MODULE-1: IMPORTANCE OF FODDERS AND GRASSLANDS IN LIVESTOCK PRODUCTION

LEARNING OBJECTIVES

- At the end of this module, the following details would be known
  - Livestock population, the demand and supply position of fodders in the country.
  - Grazing resources available.
  - Estimates of demand for the next decade.
  - Available sources for livestock feed.
  - Ways and means to increase the fodder production.

PRESENT SCENARIO OF LIVESTOCK SECTOR IN THE COUNTRY

- India is basically an agricultural country and about 70% of its people live in villages. Their livelihood is dependent mainly on agriculture and animal husbandry. India has a huge livestock population of over 481 millions (besides poultry and piggery). India ranks first in Buffalo population (54 % of world buffalo population), and also first in Cattle population (16 % of world). With regard to sheep (58.2 million) and Goat (123.5 million) population also, India ranks first. Yet, the productivity of livestock products is not comparable with the developed world.
- Our country achieved a record output of milk production (112 million tones, 2009-10) and ranks first in the world. (Per capita availability of milk consumption in India is 250 g/day). In terms of egg production (45 billions, 2006), India ranks third in the world. The total meat production stands at 4.92 (2006) million tonnes. Inspite of this enormous production, the productivity of milk, meat and egg happens to be low when compared to some of the developed nations. Though we have about one fourth of the total livestock population of the world, one of the reasons for low productivity of our livestock is malnutrition, under - nutrition or both, besides the low genetic potential of the animals.

REQUIREMENT Vs AVAILABILITY

- It is understood that there is a huge gap between demand and supply of all kinds of feeds and fodders. If we examine the land resources available in the country for growing fodder and forage crops, it is estimated that the average cultivated area devoted to fodder production is only 2.5 % of the total area and the pasture and grazing land comprises only 3.6% of the total area.
- These resources are able to meet partly the forage requirements of the grazing animals only during the monsoon season. But for the remaining period of the year, the animals have straws of jowar (sorghum), bajra (cumbu), rice, ragi, wheat, barley etc., either in the form of a whole straw supplemented with some green fodder or a sole feed.
- Apart from this, the natural grasslands and the cultivable waste and fallow lands provide some grazing during the favourable growth periods in the monsoon season.
- With regard to the demand and supply of green fodder, dry fodder and concentrates in the Country, there exist varying reports. This is beacuase of the complex nature of the feed resources which are mutually interdependent and highly dynamic and unorganized. Also there is no specific methodology available to predict the demand and supply. National Institute of Animal Nutrition and Physiology (NIANP), Bangalore

reports that the deficit is 38%, 45% and 44 % with regard to Green fodder, Dry fodder and Concentrates respectively.

BALANCE SHEET OF ANIMAL FEEDS AND FODDERS (IN MILLION TONNES) IN INDIA

	Available	Requirement	Deficit	Deficit (%)
Green Fodder 	387.3	1006	618.7	**61.5**
Dry Fodder 	437.9	560	122.1	**21.8**
Concentrates 	42.0	79.4	37.4	**47.1**

- ***Source:*** *Hand Book of Agriculture (2006), ICAR, New Delhi*

SUPPLY AND DEMAND OF GREEN AND DRY FODDER (ESTIMATES IN MILLION TONNES)*

	Supply		Demand		Deficit as % of Demand	
Year	**Green**	**Dry**	**Green**	**Dry**	**Green**	**Dry**
1995	379	421	947	526	60	20
2000	384	429	988	549	61	22
2005	390	444	1025	569	62	22
2010	395	451	1061	590	63	23
2015	401	466	1098	610	64	24
2020	406	474	1134	630	64	25
2025	411	488	1171	650	65	25

- ***Source:*** *NIANP Monograph (2007), Bangalore*
- The projected balance between demand and supply of fodder presents a challenge in coming years. While the deficits are anticipated to increase as a proportion of the requirements, the situation appears all the more

grim in case of green fodder. Focused strategies and concerted efforts are the need of the hour to face up to this challenge.

PRESENT SOURCES OF FEED

Sources of ruminant feed for Indian livestock

Feed resources for cattle

- In the case of crop residues, collection, processing, value addition, and storage are necessary inputs.
- In grazing lands, silvipastoral technology using adapted forages and trees have shown their potential for productivity enhancement. Newer avenues of varieties and management options will be required for degraded and polluted habitats.

GRAZING RESOURCES

Grazing resources (in million hectares) available for production of Fodder/pasture in Tamil Nadu and India (2006)

	INDIA	TAMILNADU
Total geographical area	328.7	13.00
Forest	67.4	2.14
Cultivable waste land	16.9	0.34
Pasture and grazing land	12.1	0.12
Fodder crops	8.3	0.17
Tree crops and grooves	3.5	0.23

- From the above table it is evident that only 2.5 % of the country's cropped area is under fodder crops. The fodder production from the meagre 8.3 m.ha. area apart from 12.1 m.ha of pasture land do not meet the requirements to feed the Indian livestock population of 482 millions.
- The situation is no different in Tamil Nadu where the number of livestock stands at 25 millions which depend on fodder from 0.17 m.ha and pasture from 0.12 m.ha.

- Such an inadequate production of fodders lead to the cause of malnutrition of the Indian livestock. To overcome the constraints, all the possible ways should be exploited to increase production of nutritive fodders.

CONSTRAINTS AND WAYS AND MEANS TO INCREASE FORAGE PRODUCTION

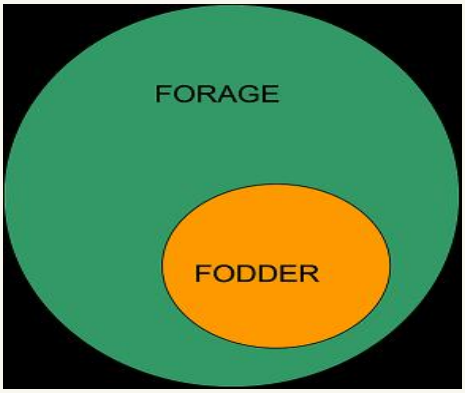
Constraints

- Less than 2.5 % of area under fodder production • Small holdings do not allow farmers for allocating area for fodder production due to preference to food crops
- More dependence on crop residues which are not that much nutritive • More dependence on grazing (on others / common) resources, which are having unpalatable species
- Less awareness among farmers with regard to the advantages of green fodder.
- Less production of protein rich legume fodders
- Huge livestock population and hence higher Green fodder demand
- Non – availability of feed/fodder data
- Poor feeding practices

Ways and means to increase fodder production

- Maximising forage production in space and time.
- Identifying new forage resources and increasing fodder seed production.
- Increasing the forage production within the existing farming systems.
- Adoption of agroforestry systems to utilise different tree fodders for livestock rearing.
- Utilising marginal, sub-marginal drylands and problem soils for developing feed and fodder resources.
- Exploiting the feasibilities of growing fodder along with food and cash crops.
- Utilising barren and uncultivated lands.
- Establishment of fodder banks in villages
- Conservation of fodder into feed blocks.
- Enrichment of straw/stover with urea/fortification.
- Use of chaff cutters.
- Comprehensive watershed development programs with inclusion of fodder component.

MODULE-2: FODDER AND ITS CLASSIFICATION



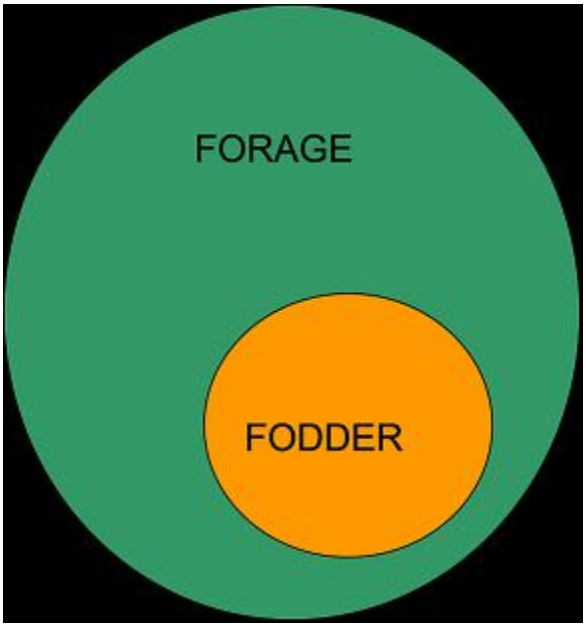
LEARNING OBJECTIVES

- One can know the following on completion of this module,
  - What are forages and fodders and how are they classified?
  - What are legumes and non-leguminous fodders?
  - What are the various plant parts used for livestock feeding?
  - What are the ideal characteristics of a fodder crop?
  - What is the growth sequence of a

	fodder crop?

DEFINITION OF 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 may be 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 FORAGES

- Forages are classified on different ways. They are
  - On the basis of season of cultivation
  - On the basis of nutrient density in the dry matter
  - On the basis of plant types
  - On the basis of crop duration
  - On the basis of plant family and duration of the crop

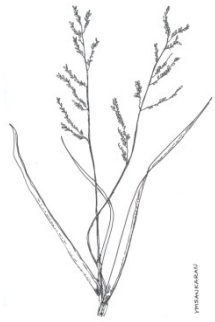
ON THE BASIS OF SEASON OF CULTIVATION

-

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

bean, Bajra, Sorghum, Maize 	Barley 	Maize 

ON THE BASIS OF NUTRIENT DENSITY IN THE DRY MATTER

Non - maintenance	Maintenance	Production	
Eg. Wheat straw, Rice straw, Ragi straw, Maize and Sorghum stover, Jungle hay, cereal forages harvested at advanced maturity 	Eg. 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.	Grasses, Shrubs and tree leaves etc.	Grass and Tree leaves	Fruits and fruit tree wastes	**Fresh** Water hyacinth lotus etc	**Marine** Algae



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

ANNUAL AND PERENNIAL NON-LEGUMES

Sl. No.	Common name	Tamil name	Scientific name
A. Annual (Summer)			
1.	Sorghum	Cholam	*Sorghum bicolor*
2.	Sudan grass		*Sorghum sundanense*
3.	Maize	Makkacholam	*Zea mays*
4.	Cumbu / Bajra /Pearl millet	Cumbu	*Pennisetum glacum*
5.	Teosinte		*Euchlaena mexicana*
6.	Finger millet/ Ragi	Kelvaragu	*Eleusine corocana*
7.	Little millet or samai	Samai	*Panicum miliare*
8.	Proso millet		*Panicum miliaceum*
B. Annual (winter)			

9.	Oats		*Avena sativa*
10.	Barley		*Hordeum vulgare*
11.	Rye		*Sicale cereale*
C. Perennial			
12.	Hybrid Napier	Cumbu napier ottupull	*Pennisetum purpureum x Pennisetum americanum*
13.	Guinea grass	Guineapull	*Panicum maximum*
14.	Para grass	Neerpull	*Brachiaria mutica*
15.	Doop grass / Bermuda grass	Arugampull	*Cynodon dactylon*
16.	Anjan grass (Buffel grass)	Kollukkattai pull	*Cenchrus ciliaris*
17.	Black anjan / Bird wood grass	Karuppu Kolukkatti pull	*Cenchrus setigerus*
18.	Rhodes grass	Mayil Kondaipull	*Chloris gayana*
19.	Signal grass		*Brachiaria decumbens*
20.	Elephant grass / Napier grass	Yanaipullu	*Pennisetum purpureum*
21.	Marvel grass		*Dichanthium annulataum*
22.	Canary grass		*Phalaris tuberosa L*
23.	Blue Panic grass		*Panicum antidotale*
24.	Molasses grass		*Melinis minutifolia*
25.	Kikuyu grass		*Pennisetum clandestinum*
26.	Deenanath grass		*Pennisetum pedicellatum*
27.	Johnson grass		*Sorghum halepense*
28.	Seteria		*Seteria anceps*
29.	Sabi grass / Little para grass		*Urochloa mosambicensis*

PERENNIAL LEGUMES, TREE FODDERS

S.No	Common name	Tamil Name	Scientific name
A. Annual legumes			
30.	Cowpea	Karamani	*Vigna unguiculata*
31.	Rice bean		*Vigna umbellata*
32.	Moth bean	Naripayaru	*Phaseolus aconitifolius*

33.	Gaur or cluster bean or french bean	Kothavarai	*Cyamopsis tetragonaloba*
34.	Field bean/Lab lab		*Lablab purpureus*
35.	Sunnhemp	Sannappai	*Crotolaria juncea*
36.	Pillipesara		*Dolichos trilobus*
37.	Berseem or Egyptian clover (Winter)		*Trifolium alexandrinum*
38.	Fenugreek (Winter)	Vendiyam	*Trigonella foenumgraecum*
39.	Senji (Winter)		*Melilotus parviflora*
B. Perennial legumes			
40.	Lucerne/Alfalfa	Kudiraimasal	*Medicago sativa*
41.	Hedge lucerne	Velimasal	*Desmanthus virgatus*
42.	Stylosanthes		*Stylosanthes hamata* *Stylosanthes scabra*
43.	Schofield stylo		*Stylosanthes guinensis*
44.	Siratro		*Macroptilium atropurpureum*
45.	Clitoria / Butterfly pea	Sangupushpam	*Clitoria ternatea*
46	Perennial ground nut		*Arachis glabrata*
47.	Centro		*Centrosema sp.*
48.	Desmodium		*Desmodium uncinatum*
III. Tree Fodders			
49.	Soobabul	Soundal	*Leucaena leucocephala*
50.	Catechu	Karungali	*Acacia catechu*
51.	Gum arabic or Babool	Karuvelam	*Acacia nilotica*
52 **.**	Israeli babool		*Acacia tortilis*
53.	Umbrella tree	Kudaivel	*Acacia planifrons*
54.	Siris	Vagai	*Albizia lebbek*
55.	Sisoo	Yette	*Dalbergia sissoo*
56.		Karun umbi	*Diospyros melanoxylon*
57.	Sesbania	Agathi	*Sesbania grandiflora*
58.	Banyan tree	Alamram	*Ficus bengalensis*
59.		Malai icchi	*Ficus lacor*

60.	Peepal tree	Arasa	*Ficus religiosa*
61.	Anjan	Achamaram	*Hardwickia binata*
62.		Uthimaram	*Lannea coromandelica*
63.	Mohwa	Illupai	*Madhuca longifolia*
63.	Neem	Vembu	*Azadirachta indica*

PLANT SOURCES OF ANIMAL FEED

The various categories of plant parts/ residues / by products used for feeding animals are given below:

- Straw: Means the dried reminant of a crop from which the seed has been threshed. The term is most commonly used to wheat, oats, barely, rice etc.

