
- The chopped material is packed in layers of not more than 50cm and is immediately compacted to drive out excess air. This is to avoid rapid oxidation (micro-activity) that could lead to rotting.
- After about two days check on the temperature of the material (37.8◦c is the ideal), more silage is added if its < 37.8 and water is added if its > 37.8◦c.
- Add 1 litre of molasses dissolved in 2 litres of water to the material. This acts a preservative encourages fermentation and adds taste.
- Also urea may be added (5kg/tone) to increase the N-content.

- Add more material/layers and compress.
- Seal off the silage chamber / pit with a plastic sheet and a 2.5cm layer of soil to keep out excess air and water.

Silage chambers

- Silage clamps (walls)
- Silage pit (15m x 6m or 7m x 4m)
- Tower silos (long feed hoppers).

Stack silos

These are emergency silos made temporally. The material outside of the stack usually rots and acts as a seed to allow the inner material to ferment well

Types of silos

Depends on technology and economy

There are:-tower silos, trench and buckers and stack silos

Tower silos:

These are constructed of concrete or brick 7 – 10m in height; diameter usually depends on amount material for silage. The most sophisticated are made from steel plates lined with glass.

Advantages:

- Are completely air tight and efficient
- Top spoilage is avoided
- Are operated by automation

Trench and bucker silos

These are excavated in well drained areas while buckers are constructed in drainage problem areas. Both are much cheaper than the tower silos and top spoilage is more than in the tower silos

The process of fermentation in silage chambers

It undergoes anaerobic fermentation through the action of lactobacilli bacteria to produce organic acids mainly lactic acid. Lactic acid gives silage a good flavour and prevents it from rotting. For this to occur, the following conditions must prevail;-

- Low PH 3.8 – 4.3
- Moderate aeration and Moderate temperature 37.8◦c.

N.B. Temperatures <37.8◦c are due to shortage of fermentable water or soluble carbohydrates (molasses) and over compaction. In such a case clostridia bacteria convert lactic acid to butyric acid and break down proteins and amino acids making silage bitter and have a foul smell.

Low temperatures can be avoided by:-

Partial wilting of the material in the field, addition of fermentable water soluble carbohydrates of molasses, filling the silage chamber rapidly while continuously pressing the material lightly and covering the soils immediately after final packing to exclude air as much as possible

Qualities of good Silage

Light sweet smell similar to that of yeast, Has PH of 3.8-4.3, has light or dark yellowish green colour and has 1.5-2.5% lactic acid content.

Quality of silage

Factors that influence silage quality

- Moulds: Insufficiently compacted materials cause moulds to grow especially in materials that were too dry
- Excessive heat and fermentation of the materials:-High moisture content (in) the material which has not been properly compacted will suffer an extended period of fermentation leading to high temperature. High temperatures reduce protein digestibility and a high proportion of the nutrients is lost
- Palatability of the material
- Odour of the silage: Well prepared silage will have a high content lactic acid and will smell of this, butyric acid smell indicates poor fermentation which may occur in lactating cows
- Material appearance: Silage colour can be olive green or dark brown. Silage prepared from grass is usually green while legumes give brown. Preservatives and additions alter the colour. Bad silage is usually dark
- Acidity of the materials: PH of < 3 – 5 is excessively acidic silage and is due to acetic acid which cause digestive upsets in animals. PH > 5 is of low quality with a foul odour. Optimum PH is 4

- Ammonia presence**:** The ensiling process breaks down proteins. Under favourable conditions, this break down does not go beyond amino acid formation. Under bad conditions the amino acids are further broken down and NH_3 is the end product. Therefore the amount of NH_3 is an indicator of the extent of ensilage
- Moisture content: 75 – 85% small changes in moisture content will cause significant changes in silage e.g. silage material that has 78% moisture content will be 20% richer in nutrients than silage with 59% moisture and Alcohol content: During fermentation process, alcohol is formed from sugar. About 1% because most of it combines with organic acid to form esters which give the material a nice aroma.

How to reduce losses during Silage making

Careful harvesting of the material to avoid loss of leaves, contamination with soil

Proper sealing of the Silos to prevent re-entry of air into the silo

Proper compaction to exclude air (oxygen)

Proper chopping of material to ease packing and to enable easy fermentation

Wilting of the material to reduce water

Addition of additives for example molasses which increases energy supply to the bacteria.

Quick covering of the ensiling chamber to reduce entry of air into the material

SUB-UNIT: CROP IMPROVEMENT

This is the art and science of manipulating and altering the genetic makeup of a crop to get off springs that are superior to their parents.

