FODDER PRODUCTION AND MANAGEMENT

CHAPTER NOTES

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Lesson 1 IMPORTANT TERMS.

AREA

a. Cent: It is a unit of measurement of an area of land which is 1/100th of an acre. This is equal to 40 square-meter.

b. Acre: A unit of measurement of an area equal to 100 cents. (4000 square meter)

c. Hectare: It refers to an area of 10000 square meter or 250 cents or 2.5 acres.

d. Are: It refers to an area of 100 square meter

SEASON

a. South West monsoon: This starts in June and ends in August/September. This is known as advancing monsoon season. About 60% of the total annual rainfall is received during this season. So, it is called the grand period of rainfall in all parts of India except in the N-E part of Tamil Nadu.

b. North East monsoon: This refers to the months of October, November and December. This is also called as retreating monsoon season. About 30-33% of the total annual rainfall is received during this season.

c. Winter season: during January and February months and this period is somewhat rainless.

d. Summer season: Summer season comprising of March, April and May months. It will bring about 7-10% of the total annual rainfall as summer showers.

PREPARATORY CULTIVATION

a. Tillage: It refers to the physical manipulation of the soil with tools and implements for loosening the surface crust and bringing about favourable conditions for the germination of seeds and crop growth.

b. Tilth: It refers to a condition of a soil, suitable for germination of seeds, growth and maturity of a crop plant. It refers to the physical condition of soil after tillage.

c. Ploughing: Ploughing is opening up of the soil with tools and implements in order to create a favourable soil condition for the germination of seeds and growth of crop plants. Ploughing may be done under wet, dry and garden land conditions.

d. Puddling: Normally puddling is done only in wetland under submerged condition. Usually puddling is done only after ploughing.

e. Levelling: Field should have even surface to get uniform germination of seeds and also for effective use of fertilizers and irrigation water. Certain specific tools like levelling board, buck scraper etc, are used to achieve uniform levelling.

f. Beds and Channels: This refers to a uniformly levelled plot area, of either square or rectangular shape and covered with bunds on all the four sides and provided with irrigation

channels at convenient intervals. Mostly closer spaced crops like rice, ragi, etc. are planted in bed and channels.

g. Ridges and Furrows: Formation of miniature hills and valleys in the field at the appropriate spacing for sowing/planting of wider spaced crops like cotton, sugarcane etc.

h. Draught: The power applied to overcome the resistance offered by the soil to the passage of ploughs, implements etc. is called as draught.

i. Human Power: Agricultural operations carried out using human labour (e.g. Trimming and plastering of bunds, planting, weeding, harvesting etc.)

j. Animal Power: Agricultural operations carried out using bullock pairs (e.g.ploughing with pairs, carting etc.)

k. Mechanical Power: Agricultural operations done by the use of tractors, power tillers etc.

l. Electrical Power: Use of electricity power for carrying out certain works like threshing the produce using thresher, irrigation by motor pump set etc.

AFTER CULTIVATION:

a. Thinning: Removal of excess plants from each hill leaving one or two healthy plants.

b. Gap Filling: Some of the sown seeds may not germinate resulting in gaps, such gaps are filled with fresh sowing in order to maintain the required plant density.

c. Weed: A weed is a plant, which is growing where it is not desired. Plants are considered as weeds when they interfere with the activities of man or his welfare. In simple sense, weeds are plant out of place.

d. Weeding: Removal of weed either by hand or by using tools or killing the seeds by use of chemicals (herbicides).

e. Hoeing: Stirring or scraping the surface soil with tools is called as hoeing. It is done mostly in order to remove weeds.

f. Roguing: Removal of plants or variety admixed with other variety of the same crop. For example, in a field where guinea grass variety, Haritha is raised and if other guinea grass variety like Marathakom is seen, such other variety plants are called rogues. This practice is adopted in seed production to maintain seed purity.

g. Earthing up: Supporting the plant hill with addition of soil surrounding the plant to form a strong hold. This facilitates better anchorage to plants.

PLANT PROTECTION:

a. Pesticide: Chemicals used to control different insect pests. Pesticides are available in the form of dusts, sprays or granules.

b. Fungicides: Chemical compounds used for the control of plant crop diseases. They are available as dusts or wettable powders and sometimes in liquid forms.

c. Nematicide: Those chemical compounds used to control plant nematodes. They

are available mostly as liquids, emulsions and granules.

d. Weed Control: The process of limiting weed infestations or killing weeds for aesthetic, economic, public health or other reasons.

e. Weedicide (or) Herbicide: A chemical used for killing plants, which are severely intercepting the normal growth process of crop plants.

Annuals

Annual crops complete their life cycle in a year or in a section or season of the year. Annual crops that take only a season to complete the life cycle are called seasonal crops. Seeds germinate with the start of the crop season, and seed production is completed by the end of the crop season. After the production of seeds, annuals die. Most of the cereal forage crops are annuals. Sometimes, they are also known based on the season in which they are grown, for example: Kharif crops (Fodder maize, Dheenanath grass) and Rabi crops (Fodder oats, Berseem).

Biennials

Biennials have a life span of two years or two seasons. In the first year or season, the plants grow vegetative and store food in the underground portions, and in the second year or season, reproductive phase starts, seeds are produced, and the plants die. Only a few forage crops fall in this group. Forage carrot (Daucus carota var. sativa) is an example. However, many of these biennials are grown by humans as annuals and harvested in the same year of planting.

Perennials

Perennials live and persist for several years. Most perennials produce flowers and seeds many times. However, a few such as bamboos produce flowers only once in their lifetime. Many tree legumes such as gliricidia, subabul and Agathi; and herbaceous ground legumes such as calopo and centro are perennials. Most of the cultivated grasses in the tropics, for example: guinea grass, napier grass, congo signal, para grass etc. are perennials.

Herbs

Herbs are plants, which have only a small amount of woody tissue in their stems and roots. Herbaceous forage crops may be grouped in to grasses such as guinea grass and maize; and forbs (all broad-leaved herbs other than grasses) such as cowpea, stylo and velvet beans. Herbs include both annuals and perennials. Examples for annual herbs include berseem, cowpea and maize; and for perennial herbs, alfalfa, calopo and guinea grass.

Shrubs

A shrub is a woody plant that branches just above the ground level, and has no obvious main stem. Shrubs are perennial in nature but grow for a limited number of years compared to trees, which grow for longer periods. An example is hedge lucerne.

Trees

A tree has a conspicuous main stem (trunk) and branches if present are limited to the upper part. Trees grow for a longer period than shrubs. Fodder trees include gliricidia and calliandra. Certain fodder crops such as subabul has both shrub and tree types.

Agrostology - Agrostology is a specialized discipline of agronomy for the study of

forage crops, their management and utilization

Browse - Browse is defined as the leaves, tender shoots, twigs and sprouts of woody plants which are eaten to a varying extent by domestic and wild animals. It also includes fruits, pods and seeds

Crude Fibre - Crude fibre refers to that portion of feed insoluble in diluted sulphuric acid and diluted sodium hydroxide solution Crude protein

Crude protein gives an approximate value of protein content in forages. It is obtained by multiplying the nitrogen percentage in the feed obtained by Kjeldahl analysis with the factor 6.25.

Fodder

Fodder is defined as any plant that is cut before being fed to animals in the green stage (soilage) or after converting to hay/silage such as guinea grass, para grass and fodder maize.

Forage-

The term forage is used broadly to mean all the plant materials that are eaten by herbivorous animals. It includes fodder crops, pastures, crop residues such as straw, stover, husk, pineapple wastes, cocoa rinds and banana leaves and foliage of certain trees and shrubs. National Academy of Sciences (1971) defines forage as any aerial plant material primarily grasses and legumes containing more than 18% crude fibre on dry matter basis.

Forb- A general term for a herb other than grass. Forbs include ground legume and other non-grassy herbs.

Forbs include ground legumes & other non-grassy herbs
Grass- A term for members of the grass family, gramineae (Poaceae)

Hay-Hay is an animal feed produced by dehydrating grass fodder to moisture content of about 15% or less so that the biological processes do not proceed rapidly enough to build up heat

Haylage- Haylage, also called low moisture silage, hay crop silage or drylage. It is a combination of hay and silage in which the moisture in the grass is reduced to 40-60% by cutting and wilting in the field before it is chopped and ensiled in a silo

Herbage- Herbage is a collective term for the above ground succulent biomass of forage crops fed to livestock

Legume- A general term for a member of the plant family leguminosae (fabaceae), which form nitrogen fixing nodules on its roots

Silage- Silage is an animal feed obtained by packing fresh green fodder in a suitable container and allowing it to ferment under anaerobic conditions, without undergoing much loss of nutrients

Ley- A field temporarily sown to grass and ploughed after 1-3 years, a temporary pasture

Ley farming- Ley farming is a rotation of arable crops requiring annual cultivation and leys occupying the field for two years or longer

Meadow- An area covered with grasses or succulent fodder legumes grown primarily for hay or silage rather than for grazing

Paddock- An enclosed field under pasture; originally near a house or stable, but now any enclosed area with pasture

Pasture- Pasture is a community of grasses with or without non-grass vegetation maintained for grazing purposes. Both natural and sown pastures are included.

Roughage- Roughage are feedstuffs for livestock that are relatively high in crude fibre (>18% CF) and low in digestible nutrients (< 60%TDN).

Sod- The grass and forb covered top surface of the ground

Soilage- Soilage is a general term to indicate green fodder cut and fed in fresh condition

Straw- The dried stalks of cereals after threshing and removing the seeds are called straw. **(Threshing** is the process of separating grain from a plant)

Sward- A portion of the ground covered with grass

Husks (Hulls): By product of milling industry like rice milling, groundnut husks, maize husks etc. They are low density and are unpalatable.

Stover: By-products after harvesting the large grains (maize, jowar, millets etc)

Bhusa: The refuse collected from threshing pulse crop like red gram, Bengal gram etc.

Haulms: Plant material above the ground level harvested, dried and used for feeding livestock (E.g. Ground nut plants)

Cover crop: A close-growing crop that provides soil protection, seeding protection, and soil improvement either between periods of normal crop production, or between trees in orchards and vines in vineyards. When ploughed under and incorporated into the soil, cover crops may be referred to as green manure crops.

Carrying Capacity: The maximum stocking rate that will achieve a target level of animal performance, in a specified grazing method, that can be applied over a defined time period without deterioration of the ecosystem

Sylvipastoral system: Production of forage grasses and legumes with multiple purpose trees used initially under cuty and carry system and later on grazing in situ.

Hydroponics system: Green fodders produced by growing seeds without soil but in water or nutrients rich solutions are known as hydroponics green fodder. Compared to conventional methods of growing fodder, hydroponic fodder requires lesser space and produces highly nutritious fodder than soil farming.

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LESSON 2 Importance of forages and fodder in animal nutrition

- Economic source of nutrients for the dairy animals and reduce cost of milk production.
- Highly palatable and digestible.
- Micro-organisms present in green fodder help in improving digestibility of crop residues.
- Rich in vitamins, minerals, fiber and proteins
- It also helps in maintaining good health and improving breeding efficiency of animals.
- Can be converted in to hay or silage and can be stored for future use.
- Production time is shorter, and as most of the varieties are perennial, fodder can be cut for many years.
- Forage crops having grass root systems improve the organic matter content of the soil.
- Forage crops reduce weed development.
- It reduces soil erosion and improves the soil fertility
- Fodder can be grown through intercropping in plantations and fields.
- Forage crops provide the bedrock to sustainable agriculture.
- Defined as the edible parts of plants, other than separated grain, that provide feed for grazing animals or that can be harvested for feeding forages play an important role in beef cattle industry while also enhancing crop diversity, wildlife habitat, and soil ecosystem services.
- Forage crops can be an important tool for producers, provided the right crop is selected careful management is required to ensure that the crop is fully utilized in its most productive and nutritious phases of growth.
- Pests and diseases must also be managed to minimize their impact on productivity.
- A well-considered grazing strategy is important in maximizing the productive potential of a fodder crop. Forage crops can either be grown exclusively for hay or silage production or grazed before being set aside for fodder conservation.
- The timing of both grazing events and the cutting for hay or silage are critical to ensuring that the quality and quantity of conserved fodder are optimized.
- The livestock sector in India contributes to nearly 32% of total agricultural output.
- India with 2.3% share of global geographical area supports nearly 20% of the livestock population of the World, notably among them are cattle (16%), buffalo (55%), goat (20%) and sheep (5%).
- The desired annual growth of agriculture sector @ 4% can also be accomplished by enhancing productivity from the livestock sector.
- This would require a steady supply of fodder for supporting the livestock population. Having only 4% of total cropping area under fodder cultivation has resulted in a severe deficit of green fodder (36%), dry fodder (40%) and concentrates (57%).
- The need of the hour is, therefore, to fulfill this shortfall in demand for fodder (which is over 55%) from crop residues and agricultural bi-products.
- Fodder deficit can mainly be attributed to our limitations in increasing the area under fodder crops, limited availability of good fodder varieties/hybrids, lack of quality seeds of improved varieties/hybrids, poor

quality of dry fodder like paddy/wheat straw etc. Besides, low priority accorded to investment in fodder production, lack of post-harvest management for surplus fodder, poor management of grazing/pasture lands and inadequate research, extension and manpower support have only aggravated the situation.

Need for a High-Tech Fodder Development Programme in the state

- In the current scenario, where competing demands on land renders even expansion of food/cash crops a difficult proposition, the probability of increasing area under fodder crops is very difficult.
- It is therefore imminent to adopt a multi-pronged strategy for adequate availability of fodder in order to provide a buffer to the farmer even in times of climatic variability.
- This strategy envisages supply of quality seeds, promoting production of fodder crops, extending fodder cultivation to currently fallow and unutilized lands, promotion of dual-purpose varieties of crops which has the potential of meeting fodder requirements in season and offseason, promotion of non-traditional fodder, post-harvest technologies for preservation of fodder etc.
- Besides, improving productivity in areas already under fodder cultivation, improving productivity of grazing and pasture lands, raising perennial fodder crops on field bunds and boundaries, peri-urban areas and exploiting unutilized and under-utilized fodder crops are also some of the promising options to enhance fodder availability.
- Plant Breeders in India have also identified a number of varieties/hybrids which could give a better quality and higher yield of crop residue without any compromise in grain yield.
- Mechanization in the field of fodder development is a need of the hour.
- Farm mechanization has been helpful to bring about a significant improvement in agricultural productivity. Thus, there is strong need for mechanization of agricultural operations.
- The factors that justify the strengthening of farm mechanization in the country can be numerous. The timeliness of operations has assumed greater significance in obtaining optimal yields from different crops, which has been possible by way of mechanization.
- As production increases with mechanization of the farm operations, it creates a good scope for commercialization of fodder cultivation.
- Normally, there are good chances to reduce the cost of production if farm operations are mechanized as it saves labour, both human and bullock.
- In the absence of mechanization, the ever-increasing wage rate of human labour and cost of upkeep of draught animals will increase the cost of production much higher. Further, large scale production means less per unit cost on the farms.
- Farm machines have not only increased the mechanical advantage, but also helped to reduce drudgery while performing the different agricultural operations.
- The contributions of agricultural mechanization in various stages of crop production could be viewed as saving in seeds, saving in fertilizers, saving in time, reduction in labour, increasing in cropping intensity and higher productivity.

Selection of fodder variety

1. Their adaptability towards the argot-climatic conditions where they are grown
2. Total and seasonal yield
3. High % of leafiness
4. Ease of establishment
5. Vigour in growth
6. Persistence
7. Palatability
8. Resistance to pests and diseases
9. Seed production ability
10. Nutritive value
11. Tolerance to stress like draught or flood

LESSON 3 Role of Leguminous fodders in Livestock feeding

- Leguminous fodders have a specific significance in agriculture that they are independent on the soil nutrients for their nitrogen requirement
- Leguminous fodder is the most nutritious fodder for livestock. They contain high levels of
- crude protein and hence provide good food stuff for growth and development of animals.
- In animals, protein constitutes about 17% of the body weight and 3-3.5% of the milk.
- These are palatable and nutritious for all livestock of thus stimulates milk production of dairy cow and buffalo.
- The high content of phosphorus aid in the maintenance of the balance between calcium and phosphorus

Role of Leguminous fodders in Livestock feeding

- Most of the leguminous fodder crops are harvested at about 50% flowering stage in order to prevent the toxic effects in the feed
- Berseem is used as nutritious green fodder for livestock in many ways.
- Persian clover (Shaftat) is an excellent green fodder for all classes of the livestock especially for milch cows and buffaloes.
- White clover is superior in palatability and protein content with less fibre content
- Lucerne is very rich in CP up to 18-21 % and is fed to horses, rabbits and milch cattle.
- Lucerne responds well to high phosphorus fertilizers, is used to enrich the straws which are poor in minerals

Role of Non-leguminous fodders in Livestock feeding

- Non-leguminous fodder crops are rich in carbohydrate and less in protein content
- It has more amount of nitrogen free extract, which help in the increase of the productivity by increasing hunger
- The non-leguminous fodders could be grown more vigorously which have great foliage and can provide much fodder for the livestock throughout the year
- Many of them constitute perennials which could be grown continuously for 4-7 years thus by preventing the scarcity of fodder crops in lean seasons
- They can also be efficiently conserved for further use by using certain techniques like silage making and other processes
- By making silage, nutrients are conserved and palatability is also increased

Role of fodder in overall development of livestock

- Helps in rumen development
- Maintains the microbial population in rumen
- Aids in digestion
- Improves growth parameters
- In sheep and goat farming, fodder also aid in providing proteins and fibers that are essential for milk, meat and wool production
- In poultry, they are useful for increasing egg production
- Intensively managed pastures of grasslands normally offer the best and cheaper source of grazing during the spring

- Rooted crops have a great importance in mixed and predominantly arable systems of farming.

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LESSON 4 Significance of Feed and Fodder

Economy in production :

- Feed & fodder cost constitute about 60-70% of cost of milk production.
- Cultivated fodder has an important role in meeting requirement of various nutrients and roughages.

Better feeding for ruminants:

- Ruminants need feeds, which not only meet their nutritional requirements but also fill the rumen & satisfy the animal.
- Fodder crops mixed with roughages improve the digestion

Good source of critical elements:

- Maize, sorghum and oats are rich in energy
- Leguminous crops are rich in proteins
- Legumes are good source of, macro & micro minerals
- Green fodder crops are cheaper source of nutrients as compared to concentrates.
- It can be stored in the form of silage or hay

Scenario of feed & fodder availability & future requirements

- Deficit in green and dry fodder is increasing every year
- while for concentrates, the gap is almost static.
- primary reasons for low productivity of dairy animals;
- Scarcity of feed and fodder resources (both quantity and quality),
- low production potential of animals,
- Non-availability of critical inputs or services in time along with access to capital and markets

Constraints in achieving higher fodder productivity

- Acute shortage of fodder especially green nutritious fodder, which is major cause of low productivity of livestock, especially in hilly area.
- Main reasons for low productivity are insufficient and low-quality fodder and feed including grazing facilities.

Reduced area under fodder crops:

- Division of the families has fragmented the land.
- At present land holdings are very small and farmers are always biased in choice of the crops.
- Due to these reasons agricultural land ratio does not permit diversion of land from food production to cultivated fodder.
- Thus, area under fodder crops is meagre.

Uncontrolled grazing of dairy animals:

- Uncontrolled grazing has led to a decline in biomass availability.
- Grazing pattern has created problems in these pastures.

Poor management practices:

- Management practices play an important role in determining productivity of grasslands.
- Factors responsible for poor productivity of grasslands
- Presence of inferior and unproductive grass species,
- Lack of fertilizer application,
- Absence of legume component,

Intense livestock population:

- population of unproductive cattle is increasing.
- This huge population and poor fodder availability have widened the gap between demand and supply of forage crops.

Fodder tree use:

- Indian sub-continent is one of the richest in biodiversities on the globe.
- Tree leaf fodder is the major feed resource during lean period

Extension strategies for revitalizing fodder production

- Extension strategies can bring the desirable changes in behaviour of the fodder growers.
- Components of extension strategy
- Awareness creation about fodder production technology
- Strengthening the extension and development activities
- Capacity building of farmers and extension functionaries
- On-farm evaluation of fodder technologies
- Conservation of forages to meet the demand in crisis
- Motivate farmers for Indigenous Technical Knowledge

Scientific interventions for revitalising fodder

- production technologies
- Fodder production is a component of farming system.
- Efforts are needed for increasing forage production in a farming system approach.
- The holistic approach of integrated resource management will be based on maintaining the fragile balance between productivity functions and conservation practices for ecological sustainability.
- The strategies for improvement and conservation of forage resources will have to be dictated by actual users
- i.e. the farmers who are the native inhabitants of that region.