- Leguminous pulse straws: Leguminous crops having fibrous residues are black gram, green gram, cowpea, groundnut etc. These residues are composed of husk of the pods with leaves and tender stems which are more nutritious than the cereal straw and stovers. They are very good feed for sheep and goats. Leguminous crop residues are highly nutritious and palatable.
- Husks (Hulls): Husks are available in bulk in the milling industry like rice milling, solvent extraction plants for groundnut oil and corn oil, groundnut husks, maize husks etc. They are of low density and are unpalatable. Some times they create a disposal problem because of being available in large quantities at the milling site.
- Hay: It consists of the entire herbage of comparatively fine stemmed grasses or other forage plants. Hay is any forage crop cut before it is ripe and dried for storage. More nutritious and palatable than straw, because the entire crop is cut before maturity and dried.
- Silage: It is the product formed when any green plant material is put where it can ferment in the absence of air. In this process of fermentation the silage develops acids. These acids preserve nutrient substances in the plant material.
- Stovers: Stovers are the byproducts after harvesting the grains (maize, jowar, millets etc). They are given to the livestock with various supplements. Stovers are much better roughages than cereal straws.
- Haulms: Plant material above the ground level harvested, dried and used for feeding livestock eg. Groundnut plants.
- Bhusa: The refuse collected from threshing pulse crop like red gram, bengal gram etc. is commonly known as Bhusa. It consists of leaves, immature pods and seeds and other empty shells of pods

and is available as an inexpensive byproduct which is quite useful for feeding cattle. It is also fairly nutritious.

- Grasses: All grasses belonging to the family of plants, gramineae comprising 450 genera and more than 6000 species distributed throughout the world. Grasses include all the cultivated cereal feed crops. Grasses considerably vary in their habbits, size and habitat. Some grasses are annuals, while others are perennials. When plants dries up after flowering and seeding in the course of a single season, it is termed as annual, but when new shoots and older ones ending in inflorescence and found mixed in the same plant, it is termed perennial.

CHARACTERISTICS OF FODDER CROPS

- Quick regrowth and short duration.
- Profuse foliage and heavy yield of fodders.
- Should have high palatability and nutritive value.
- Should be adaptable to various agro-climatic conditions and different soils.
- Capacity to ratoon and give continous supply of green fodder.
- Resistance to diseases and pests and safe to feed at all stages of its growth without any deleterious effect on animal health and growth.

MODULE-3: GRASSLANDS, TYPES OF GRASSLANDS AND MANAGEMENT TECHNIQUES

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following
  - Definition of grass land
  - Status of grazing resources in India
  - Various types of grassland covers identified in the Country
  - Overgrazing and its impact on grasslands
  - Grassland improvement methods
  - Objective of scientific grassland management
  - Types of grazing methods
  - Temporary and Artificial pasture

GRASSLANDS, TYPES OF GRASSLANDS AND MANAGEMENT TECHNIQUES - INTRODUCTION

- A grassland is defined as a natural land surface which is covered mainly by members of the grass family of plants and are used for grazing livestock.
- It is estimated that about 90% of the livestock population in India subsists on natural grasses that are available inside and outside forests. Out of the total area of 328 million hectares of the Indian union, 12.1 million hectares are classified as grazing lands i.e. as permanent pastures and meadows.
- In addition to this, 43 million hectares of cultivable and non-cultivable lands also serve as grazing grounds for Indian Livestock.
- Grasslands are thus very important as feeding grounds for the livestock of the country and deserve to be developed along proper lines. Improperly managed grasslands not only fail in primary function of feeding livestock but also aggravate soil erosion and deplete the national soil wealth.

STATUS OF GRAZING RESOURCES AND WASTE LANDS IN INDIA

- The extent of waste lands in India is approximately 158 million hectares. The extremes of climate, soil conditions, biotic factors and inconsistent rain fall are characteristic of these sites. Overgrazing of such wastelands induces secondary succession and ultimately to desertfication. It then becomes very expensive to put back the waste lands into pasture lands.
- Categories of land under different types of wastelands in India (1986).

Category	Area in million hectares
Water eroded	73.60
Degraded forest	40.00
Riverine	2.73
Ravines and gullies	3.97
Shifting cultivation	4.36
Sand dunes	7.00
Water logged	6.00
Saline/alkaline waste lands	7.50
Wind eroded	12.90
Total	158.06

ECOLOGICAL STATUS OF GRASSLANDS

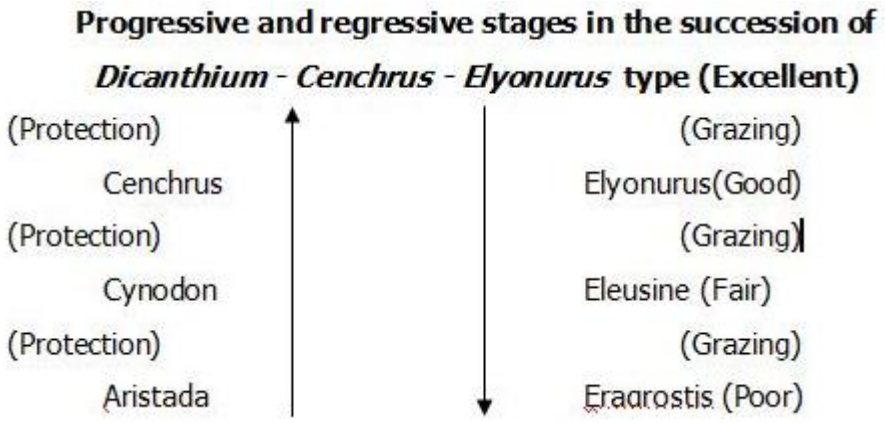
- In one end we find climax evergreen forests and on the other end deserts. Green land occupies an intermediary position. Scientific management of grasslands is based upon ecological principles. Ecology is defined as the science which deals with the inter relationship of plants with their environment.
- Plant ecology seeks to find out the loss governing the development of vegetation in different habitats and environments. This knowledge can be utilized to make natural resources serve the requirement of livestock nutrition in an efficient way.
- In the development of the natural vegetation, there is a relationship between the soil and vegetation that grows upon it. Soil is the end product of the action of both the climate and the vegetation upon the parent rock material and all soils develop ultimately into a climax soil type which is in equilibrium with the climate and other environmental factors.
- At each stage of soil formation and development, there is a corresponding stage of vegetational development. This development if left undisturbed, end in either a forest climax or grassland climax depending on the climatic conditions.
- The final type of vegetation is termed as a 'climax' in ecological nomenclature. Grassland can thus be a climatic climax or sub climax and may also rise as a result of disturbances in the forest climax.

TYPES OF GRASSLAND COVERS

- For a proper management of grasslands it is necessary to know something about the ecology of Indian grasslands, its area of occurrence, production potential and management methods. Five main types of grassland covers were identified in India.
    - Dicanthium - Cenchrus - Elyonurus type (Area : 434000 sq. km.)
    - Sehima-Dicanthium cover (Area: 17,400 sq.km.)
    - Phragmites - Saccharum cover (Area : 28,00,000 sq.km.)
    - Themada - Arundinella cover (Area : 2,30,400 sq.km.)
    - Temperate and Alpine cover

DICANTHIUM - CENCHRUS - ELYONURUS

- This type is found to occur in the north west arid and semi arid regions between 23°N and 60-80°E comprising the plains of Punjab, Rajasthan, U.P. and north Gujarat, on soils that are alluvial or sandy loam in texture.
- The main species found in this region are perennials like Dicanthium annulatum, Cenchrus ciliaris, C. setigerus, Cynodon dactylon and Elyonurus hirsutus, all of which are valuable forage grasses. However, even well developed grass lands deteriorate if grazed for too long and too heavily.



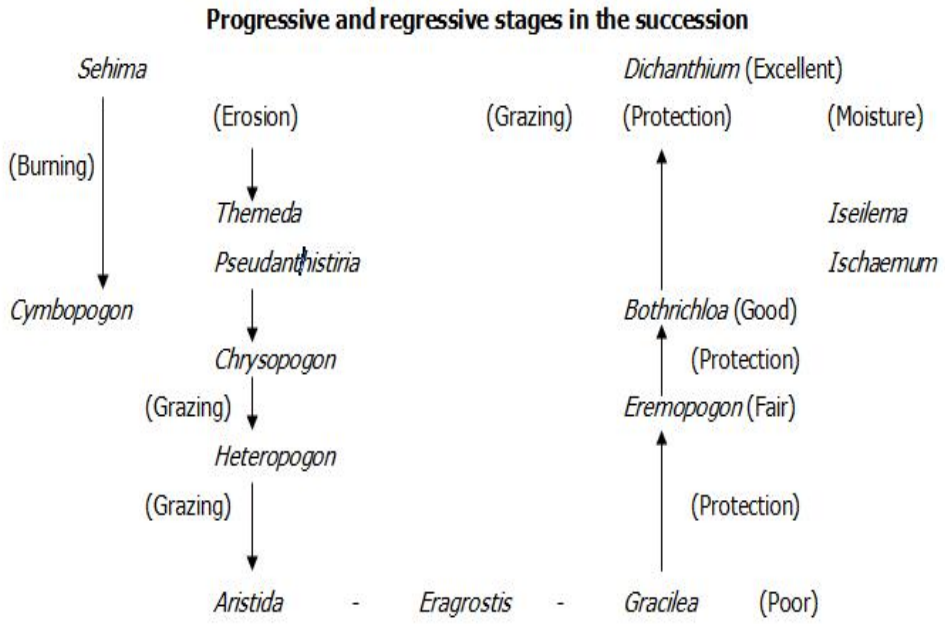
Management

- In the management of grass land of this type the objective should be to maintain a proper balance of *Dicanthium* and *Cenchrus* sp. in tracts occurring less than 20 inches and more than 10 inches of rainfall.
- Below 10 inches, the objective should be to have a stand of *Elyonurus hirsutus*. *Cynodon* sp. represents the last stage of resistance of the perennial cover and hence when this stage is reached, the grazing should be stopped, to enable the grassland to recoup itself.
- At the *Aristida* - *Eragrostis* stage, the grassland will be too poor to support any grazing and a complete closure for four to five years becomes imperative to allow the succession to attain the fair condition represented by *Cynodon dactylon* and *Eleusine flagellifera.*

SEHIMA - DICANTHIUM

- This cover occurs all over tropical India below the tropic of cancer, comprising the Deccan plateau and extending from south Rajasthan, south Uttar Pradesh, Madhya Pradesh to Bihar and parts of West Bengal. The traits characterized by undulating hills with valleys interversing.

- All types of red and black soils are associated in this cover. The species of perennial grasses that are distinctive to this region are Sehima nervosum Chrysopogon montonus, Themada trandra, Heteropogon contortus. Annuals are Themanda quadrivalvies, Apluda aristata, Dicetmis spp. On grasslands that have got badly over grazed and deteriorated, annual species alone occur such as Aristida spp., Chloris spp., Andropogon spp. and the annual form of Heteropogan contortus.
- The best among these for forage are Sehima, Dicanthium, Chrysopogon, Iseliema and Ischaemum. In sandy soils, Sehema usually dominates where as in deep moist soils Dicanthium dominates.

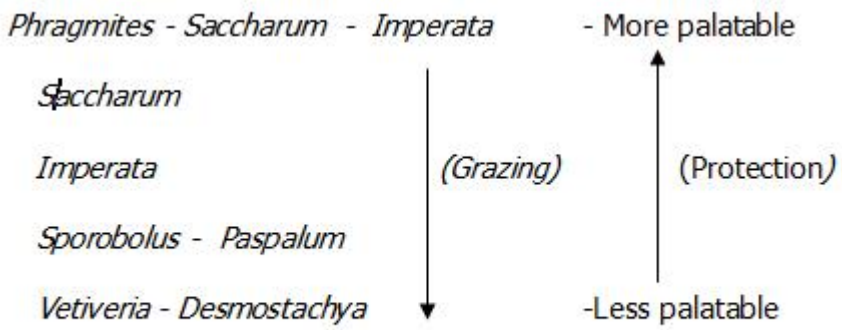


Management:

- Sehima nervosum and Dicanthium annulatum are the typical species, on gravelly and well developed soils respectively.
- Since Sehima nervosum occurs in hilly situations, adequate soil conservation measures are necessary in any plan of management for this grass. Contour furrowing along with adequate manuring would be necessary.
- Sehima grassland quickly degenerates into inferior Cymbopogon cover as a result of burning and hence this practice should be discouraged. Post-monsoon period is the safest for grazing.

PHRAGMITES - SACCHARUM

- This type of cover occurs on the eastern humid portion of the low land planes of the Ganges and Brahmaputra river basins (Manipur, Assam, Tripura,West Bengal, Bihar, Uttar Pradesh, Delhi and Punjab), especially on low lying ill drained land or in situations where the water table in high.
- The type is characterized by tall, coarse, species of reedy grasses typified by Phragmites karka, Saccharum spp. Imperata spp. Desmostachya spp.
- These grasses are useful for thatching purposes and the grass lands are generally subjected to annual growth of Imperata cylindrica.



Management :

- The management of these grasslands for grazing purpose would require drastic alterations in the soil conditions to eliminate the coarse, water loving unpalatable grasses.

THEMADA - ARUNDIELLA

- This type of grassland is found in the northern belt from 450 to 2500 meters elevation and includes species such as Themada anathera, Arundinella spp., Eulaliopsis binata, Chrysopogon sp., Heteropogon contortus and Pennisetum orientale. Legumes are represented by Desmodium and Crotalaria ; degraded stages are recognized in the cover by Dimeria, Chrysopogon, Heteropogon and Eragrostis.

Management :

- Themada anathera is the key species of the cover in this hilly region. Measures designed for soil conservation are essential for the proper management of this type of cover and the present practice of mowing the grass for hay appears to be the best practice under their circumstances.
- Light grazing during the monsoon months and moderate grazing later on, followed by cutting the grass for hay once in 3-4 years would be a good balance between the demands of livestock and the requirements of the grassland.

TEMPERATE AND ALPINE COVER

- This type of cover is met with mostly on the hills of the Himalayan region in the north and the Nilgiris in the South of India.
- It is characterized by the presence of species like Agrostis, Calamagrostis, Dactylis, Oryzopis etc., together with pasture legumes like white and red clovers, medicks and vetches, all species that are typical of grass land cover in temperate lands.

PRODUCTION LEVEL OF GRASSLAND COVERS IN INDIA

Grass cover	Potential (tonnes / ha)	Actual
Dicanthium - Cenchrus – Elyonurus (Dry/ arid , North Western India)	5.0	3.3
Sehima- Dicanthium (Semi arid, Central Southern India)	6.0	3.5
Phragmites – Saccharum (Subtropic high humid, Northern India)	5.0	5.0
Themeda – Arundinella (Sub-mountaneous Himalayan)	4.0	2.2
Temperate and Alpine (Himalayas and Nilgiris)	6.0	4.0

OVER GRAZING

- The grazing pressure on grasslands is very high. In semi arid areas, carrying capacity in good range land is 1 adult cow unit (ACU) /ha but the actual pressure is 3.2 ACU/ha. But in arid areas, carrying capacity is 1 - 4 ACU / ha as against the actual pressure of 0.2 - 0.5 ACU / ha.
- Due to over grazing run off and soil erosion are high. Results from IGFRI indicated that there was 41% run off from bare soil where as in the improved grass land vegetation, the run off was only 6.5 %. Over grazing also results in a shift in the natural succession (as seen in 3 d). Over grazing also results in greater run off and soil loss. Eg.