Objectives underlying crop improvement programmes

To develop and produce varieties of crops which are more productive in terms of yield, to develop quick and early maturing crop varieties, to develop crops which are resistant to pests and diseases, to get crops that are resistant to heat, coldness, drought, flooding and lodging (adverse weather conditions), to develop crops of the desired agronomic or horticultural characteristics such as height for easy harvesting, to develop crops that have a better response to manure and fertilizers. Develop crop varieties with seeds which are easier to germinate, to improve the quality of crops in flavour, nutritive value and malting quality in case of barley. Some perishables crops are bred in order to have a longer storage life or longer keeping quality.

Crop characteristics for commercial production

Seed viability: The seeds should have the capacity to stay alive for a long time and even be able to germinate long after harvesting. The seeds of the crop selected should have a high germination percentage of atleast 80% ++ for most of the seeds. It should have resistance to pests and diseases in the area. It should be quick maturing. It should be high yield. It should be suitable for the climatic conditions of the area. It should be suitable for the altitude, topography and the type of soil and it should have high quality products in terms of colour, shape, weight and general appearance, taste.

Methods of crop improvement

(a) Introduction

This is where new varieties of crops are brought into an area from other areas. Such crops are chosen because of their unique and good characteristics. However such crops should conform to the quarantine regulations.

(b) Selection

This may be natural or artificial. Natural selection occurs without man's influence and is based on the principle of survival for the fittest. Crops that are better suited to the environment survive in the next generation while the less suited die off. In artificial selection, the farmer chooses seeds from only those plants that have the desirable qualities. In the long run, only plants that have good qualities will remain in the population.

Methods of Selection:

Mass selection : This is used in both self pollinated and cross pollinated crops. It is called mass selection because seeds are collected from many good looking plants and mixed together.

Procedure of mass selection

The seeds from all the similarly appearing and best crops are collected, the seeds from all the selected plants are mixed together to get the mass of seeds, the mixture obtained is used for sowing the new crop from which seeds are obtained from the best appearing and most vigorous plants. The seeds are then collected and marketed as a "new" variety.

The advantages of mass selection are that; it is a quick method of improving plant varieties, the breeding procedure is simple and it permits the retention of the best features of the variety. However phenotypically superior plants which are used as a basis for judgment are not also gene typically superior. By this method, it is not possible to know whether the selected plants are heterozygous or homozygous; heterozygous plants will segregate in the generation and this will necessitate a repetition of phenotypic selection.

Strong environmental differences may lead to low selection efficiency.

Pure line Selection

This is used in improving self fertilized plants. A single good looking plant is chosen and it's off springs are used to develop a new variety.

Procedure of pure line selection

A large number of plants with desirable qualities are identified; seeds are collected from these plants and kept separate. The seeds from each plant are planted separately and in isolated fields to prevent contamination by off types, the performance of plants from each of the seeds is noted and the best performing plants are noted. The seeds of the best performing line is multiplied and released for sale as a 'new' variety. Pure line selection may also be used to produce pure lines to be used in hybridization / crossing.

Clonal Selection

This is practiced in vegetatively propagated plants.

Procedure of Clonal Selection

Crops with the most desired characteristics are identified from within the population, vegetative parts are obtained from each individual plant chosen; the vegetative parts from each plant are grown separately. The performance of the clones from each parent is noted and the best performers are chosen. The best performing clones are multiplied and compared to the normal variety (or original variety). If the clones perform significantly better than the normal or original variety, they undergo trials at different experimental stations. The successful clone are given names and released as a new variety.

Mutation breeding: This is where the genetic makeup of plants is changed using X-rays and other radioactive materials such as chemical mutagens. High temperature and colencxhicine are also used. The number of genes may be reduced or increased (Polyploidisation). The alteration in the genotype may produce desirable gene change especially in vegetatively propagated crops.

Hybridisation

This is done to combine the desired characteristics found in a population. The main purpose is to create variation by bring about new combinations of genes already present of hybridization, stock. During the course of hybridization many plants with different gene combinations are produced but the only the best among them are selected for planting.