Agronomic management of forage crops

- Herbage production from grasslands and meadows can be enhanced
- with the adoption of improved technology.
- Important components of this technology are:

a. Control of bushes and weeds
b. Pasture establishment
c. Introduction of legumes / grasses
d. Fertilizer application
e. Cutting and grazing management

Scientific cultivation of fodder crops

- Important fodder crops of temperate region are; Avena sativa, Brassica sp., Medicago sativa, Pisum sativum etc
- Foliage of fodder trees could be fed to livestock in mixture with crop residues and hay.
- Mixing of tree foliage with dry roughage improves their palatability and nutritive value. Adoption of Silvi-Pastoral System
- Silvi-pasture implies sustained and combined management of the same land for herbaceous fodder, top feeds and fuel wood, thereby leading to optimization of production.
- Silvi-pastoral systems are most important for increasing fodder production from marginal, sub-marginal and other wastelands.
- It comprises about 50 % of total land area.
- It involves planting of multipurpose trees in grazing lands or wasteland followed by sowing / planting of grasses and or legumes in between the

inter-spaces of trees. Adoption of Agri-Silvipastoral System

- Under agri-silvicultural system multipurpose trees including fodder cum fuel trees can be grown in association with crops.
- Trees are pruned annually, yielding fodder as well as fuel wood.
- ✓In addition to annual pruning, few trees are also cut down in order to allow light penetration and minimization of competition with the crops.

- Under alley cropping system multipurpose trees like Leucaena leucocephala and even perennial pigeon pea etc. are pruned frequently to provide leaf fodder to get better crop production.

Horti-pastoral system

- Forage are grown in wide inter-row spaces of fruit trees for economic utilization of orchard lands.
- Horti-pasture up to an elevation of 2000 m is catching up with the orchadist.
- Forage from horti-pasture is consumed fresh and is also conserved as hay for winters. Agri-horti-silvicultural system
- Under this system besides growing fruit trees and fodder crops, fast growing NFTs like Leucaena leucocephala can be lopped two to three times in a year to provide fodder (2.5-3.0 t/ha) and fuel wood (1.8-2.5 t/ha).
- These fodder trees also provide some protection to fruit trees during summer and cold winters

Future opportunities

- Peri-urban dairy creating organized fodder markets & need for post-harvest processing of fodder & crop residues and formulation of complete feeds will increase the demand for green fodder.
- Forage based feeding systems, grass lands composed of heterogeneous biochemical entities as well as rapid dying of dung & urine in grazing lands have potential to reduce greenhouse gas released from ruminants due to underfermentation.
- Importance of forage production in maintaining food security as well as nutritional security has been felt since long.
- The overall scene of forage production is very alarming and corrective measures have to be taken to improve this problem.
- A comprehensive grazing policy needs to be formulated and both grazing and forage cultivation has to be considered complementary to each other and simultaneous efforts are required to improve both
- Fodder tree improvement programmes for higher leaf fodder have to be initiated.

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Lesson 5 Preparation of land for planting

- For sowing or planting a crop, the field has to be prepared according to the needs of the crop.
- There may be differences in the method or in the extent of preparation for a particular crop. However, in any case, working with the soil is to have better plant growth and yield.
- The practice of working the soil with certain implements to bring about favourable conditions for plant growth is collectively called tillage.
- All the operations we do on the earth surface for the purpose of agriculture such as stirring, fining, firming and inverting come under the purview of this term.
- Tillage operations done on a field may be for different purposes.
- Seedbed preparation is foremost among them.
- Tillage is also done for the purposes of loosening the soil for root penetration, ease of planting, incorporation of surface trash, incorporation of lime and fertilizers, weed control, aerating the soil, improving water relations of soil, soil erosion control, preparing the land for water management, and for the control of insects and plant pathogens.

Tillage

- The word tillage is derived from 'Anglo-Saxon' words Tilian and Teolian, meaning 'to plough and prepare soil for seed to sow, to cultivate and to raise crops'.
- Jethrotull, who is considered as father of tillage suggested that thorough ploughing is necessary so as to make the soil into fine particles.
- **Tillage** is the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops.
- **Tilth** is the physical condition of soil obtained out of tillage (or) it is the result of tillage. • The tilth may be a coarse tilth, fine tilth or moderate tilth.

Objectives of tillage

The main objectives of tillage are

- To prepare a good seed bed which helps in the germination of seeds.
- To create conditions in the soil suited for better growth of crops. • To control the weeds effectively.
- To make the soil capable for absorbing more rain water.
- To mix up the manure and fertilizers uniformly in the soil.
- To aerate the soil.
- To provide adequate seed-soil contact to permit water flow to seed and seedling roots.
- To remove the hard pan and to increase the soil depth.

LESSON 6 Types of Tillage

Tillage operations are classified into three types on the basis of their timing.

1.Preparatory cultivation or primary tillage

2.Seed bed preparation or secondary tillage

3.Intercultivation/seed bed preparation or after tillage:

1.Preparatory cultivation or primary tillage: The tillage operations done to fields from the time of harvest of a crop to the sowing of next crop are called as preparatory cultivation. It consists of number of ploughings, harrowing and Levelling. It is a common operation to any type of crop in all the seasons. e.g. summer ploughing

2.Seed bed preparation or secondary tillage: After preparation of a land, the field is to be laid out properly for irrigating crops and for sowing seeds or planting seedings. It comprises harrowing, 1evehng, compacting preparing ridges and furrow, basins, raised beds etc. It is specific to the type of crop to be raised.

3.Intercultivation/seed bed preparation or after tillage: Once a crop is sown, other operations which are necessary are gap filling, thinning, weeding, mulching, top dressing of fertilizer, etc since these operations are to be done in between the crop rows, these are called as interculture or intercultivation.

Type of primary tillage

- Depending on the purpose of necessity, different types of tillage operations are carried out.
- They are deep ploughing, sub soiling and year-round tillage.

Deep tillage:

- One centimetre of surface over one hectare of land weights about 150 tons.
- Therefore, to plough deeper, enormous amount of energy is required.

- Plough of 5-6 cm in depth is classified as shallow, 15-20 cm in depth as medium deep and 25-30 cm in depth as deep ploughing.
- Deep tillage improves the soil moisture content.
- Depth of ploughing should be related to the annual rainfall that it can wet.

Sub-soiling

Sub-soiling is the breaking of the hard soil without inversion and with less disturbance of top soil.

Year- Round Tillage

Tillage operations which are carried out throughout the year are known as year-round tillage.

Tillage Implements

- Tillage implements can be categorized into several groups depending on the purpose for which they are used.
- Primary tillage, secondary tillage, laying out of seed bed, sowing and inter-cultivation implements.
- However, some implements are multipurpose.

Primary tillage implements

- Implements used for opening and loosening of the soil are known as ploughs.
- Ploughs are used for primary tillage.
- Ploughs are of 3 types:
- Wooden plough or indigenous ploughs
- Improved iron or inversion ploughs
- Special purpose ploughs

Wooden plough

- It can be used as a multipurpose implement for ploughing covering seed, incorporating manure, fertilizers and even for harvesting crops like tubers.
- It can be easily prepared with locally available wood.

Improved iron / Inversion plough

- It is costly but has high efficiency.
- It can be used for different soil types and different types of land preparation.
- Different types of iron ploughs are:
- Mouldboard plough, Breaker plough, chisel plough, disk plough, Subsoil plough

Disc plough:

The bottom consists of one to four large concave discs set at an angle to the line of draught and lightly tilted backwards at the top.

- The discs are mounted on a frame, which is supported on three wheels. When the discs are lowered and the plough worked, the discs rotate, scoop out furrows, invert the furrow slices and pulverize them thoroughly and better than the mouldboard ploughs.
- The disc plough is particularly suitable for ploughing land with weeds, shrubs, and hard stubbles and for ploughing in green manure crops.

Special Types of ploughs

Subsoil plough- The subsoil plough is designed to break up hard layers of soil.

Chisel plough

It is mainly used for breaking hard pans and for deep ploughing (60- 70cm.) with fewer disturbances to top layers.

Ridge plough

This plough has two mould boards, one for turning the soil to the right and other to the left.

- The ridge plough is used to split the field into ridges and furrows and for earthing up of crops.

Rotary Plough/rotary hoes

- It cuts soil and pulverize it. The cutting of soil is done by (either) blades (or types).
  - The depth of cuts is up to 12-15 cm, It is suitable for light soils.
  - It is mainly used for shallow cultivation and weed removal.

Basin Lister

- The basin-lister is a heavy implement with one or two mould board / shovels.
- This implement is used to form listed furrows (broken furrows with small dams and basins) to prevent free runoff of rainfall and blowing of the soil in low rainfall areas.

Secondary Tillage Implements

- Different types of implements like cultivators, harrows, planks and rollers are used for secondary tillage.

Cultivator

Tractor Drawn Cultivator:

- Cultivator is an implement used for finer operations like breaking clods and working the soil to a fine tilth in the preparation of seedbed.
- Cultivator is also known as tiller or tooth harrow.
- It is used to further loosen the previously ploughed land before sowing.
- It is also used to destroy weeds that germinate after ploughing.
- Cultivator has two rows of tines attached to its frame in staggered form.

- The main object of providing two rows and staggering the position of tines is to provide clearance between tines so that clods and plant residues can freely pass through without blocking.
- Provision is also made in the frame by drilling holes so that tines can be set close or apart.
- The number of tines ranges from 7 to 13.
- The shares of the tines can be replaced when they are worn out.

Sweep Cultivator

- In stubble-mulch farming, it is difficult to prepare the land with ordinary implements due to clogging.
- Sweep cultivator is the implements useful under this condition.
- It consists of large inverted V shaped blades attached to a cultivator frame.
- These blades run parallel to soil surface at a depth of 10 to I5cm.
- They are armed in two rows and staggered.
- Sweep cultivator is used to cut up to 12 to 15cm depth of soil during first operation after harvest and shallower during subsequent operations.
- It is worked frequently to control weeds

Harrows

- Harrows are used for shallow cultivation in operations such as preparation of seedbed, covering seeds and destroying weed seedlings.
- Harrows are of two types: disc harrow and blade harrow.

Disc Harrow

- The disc harrow consists of a number of concave discs of 45 to 55 cm in diameter.
- These discs are smaller in size than disc plough, but more, number of discs are arranged on a frame.
- These discs are fitted 15cm apart on axles.
- Two sets of discs are mounted on two axles. All the discs revolve together with axles.
- The discs cut through the soil and effectively pulverise the clods.

Blade Harrow

- Blade harrows are used for different purposes like removal of weeds and stubbles, crushing of clods working of soil to shallow depth, covering the seeds, intercultivation and harvesting of groundnut etc.
- Blade harrows are two types viz. indigenous and improved.

Indigenous Blade Harrows

- The general design of an indigenous blade harrow which is known as guntaka consists of a beam to which two pegs are attached at the ends.
- A blade is attached to these two pegs.
- Two shaft poles and a handle are the other parts of guntaka.
- Depending on the beam length and weight, they are known by different names and used for different purposes.

Plank and Roller

- Plank is a very simple implement and consists of a heavy wooden beam of 2 m in length.
- In addition, shafts and handle are fixed to the beams.
- When it is worked most of the clods are crushed due to its weight.
- It also helps in micro levelling and slight compaction necessary after sowing.
- Rollers are used mainly, to crush the hard clods and to compact the soil in seed rows.

Ridges and Furrowers

- A furrower consists of a general type of mould board which are two in number joined together as a single piece.
- The soil is thrown in both directions to form furrows or channels.
- It is used for making irrigation channels and boundaries of a field.

Implements for Layout of seed bed

a. Country plough
b. Ridge plough
c. Bund former

- **Country plough** and ridge plough are used for laying out the field into ridges and furrows or to layout irrigation channels.
- **Ridge ploughs**, when attached to a frame can be used for making broad-bed furrows

Bund Former

- Bunds for irrigation in the garden lands are made usually by manual labour using spades.
- Bunds are also formed across the contours in the low rainfall regions to conserve soil moisture.
- The bund former is designed to form these bunds replacing manual labour.

- This implement consists of a pair of iron mould boards fixed in opposite direction facing each other with the front end opening outwards and rear and closing in to form bunds **Intercultivation/After cultivation**
- Inter cultivation in Farming generally involves operations like tilling, weeding etc. in rows of standing crop.
- All the practices that are carried out after the establishment of the crop are called as intercultivation/after cultivation practices.
- It refers to cultivation practices taken up usually after sowing of crop.

Intercultivation/after cultivation practices

- Thinning
- Gap filling
- Weeding
- Hoeing
- Roguing
- Earthing up

Modern concepts in tillage

1.Minimum tillage:

- It aims at reducing tillage operations to the minimum necessity for ensuring a good seed bed.
- The advantages of minimum tillage over conventional tillage are,
  a. The cost and time for field preparation is reduced by reducing the number of field operations.
  b. Soil compaction is comparatively less.
  c. Soil structure is not destroyed.
  d. Water loss through runoff and erosion is minimum.
  e. Water storage in the plough layer is increased.

2.Zero tillage (No tillage):

- In this, new crop is planted in the residues of the previous crop without any prior soil tillage or seed bed preparation
- It is possible when all the weeds are controlled by the use of herbicides.
- Zero tillage is applicable for soils with a coarse textured surface horizon, good internal drainage, high biological activity of soil fauna, favourable initial soil structure and an adequate quantity of crop residue as mulch.

3. Stubble mulch tillage or stubble mulch farming

- Soil is protected at all times either by growing a crop or by leaving the crop residues on the surface during fallow periods.
- Sweeps or blades are generally used to cut the soil up to 12 to 15 cm depth in the first operation after harvest and depth of cut is reduced during subsequent operations.
- When large amount of residues are present, a disc type implement is used for the first operation to incorporate some of the residues into the soil.
- This hastens the decomposition but still keeps enough residues on top soil.

4.Conservation tillage:

- The major objective is to conserve soil and soil moisture.
- It is a system of tillage in which organic residues are not inverted into the soil such that they remain on surface as protective cover against erosion and evaporation losses of soil moisture.
- If stubble forms the protective cover on the surface, it is usually referred to as stubble mulch tillage.

- The residues left on soil surface interfere with seed bed preparation and sowing operations.
- It is a year-round system of managing plant residue with implements that undercut residues, loosen the soil and kills the weeds.

Hoes:

A long-handled implement having a thin, flat blade usually set transversely, used to break up the surface of the ground, destroy weeds, etc

Different equipment's used for various types of activities are

1. **Layout of seedbed**: Country Plough, Ridge Plough, Bund Former
2. **Sowing:** Plough, Seed Drill, Ferti-cum Seed Drill, Mechanical Seed Drill
3. **Inter-cultivation:** Wooden Plough, Small blade harrow, Rotary weeders.

TRACTORS

A tractor can be defined as a machine capable of pulling, carrying or operating a variety of agricultural implements and machines. A tractor is a 'prime mover'. The farmer, according to his requirement, attaches different types of implements to this and carries out various agricultural operations. Since more power is generated in a tractor, it can do more jobs, which cannot be done by bullock power. The tractor is actually a modification of a motorcar to perform agricultural operations. However, its wheels are bigger, speed slower, and are sturdier, so that it can work in rough fields. Arrangements will also be there to attach different implements to it, and also for running stationery machines by using the power take off device**.**

Tractors are divided into two broad classes, viz., ride-on tractors (tractors on which the operator rides) and pedestrian-operated tractors (the operator walks behind or beside and controls the work).

Ride-on Tractors

Ride-on tractors are tractors on which the operator rides. These may be with four wheels or three wheels. However, most of the agricultural tractors are four wheeled with an average horse power (HP) of 30-35. Ride-on tractors with 15-60 HP are usually classified as large reactors, and those with 5-15 HP are known as small tractors. The tractors are fitted with pneumatic tyres They can be used for ploughing, cultivating, harrowing, sowing, harvesting, transporting and for belt work. They can also be used for intercultivation in row crops by making use of an arrangement by which the width between the wheels can be changed. By attaching trailers, tractors can also be used for transporting manures, fertilisers, seeds, cut fodder and other farm produces. Belt works such as lifting water can also be done.

Miscellaneous tools:

Crow-bar: Crow baring the field is done for digging channels, trenches, uprooting stubbles, deep rooted weeds and thorny plants·, harvesting tuber crops, etc.

Wooden hand-rakes: These consist of wooden or iron pegs and are used for cleaning the field from weeds, gathering and spreading manures, soil, seeds, etc. in many farm operations.

Spade: It is very useful implement for digging soil, spreading manures, preparation of beds and channels for guiding water, etc.

Pickaxe: It is employed to digging the soil for loosening, for digging channels, for uprooting deep-rooted weeds, for making trenches in combination with spade.

Shovel: It is worked in combination with the pickaxe for moving soil or manure heaps to shorter distances.

Digging fork: It is used to dig the grass fields, for loosening farmyard manure, etc.

Wooden mallets: These are meant to breaking clods of soil and manure.

Sickle: This is a common tool used for harvesting operations, for cutting fodders, green grass, for removal of weeds, etc.

Axe: It is useful for cutting woody plants, thorny bushes for land clearance work to establish a good grassland, etc.

Layout of Seedbed and Sowing

After the seedbed preparation, the field is laid out properly for irrigation and sowing or planting seedlings. These operations are crop specific. For most of the crops like wheat, soybean, pearl millet, groundnut, castor etc., flat levelled seedbed is prepared. After the secondary tillage, these crops are sown without any land treatments. However, growing crops during rainy season in deep black soils is a problem due to ill-drained conditions and as tillage is not possible during the rainy season. Broadbed and furrows (BBF) are, therefore, formed before the onset of monsoon and dry sowing is resorted to.

For some crops like maize, vegetables etc., the field has to be laid out into ridges and furrows. Sugarcane is planted in the furrows or trenches. Crops like tobacco, tomato, chillies are planted with equal inter and intra-row spacing so as to facilitate two-way intercultivation. After field preparation, a marker is run in both the directions. The seedlings are transplanted at the intercepts.

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Lesson 7 Sowing and planting

Sowing or seeding is an art of placing seeds in the soil to have good germination in the field. A perfect seeding gives correct amount of seed per unit area, correct depth at which seed is placed in the soil and correct spacing between row-to-row and plant to plant.

Methods of sowing

There are different methods of sowing such as Broadcasting, Dibbling, Drilling, Seed dropping behind the plough, Transplanting, Hill dropping and Check row planting.

1.Broadcasting

Broadcasting is the process of random scattering of seed on the surface of seedbeds. It can be done manually or mechanically both. When broadcasting is done manually, uniformity of seed depends upon skill of the man. Soon after broadcasting the seeds are covered by planking or some other devices. Usually higher seed rate is obtained in this system. Mechanical broadcasters are used for large-scale work. This machine scatters the seeds on the surface of the seedbed at controlled rates.

2. Dibbling

Dibbling is the process of placing seeds in holes made in seedbed and covering them. In this method, seeds are placed in holes made at definite depth at fixed spacing. The equipment used for dibbling is called dibbler. It is a conical instrument used to make proper holes in the field. Small hand dibblers are made with several conical projections made in a frame. This is very time-consuming process, so it is not suitable for small seeds. Mostly vegetables are sown in this way.

3. Drilling

Drilling consists of dropping the seeds in furrow lines in a continuous flow and covering them with soil. Seed metering may be done either manually or mechanically. The number of rows planted may be one or more. This method is very helpful in achieving proper depth, proper spacing and proper amount of seed to be sown in the field. Drilling can be done by (1) Sowing behind the plough (2) Bullock drawn seed drills (3) Tractor drawn seed drills.

4. Seed dropping behind the plough

It is very common method used in villages. It is used for seed like maize, gram, peas, wheat and barley. A man drops seeds in the furrow behind the plough. Sowing behind the plough can be done by a device known as malobansa. It consists of a bamboo tube provided with a funnel shaped mouth. One man drops the seeds through the funnel and other man handles the plough and the bullocks. This is a slow and laborious method.