Results from IGFRI, Jhansi (96 -97)

- Total quantum of water received through rainfall - 6035 cum/ha
- Grazing pressure 1.5 ACU/ha. in grazing systems

Grazing system	Total run off (cum/ha)	Soil loss (t/ha)	Run off Co eff (%)
Rotational grazing	376	0.17	6.2
Differed grazing	423	0.26	7.0
Continuous grazing	457	0.46	7.5
Cut and carry system	383	0.13	6.3
Bare plots	1173	0.68	19.4

GRASSLAND IMPROVEMENT AND MANAGEMENT TECHNIQUES

- The main objective in the management of grassland is to secure the maximum production of livestock without any detrimental effect to the productivity of grass land.
- It is therefore essential to see that the grassland under consideration is kept at its peak level of productivity as long as possible. Decline of herbage productivity may be due to bad drainage or lack of sufficient nutrients in the soil or over grazing.
- It is easy enough to recognize defects like bad drainage in soils by the presence of species that are typical of swampy location such as Cyperus spp. wildrice, Panicum repens. In such case the productivity grass lands can be improved by adopting follow measures.
- The methods to be adopted for the improvement of such areas will be mainly mechanical, designed to remove excess water from the soil. Nutrients and physiological defects may be caused by the lack of any one or more of the essential plant nutrients.

- Continued removal of the grass cover and consequent leaching may deplete the soil of plant nutrients so much that they become limiting factors in the growth of vegetation. In such cases the productivity of grassland can be restored only by the use of fertilizers to supply the deficient elements.
- The majority of grass lands will as a rule beneficial by applications of nitrogenous and phosphatic fertilizers.
    - Weed control (Bush control)
    - Burning of grass lands
    - Enclosure of grass lands
    - Reseeding
    - Conservation of soil and moisture
    - Grazing management

WEED CONTROL / BUSH CONTROL

- Both herbaceous and shrubby weeds are found to invade deteriorated grasslands. Eradicating weeds is to be a continous process in deteriorated grasslands. To eradicate the weeds, various methods are available such as
    - Manual cutting
    - Mechanised means by the use of implements
    - Digging out
    - Burning (in case of heavy infestation)
    - Use of weedicides

BURNING OF GRASS LANDS

- Setting fire to dry vegetation in order to encourage new growth after the next monsoon rains, is a wide spread practice in many parts of India.
- It is a convenient method of removing unutilized herbage residues of the previous year so that, a new growth of vegetation may develop unhindered and become available to grazing animals.
- It is also helpful in eradicating undesirable weeds and shrubby growths that may compete with desirable grasses and legumes.
- Burning is also helpful in encouraging an early spring growth of grasses and discouraging encroachment of jungle growths. In humid high rainfall areas, burning may not be very harmful, but in semi-arid regions burning is definitely harmful.

ENCLOSURE OF GRASS LANDS

- Elimination of the grazing factor, which is directly responsible for the deterioration of the grasslands, induces a progressive succession. It can therefore serve as a very effective method of improving degraded grasslands.
- Closure for a few years will be effective when the reminants of better species are still scattered in the area, to serve as seed sources. 4 or 5 years of closure may be necessary but if the deterioration has already proceeded to the 'poor' condition when only annual species of grasses are left to grow, than the regeneration even under closure may be much slower.

RESEEDING

- On highly degraded grasslands, surest and quickest way of regeneration is re-seeding, but the topography of the land will be an important consideration in under taking the re-seeding operation.

- On level grounds, the operation is fairly easy and effective. Sufficient preliminary information should also be gathered on the choice of species to be sown, the quality of the seed, preparation of soil, moisture conditions and method of re-seeding, if the re-seeding programme is to be successfuly. On undulating sites soil conservation measures are essential before re-seeding.
- Re-seeding can be done on level land in rows 54 cm apart but the spacing can be increased if necessary, depending upon the quality of seed available, the urgency of regeneration and other factors.
- Normally, it is easier to secure a good stand, if reseeding is done after the monsoon sets in, but sometimes the dry sowings before the monsoon can also be done.
- After sowing the soil is given a light harrowing. The grazing during the first year of reseeding should be very light and allowed only after the grass has set seed. From the 2nd year onwards, moderate grazing can be allowed.

CONSERVATION OF SOIL AND MOISTURE

- The proper conservation of both water and soil is an integral part of all good grassland management systems. When properly grazed, eroding forces are kept in check and the grassland is in balance with erosive factors and no special conservation measure could be needed, but when grasslands have been mismanaged by neglect and over grazing for many years, soil and water conservation measures becomes essential for any improvement plan.
- On degraded grassland especially on sloppy ground, the first measure of improvement could be to prevent any further erosion of the soil. Where the erosion has already progressed to the stage of gully formation, dams will have to be put across the gully channels.
- A number of small check dams being more effective than a few large ones. Terraces or surges are useful in high rainfall regions in directing water from the slopes to the channels with a minimum of soil loss from the grasslands.
- Erosion can be controlled by avoiding excessive removal of herbage, adopting contour bunding for soil as well as moisture conservation.

GRAZING MANAGEMENT

- Since a smaller number of well fed animals is always better than a large number of half starved ones, a strict control of the number of animals let in for grazing is the first principle of all grazing systems.
- In fixing the number of animals, the carrying capacity of the grassland should be taken into consideration. This is defined as the number of animals that can graze in a unit area without over grazing or undergrazing in an average season.
- The greatest single factor which causes determination of grasslands is over-grazing on account of selective grazing habit of animals, desirable species tend to get depleted much faster than the less palatable species.
- To avoid this risk, grazing must be stopped at some stage or other i.e., in grassland terminology the grazing has to be deferred since it will seldom possible to stop grazing over entire area, when no other alternative areas are available.
- The practical method is to defer grazing in a part of the grassland and to allow grazing in the other part in a 'rotational' system.
- Over grazing deteriorates the grasslands. Just like human beings, grazing animals, too, have their likes and dislikes and certain grasses are preferred while certain others are avoided.
- On account of the relative grazing habit, desirable species tend to get depleted in grasslands much faster than other species that are not so palatable.
- In most perennial grasses, new shoots are produced by utilizing the reserve food material that is stored in the underground parts. Before the new growths are in a position to build up food reserves by their own

photosynthetic activity, there is a stage in the life history of the perennial plant when the food reserves are at their minimum.

- When the plant produces food material in excess of its growth requirements, the surplus is translocated in to storage organs. At the commencement of next growing season this surplus is utilized for the production of new shoots.
- Under grazing conditions these fresh shoots get removed by the grazing animals and the plant never get a chance to build up any reserve food material. There is thus a continuous drain on the food reserves of the plant, so that at the next growing period, the plant has to start with greatly depleted food reserves. If this over grazing continues, the food reserves get exhausted soon and the plant becomes weaker and weaker and ultimately dies.
- Hence in grasslands, it is essential to allow the plants to build up their food reserves before the forage is utilized for grazing purposes.
- In the case of annual plants, which can continue to exist only through seed formation and germination of that seed each year, the correct management of grasslands dominated by animals is to cut it for forage only after the seed formation stage.

GRAZING METHODS

- The object of scientific grassland management is therefore
    - is to maintain the grassland in the highest state of herbage production and at the same time
    - is to satisfy the forage requirements of the grazing animals
    - is to maintain the fertility of the soil unimpaired.
- In any plan of grazing management, therefore the main principles are to utilize the grass at a time when the growth and reproduction are least un interfered with and to utilize the grass when it is most palatable and nutritious.
- Grasses in general are most palatable and nutritious at the young stage, but the grazing at this stage is harmful to the plants. The palatability and nutritive value decreased with the maturity of the plant and when the grass is consumed only at the late stage, the grazing animal is at a disadvantage because of lower nutritive value. Thus the requirements of the grassland and those of the grazing stock are some what antagonistic and good pasture management consists in effecting a satisfactory compromise between these divergent needs.
    - Controlled continuous grazing
    - Deferred grazing
    - Rotational grazing
    - Deferred and rotational grazing

CONTROLLED CONTINUOUS GRAZING

- The present practice of uncontrolled continuous grazing results in depletion of all the desirable species, leaving only week and stunted growth of undesirable species.
- Controlled grazing even, if it is continuous, can mitigate this effect to a great extent. The grazing is stopped when a certain minimum number of preferred plants are still left with sufficient seed stock.
- When managed on these lines, the system would permit a progressive development of grassland area.

DEFERRED GRAZING

- This system consists in delaying grazing in a part of the grassland area until after seed maturity in order to give a chance for the herbage to make sufficient growth and to accumulate sufficient reserved food material to maintain vigour of the plants and produce new shoots next year from the seeds that are shed. This system is applicable where perennial grasses are predominant.
- In practice the grassland is divided into three compartments. One compartment is completely closed to grazing during the growing season, while the animals are allowed to graze in other two compartments alternately.

- Grazing is allowed in the closed "compartment later on, before the herbage becomes too old and unpalatable. Grazing at this stage help in the disposal of seeds and their placement in the soil, thus favour good germination.
- Grazing in the other two compartments gives the benefit of early growth, to the grazing animals, while the alternation of grazing in two plots enables the plants to recoup their vigour after grazing, the grass in the deferred plot though less nutritious makes up for it by its greater quantity.
- Each year one compartment is deferred in this manner, so that in three years, each compartment gets an adequate period of rest, during which the plants would recoup their vigour.
- In deteriorated grass lands, where the perennial grasses are in a badly weak condition, grazing can be deferred for two years in each compartment or even longer, until the desired improvement is seen.

ROTATIONAL GRAZING

- In this type of grazing, animals are allowed for grazing into different sub units of the grassland area in rotation at suitable intervals during the grazing season, so as to bring about uniform grazing without making it too close.
- The quick change over from one compartment to another provides the advantages of giving the animals a nutritive, young herbage and at the same time provides a period of rest during the growth season. The disadvantages in this method is that it gives no chance for seed formation.

Hohenheim System:

- This is an improved system of rotational grazing developed in Germany during the 1st world war to produce sufficient milk without any need to feed concentrates to milch cattle.
- It consists of dividing the pasture into several equal sized plots or paddocks and applying large quantities of nitrogenous fertilizers in these paddocks.
- The dairy cattle are separated into 3 groups high, medium and poor milkers and are let into the paddocks in rotation, so that the best milkers will get the youngest and most nutritious grazing.
- Assuming a growing period of 3 months from July to September the plan of grazing in this system, will be

	July	August	September
1st Year	I	II	III
2nd Year	II	III	I
3rd Year	III	I	II

DEFERRED AND ROTATIONAL GRAZING

- This system is useful for grasslands where annual species predominate and where seeding of the perennial species is desired to maintain the density of the grass cover.
- The grass land is divided into three compartments and grazing is allowed in rotation, so that each compartment is grazed for the grazing season and protected afterwards, until the seed mature.
- By the time the animals are let into the 3rd compartment, the seeds would have matured and got shed. In subsequent years, the same order is followed for each compartment in rotation, so that in 3 years the grasses in each compartment would have produced enough seed with the partial protection afforded to the grasses.
- Eg. In this deferred and rotational type of grazing, the grazing area is divided into four compartments. The calving interval of grazing animals is reduced to 25 months as against 36-42 months under traditional open grazing.

Year	Compartment	Months of grazing in different compartments

	closed to grazing	July-Oct Jan-Apr	Aug-Nov Feb-May	Sep-Dec Mar-Jun
1 st	A	B	C	D
2 nd	B	C	D	A
3 rd	C	D	A	B
4 th	D	A	B	C

PASTURE – PASTURAL FARMING OR RANCHING

- Pastures are grass land where grasses are grown and animals are allowed to graze. In pasturing the animals, there is no expenditure involved for raising fodder, harvesting and distribution as in the case of stall feeding there by reducing the cost of production.

Pastural Farming or Ranching:

- It is a type of farming practice in which livestock are reared by pasture.
- It is a common practice in cooler regions like Australia and New Zealand where wool production is a common feature.
- In Tamil Nadu at Darapuram, Kangeyam breeds are commonly reared for draught purpose. Usually the common grass *Cenchrus ciliaris* is cultivated under rainfed conditions. For the first 2 years the animals will not be allowed inside the field because of the initial establishment of the pasture.
- Pastures are of two types
    - Natural Pasture
    - Artificial Pasture

NATURAL PASTURE

- Grasses grown in wasteland offers this facility for natural pasture. In this method, grasses get established spontaneously (eg.) Hariyali and Denanath grasses without sowing and provides excellent grass cover under good management by nature.
- Some of the pastures are allowed for grazing and some are also used for hay making. After allowing the grasses to grow to the full potential, these pastures are called meadows.
- The grasses that establish after the main harvest is called the *aftermath*, which in latter stage can be used for the animals to graze.

ARTIFICIAL PASTURE

- The inclusion of grasses in crop rotation is common feature in foreign countries. Grasses kept in field for 3 to 10 years, then field is ploughed and brought under other crops. These grasslands are otherwise called as *temporary pasture or ley farming or leys.*
- The land is prepared similar to other crops. In this method seeds of grasses and legumes are mixed together and sown as a mixed crop. The inclusion of legumes is advantageous in many ways.
- They are rich in protein and they raise protein content of the feed. They enrich soil by fixing atmospheric nitrogen and consequently the grasses that are associated with legumes make a better growth than the grasses which are grown alone.
- The grasses and legumes selected should be rich in foliage growth which inturn have rich protein and minerals.

MODULE-4: AGRONOMICAL PRACTICES FOR PRODUCTION OF CEREAL AND GRASS FODDERS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following
  - What are cereal fodders?
  - What are the cereal fodders specific to irrigated, rainfed and hilly regions?
  - What are the agronomical package of practices for cultivation of these cereal fodders?
  - What are the cropping systems to get year around fodder supply?
  - What is the right time of harvest for the important cereal fodders and why it is so?
  - What are minor millets and its fodder yield?
  - What are the annual and perennial grass fodders specific to irrigated, rainfed and hilly regions?
  - What are the agronomical package of practices for cultivation of these grass fodders?
  - What is the proper time of harvest for the important grass fodders?