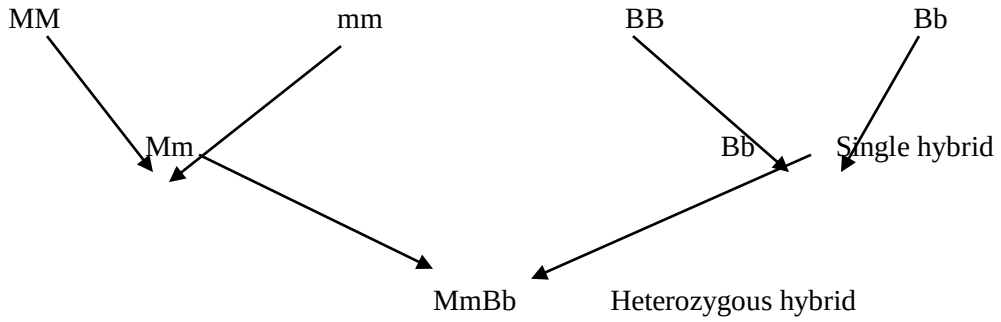
Procedures of hybridization:

Plants with the desirable qualities are selected, seeds from the selected plants are collected and selfed i.e. allowed to self pollinate to obtain homozygosity i.e. pure lines. This is only because self pollinated plants are already homozygous due to natural selfing. The seeds of the pure lines

are then collected and planted. The (male) parts of plants which are serving females are removed before they are mature. This is to prevent self pollination in self pollinated plants. This process is called **emasculation** and is not done in unisexual plants. The females and males are then tagged and labelled for easy identification during crossing. The flowers of the males and females are then covered (bagged). The females are covered to prevent natural cross pollination and the males to prevent contamination of pollens with foreign pollens and to ease collection of pollens for crossing. Crossing is then carried out. The pollens from the already bagged males are collected and dusted on the already bagged females and labelled. The seeds are then collected after maturity and sown in the next season. The off springs of the F1 are vigorously tested at various research stations to find their suitability in the various environments and if found desirable, the seeds are multiplied on seed multiplication farms, given names or numbers and released to the farmers.

Illustration of hybridization in maize

Four In-bred strains of maize



Advantages of hybridization:

Variation in plants is created; there is increased fruit size and numbers. There is also increased resistance to diseases and pests, plants may or are early maturing. Generally the yield is increased due to hybrid rigor. However seeds from commercial crops cannot be used successfully to raise a new crop because they lose hybrid vigour due to in breeding as they continue going back to their homozygous state. Hybrids need maintenance of parent stocks from which hybrid seeds are produced each year, thus farmers must buy new seed each season. Hybrid seeds are expensive and require appropriate agronomic practices to obtain high yield.

Back Crossing

This is a form of re-current hybridization where by the initial F_1 is successively back crossed to otherwise desirable variety to which a certain character has to be transferred. It is a form of upgrading.

Procedure:

Two parent plants are selected; the adapted commercial variety which is usually a recurrent parent is a female and an inferior but disease resistant variety which is a donor plant is a male. The two selected parents are crossed to get an F_1 and then F_1 is back crossed to an adapted variety. From the progeny derived from the above cross disease resistant plants are selected. These selected plants are again crossed to the commercial variety and disease resistant plants are again selected. The procedure is repeated for about 4 -5 generations and by the end of the 5^{th} generation, the selected disease resistant plants may have more than 99% gives from the commercial variety.

N.B; at each stage, selection is by use of progeny tests using progeny rows in the field to provide the dominant characteristics. The selected disease resistant plants are bulked and then multiplied to be released to the farmers.

Illustration

100%	A	X	R	100%		R –Recurrent Female A – Donor Male
	A	X	R			
50%				50%	F_1	
30%	A	X	R	70%	F_2	
22.5%	A	X	R	88.5%	F_3	
6.3	A	X	R	93.7	F_4	
3.1%	A	X	R -	96.9%	F_5	
	A		R -	100%	F_6	

Explanation

In the first back cross plants have 50% genes of the recurrent parent and 50% of the donor parent (disease resistance). In the second backcross plants have 70% of the recurrent and 30% of the donor plant. In the 3^{rd} backcross, they have 87.5% of the recurrent parent and 22.5% of the donor parent. In the 4^{th} backcross, they have 93.7% the recurrent parent genes and 6.3% of the done parent genes. In the 5^{th} backcross, they have 96.9% of the recurrent genes and 3.1% of the donor plant and in the 6^{th} backcross; the plants have 100% of the characteristics of the recurrent parent and are also disease resistant.

The advantages of backcrossing are that the improvement is made in a step wise manner. The results are predictable. It requires a small number of plants. By breeding standards, it is a rapid method. The environment does not influence the results. The method can be repeated. However the demerits are that it does not allow recombination of genes from two or more varieties (only one character is transferred at a time) and the method does not permit transgressive segregation