5.Transplanting

Transplanting consists of preparing seedlings in nursery and then planting these seedlings in the prepared field. It is commonly done for vegetable and flowers. It is very time consuming operation. Equipment for placing plants in the soil is called transplanted.

Advantages

- Can ensure optimum plant population
- Sowing of main field duration, i.e., management in the main field is reduced
- Crop intensification is possible under transplanting

Disadvantages

- Nursery raising is expensive
- Transplanting is another laborious and expensive method

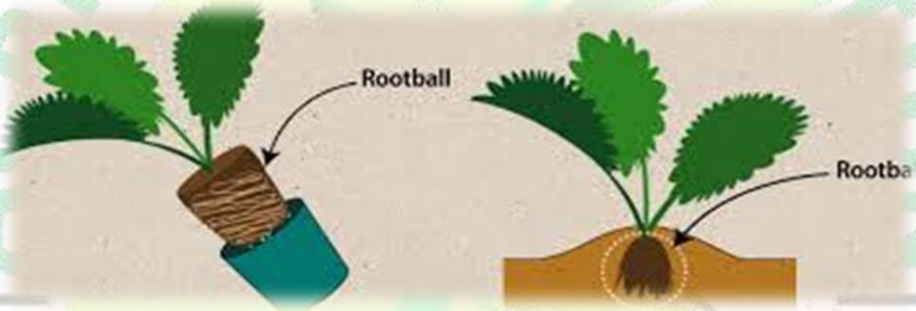
6. Hill dropping

- In this method, seeds are dropped at fixed spacing and not in a continuous stream. Thus, the spacing between plant to plant in a row is constant.
- In case of drills, the seeds are dropped in continuous stream and the spacing between plant to plant in a row is not constant.

7. Check row planting

It is a method of planting, in which row-to-row and plant-to-plant distance is uniform. In this method, seeds are planted precisely along straight parallel furrows. The rows are always in two perpendicular directions. A machine used for check row planting is called check row planter.

8.Planting



Individual seeds are dropped with a fixed seed to seed spacing

Vegetative propagation in fodder crops

vegetative propagation (vegetative multiplication or cloning) is any form of asexual

reproduction occurring in plants in which a new plant grows from a fragment or cutting of the parent plant or a specialized reproductive structure

- Types of vegetative propagation – Cutting, Grafting, Layering and Tissue culture
- Use of cuttings in propagation of fodder grasses:
  Three Types

1. Stem cuttings

2. Split cuttings

3. Rhizome cuttings

1.Stem Cutting:

These are planting materials which are planted directly into the field. E.g. Stem cuttings of napier grass should be taken from the parent plant which has been allowed to grow for 6 months. The stems are cut into pieces known as setts. The setts should be 30 cm – 45 cm long and should have 3–5 nodes.

2.Rhizome cuttings

These cuttings are made by splitting a clump 6 months old into single plants of between 5 and 10 cm in length. The root and shoot portion between 5 and 10 cm. Guatemala, napier and brachiaria grass are propagated using rhizome cuttings

3.Split Cuttings

Most clumping grasses can also be propagated from splits. These are small plants which are divided or split from the original mother

plants. Each split contains some roots and shoot. The shoot is trimmed to 15 cm and the lateral roots are also trimmed. Each split includes at least two to three shoots.

- Fodder grasses that can be propagated using splits include napier grass, Guatemala grass and Brachiaria mulato grass.

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Lesson 8 PROPERTIES OF SOIL

What are the soils?

Soil is a living body covering the surface of the earth in a thin layer. It consists of inorganic matter derived from the rocks and organic matter derived from the plant residues, water, air and millions of living organisms. Soil can be defined as the mixture of mineral and organic matter at the land surface of the earth that is capable of sustaining plant life. Soil is a dynamic body.

Functions of Soil: Soil performs three major functions.

1. Physical functions: Soil provides mechanical support to plants. Soil also provides the required moisture and aeration for proper growth of plants.

2. Chemical functions: Soil is a store house of plant nutrients. It is the medium through which alone crops can take water and nutrients.

3. Biological functions: Soil microorganisms decompose the dead remains of plants and animals and the soil is enriched.

ESSENTIAL SOIL ELEMENTS

There are 18 essential elements that plants must have in order to grow

properly.

18 Essential Nutrients

Nutrient elements obtained from atmosphere through

photosynthesis

- Hydrogen
- Carbon
- Oxygen

Nutrient elements obtained from the soil

- Nitrogen
- Phosphorus
- Potassium
- Sulfur
- Magnesium
- Calcium
- Iron
- Boron
- Manganese

- Zinc
- Molybdenum
- Copper

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LESSON 9 Physical and Chemical properties of soil

Physical Properties of soil

It depends upon the amount, size, shape, arrangement, and mineral composition of soil particles. It also depends on the organic matter content and pore spaces.

Soil Texture:

Soil texture defines the proportion in which the soil separates to make the mineral component of the soil. These separates can be classified as sand, clay, and silt. Sand and silt are of no importance to the soil as they don't contribute to the soil's ability to restore water or nutrients. Clay is an active part of soil texture as clay has a small size and it has a large amount of surface area per unit mass and it helps in storing ions and water. Soil Texture [Size of the individual soil particles]

➢ Sand = <2 to 0.05 mm

➢ Silt = 0.05 to 0.002 mm

➢ Clay = <0.002 mm

The soil texture refers to the coarseness/fineness of the mineral matter in the soil. It is determined by the proportion of the sand, silt, and clay particles. The equal proportion of all three of them is known as loam. Soil texture affects the water holding capacity, nutrient retention, nutrient fixation, drainage, compressibility, and aeration of the soil.

Soil Structure:

It is the arrangement of soil particles into certain patterns like- plate like structure, block like structure, prism-like structure, etc.

Soil structure describes the way the sand, silt, and clay particles are clumped together. Organic matter (decaying plants and animals) and soil organisms like earthworms and bacteria influence soil structure.

Clays, organic matter, and materials excreted by soil organisms bind the soil particles together to form aggregates. Soil structure is important for plant growth, regulating the movement of air and water, influencing root development, and affecting nutrient availability.

Good quality soils are friable (crumbly) and have fine aggregates so the soil breaks up easily if you squeeze it. Poor soil structure has coarse, very firm clods or no structure at all.

Soil color:

Basically, soil color (brown, yellow, red) depends on oxidized or ferric iron compounds. Darker the color of the soil, the more organic content it contains. The higher the organic content, the higher soil temperature as they absorb more heat due to the darker color.

Soils rich in humus tend to be dark because decomposed organic matter is black or brown. Soils with high humus content are usually very fertile, so dark brown or black soils are often referred to as 'rich'. Red or yellow soils typically indicate the presence of iron

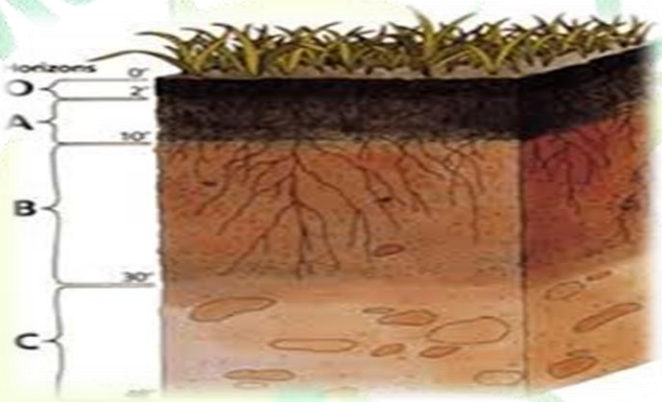
Soil permeability:

Soil permeability is a broad term used to define the ability of the soil for transmitting water. It is important to understand the water dynamics and the water balance of the soil and it must be known for accurate management of irrigation. It is determined partly by texture, with sandy soils having high permeability as compared to clay soils and it can be altered by soil management.

Most porous rocks are permeable with the exception of clay in which pore spaces are so small that they are often sealed with groundwater held by surface tension. Another exception – granite is non-porous but permeable. It is a crystalline rock and hence non-porous. Its individual crystals absorb little or no water but the rock may have numerous joints/ cracks through which the water can pass rendering it permeable.

A soil with high organic content also tends to have high porosity.

Soil Horizon:



The soil is divided vertically into different horizons from top to bottom namely:

A-Horizon: This is the uppermost layer of soil and also called topsoil. This layer is rich in humus and minerals and holds most of the water as compared to other layers. This layer consists of sand, silt, and clay. It is also home to many living organisms like snakes, earthworms, etc.

B-Horizon: This is the second layer from the top and is a little rich in humus and it supports moisture. This layer consists of silt, clay, weathered rocks, and some nutrients. Minerals are more in this layer as compared to the top layer.

C-Horizon: This layer consists of small pieces of rocks broken down due to weathering.

BedRock: This layer is the last layer and consists of layers of solid unweathered rock.

Bulk Density

- Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimetres (g/cc).

- Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space:

- Pore space = 1 – bulk density/particle density
- For example, at a bulk density of 1.60 g/cc, pore space equals 0.40 or 40%. At a bulk density of 1.06 g/cc, pore space equals 0.60 or 60%.

Chemical properties of soil

Chemical properties of soils depend on the following factors:

Inorganic matter present in the Soil: The mineral content of the soil is the major factor that differentiates various types of soil. It is so because of its abundance in the soil.

Organic matter present in Soil: Though these matters present in very small quantities but they play important role in deciding the fertility of the soil.

Colloidal properties of Soil: Colloids are mainly of two types:

Clay Colloids: they are important for the adsorption of a large quantity of water.

Organic Colloids: these help in increasing the moisture and nutrient retention capacity of the soil.

the pH of Soil: The measure of the chemical reaction which a soil shows is expressed by its pH value. The pH value of soil determines its acidic or basic nature.

Acidity & Alkalinity:

An important aspect of soil chemistry is acidity, alkalinity (baseness), or neutrality.

Low pH values indicate acidic soil, and a high pH indicates alkaline conditions. Most complex plants grow only in the soils with levels between pH 4 and pH 10 but optimum pH varies with the plant species.

- In arid and semi-arid regions, soils tend to be alkaline and soils in humid regions tend to be acidic.
- To correct soil alkalinity and to make the soil more productive, the soil can be flushed with irrigation water.
- Strongly acidic soils are also detrimental to plant growth, but soil acidity can generally be corrected by adding lime to the soil.

Soil Colloids:

Soil colloids are the most active constituent of the soil and they are important because their surfaces attract soil nutrients dissolved in soil, water as positively charged mineral ions, or cations.

Some cations are needed for plant growth, including calcium (Ca^{++}), Magnesium (Mg^{++}), Potassium (K^{+}), and sodium (Na^{+}). They need to be dissolved in a soil-water solution to be available to plants when they are in close contact with root membranes.

The fertility of the soil-water solution for plants is based on the capability of the soil to hold and exchange cations; this is referred to as the cation-exchange capacity. Without soil colloids, most vital nutrients would be leached out of the soil by percolating water and carried away in streams.

Lesson 10 Fertilizers

Chemical Fertilizer

- A chemical fertilizer is defined as any inorganic material of wholly or partially synthetic origin which contains one or more plant nutrients and that is added to the soil to sustain plant growth.
- Fertilizers are industrially manufactured chemicals containing plant nutrients.
- Nutrient content is high in fertilizers than in organic manures and nutrients are released immediately.

Fertilizers and Manures

Fertilizers are inorganic materials which can supply plant nutrients in available form, concentrated in nature, having the high analytical value and having a definite composition and mostly are industrial products.

Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Manures with low nutrient content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilisers with high nutrient content.

Major organic sources of plant nutrients include:

- Cattle shed wastes-dung, urine and slurry from biogas plants.
- Human habitation wastes-night soil, human urine, town refuse, sewage, sludge and sullage, poultry litter, droppings of sheep and goat.
- Slaughter house wastes-bone meal, meat meal, blood meal, horn and hoof meal.
- Fish wastes.
- By-products of agroindustry's-oil cakes, bagasse and press mud, fruit and vegetable processing wastes etc.
- Crop wastes sugarcane trash, stubbles and other related material.
- Water hyacinth, weeds and tank silt.
- Green manure crops and green leaf manuring material.

	Inorganic fertilisers	**Organic manures**
1.	More or less pure minerals (chemical substances).	Complex mixtures from animal, human and plant residues.
2.	Relatively rich in plant nutrients.	Bulky and poor in plant nutrients.
3.	Release nutrients more rapidly.	
4.	Highly water soluble; so more likely to be lost through leaching.	Less water soluble; so less likely to be lost through leaching
5.	Supply mainly only one or two nutrients chosen for the purpose.	Supply more nutrients (N, PK, Ca, Mg, S) in addition to some micronutrients in small amounts.
6.	Generally, no effect on the physical condition of the soil.	Improve the soil physical condition due to large amount of organic matter content.
7.	Some of the inorganic fertilisers can be applied to crops as foliar spray	No scope of application as foliar spray.
8.	There is scope for fixation of nutrients in the soil complex.	No scope for such fixation.
9.	N and K fertilisers can be applied in split doses.	No such split applications.
10.	When applied at high rates at planting time or too close to seeds or seedlings, salt damage	Salt damage is less likely.

LESSON 11 Classification of Manures

Some manures are relatively low in nutrient content compared with others. On nutrient content per unit quantity, manures are broadly grouped into two classes: bulky organic manures and concentrated organic manures. Bulky organic manures are relatively low in nutrient content per unit quantity of the material. On equal nutrient basis, they should be applied in bulky quantities. Concentrated organic manures contain relatively higher nutrients per unit quantity. Hence, they need to be applied in lesser quantity on equal nutrient basis. Green manures, although bulk in nature, are specially grown for incorporation into the soil need to be considered differently.

BULKY ORGANIC MANURES

Farm Yard Manure (FYM) compost and green manure are the important and commonly used bulky organic manures. Nutrient content (Table 6.10) of these manures depends on several factors.

Farm yard manure (FYM): It is a decomposed mixture of dung and urine of farm animals along with waste feeds, fodder, litter, etc. The composition depends on kind of animal, feed and fodder used, age and condition of the animal, nature of litter and method of storage. Failure to collect urine and converting dung as fuel are the two major losses during handling. Leaching and volatilisation are the major losses of nutrients in storage. Trench method of FYM preparation, use of chemical preservatives such as gypsum and superphosphate and gober gas plant can considerably reduce storage and handling losses for improving the quality of FYM.

Compost: The process of decomposing organic wastes is called composting and the decomposed material is called compost. Composting is essentially a microbiological decomposition of organic residues collected from rural area (rural compost) or urban area (urban compost).

In Coimbatore method, composting is done in pits of different sizes depending on the waste material available. A layer of waste materials is first laid in the pit. It is moistened with a suspension of 5-10 kg cow dung in 2.5 to 5.0 1 of water and 0.5 to 1.0 kg fine bone meal sprinkled over it uniformly. Similar layers are laid one over the other till the material rises 0.75 m above the ground level. It is finally plastered with wet mud and left undisturbed for 8 to 10 weeks. Plaster is then removed, material moistened with water, given a turning and made into a rectangular heap under a shade. It is left undisturbed till its use.

It the Indore method of composting, organic wastes are spread in the cattle shed to serve as bedding. Urine soaked material along with dung is removed every day and formed into a layer of about 15 cm thick at suitable sites. Urine soaked earth, scraped from cattle sheds is

mixed with water and sprinkled over the layer of wastes twice or thrice a day. Layering process continued for about a fortnight. A thin layer of well decomposed compost is sprinkled over top and the heap given a turning and reformed. Old compost acts as inoculum for decomposing the material. The heap is left undisturbed for about a month. Then it is thoroughly moistened and given a turning. The compost is ready for application in another month.

In the Bengaluru method of composting, dry waste material of 25 cm thick is spread in a pit and a thick suspension of cow dung in water is sprinkled over for moistening. A thin layer of dry waste is laid over the moistened layer. The pit is filled alternately with dry layers of material and cow dung suspension till it rises 0.5 m above ground level. It is left exposed without covering for 15 days. It is given a turning, plastered with wet mud and left undisturbed for about 5 months or till required.

Green manures: Collecting green twigs and leaves from all available sour Incorporating in the puddle for low-land rice is an age old practice in south India It is green leaf manuring. Growing a crop purposefully for incorporating in the soil for man **called green manuring**. Usually legumes alone are used for green manuring because of advantage of atmospheric nitrogen fixation in root nodules. Nitrogen contents of important manure and green leaf manures are given in Table 6.11.

Brown Manuring: We need an ecologically safe and economically viable Agrico technology in the context of changing scenarios of climate, labour availability, resource etc. Brown manuring is expected to aid in achieving such an ecologically safe and economy viable agricultural technology. Brown manuring practice was first initiated in Lockhart distal North South Wales, Australia in 1996. Its concept has been indicated as:

Brown manuring ➡ No till Herbicides + Mulch

VERMICOMPOSTING

It is a system of composting in which organic wastes are decomposed using biological agent, earthworm, for making vermicompost for use in agroecosystem and aquaculture for sustainable production. Earthworms along with soil microorganisms play a vital role in degrading organic wastes and thus maintain a nutrient flux in the system. Earthworm is physically an aerator,

crusher, mixer, chemically a degrader and biologically a stimulator in the decomposer system. The entire biodegradation process of organic wastes by earthworms and microorganisms is called vermicomposting and the end product vermicompost. It contains 1.2 to 1.6 per cent more nitrogen, 1.8 to 2.0 per cent more phosphorus and 0.5 to 0.75 per cent more potassium compared to usual FYM. Besides major nutrients, it contains nearly all

the micronutrients, hormones like auxins and cytokinins, enzymes, vitamins and several useful bacteria, actinomycetes, fungi etc. Earthworms are highly sensitive to sunlight and rain. As such, composting should be done in shade.

Two methods are adopted for waste treatment by earthworms. In the first method, solid organic wastes are spread on the soil surface for incorporation into the soil directly where earthworms contribute to the burial and decomposition of the waste material. In the second method, the wastes are stacked into heaps and earthworm's activity results in the production of large quantities of earthworm casts, sold as vermicompost for application to soil. In India, two species of earthworms (Erudrilus eugeniae and Eisenia foetida) are used for vermicomposting

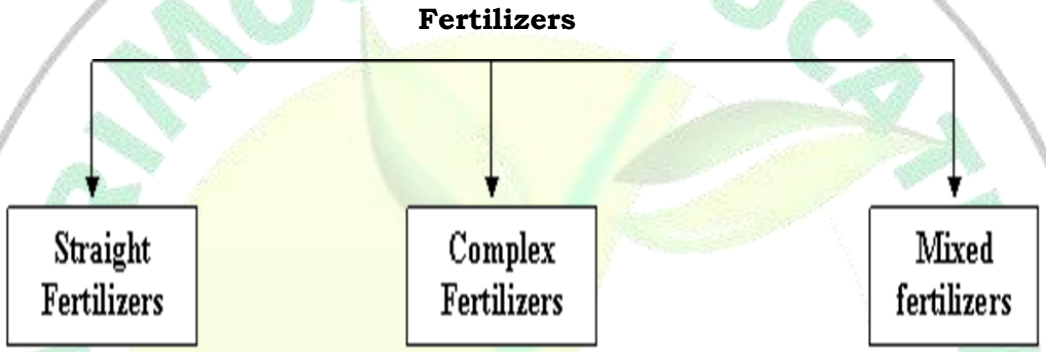
For field crops, the rate of application is 2.5 to 3.0 t/ ha as basal application, 1.2 to 1.51 t/ha as top dressing at 4 leaf stage and 1.2 to 1.5 t/ ha at flowering. For fruit trees, 1 to 10 kg /tree depending on the age. For vegetable crops, the rate of application is around 10 t/ha Approximate

Green manuring	**Brown manuring**
It refers to the incorporation of a manure crop by tillage prior to seed set usually around flowering	It is a no till version of green manuring where herbicides are used to kill the manure crop and weeds
Risk of surface erosion	Plants are left standing providing protection to lighter soil at risk from erosion
Moisture is necessary for incorporation and decomposition	Moisture conservation
Microbial population is necessary for decomposition	Chemical desiccation

	N	**P_2O_5**	**K_2O**
FYM	0.5-1.5	0.4-0.8	0.5-1.9
Compost	1-2.0	1	1.5
Groundnut cake	7-7.2	1.5-1.6	1.3-1.4
Bonemeal	3-4	20-25	-
Green manure (avg)	0.5-0.7	0.1-0.2	0.6-0.8

Green manure	N content (%)
Sunnhemp	2.80-3.15
Daincha	2.55-3.21
Sesbania	2.29-3.10
Pongamia glabra	2.30-3.31

CLASSIFICATION OF FERTILIZERS



According to the nutrient or nutrients they contain, fertilizers are classified as straight, complex or compound and mixed fertilizers.