CEREAL FODDER

- Cereals, grains or cereal grains, are grasses belonging to the members of the monocot families Poaceae or Gramineae. These are cultivated for the edible components of their fruit seeds having the endocarp, germ and bran.
- In their natural form (as in whole grain), they are a rich source of vitamins, minerals, carbohydrates, fats and oils, and protein. However, when refined by the removal of the bran and germ, the remaining endocarp is mostly carbohydrate and lacks the majority of the other nutrients.
- The word cereal derives from *Ceres*, the name of the Roman goddess of harvest and agriculture. The word fodder refers to food for animals
- Cereal fodders play an important role in the feeding of dairy animals. Farmers in general are not growing cereals exclusively for fodder purpose.
- Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crop; they are therefore staple crops.
- Rather they grow them mainly for grain and after the separation of grains through harvest, the residue (straw /stover) is used as cattle feed. But such straw/stover are very poor in their nutritive value compared to their value as green fodder. There are varieties developed for fodder purpose in the Cereal group that are called cereal fodders.
    - Cereal fodder crops for irrigated Condition.
    - Cereal Fodder for rainfed condition.
    - Cereal fodder for hilly/temperate zone.
    - The word Cereal was derived from `Ceres' meaning roman goddess of agriculture. Earlier history referred cereal as `grass yielding edible grain'. Fodder refers to `food for animals'

CEREAL FODDER CROPS FOR IRRIGATED CONDITION

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Fodder sorghum / Jowar (*Sorghum bicolor*)	Co-11, Co-27, Co FS. 29 (Multicut) PC-6, PC-9, PC-23 SSG - 59-3 (Sweet sudan - multicut) MP chari -North India - Single cut
Fodder maize (*Zea mays*)	African Tall Vijay composite, Manjri composite Moti composite, Ganga 5, Jawahar
Fodder cumbu / Bajra (*Pennisetum glacum*) syn. *P.americanum*	Co-8 Entire country Giant Bajra (Single cut in Maharastra and Central India and Multicut in rest of India) VUJ-IV-M- entire country
Teosinte (*Zea mexicana*) (Syn. *Euchlaena mexicana*)	Improved Teosinte (North, North west and Central India) TL-1 (Punjab)

CEREAL FODDER FOR RAINFED CONDITION

Fodder Sorghum / Jowar	June - July : Co-11, Co-27 Sep.- Oct. : K-7, K-10, Co-27 SSG 59-3, M.P.Chari, MD.2, PC-6, MC-136
Fodder cumbu / Bajra (Click here for video...)	Co-8, Giant Bajra, Rajko
Ragi (*Eleusine coracana*)	Co-11; Indaf 8 and PR 202
Tenai (*Setaria italica*)	Co-1
Kudiraivali (*Echinochloa colonam*)	Co-1
Panivaragu (*Panicum miliaceum*)	Co-1
Samai (*Panicum. miliare*)	Co-1
Maize	VL 71, Kisan composite , African Tall
Paddy and wheat straw (crop residue)	

CEREAL FODDER FOR HILLY / TEMPERATE ZONE

Oats (*Avena sativa*)	Kent , OS-6, OS-7, OL-9, JHO 99-2 and 125
Rye (*Secale cereale*)	JHO- 822, UPO -94 and 212
Barley (*Hordeum vulgare*)	DL -36, DL-157, DL-417, DL-454 and Azad

CULTIVATION METHODS

- Field preparation
- Seeds and Sowing
- Manures and Fertilizers
- Weeding
- Irrigation
- Mixed Cropping
- Plant protection
- Harvest

FIELD PREPARATION

- Two ploughings either with country plough or with tillers (tractor drawn) are needed.
- For irrigated crop either beds and channels or ridges and furrows are formed.
- In rainfed condition, only two ploughing is done and one more shallow ploughing is given after sowing to cover the seeds.

SEEDS AND SOWING

- In irrigated condition seed rate is generally less because line sowing is done with proper spacing (30-40 x 10 cm).
- Whereas in rainfed sowing seed rate is generally high because sowing is done by broadcasting method.

MANURES AND FERTILIZERS

- Farm yard manure at 25 t/ha for irrigated crop and at 12.5 t/ha for rainfed crop is applied. For irrigated crop both basal (30:40:20 kg NPK /ha) and top dressing (30 kg N /ha) is done. Whereas for rainfed crop basal dressing only is given. (Depending on the soil type, crop to be grown).
- The dosage of fertilizer will be less in the rainfed conditions when compared to irrigated conditions. If the rainfall is favourable, top dressing is resorted to @ 10-20 kg N/ha.
- Application of fertilizers, especially N, was found to increase the green fodder yield in cereals by 2-3 times. Experiments conducted in North Indian conditions revealed that green fodder(GF), dry matter (DM) and crude protein (CP) yield were increased considerably by N application on fodder sorghum.
- Biofertilizers viz., *Azospirillum* + *Phosphobacterium* mixture both as seed treatment and soil application is recommended @ 3 packets (600 g) for seed treatment and 10 packets (2000 g) for soil application per hectare.

Effect of Nitrogen on the yield of green fodder, DM and CP of sorghum:

Nitrogen applied (kg/ha)	Green fodder yield (t/ha)	Dry matter (t/ha)	Crude protein (kg/ha)
0	22.5	5.1	122.6
30	35.3	7.4	424.0
60	43.1	9.3	632.5
90	49.5	10.9	817.5
120	58.4	11.7	958.0

WEEDING

- One or two weedings before 40th day is required to have a good stand of cereal fodder.
- If weeding is not done, the crop will be suppressed by weeds and ultimately the green fodder yield gets reduced.
- Weed control using herbicide is not done usually because of the likely chance of residual toxicity to the animals through the green fodder.

IRRIGATION

- Life irrigation is given on 3rd day of sowing for irrigated crop. Subsequent irrigation is given once in 7-10 days depending on the soil and climatic conditions.
- Totally about 6-7 irrigations are needed.

MIXED CROPPING

- For improving the quality of fodder, legumes are generally mixed with cereals both under irrigated and rainfed conditions.
- Trials conducted at Tamil Nadu Agricultural University, Coimbatore, revealed that legume as intercrop with cereal fodder increased the crude protein content.
- Crude protein content of fodder as influenced by crop mixtures:

Crop mixture	Crude protein content (%)
Sorghum + legume	13.94
Bajra + legume	14.98
Maize + legume	14.58
Bajra Napier hybrid grass + legume	12.82

Cropping system approach for year round fodder supply:

- Since most of the cereal fodder crops are shorter in duration, they are amenable to fit in a cropping system.
- Experiments conducted in Tamil Nadu revealed that the following cropping sequence in a year were found to give more green fodder yield.

Sl. No.	Cropping sequence in a year	Yield
1	(Maize + Cowpea) - (Maize + Cowpea) - (Maize + Cowpea)	106 t/ha
2	(Sorghum + Cowpea) - (Maize + Cowpea) - (Maize + Cowpea)	110 t/ha
3	Cumbu Napier Hybrid grass + Hedge lucerne (*Desmanthus*)	225 t/ha

PLANT PROTECTION

- Generally plant protection is not needed. However, we may anticipate pests such as shoot fly, stem borer, aphids etc., in sorghum, maize and bajra.
- Similarly diseases such as downy mildew, leaf spot etc., may occur. If the pests and disease occur in the early stage of the crop (before 30th day), then we have to take up plant protection measures.
- Care should be taken to avoid cutting the fodder within 30 days of application of fungicides or pesticides.

HARVEST

- Harvesting is done at 50% flowering . For most of the cereal crops 50% flowering will occur between 60-75 days.
- For other minor/small millets 50% flowering may occur 10-15 days earlier i.e., 50-65 days.

HARVESTING TIME

Right harvesting time for important cereals:

- From the following table, we understand that flowering stage is the optimum time of harvest in which animals will get the maximum nutrients.

Composition and IVDMD % at pre-flowering, flowering and post flowering

Treatments	DM	CP	SILICA	IVDMD%
Legumes				
Pre - flowering	14.7	23.4	0.8	73.1
Flowering	18.3	18.9	1.3	66.4
Post flowering	28.1	15.7	1.5	63.6
Non-legumes				
Pre - flowering	15.5	10.5	1.7	70.1
Flowering	24.2	7.9	2.3	63.6
Post flowering	34.4	6.1	2.9	57.4

PROPER TIME OF HARVEST

- **Sorghum/Jowar** - immediately after flowering and upto 50% flowering. For multicut varieties: 1st cut two months after sowing and subsequently once in 35 to 40 days.
- **Maize :** Cob formation to milk stage (60 - 70 days).
- **Bajra :** Boot leaf stage to early flowering.
- For multicut varieties 1st cut at boot leaf stage and subsequent at the intervals of 35 to 40 days
- Harvest at the above period produces forage of good quality with higher nutrients to animals and also highly palatable stage with higher forage production.
- Yield :
    - Green fodder yield varies greatly with crop and variety. The average yield of fodder sorghum and fodder maize is about 35-40 t/ha. The average yield of bajra ranges from 30-35 t/ha.
    - The yield of ragi varies from 15-20 t/ha. For other small/minor millets the yield variation is between 10 and 20 t/ha.

Comparative yield of small millets:

S. No	Crop	Duration (days)	Green fodder (t/ha)	Crude protein (%)
1	Arisipillu (Brachiaria ramosa)	54	18.70	13.53
2	Kudiraivali (Echinochloa colona)	53	18.20	11.93
3	Tenai (Setaria italica)	53	14.57	9.95
4	Varagu (Paspalam scrobiculatum)	64	13.92	9.95
5	Ragi (Eleusine coracana)	66	13.00	9.95

6	Samai (Panicum miliare)	46	9.46	9.76

SORGHUM

INTR RASS FODDERS

- Cultivation of crops in general refers to seed to seed agronomic packages involving the art and science of crop raising.
- In respect of forage grasses, cultivation means various agronomic operations from sowing to harvest of grasses for the purpose of green fodder.

GRASSES FOR IRRIGATED CONDITIONS

- Irrigated (Perennials)

Bajra Napier hybrid grass (*Pennisetum glaucum x P.purpureum*)	NB 21, NB 37, BN-2, Co-1, Co-2 Co-3, Co. CN-4, Pusa Giant, IGFRI 3,5,6,7 &10
Guinea grass (*Panicum maximum)*	Co -1, Co-2, Co. GG 3 (latest variety), Hamil, Makuni, PPG-1, 9, 13 & 14
Water grass / Para grass/buffalo grass (*Brachiaria mutica*)	No improved variety

- Irrigated (annual /biennial)

Deenanath (*Pennisetum pedicellatum*)	Co-1, PS-3, IG FRI - 3808
Teosinte (*Euchlaena mexicana)(Zea mexicana)*	Improved teosinte; TL-1(*Zea mexicana)*

CHOICE OF GRASSES FOR RAINFED CONDITIONS

- Blue buffel (*Cenchrus glaucus*): Co-1
- White kolukkattaigrass /Anjan grass: IGFRI 3108, Cenchrus ciliaris, Marwar Anjan (CAZRI -75)
- Black kolukkattai grass/ Dhaman grass: Marwar Dhaman (CAZRI -76) Black Anjan (*C. setigerus*)
- Marvel grass (*Dicanthium annulatum*): GMG .1
- Rhodes grass (*Chloris gayana*)
- Spear grass (*Heteropogon contortuous*):
- Setaria grass (*Setaria anceps* and Nandi, Narok, PSS 1 (*S. sphacelata*)
- Blue panic/Australian grass (*Panicum antidotale*)
- Congo signal grass (Ruzi grass) (*Brachiaria ruziziensis*)
- Signal grass (*Brachiaria decumbens*)
- Arisipillu (*Brachiaria ramosa*)
- Sudan/Johnson grass (*Sorghum sundanense and Sorghum halepense*)

CHOICE OF GRASSES FOR HILLY REGIONS

- Kikuyu grass: *Pennisetum clandestinum*
- Tuber grass: *Phalaris tuberosa*
- Rye grass: *Lolium multiflorum*; *L. Perennae*
- Dactilis grass: *Dactilis glomerata*
- Setaria: *Setaria anceps*; *S. sphacelata*

CULTIVATION METHODS

- Cultivation methods include all the package of practices to be adopted for getting higher green fodder yield.
- It includes
    - Field preparation,
    - Seeds and sowing,
    - Manures and fertilzers,
    - Weed and irrigation management,
    - Plant protection and
    - Harvest.

FIELD PREPARATION

- For both irrigated and rainfed grasses, especially perennial grasses, deep ploughing with disc/mould board plough is essential. Because the perennials will be maintained in the field for many years. Their fibrous roots must have more soil depth for effective uptake of soil moisture and nutrients.
- Deep ploughing is essential to eliminate unwanted weeds besides improving the infiltration of soil for better harvest of rain water, especially in rainfed areas.
- For better utilization of water, the scarce commodity, beds and channel or ridges and furrows system of irrigation is recommended.
- Mostly ridges and furrows system is preferred, not only for higher water use efficiency (WUE) compared to beds and channels but also for certain other advantages such as easy cultural operations in view of line sowing/planting on the ridges.
- Under rainfed condition, in particular for pasture development, when there is no water for irrigation, formation of ridges and furrows or beds and channels are not needed.
- Instead, after ploughing, the land is left as such for sowing. Sometimes, if needed, leveling of ploughed field will be done.

SEEDS AND SOWING

- Seed collection is a problem in many of the grass species. The seeds of Bajra Napier hybrid grasses (Co-1, Co-2, C-3 and Co CN-4) are sterile and there is no chance of seed propagation. Hence, vegetative propagation either through root slips or stem cuttings is done.
- By this way, we are able to maintain genetic purity also. One disadvantage of using root slips is that we need more volume of bulky stem cuttings/root slips which warrants additional expenses on cutting and transport.
- For guinea grass, seeds are available but there is seed dormancy for about 6-8 months and the germination is also very poor (20-40%). Considering this aspect, propagation through root slips is better. Similar is the case with buffalo / water grass and Cenchrus species. Hence, we can go for root slips in respect of guinea and water grass.
- In case of *Cenchrus* and other grass species, depending on the availability we can use either root slips or seeds (if available) or both (for covering larger area for pasture) under rainfed condition. Almost all the grass seeds are having dormancy at least for 4-6 months. Deenanath and Teosinte can be propagated through seeds.
- Season is also an important consideration for the success of the crop. Irrigated grass can be sown/planted throughout the year since there is water availability.
- Whereas, under rainfed condition, the grasses are to be sown/planted only during the onset of monsoon season (June / July sowing for S.W monsoon; Sept/ Oct sowing for N.E.monsoon)

MANURES AND FERTILIZERS

- Since all the grass species are having only fibrous root system, they are getting their nutrients mainly from the top soil layers (0-30 cm depth). Hence, keep the soils fertile and aerated. Application of organic matter, irrespective of the soil type is essential.
- Also the grasses are perennial and they need sustained support through improved physical condition of the soil. This can be achieved through adequate supply of FYM (Farm Yard Manure) or compost @ 25 t/ha.
- Moreover, grasses are the most neglected crops among the cultivated crops. Hence, it is obvious that only marginal or poor lands will be allotted to them. Under that situation, not only application of FYM/compost is essential, but application of inorganic fertilizers such as NPK (Nitrogen, Phosphorus and Potassium) as basal is essential.
- In Europe and other western countries, the farmers are applying the micronutrients (such as Iron, Zinc, Copper, Boron, Molybdenum, Manganese, Sodium etc.,) to irrigated and rainfed pastures to avoid micronutrient deficiency in the animals. Such awareness and practice are yet to be inculcated to our farmers.

- Application of NPK have been found to increase the fodder yield of grasses by nearly 2 to 4 times. In irrigated grasses such as Bajra Napier hybrid and guinea grass, top dressing of N after every cut is adopted. But in rainfed grasses, it is not followed in view of the non-availability of water. However, application of N to the tune of 20-40 kg/ha is advocated, whenever there is favourable rainfall.
- Biofertilizers such as Azospirillum + Phosphobacterium mixture can be used for both seed treatment (3 packets 600 g/ha) and soil application (10 packets or 2000 g/ha) before sowing. Biofertilizers were found to increase the green fodder yield by 1-2 t/ha.

WEEDING

- It is an important operation to be done both for irrigated and rainfed grass at the early stage of the crop, between 20-40 days after sowing/ planting.
- Otherwise, the grass will be suppressed by the prolific growth of weeds and this may result in gaps in the field (due to mortality of grasses) and ultimately results in reduction in the green fodder yield.
- Preferably weeding with hand hoes is better since it creates better aeration for soil by the way of scrapping the soil surface.
- Depending on the weed intensity and nature of grass growth, either one weeding (between 20-30 days) or two weedings (20^{th} and 40^{th} day) may be needed.
- Under irrigated condition, weeding and earthing up is essential after every harvest.
- In rainfed condition, unwanted bushes, shrubs and prominent weeds should be removed as and when they are noticed.
- Once in a year, shallow ploughing with worn out country plough or worn out tractor tiller harrow, may be given. This practice not only keeps the unwanted weeds under check but also incidentally improves soil aeration and grass growth by root pruning, besides conserving rain water.

IRRIGATION

- For irrigated grasses (Bajra Napier grass, guinea grass, buffalo grass, Teosinte and Deenanath), life irrigation must be given on 3^{rd} day after sowing/planting. Thereafter depending on the soil and climatic conditions, irrigation must be given once in 7-10 days.
- If there is a moisture stress due to some unexpected reasons, it will be ultimately reflecting on the yield.
- Under rainfed condition compartmental bunding can be followed for better harvest of rain water.
- If there is excess moisture/water, it has to be drained out. Water logging for more than 3 days may affect the growth of certain grasses such as *Cenchrus* sp. *Panicum maximum*, *P. antidotale* etc.

PLANT PROTECTION

- It is generally not needed for Bajra Napier grass, guinea grass and buffalo grass. But in Teosinte and Deenanath, there may be some pests (aphids, shoot fly) and diseases (rust, leaf spot etc.)
- Since they are mainly used as fodder crops, the occurrence of pests and disease at later stages (beyond 40 days) may not affect the crop yield and quality to a greater level.
- If they occur in the early stage, we have to resort to plant protection. It must be borne in mind that the crop should not be fed within 30 days of pesticide/fungicide application, to avoid any residual toxicity to animals.

HARVEST

Proper stage of harvest of grass fodders:

- Hybrid Napier: 6-7 weeks (40 to 45 days advocated to have less oxalate toxicity)
- Guinea Grass: At 6 weeks intervals
- Para grass: 4 to 6 weeks intervals
- Deenanath: At Mid flowering
- Blue panic grass: Every two months
- Rhodes grass: At flowering
- *Cenchrus*: At 50% flowering

GREEN FODDER YIELD

- The green fodder yield ranges from 300-350 t/ha in respect of BN hybrid grass, for guinea grass it ranges from 200-250 t/ha and for buffalo grass it ranges from 120-180 t/ha. Deenanath will yield 50-60 t/ha and Teosinte will give 30-35 t/ha.
- Kolukattai grass(*Cenchrus* sp.) yields about 20-30 t/ha. The other rainfed grasses yields on an average 10-15 t/ha/year. We must remember that yield is the function of genetic potential, environment and management factors.

Y = **Genetic potential** (Variety) x **Environment** (Climate & soil) x **Management** (Agronomic packages)

- When any one of the above three factors are below optimum, then the yield will be reduced drastically. This implies that even with good variety and suitable soil and climate for a particular crop, without proper agronomic management will result in poor yield.

MODULE-5: AGRONOMICAL PRACTICES FOR PRODUCTION OF LEGUME AND TREE FODDERS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - What are legume fodders?
  - What are the annual and perennial legume fodders specific to irrigated, rainfed and hilly regions?
  - What are the agronomical package of practices for cultivation of these legume fodders?
  - What is the right time of harvest for the important legume fodders?

	o What are the importance of tree fodders? o What is sylvipasture and the important fodder components in the system? o What are the suitable tree species for different zones of the country? o Multi-tier sytems for grassland development. o Nutritive value of important tree leaves. o Various multipurpose tree species for different rainfall zones.

INTRODUCTION

- Legumes are most important component of animal fodder in view of their high content of crude protein (20-25%) compared to fodder cereals (8-12%) and fodder grasses (5-10%).
- Non-leguminous fodders (Cereal and grass) provide much of the required energy (carbohydrate) for livestock, while legumes improve the quality of fodders when mixed with non-leguminous fodders. This is by virtue of the high protein content present in the legumes.
- Green fodders of non-legumes are fed in bulk quantities (about 10% of body weight of the animal) whereas that of legumes are fed in small quantities (1-2% of body weight).
- If legumes are fed in bulk, it may create problems like bloat in animals. The following are the choices of leguminous fodder.

LEGUME FODDERS FOR IRRIGATED CONDITIONS

Irrigated legumes - Perennial

- Lucerne (*Medicago sativa*)(Click here for video...): Co-1, T-9 Anand 1 & 2, Chetak (S-224), RLS -88
- Desmanthus (*Desmanthus virgatus*) (Click here for video...): local varieties

Irrigated legumes - annual

- Cowpea (*Vigna unguiculata*): (Click here for video...) Co-5, Russian Giant, EC 4216, UPC –287, Co- F.C 8, BL 1 and BL 2.
- Cluster beans (*Cyamopsis tetragonaloba*): Guar -80, FS-277, HFG.119 and 156
- Soybeans (*Glycine max)*

LEGUME FODDERS FOR RAINFED CONDITIONS

Rainfed legumes - perennial

- Desmanthus: *Desmanthus virgatus*
- Stylo: *Stylosanthes hamata, S. scabra, S. guianensis, S. humilis*
- Desmodium: *Desmodium tortuosum* (green leaf), *D. unciniatum* (Silver leaf)
- Siratro: *Macroptilium atropurpureum*
- Clitoria: *Clitoria ternatea*
- Centro: *Centrosema pubescens*
- Rice bean: *Vigna Umbellata* - K.1, K.16 ,Syn. Phaseolus calearatus
- Moth bean: *Phaselous aconitifolius*
- Vigna marina bean: *Vigna marina*
- Velvet bean: *Stizolobium deringianune* (IGFRI -S-219895, IGFRI - S-2286)
- Beans: *Phaseolus vulgaris*
- Jack bean: *Canavalia gladiata* (white seed)
- Sword bean: *C. enciformis* (Pinkish seed)
- Red gram: *Cajanus cajan* - BSR -1

Rainfed legumes - annual

- Red gram: *Cajanus cajan* : Co-1, Co-6
- Horse gram: *Macrotyloma uniflorum* : Co-1 and Paiyur -1
- Lab - lab: *Lab-lab purpureus var. typicus* : Co-1 to Co-12, Lab - lab purpureus var. lignosus : Co-1, Co-2
- Cowpea: *Vigna unguiculata* : Kohinoor, NP-3 , HFC 42-1, UPC - 5287, Co.FC 8
- Cluster bean: *Cymopsis tetragonaloba* : Durga pura safed, HFG - 119, IGFRI -S- 212

LEGUMES FOR TEMPERATE REGIONS

- Berseem / Egyptian clover (*Trifolium alexandrianum*): Wardan, Mescavi and BB 3
- Lucerne (Alfalfa) *Medicago sativa*: T9, LLC-3 & 5, Chetak
- Senji (Sweet clover) *Melilotus indica*: Safed-76, FOS-1,YSL-106
- Shaftal (Persian clover) *Trifolium resupinatum*: Ch.20, Ch.48
- Beans / Velvet bean / Jack bean / sword bean
- Lotus: *Lotus corneculatus*

CULTIVATION METHODS

- Cultivation methods include all the package of practices to be adopted for getting higher green fodder yield.
- It includes field preparation, seeds and sowing, manures and fertilzers, weed and irrigation management, plant protection and harvest.

FIELD PREPARATION

- A deep ploughing with disc/mould board plough followed by working with tillers/harrows for 2 times is essential, to bring the soil into fine tilth.
- Then beds and channels are formed for irrigated crops. Ridges and furrow system is followed wherever water is scarce.

SEEDS AND SOWING

- Seed rate differs with size of the seeds. For small seeded crops like lucerne, desmanthus etc., 15-20 kg/ha are needed.
- For cowpea, cluster bean, lab- lab, horse gram and red gram, a seed rate of 20 -25 kg/ha is needed. For soyabean about 75-80 kg/ha is recommended.
- Before taking up sowing, seed treatment with *Trichoderma viridi* has to be done to avoid root rot/wilt disease.
- In irrigated condition, line sowing is a must to maintain adequate population as well as to exploit the resources viz., water, sunlight, space and nutrients effectively. In rainfed condition broadcasting is practiced.

MANURES AND FERTILIZERS

- Application of FYM at 25 t/ha and 12.5 t/ha is essential under irrigated and rainfed conditions, respectively.
- Inorganic fertilizers at 25:120:40 kg NPK/ha is advocated for lucerne, 25:40:20 kg NPK/ha for cowpea and 10:60:30 kg NPK /ha for *Desmanthus* under irrigated conditions. Half of this dose will be sufficient under rainfed conditions for these crops.
- For all other rainfed pulses, fertilizer dose of 10:25:0 kg NPK/ha is recommended as basal dose. Biofertilizers viz., Azospirillum + Rhizobium + phospho-bacterium mixture both as seed inoculation and soil application is recommended. Wherever possible specific strains of rhizobium should be used for better results.

WEEDING

- Both perennial and annual legumes under irrigated as well as rainfed conditions, needs one (20^{th} day) or two (20^{th} and 40^{th} day) weeding and hoeing.
- For all the perennial legumes, one hoeing and weeding is essential after every harvest to keep the soil aerated as well as to keep the weeds under check.

MIXED CROPPING/ INTERCROPPING

- Legumes are generally grown only as mixture with non-legumes, with an exception of lucerne and desmanthus. The later being a perennial is grown as pure crop in view of their high yielding potential.
- And also repeated harvests and cultural operations in the standing crop become easy when grown as purecrop. However growing legumes as intercrop with cereal fodders or grass fodders make the green fodder available a complete and balanced source of nutrients to the animals.
- For improving the quality of pastures, legumes such as stylo, clitoria, siratro etc., may be mixed with grass species such as *Cenchrus ciliaris, C. Setigerus, C. glaucus* and *Stylosanthes* at one row of legumes for every three rows of grass, if line sowing is possible.
- Otherwise the seeds of legumes and grasses can be mixed in the same proportion and sown by broadcast method.

PLANT PROTECTION

- Generally plant protection is not needed. However, if any insect pest or disease is noticed, one can take up plant protection measures.
- Care must be taken for not feeding the fodder within 30 days of fungicide or insecticide application.

IRRIGATION

- Depending on the soil and climatic condition, irrigation is needed once in 7-10 days for irrigated legumes.
- Though irrigation is very much essential to obtain maximum yield, waterlogging for more than 48 hours may result in wilting/rotting of most of the leguminous fodder crops.

HARVESTING

- Harvesting is to be done at 50% flowering. Fodder cow pea is ideal for harvesting around 70 to 75 days.
- Lucerne is harvested at an interval of 40 days in summer and at an interval of 20 to 30 days during winter months.
- Delay in harvest may affect the quality of the fodder interms of crude protein content and other nutrients.

YIELD

- Desmanthus yields about 125 t green fodder/ha, while lucerne yields 70-80 t/ha.
- The fodder yield of cowpea, cluster bean and soybean ranges from 20-30 t/ha.
- For all other legumes the yield of green fodder under rainfed condition may range from 10-15 t/ha/year.

WHY TREE FODDER?

- All the tropical and subtropical grasses, owing to their faster rate of growth during the monsoons provide grazing for the livestock, mainly in the monsoon and post-monsoon periods.
- With the advent of winter in most parts of the northern India, and owing to the lack of sufficient moisture in the soil in a ready available form, they enter dormancy.
- In the case of south Indian conditions, the grass land look dried or partially dried during the summer months and post monsoon periods thereby causing poor grass growth and grass land deterioration.
- During these periods, livestock gets only a meager part of the feed requirement through grazing. For such lean periods, tree-tops come to the rescue of the livestock-owners.
- The young leafy, succulent material, highly nutritive and rich in crude protein and minerals, serve as a concentrate, even if fed in small quantities along with other dried grasses and crop residues.
- The loppings of the trees obtained in spring and summer seasons also contain some substances which bring the animals quickly into the reproduction phase.
- Some of the important trees giving loppings and producing gum are Soobabul (*Leucaena leucocephala*) and *Sesbania aegyptica* and *S. maculeata*.Click

SYLVIPASTURE SYSTEM

- The silvipastrol system involves production of forage grasses and legumes with multiple purpose trees used initially under cut and carry system and later on grazed *in situ*.
- The current land use statistics show more than one- third of the land area as wastelands needing early attention for their development to meet the growing shortage of forage/grazing, firewood and healthy environment.
- It becomes still more important when we cannot increase the area under fodder crops due to growing demand for food of human population.
- Thus, under present circumstances it is essential to follow an integrated approach of growing trees and forage grasses and legumes simultaneously on the same land under

sylvipastoral system of farming - which is closer to the natural approach and is ecologically sound.

- It has three major components:
  - The trees: Conserve land and ameliorate climate in arid and semi- arid regions, besides their forage, fuel and timber value
  - Animals: Milk, meat, energy, manure, etc.
  - Occasional cash crops: Income for farmers.

FODDERS FOR SYLVIPASTURE SYSTEM

Trees

- Subabul, *Desmanthus*, *Albizia*, *Acacia*, *Hardwickia*, *Dalbergia sissoo*

Grasses

- *Cenchrus ciliaris*, *Cenchrus setigerus*, *Chrysopogon fulvus*, *Dicanthium annulatum*

Legumes

- *Stylosanthes scabra* (in arid and semi-arid regions), *Stylosanthes hamata*, *Stylosanthes guianensis* (in high rainfall areas), *Macroptilium atropurpureum*, Lablab etc.
- In sylvipastoral system the trees are planted at a spacing of 6x 5m, 4 x 3m or 3 x 2 m depending upon their rotation.
- The experiment conducted in vertisols of Regional Research Station, Aruppukottai during rainy season (North-east monsoon) revealed that subabul (16.2 t/ha) and Desmanthus (14.5 t/ha) recorded higher fodder production compared to Sesbania.
- Among the different forage crops grown under this system Subabul + sorghum combination recorded higher fodder production (20.5 t/ha).
- For the terrains and difficult areas, some of the fodder - trees that have shown promise and compatibility with the grass species in various parts of our country are given below.