Few terms

- Primary nutrient
- Secondary nutrient
- Micro nutrient
- Macro nutrient
- Essential nutrient
- Beneficial nutrient

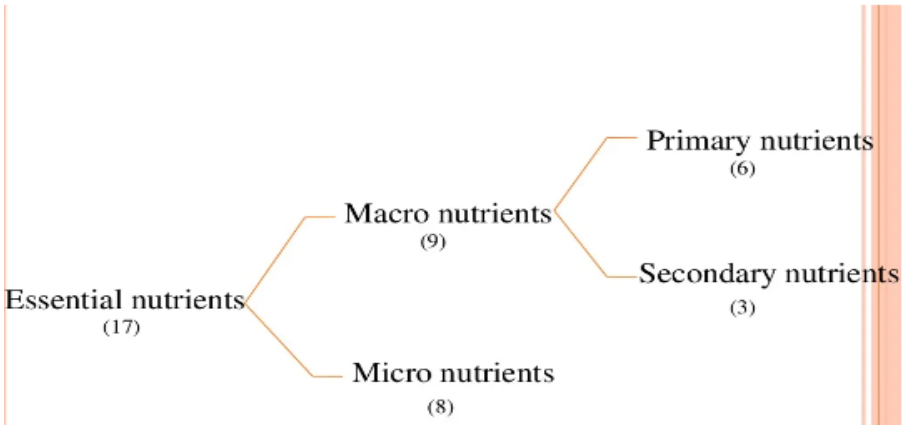
Criteria of essentiality :

There are **17** elements that are essential for the growth and full development of higher green plants according to the criteria laid down by **Arnon and Stout** (1939) which was refined by Arnon (1954). These criteria are:

1. A deficiency of an essential nutrient makes it impossible for the plant to complete the vegetative or reproductive stage of its life cycle.
2. Such deficiency is specific to the element in question and can be prevented or corrected only by supplying this element.
3. The element is involved directly in the nutrition and metabolism of the plant.

ESSENTIAL NUTRIENTS :

- According to Arnon & Stout there are 17 essential nutrients for plants.
- **Nickel (Ni) is the 17th essential nutrient known in 1987.**
- Essential nutrients are classified in 2 types:
  (1) Macro nutrients: These are absorbed in large amount from soil and fertilizers.
  (2) Micro nutrients: These are required in small amount from soil and fertilizers.



- **Macro nutrients**: There are 9 macro nutrients required for the growth and development of plants. These are further sub divided in 2 groups-

(A) Primary nutrients:
1) Carbon (C)
2) Hydrogen (H) — Basic nutrients
3) Oxygen (O)
4) Nitrogen (N)
5) Phosphorus (P)
6) Potassium (K)

(B)Secondary nutrients:
7) Calcium (Ca)
8) Magnesium (Mg)
9) Sulphur (S)

- **Micro nutrients**: There are 8 micro nutrients required for the growth and development of plants. These are-

1) Boron (B)
2) Manganese (Mn)
3) Copper (Cu)
4) Zinc (Zn)
5) Molybdenum (Mo)
6) Chlorine (Cl)
7) Iron (Fe)
8) Nickel (Ni)

Nickel (Ni) is the 17th essential nutrient known in 1987.

Straight fertilizers

Straight fertilizers are those which supply only one primary plant nutrient, namely nitrogen or phosphorus or potassium.
E.g. Urea, ammonium sulphate, potassium chloride and potassium sulphate.

Straight nitrogenous fertilizer e.g. Urea, Ammonium sulphate

Straight phosphatic fertilizer - e.g. Single Super Phosphate (SSP)

Straight potassium fertilizer e.g. Muriate of Potash (Potassium chloride), Sulphate of potash (Potassium sulphate)

Complex or compound fertilizers

- Complex fertilizers **contain two or three primary plant nutrients** of which **two primary nutrients are in chemical combination**.
- A fertilizer intended to supply more than one primary nutrient, the production of which involves some chemical reaction.
- These fertilizers are usually produced in granular form.

e.g. **Diammonium phosphate, nitro phosphates and ammonium phosphate**.

- NP fertilizer (two primary nutrients)- Diammonium phosphate, nitro phosphates, ammonium phosphate and Ammonium phosphate sulphate (20:20:0)
- NPK fertilizer (3 primary nutrients) - NPK 19:19:19 complex

Mixed fertilizers:

- Mixed fertilizers are physical mixtures of straight fertilizers. They contain two or three primary plant nutrients.
- Mixed fertilizers are made by thoroughly mixing the ingredients either mechanically or manually.
- Physical mixture of fertilizer materials containing two or more major plant nutrients without involving chemical reaction or process in a calculated ratio, for example: FACTAMPOS (Ammonium Phospate & Ammonium Sulphate)20:20:0:13

Fertilizer Grade:

Regarding fertilizer mixtures, few important terms must be learnt

- Fertilizer grade refers to the guaranteed minimum percentage of nitrogen (N), phosphorus (P) and potash (K) contained in fertilizer material.
- The numbers representing the grade are separated by hyphens and are always stated in the sequence of N, P, and K
- For example, label on the fertilizer bag with a grade 28-28-0 indicates that 100 kg of fertilizer material contains 28 kg of N, 28 kg of *P* and no potash.
- Different grades of fertilizers are available in India.

- Some
  28-28-0,20-20-0 ,14-35-14 ,17-17-17,14-28-14 etc.

Fertilizer ratio

It refers to the ratio of the percentage of N, P_2O_5 and K_2O in the fertilizer mixture e.g., the fertilizer grade 12-6-6 has a fertilizer ratio of 2:1:1.

Conditioners

These are low grade organic materials like peat soil, paddy husk, groundnut hulls etc., which are added to fertilizer mixtures during their preparation for reducing hygroscopicity and to improve their physical condition.

Filler

A filler is a weight make material like sand, soil, coal powder etc. added to the fertilizer ingredients so as to produce a mixture of the desired grade.

Classification of fertilizers

Fertilizers can also be classified **based on concentration of primary plant nutrients**,

i. Low analysis fertilizers – Contain **less than 25% of primary nutrients**

- E.g. Single superphosphate (16% P_2O_5), Chilean nitrate or sodium nitrate (16% N)

ii. High analysis fertilizers – Contain more than 25% of primary nutrients

- E.g. Urea (46% N), anhydrous ammonia (82.2 % N), ammonium phosphate (20% N + 20% P_2O_5) and diammonium phosphate (18% N + 46% P_2O_5)

Fertilizers can also be classified based on physical form:

- Solid
- Liquid fertilizers

Solid fertilizers are in several forms *viz.*

- Powder (single superphosphate),
- Crystals (ammonium sulphate),
- Prills (urea, diammonium phosphate, superphosphate),
- Granules (Holland granules),
- Supergranules (urea supergranules) and
- Briquettes (urea briquettes).

Liquid fertilizers:

- Liquid form fertilizers are applied with irrigation water or for direct application.
- Ease of handling, less labour requirement and possibility of mixing with herbicides have made the liquid fertilizers more acceptable to farmers.

Fertilizers are grouped based on the nutrient present in the fertilizers

1. **Nitrogenous fertilizers**
2. **Phosphatic fertilizers**
3. **Potassic fertilizers**

1. Nitrogenous fertilizers

- Nitrogenous fertilizers take the foremost place among fertilizers since the deficiency of nitrogen in the soil is the foremost and crops respond to nitrogen better than to other nutrients.
- More than 80 per cent of the fertilizers used in this country are made up of nitrogenous fertilizers, particularly urea.
- It is extremely efficient in increasing the production of crops and the possibilities of its economic production are unlimited.

Classification of nitrogenous fertilizers

Nitrogenous fertilizers are classified into four groups based on the chemical form in which nitrogen is present in them.

These are ammoniacal fertilizers, nitrate fertilizers, fertilizers containing both ammonium and nitrate ions and amide fertilizers

Nitrogenous fertilizers

Ammoniacal	Nitrate	Ammoniacal and Nitrate	Amide fertilizer
➢ Ammonium Sulphate ➢ Ammonium chloride ➢ Anhydrous ammonia	➢ Sodium Nitrate ➢ Calcium Nitrate ➢ Potassium Nitrate	➢ Ammonium Nitrate ➢ Calcium Ammonium Nitrate ➢ Ammonium Sulphate Nitrate	➢ Urea ➢ Calcium Cynamide

1. Ammoniacal fertilizers

- Ammoniacal fertilizers contain the nutrient nitrogen in the form of ammonium ions (NH_4^+) or ammonia (NH_3).
- Ammoniacal fertilizers are readily soluble in water and therefore readily available to crops.
- Except rice and sugarcane, all crops absorb nitrogen in nitrate form. Ammonium form is more or less rapidly transformed into nitrate form (NO_3^-) in the soil
- These fertilizers may produce acidity in the soil.
- These fertilizers are resistant to leaching loss, as the ammonium ions get readily absorbed on the colloidal complex of the soil.

- **Ammonium Sulphate, ammonium chloride and anhydrous ammonia** are examples.
- Among these, ammonium sulphate is the most common and widely used fertilizer.

a) Ammonium sulphate **[$(NH_4)_2 SO_4$]**

- It is a white salt completely soluble in water containing 20.6. per cent of nitrogen and 24.0 per cent of sulphur.
- It is used advantageously in rice and jute cultivation.
- It is easy to handle and it stores well under dry conditions. But during rainy season, it sometimes forms lumps.
- It can be applied before sowing, at the time of sowing or as a top-dressing to the growing crop.

b) *Ammonium chloride* (NH_4Cl)

- It is a white salt contains 26.0 per cent of nitrogen.
- It is usually not recommended for tomato; tobacco and such other crops as may be injured by chlorine.

c) *Anhydrous ammonia* (NH_4)

- 82.0 per cent nitrogen.
- It is an acid forming fertilizer

2. Nitrate Fertilizers

- Nitrate fertilizers contain the nitrogen in the form of nitrate ion (NO_3^-)
- Plants readily take up nitrogen in this form.
- These ions are easily lost by leaching because of the greater mobility and solubility of nitrate ions in the soil.
- Nitrate ion is susceptible to denitrification especially under waterlogged conditions (anaerobic condition)
- Continuous use of these fertilizers may reduce the soil acidity as these nitrogenous fertilizers are basic in their residual effect on soils.
- Nitrate fertilizers are not popular in India.
- Sodium nitrate 16% N), calcium nitrate (15.5 % N), Potassium nitrates (13 % N) are examples.

3. Ammoniacal and nitrate fertilizers

- These fertilizers contain nitrogen in both ammonium and nitrate forms. The nitrates are useful for rapid utilization by crops and the ammoniacal is gradually available (at later stages of growth).
- Examples are Ammonium nitrate (35 % nitrogen, half as nitrate nitrogen and half in the ammonium form), Ammonium sulphate nitrate (26% N, 19.5 % N in ammoniacal form and 6.5 % N in nitrate form, 12 % S) and Calcium ammonium nitrate (CAN) (25 % N, half as nitrate nitrogen and half in the ammonium form)

- These fertilizers are hygroscopic and cakes up if stored for a long time.

4. Amide fertilizers

- The nitrogen in amide form is not directly available to plants. It has to be made available by microbial action in the soil. However, plants can absorb nitrogen in amide form when it is sprayed on foliage.
- Amide fertilizers are readily soluble in water and easily decomposable in the soil.
- The amide form of nitrogen is easily changed to ammoniacal and then to nitrate form in the soil.
- Urea and Calcium cyanamide are examples

a) *Urea* [CO (NH2)2]

- It is the most concentrated solid nitrogenous fertilizer, containing 46 per cent nitrogen.
- It is a white crystalline substance readily soluble in water.
- It absorbs moisture from the atmosphere and has to be kept in moisture proof containers. It is readily converted to ammoniacal and nitrate forms in the soil.
- Urea dissolves in water readily and therefore subject to rapid leaching.
- Urea has a slightly acidic reaction in the soil.
- Urea foliar sprays are readily absorbed by plants.
- It may be applied at sowing or as, a top-dressing.
- It is suitable for most crops and can be applied to all soils.

b) *Calcium cyanamide* (CaCN2)

- Calcium cyanamide or nitro lime contains 20.6 per cent of nitrogen.
- It is a greyish white powdery material

Phosphatic fertilizers

- Phosphatic fertilizers are chemical substances that contain the nutrient phosphorus in absorbable form.
- Single super phosphate (16 % P_2O_5), Triple superphosphate (46- 48% P_2O_5) Basic slag (14 -18 % P_2O_5), Rock phosphate (20 % P_2O_5) etc.

Classification of phosphatic fertilizers

- Based on the relative solubility of phosphate and availability to crops, the phosphatic fertilizers are classified into following three types:

a. Water soluble phosphorus fertilizers

b. Water insoluble but citrate soluble phosphorus fertilizers

c. Water and citrate insoluble phosphorus fertilizers

a. Water soluble phosphorus fertilizers

- These fertilizers are available in the form of monocalcium phosphate or ammonium phosphate.

i)Single super phosphate or superphosphate(16 % P_2O_5)

ii) Double superphosphate (32%P_2O_5)

iii)Triple superphosphate (46- 48 %P_2O_5)

iv)Ammonium phosphate (20 % P_2O_5 and 20% N)

v)Monoammonium phosphate (48 % P_2O_5 and 11% N)

vi)Ammonium phosphate sulphate (20 % P_2O_5 and 20% N)

- P is easily available to plants from these fertilizers.
- These fertilizers are most suitable for neutral and alkaline soils.
- However, they form insoluble iron and aluminium phosphates in acid soils.
- These fertilizers are used when crop requires quick start and or short duration crops like wheat, sorghum, pulses etc.

b. Water insoluble but citrate soluble phosphorus fertilizers

- These fertilizers contain citrate soluble phosphoric acid or dicalcium phosphate
- They are converted to monocalcium phosphate in acid soils.
- As they are basic in reaction and contain calcium they are suitable for acid soils.
- These fertilizers are used for long duration crops like sugarcane, tapioca, tea, coffee and also for lowland rice.
- Basic slag (14 -18 % P_2O_5) and dicalcium phosphate (34-39% P_2O_5)

c. Water and citrate insoluble phosphorus fertilizers

- These fertilizers contain phosphoric acid which is not soluble in water or citric acid.
- They are suitable for strongly acidic or organic soils.
- The availability of P from these fertilizers can be increased by ploughing in along with green manures.
- These fertilizers are suitable for plantation crops like tea, coffee, rubber, cocoa, coconut etc.
- **Rock phosphate (20 % P_2O_5), Raw bone meal (20 -25 % P_2O_5), Steamed bone meal (25 -30 % P_2O_5)**

Potassic fertilizers

- Potassic fertilizers are chemical substances containing potassium in absorbed form (K+). They are water soluble and so are readily available to plants.
- These are grouped into two:

  i) **Chloride form** - Potassium chloride (KCI), commonly called as muriate of potash (60 %K_2O)

  ii) **Non- chloride form**.

- Potassium sulphate or sulphate of potash (K_2S0_4) (50 %K_2O)

- Potassium magnesium sulphate (22 %K_2O)
- Potassium nitrate (44 %K_2O)

a) *Potassium chloride* (KCI)

- Potassium chloride or muriate of potash is a white or red, crystal containing 60.0 per cent K_2O.
- It is completely soluble in water and therefore readily available to the crops.
- It is not lost from the soil, as it is absorbed on the colloidal surfaces.
- It can be applied at sowing or before or after sowing.
- The chlorine content is about 47.0 per cent.
- Its chlorine content is objectionable to some crops like tobacco, potato, etc. where quality is the consideration.
- It is suitable for most of the crops except sugarcane, sugar beet, potato and tobacco. In sugar crops, accumulation of sugar is affected due to chloride ion -present in fertilizers.
- This fertilizer is suitable for acidic and heavy soils but not for alkaline soils.

***b) Potassium sulphate* (K_2SO_4)**

- Potassium sulphate or sulphate of potash is a white salt and contains *48* per cent K_2O.
- It is soluble in water and therefore readily available to the crop.
- It does not produce any acidity or alkalinity in the soil.
- It is preferred for fertilization of crops like tobacco, potato etc., where quality is of prime importance.
- It is costly because it is made by treating potassium chloride with magnesium sulphate.

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LESSON 12 Principles of fertilizer application

- To obtain the maximum benefit from fertilizers, it is most essential that right fertilizers are applied in right quantity at the proper time and place.
- Thus, the time, method and rate of application will vary in relation to the nature of the fertilizer, soil type and difference in nutrient requirement and nature of field crops

KIND OF FERTILIZER

- Nitrate N-not ideal for sandy soil
- Ammonia or ammonia forming fertilizer-lowland rice
- Acid forming fertilizer-neutral,alkaline
- Water soluble phosphatic fertilizer-neutral soils
- Citrate soluble phosphatic fertilizer –acid soil
- Fertilizer containing chloride not ideal for tobacco,tomato

QUANTITY OF FERTILIZERS

- Soil analysis
- Threshold dose
- Minimum threshold dose
- Optimum dose
- Yield maximising dose

FREQUENCY OF APPLICATION

- Nature of soil ,duration of crop

TIME OF APPLICATION

- Basal application –arid and rainfed crops
- Early application –short duration crops
- N-one at sowing and before flowering
- P and K- basal

PLACEMENT OF FERTILIZER

Based on time of application, application of fertilizers are classified into two types

1.Basal application

- Application of fertilizers before or at the time of sowing is known as basal application.

2. Top dressing

- Application of fertilizers in the standing crop is known as top dressing.

- Nitrogenous fertilizers are soluble and highly mobile in soil. Nitrogenous fertilizers are lost into deeper layers beyond root zone if the entire quantity of fertilizer is applied basal especially in light textured soils (sandy soils).
- Phosphatic fertilizers which are highly reactive are fixed in the soil and become immobile in soil. Potassium fertilizers are less mobile since they are adsorbed on the clay complex. The entire quantity of phosphatic and potassium fertilizers are, therefore, applied in one dose at the time of sowing (basal).

Split application:

- **Application of recommended dose of fertilizers in two or three splits during crop period** is known as split application of fertilizers.
- The number of split applications has to be more in light soils (sandy soils) and less in heavy soils (clayey soils) especially for nitrogenous fertilizers.
- The number of splits are more under irrigated conditions than in rainfed conditions.

Methods of application

- **Different methods of application**

1.Solid fertilizers

- Broadcasting
- Top dressing
- Placement
- Plough sole placement
- Deep placement
- Localised Placement (close to seed/plant)
- Contact or drill placement (seed and fertilizer simultaneously at sowing)
- Band placement
- Pellet placement
- Liquid fertilizers
- Starter solution (soaking seed,dippling roots)
- Foliar solution (standing crop)
- Soil application (liquid manures)
- Fertigation

i. Broadcasting

- **Application of fertilizer uniformly on the soil surface** is known as broadcasting of fertilizer.
- This is done either before sowing of the crop (basal) or in the standing crop (top dressing).

- Broadcasting is the most widely practiced method in India due to ease in application.
- Top dressing: application of fertilizers in standing crop
- Placement: Fertilizers are placed in soil either before sowing or after sowing the crop
- Plough sole placement: placing the fertilizer in a continuous band at the bottom of furrow
- Deep placement: Application of fertilizers in reduced zone
- Localized placement: Fertilizers applied close to seed or plant
- Contact placement: Refers drilling seed and fertilizers simultaneously at sowing
- Pellet placement: Application of fertilizer's in pellet form

Fertigation

- **Application of fertilizers with irrigation water is known as fertigation**.
- Straight and mixed fertilizers containing N, P and K easily soluble in water, are allowed to dissolve in the irrigation stream. The nutrients are thus carried into the soil in solution. This saves the application cost and allows the utilization of relatively inexpensive water soluble fertilizers.
- Usually nitrogenous fertilizers are most commonly applied through irrigation water.
- It is generally followed with drip irrigation.