Trees + Grasses

- Israli babool (*Acacia tortilis*) + Anjan (*Cenchrus ciliaris*, *C. setigerus*)
- Babool (*Acacia arabica*) + Dhaulu (*Chrysopogon fulvus*)
- Siris (*Albizia lebbeck*) + Sain (*Sehima nervosum*)
- Unjal (*A. amara*) + Dinanath (*Pennisetum pedicellatum*)

NORTH - WESTERN REGION

- *Acacia tortilis*, *A. Catechu*
- *A. nilotica (Syn. A. arabica)*, *Albizia amara*
- *A. lebbeck*, *Anogeissus pendula*
- *Azadirachta indica*, *Capparis spinosa*
- *Dalbergia sissoo*, *Grewia oppositifolia*
- *Ficus carica*, *Leucaena leucocephala*
- *Prosopis cineraria*, *P. juliflora*
- *Quercus incana*, *Q. semecarpifolia*
- *Salix tetrasperma**, *Robinia psedacacia*
- *Salvadora oleoides*, *Dendrocalamus strictus*

INDO-GANGETIC PLAIN

- *Acacia nilotica , Acacia torilis*
- *Alibizia amara, A. lebbeck*
- *Adina cordifolia, Anogeissus latifolia*
- *A. pendula, Azadirachta indica*
- *Artocarpus integrifolia, A.chaplasha*
- *Basia latifolia, Bridelia retusa*
- *Bauhinia spp, Cassia fistula*
- *Cordia dichotoma, Castania sativa*
- *Dalbergia sissoo, Ehretia laevis*
- *Syzygium cumini (Eugenia jambolana), Fagus sylvatica*
- *Ficus spp., Gmelina arborea*
- *Grewia oppositifolia, Helicteres isora*
- *Kydia calycina, Leucaena leucocephala*
- *Mallotus philippinensis, Millettia auriculata*
- *Moringa pterigosperma, Morus spp.,*
- *Qugeinia dalbergioides, Musa sapientum*
- *Pithecellobium dulce, Delonix regia*
- *Quercus spp., Schleichera trijuga*
- *Sesbania grandiflora, Terminalia spp.,*
- *Tamarindus indica, Ulmus wallichiana*
- *Zizyphus jujuba, Dendrocalamus strictus*

CENTRAL ZONE

-

Adina cordifolia	*Abizia lebbeck*
Anogeissus spp.,	*Azadirachta indica*
Artocarpus integrifolia	*Basia latifolia*
Bridelia ratusa	*Bauthinia spp.*
Cordia dicholoma	*Dalbergia latifolia*
Syzygium cumini	*Ficus spp.*
Gmelina arborea	*Gliricida maculata*
Hardwickia binata	*Kydia calycina*
Leucaena leucocephala	*Moringa pterigosperma*
Morus spp.,	*Qugeinia dalbergioides*
Pithecolobium saman	*Delonix regia*
Pterocarpus marsupium	*Terminalia spp.,*
Zizyphus jujuba	

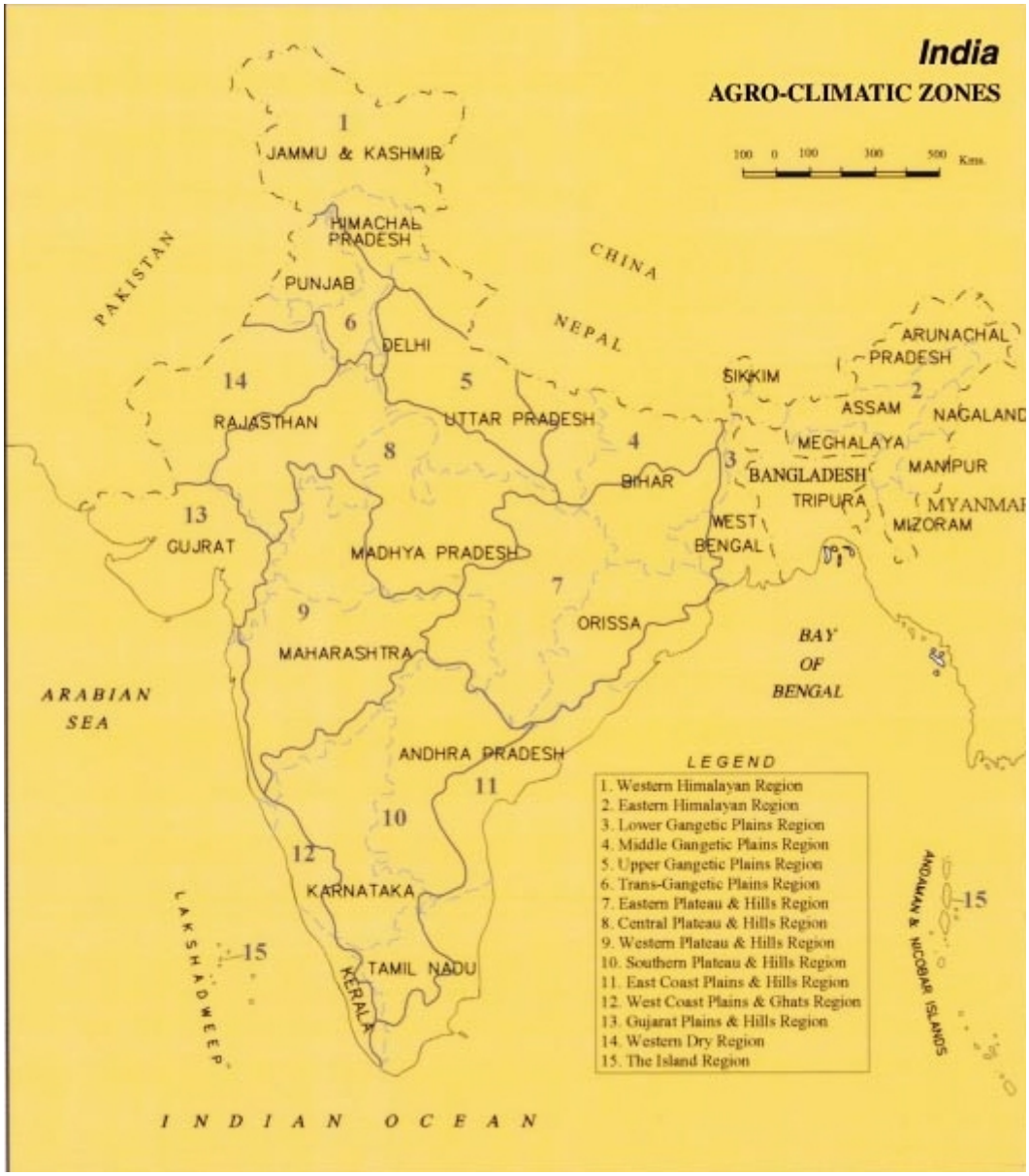
COASTAL ZONE

Acacia tortilis	*Cassia siamea*
Tamarix articulata	*Albizia amara*
Syzygium cumini	*Ficus retusa*
Erythrina indica	*Ailanthus malabarica*

NORTH-EASTERN ZONE

- *Alibizia spp., Bamboos*
- *Artocarpus integrifolia, A. chaplasha*
- *Bauhinia spp., Castania sativa**
- *Desmodium spp., Fagus sylvatica**
- *Syzygium cumini, Ficus benghalensis*
- *F.religiosa, Gliricida maculata*
- *Gmelina arborea, Moringa pterigosperma*
- *Morus alba, Ougeinia dalbergioides*
- *Delonix elata, Schleichera oleodies*
- *Terminalia tomentosa, Tinospora cordifolia*

**Species for high altitudes*



MULTI-TIER SYSTEMS (COMBINING TREES) FOR GRASSLAND DEVELOPMENT

- Silvipastoral systems or the combining of fodder and fuel plantations seem to be the answer for meeting the chronic shortages of fuel and fodder in the country.
- Vast areas of culturable wasteland and marginal forest lands extending over 47 million hectares in the country may be particularly suitable for the purpose Multi-tier system of growing trees and grasses/legumes. The central soil and water conservation research and training institute (CSWCRTI), Dehra Dun and its regional centres have generated valuable information in this regard.
- At Dehra Dun, *Delbergia sissoo* (fuel), *Chrysopogon fulvus* (fodder) and *Acacia catechu* (fuel) + *Eulaliopsis binata* (fibre) plantations were found to be highly successful in the old terraces of the torrents of the region which are bouldery in nature.

- At Chandigarh, on sloping lands, the combination of *Eucalyptus* hybrid (fuel) and *Eulaliopsis binata* (fibre) , adapting tie ridging technique for moisture conservation has yielded 179 tonnes/ha of air - dry mass of fuel and 45 tonnes/ha of grass within a period of 8 years and 3 months. In the ravine lands of Agra, gullied lands were found to support good stands of *Acacia nilotica* and *Cenchrus ciliaris*.
- At Kota and Vasad, on the other hand, *Prosopis juliflora* was found to be good for plantation on gully side slopes, Dendrocalamus strictus alongwith either *Dichanthium annulatum* or *Cenchrus ciliaris* is found to be good for gully-bed plantation.
- In the semi-arid deep black soils of Bellary, *Acacia nilotica* and *Cenchrus ciliaris* have been found to be good fuel-cum-fodder plantations.

MULTI-PURPOSE TREE SPECIES

- Annual rainfall - Poor (< 500 mm) - Dantiwada, Hisar, Hoshiarpur, Jhansi, Jodhpur, Rajkot, Udaipur
    - *Acacia nilotica*
    - *A. aneura / torilis*
    - *A. catechu / senegal*
    - *Colophospermum mopane*
    - *Eucalyptus camaldulensis*
    - *Faidherbia albida*
    - *Parkinsonia aculeata*
    - *Prosopis cineraria*
    - *P. juliflora*
    - *Pithecellobium dulce*
- Moderate (500 - 750 mm) - *Akola, Anantapur, Bangalore, Bellary Hyderabad, Indore, Solapur*
    - *Acacia nilotica*
    - *A. ferruginea*
    - *Ailanthus excelsa*
    - *Albizia lebbeck / amara*
    - *Azadirachta indica*
    - *Butea monosperma*
    - *Cassia flstula*
    - *Casurina equisetifolia*
    - *Eucalyptus sp.*
    - *Leucaena leucocephala*
    - *Tamarindus indica*
    - *Terminalia alata*
- Good (> 750 mm) - Bhubaneshwar Dehra dun,Kovilpatti, Rakh Dhiansar
    - *Acacia nilotica*
    - *Albizia lebbech*
    - *Alnus nepalensis*
    - *Azadirachta indica*
- Good (> 750 mm) - Ranchi, Rewa,Varanasi
    - *Bauhinea purpurea*
    - *Casuarina equisetifolia*
    - *Dalbegia sissoo / latifolia*
    - *Emblica officinalis*
    - *Eucalyptus sp.*
    - *Gmelina arborea*
    - *Grewia optiva*
    - *Grevillea robusta*
    - *Hardwickia binata*
    - *Melia azedarach*
    - *Morus alba*
    - *Populus sp.*

- *Sesbania sp.*
- *Terminalia sp.*

NUTRITIVE VALUE OF COMMON TREE LEAVES
(Jack fruit, Neem, Mowra, Indian Kapok, Coffee, Banyan, Fig and Peepal)

- The utilization of tree leaves for feeding to livestock is not common. They are, however, used for feeding sheep and goats, and are sometimes fed to cattle during periods of fodder crisis.
- In the early stages of their growth, leaves contain fairly high amounts of crude protein and a comparatively low percentage of crude fibre.
- As maturity progresses, there is a gradual decrease in protein content with a concomitant increase in crude fiber. The tree leaves and shrubs are generally rich in calcium but poor in phosphorus.

Jack fruit (*Artocarpus heterophyllus*)

- A tree up to 15m high with stiff, 3-lobed leaves on young shoots. The fruits are green and clump - formed with a papillate surface. They grow all along the trunk of the tree.
- The fruits are an important food in the eastern tropics. The leaves are relished by the goat, sheep and cattle and fed particularly in Kerala, Maharashtra, Orissa and West Bengal.

Fresh leaf : As % of dry matter

D.M.	C.P.	C.F.	Ash	EE	NFE	Ca	P
53.0	18.5	26.2	10.2	5.0	40.0	2.00	0.11

Neem (*Azadirachta indica*)

- Neem trees grow throughout South and South East Asia. The tree remain green all the year round and is drought resistant. Although the leaves are not relished by normal livestock, but buffaloes are found to consume about 5 kg per day.

Fresh leaf : As % of dry matter

C.P.	C.F.	Ash	EE	NFE	Ca	P
15.4	12.7	11.2	4.2	56.5	2.65	0.24

Mowra (*Bassia latifolia* or *Madhuca indica*)

- A large deciduous tree with a short trunk, spreading branches and a large rounded crown. Flowers are used as vegetable and as source of alcohol. The cake from the oilseed is used as fertilizer. Cattle eat the leaves, flowers and fruit.

Fresh leaf : As % of dry matter

C.P.	C.F.	Ash	EE	NFE	Ca	P
9.1	18.7	7.8	4.1	60.3	1.53	0.24

Indian Kapok or Red silk cotton tree (*Bombax malabaricum*)

- A tree native to India cultivated for the fine, lustrous material (kapok) obtained from the seed hairs. The flowers are collected for human consumption. The leaves which are 5 to 8 cm long are felted with star shaped hairs. These, together with the twigs, are lopped for fodder.

Fresh leaf : As % of dry matter

CP	CF	Ash	EE	NFE	Ca	P
12.6	22.3	9.3	6.4	49.4	2.70	0.19

Coffee (*Coffea arabica*)

- The dark, glossy green leaves of the coffee bush are, in some areas, dried and included in concentrates for cattle. The leaves are reported as palatable and can be fed without any unfavourable side effects. It has been claimed that feeding of coffee leaves extends the lactation period.

Dried leaf : As % of dry matter

DM	CP	CF	Ash	EE	NFE	Ca	P
93.6	9.9	18.7	13.0	5.9	52.5	----	----

Banyan (*Ficus benghalensis*)

- A large tree, which can have a huge crown of horizontal branches covering as much as 200 square metres. The crown is supported by aerial roots. It is often planted as shade tree. The leaves are relished by sheep, goat, cattle and buffaloes.

Fresh leaf : as % of dry matter

CP	CF	Ash	EE	NFE	Ca	P
9.7	22.6	14.4	2.9	50.4	2.56	0.19

Fig (*Ficus carica*)

- A small spreading shrubby tree with large leaves, native to Asia, but now cultivated in sub-tropical countries also. The leaves can be used as fodder for cattle and should be collected as soon as the fruit has been harvested and before yellowing begins.

Fresh leaf : As % of dry matter

DM	CP	CF	Ash	EE	NFE	Ca	P
34.2	14.2	17.1	16.7	5.9	46.1	3.16	0.16

Peepal (*Ficus religiosa*)

- A large glabrous tree with leathery, shining, broad based, pointed leaves, Commonly grown as an avenue tree. Although the palatability and nutritive value of peepal leaves is not very good but still the leaves and branches are extensively lopped for fodder.