  - Fertilizers suitable for fertigation
  - Highly water-soluble fertilizers
- Urea, Potash
- Mono ammonium phosphate,

  Di ammonium phosphate

- 19: 19: 19
- Starter solution: These are solutions of fertilizers prepared in lower concentration used for soaking seed, dipping roots or spraying on seedlings for early establishment and growth

Foliar application

- Application of fertilizers to foliage of the crop as spray solution is known as foliar spray of fertilizers. It is also called non-root feeding.
- Foliar feeding is an efficient method of fertilization supplementary to soil feeding. It is not a substitute for soil application, but only a supplement to it.
- The spray solutions may be prepared in a low concentration to apply any one of plant nutrient or a combination of nutrients.
- This method is suitable for application of small quantities of fertilizers, especially micronutrients.
- Major nutrients can also be applied by this method when there is not adequate moisture in the top layer of soil.
- Soil application: Liquid fertilizers such as anhydrous ammonia are applied directly to the soil with special injecting equipment
- Liquid manures such as urine, sewage water and shed washings are directly let in to the field
- **Factors influencing methods of application**
- Suitable method for a particular situation depends on the nature of the soil, crop and fertilizer material.

a) Nature of the Soil

Soil properties like texture, pH, CEC, nutrient and moisture status are important factors to be considered for selecting suitable method of application

b) Nature of the Crop

- Depending on the type of root system and spacing adopted for the crop, different methods of fertilizer application are practiced.
- In crops with fibrous root system and those grown with closer spacing, most of top layer of the soil is occupied by the root system. In such a situation, broadcasting of fertilizer is resorted to followed by irrigation.
- **In widely spaced crops** with initial slow growth, point placement is adopted instead of broadcasting over the entire field.

c) Nature of the fertilizer

- Suitable method of fertilizer application depends on the properties of fertilizers such as physical form, solubility and mobility.
- Mud-ball urea, pellets and briquetts of urea are amenable for placement with hand.
- Granules and prills can be drilled while granules, prills and powders can be broadcasted.

- Liquid fertilizers are applied with irrigation water alone or mixed with herbicide sprays.
- Soluble fertilizers can be applied as foliar application.
- Fertilizers containing plant nutrients which are immobile or less mobile are applied in the root zone.
- Fertilizers which are subject to volatilization and denitrification losses are incorporated into the soil.

Soil fertility and soil productivity

	Soil fertility	**Soil productivity**
1.	Considered as an index of nutrient avail-ability to plants.	Usually, used to indicate the ability of the soil for crop yield.
2.	One of the factors of crop production (water, solar radiation etc.).	Interaction of crop production factors.
3.	Usually assessed in the lab.	Assessed in the field with reference to a particular climate.
4.	Soil potential to produce a crop.	Result of different factors influencing soil management.
5.	Depends on physical, chemical and biological factors of soil.	Depends on, soil physical conditions and fertility, climate and weather etc.
6.	Function of available nutrients in the soil.	Function of soil fertility, soil and crop management and climate.
7.	Fertility of certain soils may be same in all the climates.	Differs in response to variation in climate and location.
8.	Soil fertility = f(nutrient status of soil).	Soil productivity = f (soil fertility + manage- ment + climate)

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Lesson 13 SYSTEMS OF FARMING

- The systems of farming and types of cultivation vary according to the climatic condition, soil types and irrigation potential available in a particular place.

The common systems of farming are dry land farming, garden land farming and wetland farming.

Definitions: Farm – is a piece of land with specific boundaries, where crop and livestock enterprises are taken up under common management Farming – is the process of harnessing solar energy in the form of economic plant and animal products System – a set of components which are interdependent and interacting

There are 3 systems of farming

1. Wetland farming

2. Garden land farming

3. Dryland farming

- Farming Systems Farming system is a set of agro-economic activities that are interrelated and interact with themselves in a particular agrarian setting. It is a mix of farm enterprises to which farm families allocate its resources in order to efficiently utilize the existing enterprises for increasing the productivity and profitability of the farm. These farm enterprises are crop, livestock, aquaculture, agro-forestry and agri-horticulture (Sharma et al 1991).
- Farming system is a mix of farm enterprises such as crop, livestock, aquaculture, agro forestry and fruit crops to which farm family allocates its resources in order to efficiently manage the existing environment for the attainment of the family goal (Pandey et al 1992).

Types of farming

Commercial Farming - the growing of crops / rearing of animals to make a profit
Subsistence Farming - where there is just sufficient food produced to provide for the farmer's own family.
Arable Farming - involves growing of crops
Pastoral Farming - involves rearing of animals
Intensive Farming - where the farm size is small in comparison with the large amount of labour, and inputs of capital, fertilizers etc. which are required.
Extensive Farming - where the size of a farm is very large in comparison to the inputs of money, labour etc. needed

Types of farming system
Classification according to size of farm
a. Collective farming: Collection of plant products from non-arable lands, Actual cultivation is not needed, natural products like honey, gum, flower, silkworm cocoons are collected from forest area.
b. Cultivation farming: farming community cultivate the land for growing crops for obtaining maximum yield.

Classification according to proportion of land labour and capital investment

a. Intensive cultivation: In intensive cultivation more labour and capital invested in the same piece of land. Land remains fixed in quantity while other factors are increased.

b. Extensive Cultivation: When more area is brought under cultivation to increase the output it is termed as extensive cultivation. In extensive cultivation land chiefly available but availability of other factors increases less proportionately

Classification according to value of products or income

a. Specialized farming: The farm on which 50 % or more than 50 % income is received from a single source known as a specialized farming.

b. Diversified Farming: A diversified farm is one that has several production enterprises or source of income but no source of income equal as much as 50% of the total receipt. c. Mixed farming: Mixed farming is one in which crop production is combined with rearing of livestock. In mixed farming at least 10 % income is obtained from livestock up to 49% from crop under Indian condition.

Classification according to Water supply

a. Rainfed farming: Growing of field crops which are entirely dependent on rain water for their water requirement is known as rainfed farming.

b. Irrigated farming: Water is applied through external sources in addition to natural sources.

Classification according to degree of commercialization:

Classification depending upon the quantity of produce sold in the market for earning money.

a. Commercialized farming: More than 50% of the produce is for sale.

b. Partly Commercialized farming: more than 50% of the value of produce is for home consumption.

c. Subsistence farming: Subsistence farming is a type of farming where the farmers cultivate the crop in their land for the living. Virtually there is a no sale of crop and animal products, but used for home consumption.

Classification according to implements used for cultivation

a. Spade farming: Manual labour is used for different farm operations.

b. Farming with animal traction: Bullock power is used for cultivation.

c. Mechanized or tractor farming: Power operated big implements and machinery are used for cultivation e.g. tractor operated plough, combined harvester etc.

There are 3 systems of farming

1.Wetland farming
2.Garden land farming
3.Dryland farming

Wetland farming

Wet land – soils flooded or irrigated through lake, pond or canal and land is always in submerged condition

Wetland farming: is the practice of growing crops in soils flooded through natural flow of water for most part of the year Garden land/ irrigated Dryland farming

Garden land – soils irrigated with ground water sources

Garden land farming: Growing crops with supplemental irrigation by lifting water from underground sources. Dryland farming

Dry land – soils purely depends rainfall for moisture

Dryland farming: is the practice of crop production entirely depending upon rainfall and the moisture conserved in the soil This is practiced in areas where annual rainfall

is less than 800mm.The crops may face moisture stress frequently due to erratic distribution or failure of monsoon

Rainfed farming

- Crop production in areas where rainfall is more than 800mm (i.e assured rainfall areas). Here moisture stress will be minimum. Soil conservation is given more importance

Opportunity farming (Marketing)

- Profit is the deserving factor.
- Example: Basmathi 2 ½ t/ha - Rs. 25/- per kg

Response farming

- We are aiming for maximum output.
- Example: IR.50 - 5 t/ha - Rs. 5/- per kg

Irrigated dry:

- Sorghum - Cotton - Pulse ✓ Oilseeds - Cotton - Pulse Irrigated wet:
- Turmeric - Rice - Rice - Pulse
- Banana - Banana (ratoon) - Rice sequence
- Sugarcane - Sugarcane (ratoon) - Rice sequence

Rainfed dry:

- (mono modal): Single crop of any one of the following
- (Sorghum / cotton / maize / groundnut

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LESSON 14 INTERCROPPING

Growing two or more crops simultaneously on the same piece of land is termed as intercropping. These crops are grown together for their entire life cycle or at least for part of their life cycle.

Base crop: This is one which is planted/ sown at its optimum sole crop population in an intercropping situation.

Intercrop: This is a second crop planted in between rows of base crop with a view to obtain extra yields with intercrop without compromise in the main crop yields

Objective: To utilize the space left between main crops and to produce more yield per unit area.

- Any subsidiary crop grown in association with a main crop is called a companion crops.
    - To higher productivity in unit area in unit time with yield Stability.
- **Advantage:** Soil that is otherwise bare after main crops harvest is protected from soil degradation.
- If the companion crop is a legume, soil fertility may also be increased because of nitrogen fixation.
- In open areas, intercropping of protein rich leguminous forage crops

with grasses of wide adaptability is usually recommended to obtain high herbage yields with high quality.

- Reduces soil crust formation.
- Improves soil fertility.
- Ecological stability.
- Controlling of soil erosion.
- Economy in space and time.
- Suppression of weeds.

Different systems of intercropping: There are different systems of intercropping. Usually a legume and a non-legume are sown together in these systems.

1. **Mixed cropping**:

When seeds of two or more crops are mixed and sown by broadcasting without distinct spacing, the system is termed as mixed cropping. E.g. Sorghum + cowpea + cucumber

2. **Row intercropping:**

Sowing two or more crops in distinct rows with narrow ratios of 1:1 or 1:2 or 2:2 etc. is termed as row intercropping. E.g. Sorghum + cowpea, Maize + cowpea etc.

3. **Strip intercropping:**

The system of sowing two or more crops in alternate strips (slightly larger ratios such as 10:10 or so) is termed as strip cropping. E.g. Stylosanthes sp. + guinea grass.

Relay cropping:

Relay cropping is a system when seeds of one crop (usually legume) are sown into the standing crop (usually rice) before its harvest so that there is overlapping of part of their life cycles. E.g. Rice - sunnhemp; Rice - Pillipesara (Food crop followed by fodder crop).

Crop rotation

- Crop rotation is defined as the growing of different crops more or less in a definite order in the same field.
- If the same crop is grown season after season, or year after year it is called as monoculture and if different

crops are grown it is termed as crop rotation.

Benefits of Crop Rotation

(i) By growing different types of crops considerable amount of organic matter in the form of crop residues are added to the soil.

(ii) The system helps in building up of physical properties of soil

(iii) It is used to increase the efficiency of farm

(iv) It results in efficient utilisation of available resources

(v) Better control of pests, diseases and also weeds

Multi storey cropping

- Cultivation of more than two crops of different heights simultaneously on a piece of land in any certain period
- Ex: Coconut + Pepper + cocoa + pineapple
- Coconut at 7.5 x 7.5 m spacing,
- A single row of cocoa is planted in centre space of coconut rows
- Pineapple planted in left out space
- ✓Coconut grows to a height of 10 m –top floor (roots =100 cm depth)
- Pepper grows to a height of 6-8 m (2nd floor) (grows shallow)

Sequential cropping: Growing two or more crops in a sequence, one after the other, on the same piece of land is termed as sequential cropping. Availability of irrigation water is more important to adopt sequential cropping systems. Depending on the number of crops grown in one year, the systems are called as double cropping, triple cropping, quadruple cropping, etc.

Monoculture and crop rotation: If the same crop is grown season after season or year after year, it is termed as monoculture. If different crops are grown, it is termed as crop rotation. E.g. Maize- Berseem; Sorghum Oats Maize; Maize Cowpea SSG 59-3 (multicut sorghum)

Ley farming

- This is a crop rotation system in which a grass-legume mixture is grown in rotation with agricultural crops.
- The system is sometimes called " alternate husbandry "or mixed farming. • The grass-legume mixture is called the ley.
- The grass improve the soil structure and prevents erosion while legume enriches soil nitrogen.
- It is economical for rain fed farmers as they need not invest much in nitrogen fertilizer input plant for food grain crops but can depend on the nitrogen built up by pasture legumes.
- In rainfed farming, Stylosanthes hamata raised for a period of 2-3 years in a 4 yearly period helps in building soil nitrogen up to 35 kg per hectare.
- Additional cost of nitrogenous fertilizer application is minimised

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Cultivation of fodder crops in intercropping: Intercropping is defined as cultivation of forage crop in the space available between the two rows of main crop during early growth. Though the main crop and subsidiary fodder crop are sown at the same time the subsidiary crop is harvested earlier (short duration crops). This is necessary to prevent competition between the main crop and the subsidiary crop for soil moisture, nutrients and sunlight. The best intercrops are short duration legumes since they fix atmospheric nitrogen in the soil resulting in an overall increase in production and income per unit area of land. Cowpea is the best intercrop with maize / sorghum / bajra.

Advantages of Intercropping

1. The total yield from unit area of land can be increased.

2. Fertility status of the soil can be increased by growing suitable cereals and legumes.

3. Reduction in cultivation expenses by growing 2 or 3 crops simultaneously in the field.

4. Fodder value in terms of quality and quantity will be higher by growing suitable cereals / grasses with legumes; sorghum + cowpea is better than sorghum alone

5. Mixed/Intercropping provide balanced nutrition to the farmer as well as to his livestock.

6. In a grass legume mixture, the grass roots bring about better soil aggregation, whereas legume fixes the atmospheric nitrogen in the soil.

The different systems of fodder production fall into two categories

1. Intercropping of fodder crops: This system was evolved by taking advantage of the growth periods of different species to ensure a uniform supply of green fodder throughout the year. This system is called as overlapping since a fodder crop is introduced in the field before the other crop completes its life cycle. Example: Hybrid napier + cowpea (khariff) Hybrid napier + Lucerne (rabi); This system continues for 3 years.

2. The relay-cropping: The fodder crops are grown in successions, i.e. one after another, the gap between the two crops being very small.

Year-round fodder production

To achieve year-round fodder production two methods may be adopted:

1. Adoption of multiple cropping of fodders,

Where water is not a limiting factor, multiple cropping of fodder crops can be taken up. Rotation of fodder crops: Sorghum Berseem Bajra: Maize - Berseem Bajra + Cowpea; Sorghum - Berseem Maize + Cowpea; Mixed cropping of maize + cowpea, sorghum + cowpea and bajra + cowpea improves the quality as well as the taste of the fodder.

2. Intercropping of fodder with perennial and annual fodder crops

Intensive production of fodder with intercropping perennial grasses and annual fodder crops: Promising perennial grasses like hybrid napier, para, guinea etc., assure continuous supply of green fodder under assured irrigation and best crop management practices. Annual grasses such as fodder sorghum, legumes like cowpea etc. are grown as inter crops.

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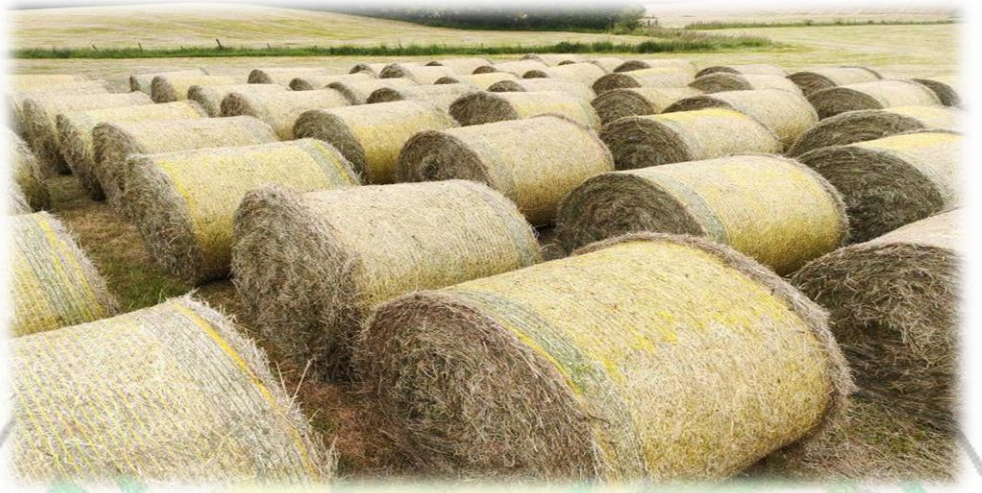
Lesson 15 Hay making



Hay is produced by converting green forage into dry form in such a way that the quality of original material is not affected.

- The moisture content of green material is brought down to 15% or less, so that the biological processes do not proceed rapidly enough to build up heat.
- Good quality hay must retain a layer proportion of leaves, which should not become brittle on drying and full of quickly.
- The cured hay should have a natural green colour, pleasant aroma, optimum moisture content and freedom form moulds.
- To avoid bleaching, excessive and direct exposure to sunlight should be avoided while drying.

Factors affecting Hay yield

- Forage species
- Stage of harvest
- Leaf- stem ratio in the forage
- Moisture content
- Chemical composition
- Anti-nutritional factors
- Foreign materials
- Physical form of the material
- Damage or deterioration during harvest and storage

Suitability of forages for Hay-making

- Best quality hay is made from leguminous plants such as Lucerne, berseem and other clovers such as sweet clovers.
- Among the cereal fodders, fodder oats in the most suitable.
- Other cereal fodders: Fodder sorghum

Methods of Hay making

In India, hay is usually made by

1. Field curing or

2. Hay curing structures

- In many advanced countries hay-making is done in hay barns, which are specially designed structures in which artificial drying is done by circulating hot air.

1. Field curing

- Field curing is the widely accepted form of hay making in India.
- Chopped or whole plant material is thinly and evenly spread over a pucca floor to prevent soiling
- Forage materials are chopped into 10-15 cm lengths, as it is effective to prevent shedding of leaves and to hasten drying.
- Chopping or chaffing the material into small pieces is usually done with a chaff cutter.
- Crushing of the cut fodder also hastens drying.
- The drying time is reduced by 30-50% by these techniques.
- The chopped materials are spread evenly in thin layers, and are turned two or three times daily.
- In the evening, the half-dried material is raked and collected in the form of a cone to prevent the exposure of the material to dewfall at night.
- This is repeated until the material dries completely.
- The hay is transported to the hay barn for storage.
- These are usually stacked as 3m or up to 13m stacks by hay loader.
- Good quality hay should retain green colour & good aroma flavor.

2. Hay curing structures

- Hay curing structures are special devices to improve field curing

1. Fence method

- In this method forage is cut and spread evenly and thinly over fences of paddocks, fields etc. These, fence help to dry the material quickly.

2.Tripod Method

- In this method tripod stands of convenient height are made using local materials such as wood or galvanized iron poles
- In between these poles, horizontal supports are fitted to increase its carrying capacity

Fence method

fence method of hay storage is a traditional technique used to preserve and protect hay, particularly in rural or less industrialized settings. This method involves creating a fenced enclosure to stack and store hay, keeping it off the ground and protecting it from animals and weather. Here's how it typically works:

Steps for the Fence Method of Hay Storage:

1. **Select a Location**: Choose a dry, well-drained area to build the enclosure. It should be away from low-lying areas where water might accumulate.
2. **Build the Fence**:
   - Erect a fence around the chosen area. The fence can be made from wooden posts, metal stakes, or other sturdy materials.
   - The height of the fence should be sufficient to prevent livestock or wildlife from reaching the hay. A typical height is around 6-8 feet.
3. **Create a Base**:
   - Lay down a base to keep the hay off the ground and reduce moisture absorption. This can be done by placing wooden pallets, logs, or a layer of gravel inside the fenced area.
4. **Stack the Hay**:
   - Stack the hay bales neatly within the enclosure. The bales should be stacked tightly together to minimize air circulation and exposure to moisture.
   - If stacking loose hay, create a conical shape to allow water to run off easily.
5. **Cover the Hay**:
   - Use a tarp or other waterproof covering to protect the hay from rain or snow. Secure the covering to prevent it from blowing away in the wind.
   - Ensure the cover allows for some ventilation to prevent the hay from becoming too moist and spoiling.
6. **Maintenance**:
   - Regularly inspect the hay for signs of moisture, mold, or pest infestation. Adjust the covering as needed and remove any spoiled hay.

Advantages of the Fence Method:

- **Cost-Effective**: Utilizes readily available materials and requires minimal investment.
- **Accessibility**: Makes it easy to access hay when needed.
- **Protection**: Shields hay from animals and reduces the risk of spoilage from ground moisture.

Tripod method

Steps for the Tripod Method of Hay Storage:

1. **Gather Materials**:
   - You will need three long, sturdy poles or logs, typically about 10-12 feet in length.
   - You'll also need some rope or twine to tie the poles together at the top.
2. **Construct the Tripod**:
   - Arrange the three poles in a triangular formation on the ground.
   - Tie the top ends of the poles together securely with rope or twine, leaving some space at the very top to allow for spreading the poles.
   - Stand the tied poles up and spread the bottom ends outwards to form a stable tripod. The poles should be spread far enough apart to create a wide base, ensuring stability.
3. **Prepare the Ground**:
   - Clear the area where the tripod will stand, removing any grass or debris.
   - To minimize ground moisture, you can lay down a base of wooden pallets, logs, or a layer of straw.
4. **Stack the Hay**:
   - Start stacking the hay around the base of the tripod. If you are using loose hay, stack it in layers around the tripod, creating a conical shape.
   - If using hay bales, you can stack them in a pyramid shape around the tripod, using the poles as a central support.
   - As you build up the hay, keep it compact to reduce air circulation, which can help protect it from moisture and wind.
5. **Cover the Hay**:
   - Once the hay is stacked, you can cover it with a tarp, plastic sheeting, or any other waterproof material to protect it from rain.
   - Secure the covering to the tripod and around the base to prevent it from being blown away by wind.
   - Ensure the covering is properly vented to prevent moisture buildup inside, which can lead to mold.

Advantages of the Tripod Method:

- **Low Cost**: Requires minimal materials and is easy to set up, making it a cost-effective option.
- **Effective Drainage**: The conical shape of the haystack and the elevation provided by the tripod help rainwater drain away, reducing the risk of moisture damage.
- **Improved Air Circulation**: The open structure allows for better air circulation, which helps to keep the hay dry.

Advantages of Hay Making

- Less expensive to prepare
- It is possible to maintain more stock on a certain area of barn (66 kg/m3)
- Most suitable method of conservation of green fodder for small holders
- Many undesirable things present in the fresh crops are eliminated after it is converted to hay.

Characteristics of good quality hay

- Good quality hay should be leafy.
- It has been found that leaves are richer in food value compared to other parts of the plant.
- It should be prepared out of herbage, cut at a stage nearing maturity, preferably at the flowering stage when it has the maximum of nutrients.
- It should be green in colour.
- The green colour of leaves indicates the amount of carotene which is a precursor of Vit-A
- It should be soft and pliable.
- It should be free from dust and moulds.
- It should be free from weeds.
- It should have the smell and aroma characteristic of the crop from which it is made.
- The moisture percentage should not exceed 15%.
- Hay of average quality will usually have 25-30 % CF and 45-60 % TDN.

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Lesson 16 Silage

Preserved green fodder material produced by controlled fermentation of a crop.

Silage is a fermented feed resulting from the storage of high moisture crops, usually green forages, under anaerobic conditions in a structure known as a silo.

Ensiling (process)

- The name actually stands for all physical and chemical changes that take place when forage or feed with sufficient moisture are stored in a silo in the absence of air.
- The entire ensiling process requires two to three weeks for converting forage into silage

Silo (the container) Types of silo

- A silo is an airtight to semi-airtight structure designed for the storage and preservation of high moisture feeds as silage.
- Silos are of different types.

Pit silo - India

- A pit silo is shaped like the tower silo, but inverted into the ground. It resembles a well. This type of silo can be made only in places where the water table is low enough (in semi- arid or in arid regions) that the silo will not fill with water.
- In comparison with tower silos, pit silos have the following Advantages
- They are never damaged by storm, and
- Require less reinforcing.

Disadvantages

- They are dangerous, due to the frequent presence of suffocating Co2, and
- Considerable work is involved in removing the silage.

Bag Silo

- A "bag silo" typically refers to a storage solution used in agricultural settings to store grains, silage, or other bulk materials.
- These silos are large, usually cylindrical structures made of durable materials that can protect the contents from moisture, pests, and other environmental factors.
- Bag silos are particularly useful for preserving the quality of stored materials over time.
- The concept can also apply to certain industrial contexts where materials like sand, cement, or feed are stored in large bags within a silo structure for easy handling and distribution.

Tower silo

- All upright silos are circular in shape and equipped with a series of doors about 2 sq. ft. approximately every 6 ft. up on one side of the silo.
- These are closed as the silo is filled and opened as the silo is emptied. Recent developments in construction of tower silos have been made in bottom 170 unloaders with large diameter features (24-30 ft.).
- However, the size varies from about 12-20 ft. in diameter and 40-80ft. in length. For effective preservation of silage, the forage should contain between 25 and 35 per cent dry matter.

Trench silo

- At a comparatively low cost this type of silo can be constructed quickly. It is most popular in areas where the weather is not too severe and where there is good drainage. A trench silo should be wider at the top than at the bottom, and the bottom should slope away from one end so that excess juices will drain off if material with high moisture content is ensiled.

Advantages

- Low initial cost and ease of construction.

Disadvantages

- In comparison with the tower type it will require larger space to seal. When filling is completed, the top should be carefully sealed by polyethylene, plastic or by wet straw mixed with mud or by saw dust to make it air tight.

Bunker silo

As a labour-saving measure, bunker type of silos above the ground (for slightly recessed) usually with concrete floors are generally catching the attention of many farmers.

Crops used for silage making

- The most commonly used silage crops are:
- Graminaceous.
- Maize, sorghum, sudan grass, bajra, hybrid napier, etc.
- Out of all, mazie and sorghum are supposed to the best crops for silage making.
- Graminaceous forage crops can be mixed with legumes for making silage of good quality.
- Leguminaceous
- Lucerne, Berseem, Cowpea etc.,
- For preserving leguminous crops which have less percentages of sugar, the fodder is sprinkled with a solution of molasses in water at every one-third metre of filling to provide the necessary amount of sugar for silage making.

Why Silage?

Dairy Farming

- Green fodder- economical source
- High cost of Concentrates feed ingredients
- Need to increase fodder production per unit area
- Regular supply of quality fodder during lean period
- Green fodder Conservation during lush season

Qualities of Silage

- Golden/Greenish yellow in colour
- Bright and moist
- Pleasant Aroma
- Highly Palatable
- Slightly laxative
- Easily Digestible
- Presence of Carotene

Crops suitable for silage making

- Rich in soluble carbohydrate content
- Fodder cereals-Maize, Sorghum, Oats, Bajra
- Fodder grasses- Hybrid Napier
- Leguminous fodder- less suitable

Selection of Crops

- Cereal fodders>> Grasses >>Legumes υ Optimum dry matter (DM) content 35% υ Best crops – maize, bajra and sorghum [High soluble CHOs]
- Leguminous crops --> low soluble CHOs-- Not suitable eg: Berseem & Lucerne.
- Clostridial organisms multiply.
- Butyric acid type of fermentation.

Infrastructure required

- Silo – Surface or trench
- **Farm machinery** like tractor, trailer, fodder harvester & power chaff cutter.

Large farmers/community silage making

- 100 MT of preserved green fodder–Rs. 12.00 lakh
- Fodder harvester/chopper -1.50 lakhs

Medium class farmers

- 5-7 MT surface silos (manually pressed) - Rs. 25000/-
- Chaff cutter Rs. 25000/-

Steps in the preparation of silage

1) Construct a pit silo (silage storage structure)

2) Select the green grass fodder crop with 35% DM

3) Sunny day for silage making 4) Chopping -->enables best packing

5) Use additives during filling of fodder in the silo

6) Rapid filling of silos with chopped fodder

7) Trampling and tight packing (mechanical/manual)

8) Packing of fodder on top of silo 3-4 feet above the ground level. 9) Layering paddy straw on top and sides of silo

10) Sealing top of silo with wet mud and dung

11) Anaerobic fermentation for 60 days

Chopping of fodder

2-2.5 cm size

Silage making

- Chemical changes during Ensilage
- Aerobic phase Oxygen utlization-5hrs-T 30-38 °C
- [CO2] increase-> favour Acid forming bacteria
- Fermentation of sugars-> Latic Acid + VFA(Acetate) Organic Acid--> reduce undesirable microbial growth (Clostridia)
- pH End of bacterial fermentation

Lactic Acid producing bacteria

Homofermentative type

 -->2 M of Lactic acid / 1 glucose or fructose

Heterofermentative type --> 1 M of lactic acid+ 1 mole of ethanol + 1 mole of CO2 /1 Glucose or --> 1 M Lactic acid+mannitol+acetic acid +CO2/ 1 Fructose

Chemical changes during Ensilage

- Saccharolytic clostridial fermentation produces Butyric acid, CO2 and H2
- Butyric acid - sharp disagreeable odour
- Proteolytic clostridia produce ammonia and volatile amines
- First 5-7 days: proteins -->amino acids, amides, amines etc (protease enzyme)
- Optimum pH for proteolysis: 6.0
- pH 4.0: End of plant proteases action

Poor Silage

- Extensive proteolysis & putrefaction
- Betaine, Adenine & Pentamethylene diamine
- Maillard reaction: Polyphenol oxidases -->quinones +proteins -->brown coloured product
- Dark brown or Black Silage --@High Temp.

Good Silage

Phaeophytin: Mg free derivative of chlorophyll-- >Greenish brown colour of good quality silage.

Classification of silage

PARAMETER	VERY GOOD	GOOD	PAIR	POOR
pH	3.5-4.2	4.2-4.5	4.5-4.8	More than 4.
Ammoniacal nitrogen as a % of total nitrogen	Less than 10%	10-15%	15-20%	More than 20%
Butyric acid content	Less than 0.2%	0.3-0.5%	More than 0.5%	Very high
Smell	Good (acidic)	Satisfactory (acidic)	Slightly acidic	Bad (pungent)
Fungal/mould growth	Absent	Absent	Slight	More

Losses of nutrients during ensilage

- Field losses: Increased DM loss--> wilting for longer period prior to ensiling
- Oxidation losses: during early days plant/microbial enzymes act on CHOs --> CO2+H20
- Well filled silo: Loss of < 1% of DM
- Badly filled silo: Loss of 75% of DM
- Fermentation losses: < 5% of DM
- Increases during clostridial & enterobacterial fermentations
- Effluent losses: soluble nutrients lost--vary with initial moisture content -- optimum moisture content of 65 % reduces effluent loss **Conditions for Silage making 1**
- Thick stemmed Crops rich in soluble carbohydrates: eg. Cereal fodders
- Grasses: low in soluble carbohydrates Ensiled with + molasses at 3-3.5%
- Harvesting @ 35% DM-- between flowering and milk stage (EARS) υ High moisture--> undesirable fermentation
- High DM crop: low compactness -- air is entrapped - ->spoilage **Conditions for Silage making 2**
- Anaerobic environment:
- Silo should be sufficiently deep
- Located in an elevated ground
- Chopping the crop during harvesting
- Rapid filling of the silo
- Adequate consolidation
- Sealing of silo
- Aerobic phase: decay--> inedible and toxic product

Conditions for Silage making 3

- Preventing the growth of undesirable microbes:
  - E.g. clostridia produce toxic fermentation products

Prevention by

1. Encouraging the growth of lactic acid bacteria
2. Using chemical additives

Additives in silage

- Salt @ 0.5% and urea @ 1% - improve the palatability and nitrogen content
- Molasses @ 3-3.5% to improve the sugar content of grass silage υ Limestone @ 0.5-1%
- Organic acids E.g. Propionic acid @1%
- Bacterial cultures @105 or 106 cfu/g of forage
- E.g. Lactobacillus plantarum,
- Pediococcus pentosaceus, Enterococcus faecium υ Sodium metabisulphite @ 4-8 kg/1000 kg fodder
- Crushed maize/ maize flour: @ 0.5%

Flieg index

- To evaluate silage quality
- By Illness of farm workers
- By inhalation of oxides of nitrogen
- during ensiling
- Or
- entering a silo after filling
- Oxides of nitrogen when inhaled forms nitrous acid and nitric acid in lungs
- Cause chemical pneumonia.

Advantages of silage making

- Helps in preserving green fodder
- Using Plants having thick stems not suitable for hay making
- e.g. sorghum, maize, bajra etc
- Organic acids produced are similar to rumen VFAs

Disadvantages of silage making

- Transportation is difficult
- Permanent storage structure (silo) needed.

Other ensilage methods

AIV method:

- Developed by A I Virtanen in Finland (1925)
- A mixture of dil. HCl & dil. H_2SO_4 +ensiling.
- For clover and clover grass mixtures Haylage:
- Grasses and legumes for hay are ensiled
- Wilted to 40-45% DM before ensiling
- **Wastelage** determining the relative amounts of lactic, acetic and butyric acids expressed as percentage of the total acids in silage
- Very good quality silage: 44-50 %
- Poor quality silage: <19

Silo fillers disease

- Anaerobic fermentation of animal wastes+ other feed ingredients +lactic acid bacteria.

Nutrient content of silage

- Similar to the crop selected for ensilage
- Vitamin C lost during silage making.

- β carotene stable during ensiling
- Lactic acid type of fermentation:
- DM loss 10-75%

Feeding of silage

- Silo can be opened from one side as per need after 45 days and closed properly after taking out the silage.
- Initially, silage can be fed @ 5 kg/animal to adjust the animals on silage feeding
- 10-15 Kg/day/Adult Animal recommended
- Silage is a substitute of green fodder and can be fed like green fodder after milking of cows

Characteristics of good quality silage

- Bright, light green yellow or green brown in colour.
- Lactic acid odour with no butyric acid and ammonia odour.
- Firm texture with softer material.
- Moisture should be in range of 65-70 per cent.
- Lactic acid 3-14 per cent.
- Butyric acid less than 0.2 per cent.
- pH in the range of 3.7-4.2.

Advantages of silage making

1) Ensures regular supply of fodder
2) Ensures uniform quality fodder to animals during different seasons.
3) Silage can be made under almost all-weather conditions.
4) Surplus green fodder can be conserved, minimising wastage.
5) An effective tool for the control of parasitic diseases
6) Enhances green fodder productivity by improving harvesting intensity
7) Enhances livestock productivity by ensuring fodder supply, especially during the lean period.

Critical factors effecting production of good quality silage

- Type of Silo – Surface silo are best due to ease of ensiling.
- Dry Matter of fodder – Ideal 30-35 per cent.
- Chop length of fodder – Ideal 2-3 cms, easy to get compacted. υ Pressing/compaction of fodder – As quick as possible to minimise aerobic fermentation
- Sealing of silo – To check inflow of air and water into silo

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Lesson 17 Fodder and forage

- Fodder crops - Cultivated species
  - Forages - All vegetative parts, fresh or preserved
  - Fodders crops are cultivated plant species that are utilised as livestock feed. Fodder refers mostly the crops which are harvested and used for stall feeding.
  - Forage maybe defined as the vegetative matter, fresh or preserved, utilised as feed for animals.
  - Forage crops include grasses, legumes, crucifers and other crops cultivated and used in the form of hay, pasture, fodder and silage. Forages are classified based on various features.

Classification of fodder crops

- Forages are classified on different ways.
- They are
  1) Season of cultivation
  2) Nutrient density in dry matter
  3) Plant types
  4) Crop duration
  5) Plant family and duration of crop.

ON THE BASIS OF SEASON OF CULTIVATION

Kharif (June - September)	Rabi (October -Dec/Jan)	Summer (April - June)
E.g. Cowpea, Cluster bean, Field bean, Bajra, Sorghum, Maize	E.g. Berseem, Lucerne, Oats, Barley	E.g. Cowpea, Cluster bean, Field bean, Bajra, Sorghum, Maize

ON THE BASIS OF NUTRIENT DENSITY IN THE DRY MATTER

Non - maintenance	Maintenance	Production	
E.g. Wheat straw, Rice straw, Ragi straw, Maize and Sorghum stover, Jungle hay, cereal forages harvested at advanced maturity	E.g. Sorghum, Maize, Bajra, Hybrid napier, Para grass and all grasses	**Low protein** Maize, Oats, Barley, Sorghum Root crops etc.	**High protein** Berseem, Lucerne Cowpea, Subabool and all Legumes

ON THE BASIS OF PLANT TYPES

Cultivated	Grasslands/Pasture		Forests edibles	Plantation	Aquatic
Legumes Lucerne , Berseem, Cowpea **Cereals** Sorghum, Oats, Maize, Bajra **Root crops** Turnips, Carrots	**Managed** Legume, Grass, Shrubs, Fodder trees, etc.,	**Unmanaged** Grasses, Bushes etc.			

ON THE BASIS OF DURATION OF THE CROP

Cereal - Annual	Grass		Legume		Tree
	Annual	Perennial	Annual	Perennial	
Maize, Sorghum	Deenanath grass	Hybrid Napier, Guinea grass	Cowpea, Berseem	Lucerne , Stylosanthes	Soobabul, Sesbania

ON THE BASIS OF PLANT FAMILY AND DURATION OF THE CROP

Generally, fodders are grouped as those belong to the plant family Leguminacea and those not. It is called legume fodders and non-legume fodders. Each category has annuals and perennials.

Legumes	Non-legumes
Eg. Berseem, Cowpea, Stylosanthes etc. *Annual:* Berseem, Cowpea *Perennial :* Stylo, Desmanthes	Eg. Hybrid Napier, Guinea grass, Fodder sorghum, etc. *Annual :* Fodder Maize, Sorghum *Perennial:* Hybrid Napier grass, Para grass

OR

Cultivated fodder crops are classified into

I. According to their life time

Annuals:

- Annual crops complete their life cycle in a year or in a section or season (pertaining to one season /year) of the year. Annual crops that take only a season to complete the life cycle are called seasonal crops. Seeds germinate with the start of the crop season, and seed production is completed by the end of the crop season. After the production of seeds, annuals die. Most of the cereal forage crops are annuals. Sometimes, they are also known based on the season in which they are grown, for example: Kharif crops (Fodder maize, Dheenanath grass) and Rabi crops (Fodder oats, Berseem).

Perennials:

- Perennials live and persist for several (persist for more than one year on the field) years. Most perennials produce flowers and seeds many times. However, a few such as bamboos produce flowers only once in their lifetime. Many tree legumes such as gliricidia, subabul and Agathi; and herbaceous ground legumes such as calopo and centro are perennials. Most of the cultivated grasses in the tropics, for example: guinea grass, napier grass, congo signal, para grass etc. are perennials

II. According to the differences in nutritive values

- Legumes
- Non- Legumes

Annuals

1. Seasonal Non-Legumes

- Maize or corn - *Zea Maize*
- Sorghum/ Jowar /Great millet – *Sorghum bicolor*
- Pearl millet/ Bajra - *Pennisetum americanum*
- Teosinte – *Euchlanea mexicana*

2. Seasonal Legumes

- Cow pea- *Vigna angiculata*
- Field bean -lab lab- *Lablab purpureus*
- Horse gram- *Marcotyloma uniflorum*
- Berseem/Egyptian clover- *Trifolium alexandrium*

Perennials

1.Non-legumes

- Hybrid napier- *Pennnisetum purpureum*

  Pennisetum americanum
- Para grass - angola grass/buffalo grass

  - *Brachiaria mutica*
- Ruzi grass - congo/green signal

  - *Brachiaria ruziziensis*
- Anjan grass - *Cenchrus ciliaris*
- *Sudan grass - Sorghum sudanense*

- *Deenanath grass- Penns*

2.Legumes

- *Lucerne - Medicago sativa*
- *Stylos - Stylosanthes hemata*
- *Hedge Lucerne – Desmanthes virgatus*

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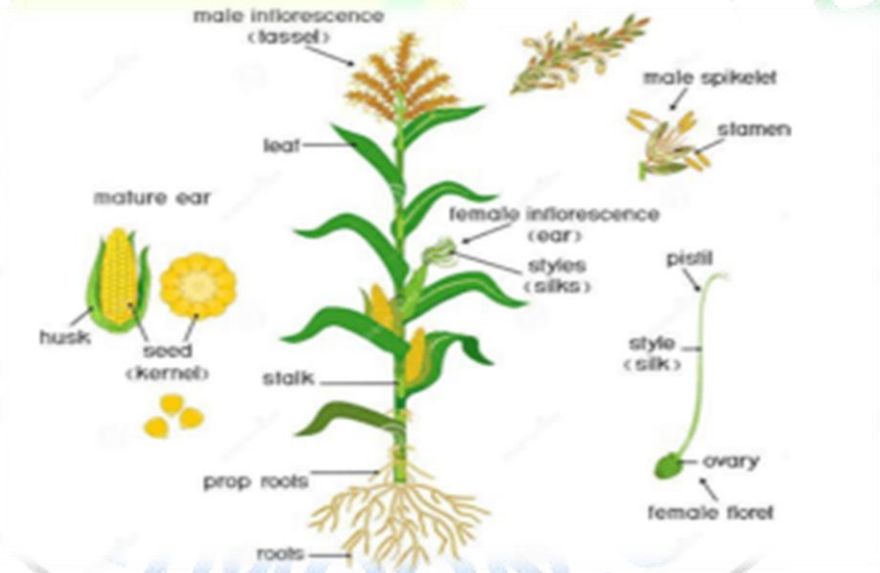
LESSON 18 Cereal forage crops

1. Fodder Maize
2. Fodder Sorghum
3. Teosinte
4. Fodder Bajra
5. Finger Millet

2. Fodder maize

Scientific name: (Zea mays) Makkacholam



- Mostly dent types (angular grain concave on the top) are grown for forage.
- The male inflorescence is called tassel and female as ear and cob.
- As a native of Mexico, maize grows best in warm climate where the day temperature is fairly light. •
- Heavy rains and dry hot winds are not suitable.