Fresh leaf : As % on dry matter basis

CP	CF	Ash	EE	NFE	Ca	P
9.0	15.9	20.0	2.7	52.4	2.97	0.21

MODULE-6: STORAGE OF FEEDS AND FODDERS
LOSSES IN STORAGE AND PREVENTIVE METHODS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - What are losses in storage of feed and feed ingredients?
  - Factors responsible for those lossses.
  - Control methods to prevent the losses.
  - Essential criteria for the safe storage of feed and feed ingredients.

STORAGE OF FEEDS AND FODDERS

Introduction

- As the population grows increasingly, the food supply becomes an urgent priority. One vital and neglected step towards this end is to reduce food losses that occur between harvest and consumption.
- Inspite of advances in technology, tonnes of cereals are wasted every year through spoilage of various sorts. Protection of food supplies through sound storage practices is a matter of most vital importance.
- Storage and marketing, if carried out efficiently will be a major contribution to the under developed and developed countries where food and feed shortage is severe.

LOSSES IN STORAGE

- Loss is measured as reduction in weight in the amount of feed available for consumption. Loss may be
  - Quantitative
  - Qualitative
  - Economical
  - Nutritional and
  - Germinative
- The loss can be prevented or reduced by better management at pre-harvesting stage, during harvesting, threshing and shelling, drying and by applying sound storage practices.
- Grains stored under favourable conditions for many years undergo relatively minor changes in composition and can be used as a source of nutritious and palatable food or animal feed, but under unfavourable conditions result in complete spoilage of grain for food or feed purpose within a few days.

FACTORS AFFECTING FEED VALUE AND DETERIORATION

- Basically there are some physical, biological and chemical agents that cause the damage and ulitmate loss to the stored feed and feed ingredients.
- It may include
    - Temperature
    - Moisture
    - Insects
    - Fungus
    - Rodents etc.

PHYSICAL FACTORS

- Moisture content and temperature are the principle factors in safe storage. At low moisture and temperature, destructive insects become inactive.
- The optimum levels of moisture for storing the feed ingredients is *less than 10% in India*. Further, the lower the temperature, higher the level of permissible moisture for storage.
- High temperature (21-43° C) speeds up the life process of all microorganisms. Temperature below 15° C retard insect reproduction.

Control

- Proper drying of the grain before storage and storing the grains at lower temperature as far as possible.

BIOLOGICAL FACTORS

- Principle biological agents that cause deterioration during storage are
    - Insects
    - Fungi
    - Rodents

INSECTS

- At temperature of 32°C rate of multiplication of insect species is fifty times. The nutritive requirements of insects are same as those of vertebrates.
- Crops with high nutritive value are more susceptible to insect damage. Dead and live insects and their excreta cause the commodity unpalatable and unacceptable.

Control

- Good hygiene.
- Cleaning and checking of storage containers as well as the stored food as far as possible.
- New dry grain should be kept separate from old grain.
- Stores should be remote from the field to reduce the risk of infestation.
- Traditional pest control system such as use of local herbs, mixing ash with grain and smoking are effective and should be encouraged.
- Making use of grain storage insecticides like
    - *Contact poisons* such as dust, dispersible powders and emulsions (Malathion),
    - *Fumigants:* Gases which can penetrate bulk of grain but should be used by trained personnel.

FUNGI

- Fungi produces metabolites like aflatoxin, zeara-lenone. The fungus development occurs in the stored feed ingredients in cases of
    - Inadequate drying,
    - Due to high humidity and
    - Due to wetting.

Control

- Losses due to fungi can be reduced by applying drying and storage technology.

RODENTS

- Rodents not only consume food but also foul with their excretions. Further they destroy containers by gnawing holes that results in leakage and wastage of grain.

Control

- Rodent exclusion efforts in store construction.
- Improved sanitation.
- Fumigation with phosphine and other gasses.
- Trapping and hunting.
- Use of cats and dogs.
- Rodent repellants.
- Poison baiting with chlorofacinone, warfarrin, coumarin, zinc phosphate, barium carbonate etc.

Dose

- In acute case :
    - Zinc phosphide
    - Calcium cyanide 0.5%
    - Aluminium phosphide
- In chronic cases:
    - Warfarin 0.05%
    - Coumarin

CHEMICAL AND ENGINEERING FACTORS

Chemical factors

- The pesticide residue in the produce will effect the feed value and detoriations occur during storage.
- Hence, care should be taken for correct dose of spraying pesticides and also avoiding spray at the late stages of maturity.

Engineering factors

- Engineering factors refer such as storage structures (bag or bulk storage), mechanical (conveying of produce, threshing and shelling).
- During these process grains are broken and may result in rapid spoilage during the storage.

DESIGNS OF STORES

- Building for the storage of feeds and feed ingredients must be watertight. The roof walls, doors, windows and floor must be leakproof.
- The floor must not transmit water vapour from the soil. Doors, windows should be sealable in order to permit control of ventilation.
- Building must have devices to protect against the entry of rats and mice and birds (gaps between roof and walls should be sealed with local mud, sheet metal or close netting).
- Pipes, shafts, ducts etc. should be fitted with wide metal guards outside and netting inside.

Essential criteria for safe storage of products

- Entirely weather proof.
- Gas tight to enable fumigation of entire contents.
- Fitted with controllable ventilation.
- Proof against entry of rodents and birds.
- Free from light transmitting areas in the roof in order to avoid high temperature areas on top of stored produce.
- Designed to permit incorporation of few fans in the walls and ducting on the floor for special storage requirement.

MODULE-7: SILAGE MAKING
IMPORTANCE, PRESERVATION METHODS AND ADVANTAGES

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - What is Silage, Ensiling and Silo?
  - Various types of silo and its size requirement
  - Preparation of forage for silage making
  - Common additives/preservatives used
  - Silo filling and sealing procedure
  - Quality characteristics of silage, advantages and disadvantages

SILAGE MAKING

Introduction

- The rainfall in India is seasonal. As a result, abundant grass is available in the rainy season, all of which is not properly utilised.
- We can also produce a good amount of fodder during this season with proper selection of the plant material and proper cultural practices.
- To satisfy the needs of the livestock during the lean months, an adequate amount of the surplus grass available during the rainy season must be conserved.
- The ideal and simple method of conservation is to drive off the moisture in the fresh grass with artificial heat and store the product as dried fodder for use when required.
- Unfortunately, considerable capital expenditure is involved. In practice the moisture in grass is reduced through exposure to sun and wind, and hay is obtained. This process is simple in theory but is fraught with difficulties in practice.
- To combine cheapness and simplicity, and yet to ensure at the same time a product of high feeding value and virtually independent of weather conditions.
- For this, natural fermentation must be used and the process of ensilage adopted. There lies the choice of the farmer - hay or silage.

SILAGE

- 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.

Click here for video...

Ensiling / Ensilage

- 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

- 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.

CHARACTERISTICS AND VARIOUS TYPES OF SILO PITS

- The size should be decided on the basis of the number and kind of animals to be fed daily, the length of the feeding period, and the amount of forage available for ensiling.
- Silos should exclude air from the stored material including entrance of air around the doors of tower soils.
- The side walls should be straight and smooth in order to prevent the formation of air pockets which may retard the normal microbial fermentation.
- Silos should be of adequate depth, thereby making for better packing and less surface area to total mass exposed.
- The walls should be strong and rigid in order to withstand the pressure which develops inside the pit as fermentation take place. Note that silage made from cut grass will exert from a 1/2 to 2 1/2 times as much pressure on the walls as does maize silage. Reinforcement of walls will be desired.
- That adequate provision be made for the escape of surplus juices, either by a drain or by a gravel bottom.
- That it be conveniently located and accessible in all kinds of weather, from the standpoint of both filling and feeding.
- That silo pits (not tower type) are always located preferably at the highest spot on the farm to avoid water seepage.

CHARACTERISTICS TYPES OF SILO

- The kind of silo and the choice of construction material should be determined primarily by economics. Silos may be classified as follows:
- Conventional upright (tower)silos
    - Concrete stave (thin strips of concrete set edge to edge to form the wall).
    - Wood stave
    - Tile block
    - Brick
- Gastight (oxygen - limiting)silos
    - Concrete stave
    - Brick
- Pit silos
- Horizontal silos
    - Trench silos (below ground level)
    - Bunker silos (above ground level)
- Temporary silos
    - Plastic or polythene bag silos
    - Modified trench - stack silos

Conventional upright (tower) silos

- 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 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.

Gastight silos or airtight or sealed silos

- These silos resemble conventional tower silos, but they are more expensive because of their construction to make the tower completely free from oxygen. Gastight silos are designed for forages having as high as 50-75 per cent dry matter or for the storage of high moisture grain containing 60-75 per cent dry matter.

Pit Silos

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

Horizontal Silos

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 silos

- 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.

Click here for video...

SIZE OF SILOS FOR CONSTRUCTION

Number of adult cow	Diameter of silo (metre)	Height of silo (metre)	Tonnes of silage

12	3.05	7.93	39.4
20	3.66	8.23	56.4
30	4.27	9.14	84.6
50	5.49	10.68	141.0
100	6.10	11.89	282.0

CROPS USED FOR SILAGE MAKING

- The most commonly used silage crops are
- Graminaceous
  - Maize, sorghum, sudan grass, bajra, hybrid napier, etc.
  - Out of all, maize and sorghum are supposed to be the best crops for silage making.
- 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. Graminaceous forage crops can be mixed with legumes for making silage of good quality.

PREPARATION OF FORAGE FOR MAKING SILAGE

- Harvest proper stage of maturity
  - The crop for silage making is generally harvested at the flowering stage when it has the maximum amount of nutrients.
  - For *maize* this is the early dent stage (well matured stage, normally harvested for seed) of maturity and for *sorghum* the late dough stage (stage at which the seeds are soft and immature).
  - Silage materials containing less than 25 per cent dry matter (more than 75 per cent moisture) will form a very sour silage and will usually lose significant amounts of silage juices during storage, involving a considerable loss of nutrients. Thus plants for silage making may be allowed to mature till the dry matter content attains *35-40 per cent*.
- Cut to proper length (Click here for video...)
  - The length of the cut sections affects the packing and hence, the quality of the silage. Silage crops usually vary from a fraction of an inch to over an inch in length. Chopping forage crops into 1 to 2 cm length is ideal.
  - Grass silages require to be more finely chopped than maize or sorghum. Wilted and dry forages and forage with hollow stems should be chopped more finely than forage of high moisture content, thus permitting more thorough packing and eliminating most air pockets.
- Control the moisture content
  - Practical experience has indicated that 35-40 per cent dry matter (that is *60-65 per cent moisture*) is very ideal for most crops to be ensiled.

Forage containing more than 60-65 per cent moisture has the following characteristics:

- It is heavier and more costly to handle that is unnecessary ;
- It will produce poor quality silage ie., slimy, putrid silage, due to the presence of butyric acid and other undesirable acids ;
- It will have excessive seepage of the juices and some loss of nutrients, except carotene, from the silo;
- It will result in excessive deterioration in the silo walls due to the high acidity;
- It will exert high pressure on the silo walls.

The high moisture content of the silage may be lowered by any one or a combination of the following methods:

- Conditioning - wilting:
  - The method is suitable for making of grass silage. Conditioning and/or wilting for three to four hours on a good drying day may reduce 10-15 per cent reduction of moisture content.
- Adding dry hay or straw:
  - During poor wilting weather, the moisture content of grass forage can be reduced within the desired range by adding 5-20 per cent straw.
- Combining high and low moisture crops:
  - By mixing at a calculated ratio between high and low moisture crops, the forage may be made into a desired moisture content.
- Addling dry preservative:
  - Dry preservatives as ground grains, maize and cob meal, dried molasses etc. will reduce moisture content.
  - If the crop is over-ripe and too dry when cut, or if it becomes over-wilted, it will be necessary to add water to the silo after fine chopping and during packing.
- Additives or preservatives:
  - Addition of additives or preservatives serve one or more of the following purposes:
    - Add nutrients.
    - Provide fermentable carbohydrates.
    - Furnish additional acids.
    - Inhibit undesirable types of bacteria and moulds.
    - Reduce the amount of oxygen present, directly or indirectly.
    - Reduce the moisture content of the silage.
    - Absorb some acids which might otherwise be lost in seepage.
    - Increase nitrogen content.

COMMON ADDITIVES / PRESERVATIVES USED

- Molasses:
  - Some green forages such as legumes and certain grasses are rather low in sugar content.
  - Adding molasses definitely improves the quality of silage by increasing lactic and acetic acid production. It also increases the palatability and nutritive value of the silage.
  - Molasses may be added (3.5 to 4 per cent of the green weight of the forage) in either liquid or dehydrated form.
  - Molasses and starches when added in the form of grains supply the silage bacteria with ample food so that fermentation proceeds normally.
- Urea:
  - Adding urea at a level of 0.5 per cent of fresh forages is recommended.
  - The very idea of adding urea is to enrich the silage with nitrogen as cereal forages are mostly deficient in this element.
- Limestone:
  - This is calcium carbonate and may be added at a level of 0.5 to 1.0 per cent to maize silage to increase acid production.
  - It neutralizes some of the initial acids as they are formed allowing the lactic acid bacteria to perform longer and to produce more desirable acids.
- Sodium metabisulphite:
  - Sulphur dioxide (SO_2 a gas) is a very good antibacterial preservative. It also improves carotene content.
- Organic acids:
  - Propionic and formic acids are used for enhancing preservation of forages without the loss of palatability.
  - These are costly and when added, the following guidelines may be observed:

        - Add 1 per cent propionic acid to the forage in the field at the time of harvest or at the chopper.
        - Limit the presence of oxygen by using a sound well built silo.
        - Prevent dilution of organic acid treated silage by rain and cover it with plastic when it is stored outside.
- Bacterial cultures:
    - Silage preservatives containing cultures of acid - forming bacteria like Lactobacillus acidophilus, Torulopsis sp., and Bacillus subtillis, are added to silage crops.
    - The basis for including these as a preservative is to provide an inoculum or to increase the number of bacteria for helping rapid fermentation.

SILO FILLING AND SEALING

- Once silo filling is started, it should be rapid, say within two days or less. For creating the desired type of anaerobic condition inside the silo, the forages during filling should be compressed. Never fill a silo when it is raining.

Distribute forage uniformly in the Silo:

- Again in order to avoid the presence of air pockets and spoilage, chopped forage should uniformly be distributed in the silo and packed well.

Sealing of Silo:

- For maintaining the silo anaerobic it is a must to stop the entrance of atmospheric air in the silo.
- This may be done as follows :
    - Level the top and tramp the last few feet, especially near the walls.
    - Cover the top by using any type of insulator like mud, plastic or loose earth.
    - For bunker or trench silo apply sufficient load on top to facilitate compactness.

Click here for video...

WHEN TO OPEN THE SILO?