Land Preparation and Planting:

- The optimum season for sowing is the last week of June to second week of July and September to October.
- The crop can be raised throughout the year in areas where irrigation facilities are available.
- The land is ploughed two or three times and beds and channels are formed.
- Seeds can be either broadcasted or dibbled at a spacing of 30 cm between rows and 15 cm between plants (30 cm x 15 cm).

Varieties:

- Hybrid varieties are African Tall, Deccan, Ganga-5, Ganga safed-2, Ganga-3 and composite varieties such as Vijay composite, Moti composite and Jawahar.
- Seed Rate:
- Seed rate for broadcasting is 80 kg /ha
- Seed rate for dibbling 40-60 kg/ ha
- To be dibbled at 5-6 cm depth @ two seeds per hole.

Manures and Fertilisers:

- FYM @ 10 t ha-¹ may be applied at the time of preparation of land as basal dressing.
- N, P_2O5 and K_2O at the rate of 120, 60 and 40 kg/ha respectively, may be given as topdressing.

Water Management: Irrigation is necessary on the day of sowing.

- Subsequent irrigations shall be given at 10-15 days interval.

Weed Management: Weeding may be done according to necessity. **Harvesting and Yield**:

- First cutting of maize can be taken after 60 days of planting or at the milky stage of the crop.
- A second cut can also be taken if there is sufficient moisture in the soil.

Uses:

- Maize can be utilised for grazing, soilage & for silage, the best silage of the grass family.

2. Fodder sorghum

Scientific name:(Sorghum bicolor) - Cholam/ Jowar.

- Sorghum is a vigorously growing cereal plant, which grows to a height of 0.5-4 m.
- Fodder sorghum is an ideal tropical forage crop.
- It is highly drought resistant and sometimes called 'crop camel' as it grows well under semi-arid conditions.
- It is not suited to higher elevations.

- The group of sorghums called 'sorgos' are grown principally for fodder or for syrup production.
- The stem contains a sweet juice in abundant quantities.
- Most of the modern fodder sorghum cultivars have been produced by crossing male sterile grain sorghums with sorgos or Sudan grass (Sorghum sudanese).

Climate and Soil.

- It is often grown as a rain fed crop and is sown from May to July depending upon the onset of monsoons.
- In South India, especially Kerala, it can be raised in North East monsoon season also, sowing time being September-October.
- With irrigation, sowing can be done any time of the year except cold season.

Cultivars

- Most of the sorghum cultivars suitable for growing as fodder are single cut types.
- However, double cut and multi-cut cultivars are also seen.
- **Single cut types** - PC-6, PC-9, PC-23, SL-44, UP Chari-1, UP Chari-2, HC-136, MPK V-1, JS -20, JS 3 and S - 1049
- **Double cut types**- Co 27, CoFS29
- **Multi-cut types** MP Chari, Meethi sudan (SSG-59-3), Pioneer-988, X-988, SSG-48, Hara Sona.

Establishment

- Sorghum is propagated through seeds.
- As it is a shallow rooted crop, deep cultivation is not required.
- Land is prepared by 2-3 ploughings.
- A seed rate of 40-50 kg/ ha is followed for fodder purposes.
- Spacing usually followed is 25-30 cm (between rows) and 10-15 cm (between plants).
- 25-30 cm x 10-15 cm.

Manures and Fertilizers

- For a rainfed crop, farmyard manure at 10 T/ha is to be applied at the time of sowing.
- For an irrigated crop, higher amount of farmyard manure at 25 T/ ha must be given.
- Fertilizers need to be applied based on the number of harvests.
- The general pattern is as follows.
- **Single cut types**: Total requirement of N. P. K (kg/ ha) - 90:30:0.

Basal dose:

- Nitrogen, two third, (60 kg/ha); phosphorus, full (30 kg/ha); remaining one-third nitrogen at 30 days after sowing.
- **Double cut types**: Total requirement of N: P: K (kg/ ha) - 120:30:0.

Basal dose:

- Nitrogen, half (60 kg / ha); and phosphorus, full (50 kg/ ha); and the remaining nitrogen (60kg/ ha) at 30 days after the first cut.

Multicut types:

- Total requirement of N: P: K (kg/ ha) - 210:60:60. • Basal dose: nitrogen, 60 kg/ ha; phosphorus, full` (60 kg / ha); and potassium, full (60 kg / ha). • The remaining nitrogen is to be applied in 3 equal splits at the rate of 50 kg/ha each after first, second and third cuts.
- In heavy soils, fertilizers are applied as a single dose basally. • In light textured soils, nitrogen may be applied in two split doses, one-half basal and the other half about 30 days after sowing.

Weeding

- Weeds may be a problem in the early stages.
- So, shallow intercultivation with a harrow or hoe is necessary.

Water management

- Fodder sorghum is grown as a rainfed crop.
- In the post-monsoon period, irrigation may provide once in every 3 weeks.

- Water stagnation must be prevented in the rainy season and drainage facilities need to be provided to drain out excess water.

Harvesting and Yield:

- At the flowering stage, the herbage contains low amounts of HCN.
- The crop at this stage can be safely grazed or cut and fed.
- Therefore, harvesting is normally done at 50 per cent flowering stage.
- In multi-cut types, the first harvest is taken after two months and subsequent cuts at an interval of 35-40 days.
- The crop produces 30-50 t/ha from a single cut crop and 50-85 t/ ha from a multi-cut crop.

Uses:

- The crop is mainly utilized as silage and hay as damages from HCN injury are reduced.
- Sorghum is one of the best crops for silage because of its high yields, sugar content and juiciness of its stalk.

Toxicity

- Sorghum shoots contain appreciable amount of cyanogenic glycosides called Dhurrin, which in turn on enzyme action will further dissociates to hydrocyanic acid (HCN).
- These compounds are toxic and affect palatability of the fodder.
- Small plants and young tillers contain high levels of Dhurrin, which decreases with the age of the plant.
- It should not be harvested before 40 to 50 days from sowing date.

3.Fodder bajra

Scientific name:(Pennisetum americanum / P. typhoides)

- Pearl millet/ African millet
- Bajra is cultivated for grain as well as for fodder purposes, mainly in the arid and semi-arid regions of the world.
- It cannot tolerate water logging.
- It is grown as a rainfed crop in Kharif or irrigated crop during the summer season.
- In India, it is mainly a Kharif crop sown during June-July.
- In South India, the crop can be sown in May- June and September-October according to the monsoons or any time of the year with irrigation.

Cultivars.

- Cultivars of bajra recommended for fodder production include 'Giant bajra', 'L-72', 'L-74", TNSC-1'and 'Rajko'

Land Preparation and Planting:

- Simple land preparation with a country plough or tractor drawn plough is enough as deep cultivation is not required.
- Normal seed rate followed is 8-10 kg / ha.
- Bajra can be sown broadcasted, drilled or sown behind the plough.
- When sown behind the plough or drilled, a spacing of 30-40 cm between rows is given.

Water Management:

- When grown irrigated, three irrigations are usually necessary.

Weed Management:

- Normally, weeds may not be a problem, as the crop develops rapidly with vigour.
- However, if heavy weed growth is expected in the early stages of establishment, 2-3 hand weeding's can be recommended. Manures and Fertilisers: Fodder bajra requires a fertilizer dose of 40 kg nitrogen and 20 kg phosphate, in addition to 10-15 T of organic manures per hectare.
- Potash must also be applied, if the soil is deficient in it.

Harvesting and uses

- The crop is ready for harvest by 60-75 days.
- It is harvested at the boot stage or at 50 percent flowering stage.
- A mean green fodder yield of 25-30 t/ha is expected.
- Fodder bajra is usually cut and fed in the stalls as green fodder.

LESSON 19 Fodder trees

1. Subabul
2. Agathi
3. Calliandra
4. Glyricidia
5. Hedge Lucerne.
6. Gliricidia

1. Subabul

Scientific name: (Leucaena leucocephala)

- Subabul is also known as leucaena or ipil-ipil.
- It had its origin from Mexico.
- It is a perennial hardy evergreen shrub.
- It has deep and strong taproot and even the seedlings are deep rooted.
- It cannot withstand water logging.
- It requires a deep well drained neutral soil and can tolerate saline and acid soil.
- It can also be grown in steep slopes, hilly terrains, gravelly areas and sandy loams.

There are four types of subabul.

- a) **Hawaiian type:**
- The plants are short bushy and remarkably drought tolerant.
- It is suited to hilly terrains in drought prone areas.
- K-341 is a Hawaiian variety.
- **b) Salvador type:**
- Tall, tree like and fast growing having maximum annual biomass production.
- Variety K-8 is useful for fodder.

c) Peru:

- Tall and extensively branching type and is ideal for fodder purpose.

d) Cunningham:

- It is a cross between Salvador and Peru types.

Establishment

- Seed viability is high, but possess dormancy because of hard seed coat.
- To hasten germination seeds are to be dipped in concentrated sulphuric acid for four minutes and then washed or put in hot water at 80°C for four minutes.
- Sundry the seeds afterwards for about one hour before sowing.
- A seed rate of 3-4 kg ha^{-1} is recommended.
- Sowing is preferably done during February-March in a nursery or polythene bags or in situ at 2-3 cm depth.

Planting

- It can grow under a wide range of conditions as a range plant, roadside plant, in pastures etc.

- The land should, however, be cleared of bushes, ploughed and levelled before sowing.
- Planting of seedlings can be done with the onset of rains in May June or September-October.
- Give irrigation if there is no rain.
- Seedlings (1.5 to 3 months old with 6-8 leaves) are planted in the main field.

A spacing of

- 1 m x 0.1 m is recommended for a pure crop of fodder,
- 1.5 m x 0.2 m for planting in boundaries and borders of coconut gardens
- 2 m x 0.2 m when raised along boundaries.

Manures and Fertilisers:

- A basal application of N:P_2O5: K_2O @ 20:50:30 kg /ha is recommended. **Weed Management:**
- Since the early growth of the crop is slow, the tender plants are to be protected from aggressive weeds.
- Two or three inter-row cultivation is essential to check weeds in early life.
- Once established, even vigorous grasses seldom smother the plants. **Harvesting and Yield**
- Subabul starts flowering at 125-150 days after planting.
- First cutting is done after 5-6 months at a height of 70-80 cm from the ground level at a time when the plants reach a height of 1.5-1.75 m.
- Subsequent harvests can be made at 50-60 days interval depending on the re-growth.
- When planted in boundaries, the main shoot is not cut; only side branches are cut for fodder, leaving the top three branches.
- An average yield of 25-30 tonnes per ha per year may be obtained from a rainfed crop.
- The irrigated crop may produce 100 t ha^{-1} of green fodder per year in seven to eight cuttings.

Uses

- Subabul is a highly nutritious leguminous tree fodder with 27-34 per cent protein.
- The fodder is rich in carotene and vitamin A.
- Pro vitamin A content is the highest among all plant species.
- The foliage contains an uncommon amino acid, mimosine, which is toxic to non-ruminants at levels of about 10 per cent of the diet.

2.Agathi

Scientific name: (Sesbania grandiflora)

- Agathi is a fast growing, soft wooded small tree or shrub with rather stout branches, which grows up to 15m tall.
- One of the major advantages of Agathi or other perennial Sesbania species over other forage trees and shrubs is their rapid early growth rate, especially its first three to four years of growth.

Establishment

- Seeds are used for propagation. Agathi can be easily planted by direct seeding.
- It is not hard seeded and usually germinates well without scarification.
- It can be planted very densely at the rate of 3000 plants / ha.
- Prolific nodulation and extremely large nodules are its characteristic features.

Harvesting and Yield

- The tender shoots and leaves of Agathi form good feed for livestock.
- Cutting management has a very important influence on the productivity of Agathi.
- Agathi cannot survive repeated cutting.
- A usual practise is to lop only the side branches of trees for fodder leaving the main growing stem untouched.
- After cutting, shoots re-sprout with vigour.
- Fodder can be harvested in this manner for 3-4 years, yielding up to about 2 kg dry matter per harvest per tree.

3. Gliricidia

Scientific name:(Gliricidia sepium)

- Madre tree, Seemakonna
- Gliricidia is widespread in the tropics as a shade tree, green manure, conservation hedge, live fence, fuel wood and as a fodder.
- Being deep rooted, it is drought resistant and tide over the drought season easily.
- Gliricidia is a small to medium sized deep-rooted perennial tree, growing to a height of about 5 m to 15 m.
- Establishment
- Propagation is by seeds, cuttings or stakes.
- Cuttings are easy to collect and plant, hence it is extensively planted for hedges and live fences.
- This character of easiness in sprouting are often gives it the name "quick stick"
- Harvesting and Uses
- Gliricidia coppices vigorously and shows high tolerance to pruning and pollarding.
- In the rainy season, the branches can be cut at an interval of 1.5-3 months.
- Toxicity
- Gliricida roots are toxic to rodents and the leaves toxic to horses.
- Cattle and goats are not affected.

- Seeds contain di-coumarol, a haemorrhagic compound which is fatal to rodents.
- Gliricidia means rodent killer (Gliricidia is from 'glires' meaning rodents and 'cida' meaning 'to kill').

4.Calliandra

Scientific name: (Calliandra calothyrsus)

- It is a small leguminous browse tree, which grows to a height of 2-12 m.
- In humid climates, the tree is evergreen, whereas areas with a long dry season, it is semi deciduous.
- Under severe drought conditions, the tree may die back but generally recover after the onset of the rainy season.
- It cannot tolerate waterlogged situations.

Establishment

- Calliandra is propagated from seed in situ or raised in a nursery and transplanted.
- Usually, no seed pre-treatments are needed for germination.

Harvesting and uses

- The plants can be harvested after one year of planting.
- The plant may attain 3-5 m tall and 5cm diameter at stump height within a year.
- The cutting is made 20cm-50cm above the ground to promote quick re-sprouting.
- Calliandra produces substantial quantity of herbage.
- Annual fresh fodder yield of up to 46.2 T / ha has been reported.

5.Hedge lucerne

Scientific name: (Desmanthus virgatus)

- Hedge Lucerne is a summer growing, under-shrub or small shrub that grows up to 2 to 3 m high and roughly resembles subabul.
- It is an ideal plant for wasteland development.
- It can be grown throughout the year under irrigation and during June-October as a rainfed crop.

Varieties:

- Desmanthes virgatus CO1, Desmanthes virgatus CO2.

Land preparation:

- Plough the field two to three times with an iron plough to obtain good tilth.

Application of manures and fertilisers:

- FYM or compost at the rate of 25 t/ha may be applied before planting or at the time of land preparation and incorporate the manure into the soil during ploughing.
- NPK requirement of crop is 25:40:20 kg/ha.

Sowing:

- Seeds are usually sown in lines at a distance of 50 cm.
- Seed rate of 20 kg /ha is required.
- The seeds may be treated with concentrated sulphuric acid for 8 minutes to break dormancy.

Water Management:

- Irrigate immediately after sowing, light irrigation on the third day and thereafter once in a week

Weed Management:

- Hoeing and weeding are given as and when necessary.

Harvesting and Yield:

i. Pure Crop: First cut on 90th day after sowing at 50 cm height and subsequent cuts at intervals of 40 days at the same height.

ii. ii. Mixed Crop: First harvest on 60th day after sowing. Subsequent cuts at intervals of 45 days at 50 cm height of Hedge Lucerne which is maintained throughout.

- It gives a yield about 40 to 70 t/ha of green fodder a year.
- It has about 22 per cent crude protein in leaves and 10 to 15 per cent in stems.

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LESSON 20 Perennial grass fodders

1. Hybrid napier
2. Para grass
3. Guinea grass
4. Congosignal.
5. Setaria grass
6. Signal grass
7. Buffel grass
8. Napier grass

1.Hybrid napier

Scientific name:(p. pupureum /p. americanum)

- Hybrid napier-Cumbu Napier /Bajra Napier Hybrid (Pennisetum typhoides x Pennisetum purpureum).
- Hybrid Napier produces more tillers and numerous leaves.
- It grows faster and produces more herbage.
- Stems are hard and the plants less persistent.
- The grass grows throughout the year in the tropics.

Varieties

The popular hybrids are

- Pusa Giant Napier, Gajraj, NB-5, NB-6, NB-21, NB-35, Co-1, Co-2, Co-3, Co-4, Co-5, Co-6, Super Napier, Australian Red Napier, Suguna, Susthira and Supriya.

Land Preparation

- Hybrid Napier requires a deep, thorough weed free and compact seed bed.
- Three or four ploughings followed by disc harrowing is ideal.

Manures and Fertilisers

- Farm yard manure 25 t/ ha and P2O5 and K_2O @ 50 kg/ha each may be applied at the time of land preparation.

- Apply N @ 200 kg /ha in two or three split doses followed by gentle raking, if possible.
Planting
- Planting is done with the onset of southwest monsoon.
- Being a sterile hybrid, the grass is planted by rooted slips or by stem cuttings (setts).
- Cuttings of moderately mature stems (3 months old) and preferably from the lower two thirds of the stem length sprout better than the older stems.
- The cuttings with two-three nodes are stuck into the soil with the basal end down, either vertically or at an angle to such a depth that two nodes remain within the soil and one above the soil surface.
- The underground nodes develop roots and shoots while the upper ones develop shoots only.
- For planting one hectare, 28000 sets are required.
- A spacing of 60 cm x 60 cm is recommended for pure crop of Hybrid Napier.
- In intercropping system, spacing is adjusted to accommodate the companion crops.
- The planting rate depends upon the spacing and the weight of the cuttings or rooted slips used.
- It is modified in crop mixtures or intercropping with other forage crops.

Water Management

- The field should be provided with good drainage during the rainy season, as the crop cannot withstand water stagnation.
- Frequency of irrigation depends upon the rainfall and weather conditions.

Weed Management:

- Early inter-cultivation once or twice is necessary before the plants establish and grow vigorously.
- Subsequently, inter-cultivation should be given as and when necessary.

Harvesting and Yield

- The first cut is taken 9-10 weeks after planting.
- Subsequent cuts are taken after four to six weeks or when the plant attains a height of 1.5 m.
- Annually at least 6 to 8 cuts are possible.
- In order to encourage quicker regeneration from the basal buds, stubbles of 10-15 cm are left out at harvest.
- Average green fodder yield ranges 200-250 t /ha per year from 6-8 cuttings.
- The grass is ideal for green fodder, silage and hay.

2.Guinea grass

Scientific name: (Panicum maximum)

- Guinea grass is a popular fodder grass of the tropics.
- It can be profitably grown as an intercrop in coconut gardens as it is moderately shade tolerant.

- It is a perennial bunch grass, 0.5 to 4.5 m high.
- The root system is deep, dense and fibrous.

Climate and Soil:

- Guinea grass thrives well in warm moist climate.
- It cannot tolerate heavy clays or prolonged water logging.

Varieties

- The important varieties are Makueni, Riversdale, Hamil, PGG-4, FR-600, Co-GG3, Haritha, Marathakom and Harithasree.
- Makueni is a drought resistant cultivar suited to rainfed situations in the state.

Land Preparation

- The grass requires thorough cultivation to prepare a weed-free seedbed for establishment.
- Two or three ploughings and one levelling are sufficient.
- In the prepared field, trenches of 10 cm width and 20 cm depth are made.

Planting

- Under Kerala conditions, the best season of planting is with the onset of southwest monsoon during May-June.
- As an irrigated crop planting can be done at any time of the year.

Establishment

- Seeds and slips can be used as planting material.
- Since seed germination is poor vegetative propagation is preferred.
- To obtain slips for planting, old clumps are uprooted and slips with roots are separated.
- For planting one hectare, 1.25 lakhs of slips are required.
- If seeds are used (3 kg/ ha), it should be sown in nursery and the seedlings transplanted in the main field.
- Slips are planted on ridges @ three slips per hill.
- The spacing of 40 cm x 20 cm is followed when grown as an intercrop.
- For a pure crop, a wider spacing of 60 cm x 30 cm is required.

Manures and Fertilisers

- A basal dose of 10 tonnes of FYM, 50 kg P_2O_5 and 50 kg K_2O /ha (applied in trenches) is recommended.
- For top dressing, use 200 kg N /ha in two split doses, the first dose immediately after-first cutting and the second dose during the northeast monsoon period.
- If irrigation facilities are available, topdressing can be given in more splits.
- The fertilizer may be applied on either side of the plants, along the row and earthed up.

Water Management

- At planting two irrigations are required within seven to ten days for quick establishment.
- Usually irrigation once in 7-10 days is required.
- Irrigation with cowshed washing or sewage water within 3-4 days after cutting gives better growth.

Weed Management

- The delicate seedlings or newly emerged shoots from slips or cuttings require protection from weeds in the first two months.
- Two inter cultivations should be given during this period.
- Later, inter cultivation may be necessary after three or four cuttings.

Harvesting and Yield

- The crop is ready for harvest when it reaches 1.5 m height.
- Cutting at 15 to 20 cm above the ground level is advised.
- The first cut is usually ready in 9-10 weeks after planting
- Subsequent cuts are taken at 45 to 60 days intervals.
- About 6 to 7 harvests can be made in a year. •

- Approximately 80-100 t /ha of green fodder is obtained per year

3.Para grass

Scientific name:(Brachiaria mutica)

- This grass is also known as buffalo grass and water grass.
- It is a perennial with prostrate shoots freely rooting at nodes forming dense cover.
- It is grown in seasonally flooded valleys and lowlands
- It can withstand water logging
- Sensitive to cold and makes little or no growth during winter months in sub-tropical regions of India.

Land Preparation:

- Prepare the land thoroughly by three or four ploughings and remove weeds.

Establishment:

- Seed setting is very poor in this grass.
- It is propagated exclusively by stem cuttings.
- Stem cuttings or pieces of creeping shoots 15 to 30 cm long with about three joints are generally planted in a slanting position.
- The planting materials can be scattered in the field and covered by ploughing crosswise during monsoon season.
- There are no improved varieties of this grass (only local).

Planting:

- Planting can be done at any time other than winter months.
- The rain fed crop is planted with the first monsoon showers.
- Slips can be planted 50 to 60 cm apart both ways between plants and rows.
- The growing runners quickly root at the joints, tiller profusely and cover the field.
- The requirement of slips for planting ranges from 27000 to 40000 per ha.
- Seed rate 2.5-3.5 kg/ha.

Manures and Fertilisers:

- The crop is highly responsive to irrigation with cattle-shed washing or sewage water.
- Apply 40 tonnes of FYM or compost along with 30 kg P_2O5 and 30 kg K_2O per ha as basal dose.
- Topdressing N 40 kg ha^{-1} after each harvest is found to enhance the forage production.

Water Management:

- Two or three light irrigations are to be provided for the initial establishment
- Irrigation once in 10 to 15 days in summer is advantageous Weed Management: The land should be kept weed free for the first two months.

Harvesting and Yield:

- First harvest is done about three months after planting when the grass attains a height of about 60 to 75 cm.
- Subsequent cuts are taken at 30 to 40 days interval.
- Annual yield of about 70 t/ ha is obtained.

- CP ranges from 2.8 to 16.1 % and CF from 28 to 34 % Uses: As para grass herbage dries slowly when cut, it is not suitable for hay-making.
- However, it can be used for ensiling.
- Harvesting and Yield:
- First harvest is done about three months after planting when the grass attains a height of about 60 to 75 cm.
- Subsequent cuts are taken at 30 to 40 days interval.
- Annual yield of about 70 t/ ha is obtained.
- CP ranges from 2.8 to 16.1 % and CF from 28 to 34 %

Uses:

- As para grass herbage dries slowly when cut, it is not suitable for hay-making.
- However, it can be used for ensiling.

4.Congo signal grass

Scientific name:(Brachiaria ruziziensis)

- Congo signal can be grown as a sole crop in open areas
- As an intercrop in coconut gardens as it tolerates shade.
- It is a creeping perennial with dense foliage and therefore can be used for soil conservation purpose as strip crop.
- It grows to a height of about 50 to 100 cm and produces 30 to 40 tillers on an average.
- It prefers a warm moist tropical climate.

Land Preparation:

- The crop is generally planted in May-June and September-October with the onset of rains.
- Prepare the land by ploughing one or two times, removing weeds and levelling.

Establishment:

- Both seeds and slips can be used.
- A seed rate of 2-5 kg/ ha is recommended.
- For sowing, a fine seed bed is required and seeds are broadcasted at 1-2 cm depth.
- When slips are used, they are planted at a spacing of 40 cm x 20 cm.

Manures and Fertilisers:

- Basal application of 5 T/ ha of FYM along with 50 kg ha each of P_2O5 and K_20 is recommended.
- Nitrogen @ 100-150 kg/ ha may be applied in two or three splits.

Weed management:

- Intercultivation during early growth stages is advisable to check weed growth.

Harvesting and Yield:

- The first harvest can be done 50 days after planting and subsequently at 30-40 days interval.

- Rain fed crop yields about 35-45 t/ha of green fodder whereas the yield will be increased to about 50-100 t/ ha under irrigated conditions.
- Average CP 9.1% and CF 33% on DM basis.

5.Setaria grass

Scientific name:(Setaria sphacelata)

- Setaria anceps is also called as Golden Timothy.
- The grass comes up well in the medium rainfall areas in the tropics and subtropics.
- It is more, cold tolerant than most of other tropical and subtropical grasses.

Varieties:

- Important varieties are Nandi, Narok and Kazungula.

Land Preparation:

- It requires thorough land preparation; two or three ploughings/diggings followed by one levelling. • The land should be free from weeds.

Establishment:

- Propagation is through rooted slips as well as through seeds.
- Seedlings can be raised in nursery and transplanted during rainy season under rainfed conditions.
- If irrigation facilities are available, planting can be done at any time between February and November.

Planting:

- As a pure crop it is planted at 50 cm x 30 cm spacing.
- If seeds are used, seed rate varies from 3.5 to 4.0 kg ha^{-1}.
- In case of rooted slips, the number of slips required varies from 33500 to 67000 per ha.

Manures and Fertilisers: •

- Organic manure, either FYM or compost @ 10 t/ ha may be applied at the time of land preparation.
- N fertiliser may be applied at 40 kg/ ha as a basal dose and subsequently at the rate of 20 kg/ha after every harvest.

Water Management:

- The grass flourishes in moist, but not wet soils.
- Setaria plots should be well drained during rainy season.
- At establishment, the crop requires two successive light irrigations in 7-10 days interval.
- Subsequent irrigation should be given as and when necessary.

Weed Management:

- One or two weeding or inter-cultivation is given in the first 2 to 3 months.
- To control weeds and to encourage fresh sprouts, one or two inter-cultivation has to be carried out every year.

Yield:

- The crop is ready for harvest by 9-10 weeks.

Subsequent cuts can be taken after every 40 to 60 days depending on the crop growth.

- At harvest, a stubble height of about 8 to 10 cm is left for good regeneration.
- Generally, about 25-40 t/ ha of green fodder can be harvested per year under rain fed situation.
- Irrigated crop yields about 75-150 t /ha per year.

CP and CF content of the grass range from 4.8 to 18.4 % and 24 to 34 % respectively **Uses:**

- The grass can be used as soilage, silage and hay.

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LESSON 21 Ground Annual Leguminous Fodders.

1. Fodder cowpea

Scientific name: (Vigna unguiculata)

- Cowpea is the most important leguminous fodder crop suitable for both summer and rainy seasons, mainly due to its quick growing habit and high yielding ability.
- Cowpea is grown as a seasonal crop, which is bushy, trailing or climbing.

Varieties:

- A number of varieties like Aiswarya, CO (FC) 8, CO 9 and TNFC 0926, Karnataka local, RS-9, UPC-1956, UPC-5287 and UPC-9805 are recommended for cultivation for fodder purpose.
- **Climate and Soil:**
- Cowpea is best suited for moderately humid areas of the tropics and subtropics.
- The plant cannot withstand frost, excessive and prolonged waterlogging.

Establishment:

- Cowpea for fodder purpose can be grown in any month if irrigation facilities exist.
- In Kerala, it is raised as a rainfed crop during May and also as summer crop in rice fallows.

Land Preparation:

- Two to three ploughings are required to produce a coarse seedbed for the crop.
- Shallow furrows at 3 m apart for leading irrigation water may also be provided.

Sowing:

- It can be broadcasted or drilled in lines.
- For seed crop, line sowing is preferred.
- Seed rate recommended is 40 to 50 kg/ ha for a broadcast crop and 15 to 40 kg/ ha for drill sown crop. For drilling, spacing of 30 to 40 cm between rows and 6 to 15 cm between plants is recommended.

Manures and fertilisers:

- For rainfed crop, at the time of land preparation, FYM @ 10 t/ ha is applied
- Basal application of N, P_2O, and K_2O @ 25, 60 and 30 kg ha is recommended.
- For irrigated crop in addition to the basal dose of 40: 30: 30 kg N: P_2O5: K_2O /ha, topdressing of N and K_2O each at 10 kg/ ha after each cut is to be given.

Water management:

- A pre-sowing irrigation is important for the proper germination of the crop.

- If there is lack of soil moisture, shallow irrigation at 3-4 cm depth once in 15 days during summer and once in a month during post-monsoon period is good.

Weed management:

- One or two weeding may be required in the early growth stages to combat weed problems.
- Usually high seed rates are effective in smothering weeds.

Harvest and Yield:

- As a fodder crop, the first cutting can be given 45 days after planting and subsequent two cuttings at 30 days intervals.
- A single cut crop yields 25 to 30 t/ ha whereas green matter yield of 40 t /ha is obtained from multi-cut cowpea.

Uses:

- Cowpea is used as fodder crop for green feeding, hay-making, grazing and also for ensiling in mixtures with sorghum or maize.
- It has about 16 per cent crude protein and 20 per cent crude fibre.

2. STYLO-Stylosanthes spp.

- Stylosanthes is a genus of summer growing perennial pasture / fodder legumes.
- The crop controls soil erosion by giving a protective soil cover.
- It also helps to smother weed growth. Climate and Soil:
- The crop is suited for growing in warm, humid tropical climate.
- It is fairly drought resistant and shade tolerant. Brazilian lucerne

Stylosanthes

Scientific name: **Brazilian lucerne (Stylosanthes guianensis)**

- This is used as a pasture legume.
- The main variety commercially grown is Schofield.
- Other varieties are Cook, Endeavour and Graham.
- Townsville stylo (Stylosanthes humilis):
- This annual type stylo is also found suitable for growing in Kerala. Major varieties are Patterson, Lawson and Gordon.

Stylosanthes

- Caribbean stylo (Stylosanthes hamata)
- This is a short-lived perennial legume similar to Townsville stylo.
- Verano is the most important variety, which combines many of the virtues of both annuals and perennials. Shrubby Stylo (Stylosanthes scabra):
- This is a perennial shrub.
- Its deep root system enables the plant to remain green even in very dry season.

- The recommended varieties of shrubby stylo are Seca and Fitzroy.

Establishment:

- Seeds of stylo are very small.
- The seed rate is 2 to 3.5 kg /ha when grown as an intercrop in coconut gardens.
- For grass legume mixtures, 1.5 kg/ ha is sufficient.
- Seeds are soaked in water overnight before sowing.

Land Preparation:

- Plough the field 2-3 times to prepare a fine seedbed.

Sowing

- Seeds are mixed with sand when sown as a pure crop or mixed with grass seeds for mixtures.
- Seeds are sown broadcast and covered with thin layer of soil or dibbled at a spacing of 30 cm between rows.
- The depth of sowing **should be 5-10 mm.**
- Seeds germinate within a week.
- **Manures and fertilisers**
- Recommended dose of N, P_2O5 and K_2O for both annual and perennial stylosanthes are 20, 80 and 30 kg per ha respectively.
- For perennial crops, phosphorus @ 80 kg/ ha and potash @ 30 kg/ ha may be applied in subsequent years.

Application of lime @ 375 kg/ ha is also recommended in acid soils.

Weeding

- First weeding is given 45 days after sowing.
- A second weeding and hoeing may also be done after the first harvest.
- Gentle raking of the interspace after the application of fertilizers in the subsequent years may be done.

Harvest and Uses

- First harvest is taken 3-4 months after sowing and subsequent harvest at 45 days intervals or according to the growth of the crop.
- A maximum of 4-5 harvests can be taken in a year for a perennial crop, which will remain in the field for 3 years.
- The crop yields 25-30 t /ha green fodder per years.

Ground legumes perennials Fodders.

1.Alfalfa or Lucerne
Scientific name: (Medicago sativa)

- **Lucerne, also termed as 'queen of forages' is a** deep-rooted perennial herb reaching a height of 60-90 cm.
- It is adapted to a wide range of conditions ranging from tropical to alpine.
- It is very palatable and nutritious forage legume containing 16-25% crude protein on dry matter basis.
- It is grown for green fodder, hay and silage but does not tolerate close grazing.
- In the tropics, it comes up in the cooler high-altitude areas.

Season and Varieties

- It is one of the most important forage crops of India grown extensively in the Rabi season.
- Not suitable for very hot and very cold climates.
- Lucerne CO2, Lucerne CO3, Lucerne CO4, Anand-1, Anand-2, Atir, Sirsa-8, Sirsa-9, IGFRI-S-244 (Chetak) and Lucerne CO 1 are some of the varieties recommended for Indian conditions.

Establishment:

- Seeds are used for propagation.
- In South India, this crop is sown from October to December.

Land Preparation:

- Plough twice with an iron plough and three or four times with country plough to obtain good tilth.

Manures and Fertilisers:

- Apply and spread FYM or compost @ 25 - 30 t/ha in the first year and @ 10 t/ha in the later years.
- Each year, NPK fertilisers may be applied at 20:90:40 kg/ha.

Sowing:

- Seeds have hard seed coats, hence soaked for 6-8 hours, and then rubbed or scarified.
- The seed is normally drilled with seed drills or broadcast after seedbed preparation.
- For broadcasting, 25-30 kg/ ha of seeds is required • For drilling, the required seed rate is 15 kg/ha.

Water Management:

- The crop responds well to irrigation.
  - A pre-sowing irrigation is necessary for germination.
  - Initially, irrigation may be given once in 7-10 days, and later, the interval can be increased to 20-25 days.
  - This crop requires 15-18 irrigation in a year.

Weed Management:

- Weeding is given as and when necessary as alfalfa is a poor competitor with weeds.
- Cuscuta is the major weed found in alfalfa fields.

Harvesting and Yield:

- Harvesting is done before full bloom.
- First harvest 50-60 days after sowing.
- Subsequent harvests are made at intervals of 30-40 days.
- 7-8 cuttings are possible in a year.

Lesson 22 Irrigation for forage crops

- Water is essential for all plants to sustain life.
- Forage crops respond well to irrigation and a shortage of water affects their normal growth and productivity.
- Successful forage crop production attempts to maintain optimum vegetative growth.
- As the prime objective of growing forage crops is herbage and not grain or seed production, the timing of irrigation with respect to critical stages does not have much relevance.
- However, water stress may have marked effect on the vegetative growth and consequently herbage yield.
- Deficiency of water negatively affects leaf production and leaf: stem ratio, besides increasing the fibre content in plant parts.
- Forage crops usually have longer seasoned of active vegetative growth, and therefore need frequent irrigation.
- Optimum growth of forage crops can be ensured only with a continuous supply of water, which maintains the soil moisture near field capacity.
- As a thumb rule, irrigate the fields to keep the available soil moisture level above 50 per cent at all the time.
- Annual fodder crops such as Fodder maize, Bajra, Sorghum or Dheenanath grass can be grown without irrigation relying only on rainfall adjusting sowing time.
- However, this is not the case with perennial crops such as hybrid Napier or Guinea grass.
- The rainfall takes care of water requirement for about six months.
- Irrigation becomes necessary for the remaining six months for a continuous supply of green herbage for the livestock.
- Otherwise, growth will be affected and the crop may even dry up in summer.

Methods of irrigation for forage crops

- Several methods are throughout the world according to the nature of crop, soil type and other characteristics.
- All the methods are; however, not suitable for the forage crops in general.
- The most suitable methods of irrigation for fodder crops are
    1. check basin
    2. furrow
    3. border and
    4. sprinkler irrigation

1. Check Basin Irrigation

- Check basin irrigation is a common surface irrigation method for close growing crops.
- The field is divided into small plots called basins.
- A basin is a flat area of land surrounded by low bunds, and the bunds prevent the water from flowing to the adjacent basins or fields.
- Check basins are commonly made for irrigating rice, as it is easy to impound water for longer periods in the basins.
- In general, the basin method is suitable for crops that are unaffected by standing in water for long periods, usually ranging from 12-24 hours. There are several fodder crops, which are amenable to this type of irrigation.

2. Furrow Irrigation

- Furrow irrigation is ideal for crops planted in rows with ridges and furrows.
- Furrows are small channels or narrow ditches dug on the field between the rows of crops.

- The furrows carry water down the land slope between the crop rows. The water flows from the field channel into the furrows by opening up the bank or dyke of the channel, or by means of siphons or spiles.
- Siphons are rubber hoses or small curved pipes that deliver water over the channel bank; whereas, spiles are small pipes buried in the channel or ditch bank for the same purpose).
- Water, as it moves along the slope, infiltrates into the soil and spread laterally. Furrow irrigation is suitable for all row crops, and is particularly suited to crops that cannot stand in water for long periods.
- usually 12-24 hours. Fodder crops, that are grown in rows such as fodder maize, and guineas grass can be irrigated by furrow irrigation.

3. Border Irrigation

- Borders or border strips are long sloping strips of land separated by bunds.
- Irrigation water is diverted to the borders in several ways. It may be through opening up the bank of channel or ditch, or by using small outlets or gates.
- Water can also be fed to the borders by means of siphons or spiles as in the case of furrows.
- In the border strips, water flows as a sheet down the slope.
- The bunds on either side guide the water flow.
- In general, border irrigation is best suited to large mechanized farms, as it is designed to produce long uninterrupted field lengths.
- Often, borders can be up to 800 m or more in length and 3-30 m wide for the ease of machine operations.
- However, in smallholder farms, where manual labour or animal power is frequently used for cultivation, its suitability is rather less.
- Border irrigation is a recommended method for forage crops, and close growing forage crops are preferred for this type of irrigation.

4. Sprinkler Irrigation

- Sprinkler irrigation is a method of applying irrigation water as a spray similar to natural rainfall.
- Water is pumped through a system of pipes.
- It is then sprayed into the air through rotating sprinkler heads so that it breaks up into small water drops, which fall to the foliage and ground.
- The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. Sprinkler irrigation is highly suited for most pasture crops.

REFERENCES

1.FODDER CROP PRODUCTION IN THE TROPICS
C. George Thomas
2.PRINCIPLE OF AGRONOMY
3.FODDER PRODUCTION AND GASSLAND MANAGEMENT.
D.V. Reddy
4. http://ecoursesonline.iasri.res.in/course/view.php?id=704
5.https://lotusarise.com/properties-of-soil-upsc/
6.http://ecoursesonline.iasri.res.in/mod/page/view.php?id=101087
7.http://www.agritech.tnau.ac.in/agriculture/agri_tillage_types