- Within a period of *two to three weeks* the forages will be converted into silage. Depending upon the type of the crop used for ensiling, addition of additives, packing and sealing of the silo pits and the atmospheric condition, the duration of silage getting ready may vary.
- However a maximum of 6 - 8 weeks is enough for the anaerobic fermentation of the forage crops to get itself converted into a good silage material.
- The silage may be taken out of the silo from the top in case of tower and trench silos and from the front side in case of a bunker silo. After opening it becomes necessary to feed a pit completely.
- A two to four inch layer of silage must be removed daily. In case the silage is not used for livestock feed immediately after its preparation, the accumulation of by-products of bacterial metabolism will tend to preserve the forage material as silage for an indefinite period unless air is permitted to enter.

QUALITY OF SILAGE

- Very good silage
    - It is clean, the taste is acidic, and has no butyric acid , no moulds, no sliminess nor proteolyses.

    - The pH is between *3.5 and 4.2*. The amount of ammoniacal nitrogen should be *less than 10 per cent* of the total nitrogen.
    - Uniform in moisture and green or brownish in colour. Taste is pleasing, not bitter or sharp.
- Good silage
    - The taste is acidic. There may be traces of butyric acid. The pH is between *4.2 and 4.5*.
    - The amount of ammoniacal nitrogen is *10-15 per cent* of the total nitrogen. Other qualities are same as that of very good silage.
- Fair silage
    - The silage is mixed with a little amount of butyric acid. There may be slight proteolysis along with some mould. The pH is between *4.5 and 4.8*.
    - Ammoniacal nitrogen is *15-20 per cent* of the total nitrogen. Colour of silage varies between tobacco brown to dark brown.
- Poor silage
    - It has a bad smell due to *high butyric acid* and high proteolysis. The silage may be infested with moulds.
    - Less acidity, pH is *above 4.8*. The amount of ammoniacal nitrogen is *more than 20 per cent*. Colour tends to be blackish and should not be fed.

ADVANTAGES OF SILAGE

- Green fodder can be kept in a succulent condition for a considerably long period. Silage furnishes high quality forage in any desired season of the year at a low expense. As there is an acute shortage of green fodder during the summer months, silage can meet this deficiency during that part of the year.
- *Grass silage preserves 85 per cent* or more of the feed value of the crop, whereas hay making will preserve significantly less percentage of nutrients.
- It is the *most economical form* in which the whole stalk of maize or sorghum can be processed and stored. On the other hand, a considerable part of this crop is wasted during the course of feeding in dry condition even if it is of good quality.
- During the monsoon months, it becomes exceedingly difficult with dry grasses for making hay. Preserving the fodder as silage avoids this difficulty.
- Weed species which tend to make poor hay may produce silage of good quality. The ensiling process kills practically all weeds that are present in the field because of their harvest before seed formation and thereby stopping dissemination of their seeds.
- Silage is a very palatable feed and slightly laxative in nature.
- It is a better source of protein and of certain vitamins, especially carotene, and perhaps some of the unknown factors, than dried forage.
- Wastage of the plant is less as the whole plant is being consumed for ensiling, which is an important consideration with coarse, stemmy forages.
- The produce from a given area can be stored in less space than dry fodder of the same quantity. A cubic foot of silage contains about *three times* more dry weight of feed than a cubic foot of long hay stored in the mow.
- It offers many advantages over pasture, including:
    - No fencing required,
    - Approximately one-third more forage from the same acreage,
    - Harvesting at optimum maturity,
    - More uniform quality, and
    - Closer observation of animals that are confined to a lot.
- It helps to control weeds, which are often spread through hay or fodder.

DISADVANTAGES OF SILAGE

- It requires a silo (a permanent structure) in comparison with the simpler methods of field curing and storing hay, this is likely to mean higher costs for small farmers.

- Wastage my be more, if silage is not properly made.
- Poorly prepared silages are not accepted by animals.
- It possess considerably less vitamin D than sun-cured hay.
- Ensiling incurs an added expenditure when preservatives are necessary.
- Extra labour is needed at silo filling time.
- Transportation problem is generally experienced in silage than that of hay.

WASTELAGE

- A material obtained after ensiling of waste material (animal organ waste) in a suitable combination with forages and additives, under anaerobic condition through fermentation by lactic acid producing bacteria.
- Except for this, the other steps in the preparation of wastelage is similar to that silage.

MODULE-8: HAY AND WASTELAGE MAKING
IMPORTANCE, PRESERVATION METHODS AND ADVANTAGES

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - What is hay and what are the requisites of good quality hay?
  - Types of hay.
  - Steps in the preparation of hay making.
  - Losses of nutrients in hay making.

WHAT IS HAY?

- Hay refers to grasses or legumes that are harvested, dried and stored at *85-90 percent dry matter*.
- In other words, Hay refers to a forage plant when preserved through reducing the moisture content to the level at which tissues are dead nor dormant.
- High quality hay is green in colour, leafy and pliable and free from mustiness.
- When harvested in the proper physiological stage of growth and well cured to *15 per cent or less moisture* at the time of storing, hay can be utilized as an excellent feed for dairy cattle, particularly when fodder is scarce or pasturage is insufficient.

PRINCIPLES OF HAY MAKING

- The principle involved in hay making is to reduce the water content of the herbage so that it can safely be stored in mass without undergoing fermentation or becoming mouldy.
- This must be accomplished in such a manner that the hay is not leached by rain and that the loss of leaves is kept at a minimum.

Requisites of good quality hay

- Good hay should be leafy. It has been found that leaves are richer in food value compared to other parts of the plant. The leaves are generally rich in proteins, vitamins and minerals. Loss of leaves in hay making would mean deterioration in feeding value of the ultimate product.
- 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. Delay in cutting would mean losses of a part of nutrients which would be used up by the plant in seed formation.
- It should be green in colour. The green colour of leaves indicates the amount of carotene which is a precursor of vitamin A.
- It should be soft and pliable.
- It should be free from dust and moulds.
- It should be free from weeds and stubbles.
- It should have the smell and aroma characteristic of the crop.
- The moisture percentage in hay should not exceed 15 percent.
- Hay of average quality will usually have 25-30 per cent crude fibre and 45-60 percent TDN.
- Hay is primarily feed to cattle, buffalo, horse, sheep and goat. Very little of hay of any kind is ever fed to swine.

TYPES OF HAY

- The hay depending on the various ways of processing can be divided into the following categories.
    - Jungle hay
    - Sundried hay
    - Barn dried hay
    - Dehydrated fodders
- Jungle hay and Sundried hay mostly refer to the field curing.
- Barn refers to a simple roofed farm building for storing hay.
- Hay is baled in the field and brought to the barn .
- Driers are also used for dehydration.
- Two types of driers are available
    - Low temperature driers, 80 to 180˚C
    - High temperature driers, 300 to 600˚C.

Advantages

- Reduce the cost of transportation to the drying site.
- Drying time is reduced.
- Loss of nutrients due to rains is avoided as the process is performed in a barn.
- Loss of plant parts especially leaves is less to that of field curing.

Disadvantages

- High cost involved during erection of dehydration plant
- High cost of processing if sufficient amount of forage is not available.
- Operation skill is required, unskilled operation may lead to fire hazards.

LEGUME AND NON-LEGUME HAY

- Legume hay
    - Good legume hay has many characteristics that make it of special value to the dairy cattle. It has a higher percentage of digestible nutrients. It has more of digestible proteins because of the high protein content. Furthermore, the proteins of legumes are of superior

quality as compared to proteins from other plants. Well - cured legume hays are higher in vitamin contents. They are particularly rich in carotene and may even contain vitamin D. They are also a rich source of vitamin E. The legume hays are particularly rich in calcium and are generally palatable. Among various leguminous fodder crops *lucerne, berseem, cowpea and soybean hays* are considered first.

- Non-legume hay
  - Non -legume hays made from grasses are inferior to legume hays. They are, as a rule, less palatable and contain less proteins, minerals and vitamins than the legume hays. Non-legume hays have the advantage over legume hays because their output per hectare is more than that of legume hays and the former can be grown easily.
- Mixed hay
  - Hay prepared from mixed crops of legumes and non-legume is known as mixed hay.
  - The composition of such a kind of hay will depend on the proportion of the different species grown as a mixed crop.

STEPS IN HAY MAKING

- Selection of crop and suitable stage of harvest:
  - The quality hay can be prepared from the forages having soft and pliable stem. Oat is the best crop for hay making as the crop has soft and pliable stem. Annual and perennial grasses are also suitable for hay making. Legumes are also used for hay making but the problem of leaf shattering should be taken care of by careful handling. Berseem, lucerne, cowpea, pillipesera etc., can be used for hay making.
  - The crop should be harvested during the day time after the dew has dried off so that plants when spread over the ground may dry evenly. Another factor which needs attention is that the field should not be wet, otherwise uniform drying will not be effected.
  - The crop cut early is higher in protein, lower in crude fibre, contains more of vitamins, is more palatable and leaf shedding will be less. The best time for cutting a crop for hay making is when it is one-third to a half in blossom.
- Selection of suitable method of drying:
  - Quantity of crop available (For a small quantity forage, skilled operation and costly structures would be unsuitable).
  - Duration for which forage is available for hay making (If forage supply is continuous for the hay making at least 300 days in a year, then the dehydrators may be worthwhile).
  - Relative humidity (Field curing is not suitable for hay making if the relative humidity is high which may cause moulds/fungi).
  - Intensity of rains (Rain causes loss of nutrients due to leaching. Continous rains combined with high relative humidity pose a serious problem for hay making).
  - Atmospheric temperature (The intensity and duration of bright sunshine hours decide the atmospheric temperature. During the hot weather period of *March-April to May - June*, hay making through sun drying is very convenient and efficient).
  - Cost of installation (The choice of barns or dehydrators depend on the cost of it. Simple field curing during summer months is cheap and best for the poor farmers with few animals).
  - In curing, it is necessary that the herbage should be saved from bleaching by the sun and as far as possible, leaves preserved from shattering. The maximum quantity of moisture should be evaporated, so that it can be stored without generation of heat and consequent loss of nutrients.
- For reasonably rapid curing and production of high quality hay, it is best to let the herbage lie in the field for a few hours until it is well wilted or about one-fourth to one-third cured. It should be raked into small loose heaps known as *windrows*. If good weather continues, the hay is cured in windrows alone.
- When the weather is such that the hay cures slowly, turning may also be necessary. Besides field curing, hay can be cured by hanging the herbage on tripods, and on farm fences.
- In artificial curing, the material is placed in a suitable chamber where it comes in contact with heated air and exposure is regulated depending on the material and the temperature.

LOSSES OF NUTRIENTS IN HAY MAKING

- Some nutrients are always lost in field curing of hay, but under favourable conditions this loss is not too much.
- Drying of green forage at ordinary temperature reduces its digestibility . If the plants are dried without fermentation or bleaching, they contain a high percentage of nutrients.

- Due to Late cutting:
  - Late cutting means greater lignification and lower carbohydrate and protein digestibility.
  - One disadvantage of early cutting is that we get low yield and high moisture content of the forages meant for hay making.
- By shattering:
  - The loss due to shattering of leaves and finer parts in hay making is of importance, especially in the case of legumes.
  - The leaves are much richer in digestible nutrients than the stem and hence losses by shattering materially decrease the nutritive value of hay. To avoid these losses, hay should never be overdried or handled during warm periods of the day.
- Loss of Vitamins:
  - In the process of drying, much of the green colouring matter containing carotene, a precursor of vitamin A is lost with bleaching.
  - In general, the carotene content of freshly cured hay is proportional to the greenness. With severe bleaching, more than 90 per cent of carotene may be destroyed.
- Losses in Fermentation:
  - In fermentation of hay, some of the organic nutrients like starch and sugars are oxidized into Co2 and water. If drying is prolonged because of unfavourable weather conditions, changes brought about by the activity of bacteria and fungi may occur.
  - Mouldy hay is not only unpalatable but also may be harmful for animals as well as for persons handling the hays due to the presence of mycotoxins. Very often such hays contain actinomycetes, responsible for the allergic condition in man known as "*Farmer's Lung*".
  - One of the ways to prevent the development of mould growth is to spray propionic acid uniformly on entire hay. In general, it is not uncommon to find patches of mouldy hay in a stack resulting from uneven drying.
- By Leaching:
  - If hay is almost cured and is exposed to heavy and prolonged rains, especially when it is in the field, severe losses may occur through leaching.
  - Unless the rain is so heavy as to soak the material, losses by leaching will not occur. For this reason losses will be much less even in heavy rain if the hay is in good sized windrows.

STORAGE OF HAY

- Hay is usually stored in stacks in this country. Care should be taken that the hay is in a good and dry condition before it is stored. It should be stacked in a shady place where there is no danger of fire.
- The stacks should be made at an elevated place. Machines are also available for baling the hay. Baled (a large package or bundle) materials occupy less space.

Brown hay

- Sometimes because of very unfavourable weather conditions, good hay cannot be obtained by the ordinary method of curing.
- Under such circumstances, hay is allowed to dry until about 50 per cent moisture has been removed and then it is packed in stacks or piles.
- Fermentation takes place and the hay may become very hot, the temperature however, should not be allowed to exceed 80°C .
- There are great losses in the nutritive value on account of fermentation. These losses range from 30 to 40 per cent. Such hay is often quite palatable.

MODULE-9: SCARCITY FODDERS

NECESSITY AND VARIOUS TYPES OF SCARCITY FODDERS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - Various types of scarcity fodders,
  - Importance of straw as a valuable feed during scarcity,
  - Possibility of using the Failed crops, Vegetable crop residues, Non traditional plants, Agro industrial wastes and unconventional feeds as scarcity fodder

SCARCITY FODDERS

Introduction

- Scarcity of feeds may result due to either floods or droughts. During 1986-87, 75% of the cultivated area in India was severely affected due to drought and the remaining 25% due to floods.
- Even during normal years, there is *shortage* of animal feeds to the tune of *60% or more*.
- Ruminants, owing to their larger body size, need huge quantity of feed dry matter. They need bulky and fibrous feeds. Roughages are natural feeds for ruminants.
- However, roughages are usually not available in adequate quantity during scarcity. During the scarcity it is important to find out the roughage substitute which will be helpful in providing minimum roughage requirement of animals.

TYPES OF SCARCITY FODDERS

- Failed crops
- Crop residues
- Vegetable crop residues
- Non traditional plants
- Plant oriented wastes
- Agro- Industry wastes and other unconventional feeds

- Vegetable and Animal protein sources

FAILED CROPS

- When ever failure of monsoon occurs, the existing crops fail to grow adequately and such crops can be utilized for feeding the animals under scarcity condition.

Sugarcane:

- It occupies in the country about 2863 thousand hectares of land. Cane byproducts available are
    - Tops and leaves (DCP 2.3 % and TDN 18.8%): 68 million tonnes
    - Bagasse: 15455 tonnes and
    - Molasses: 5152 tonnes
- Sugarcane being deficient in protein and phosphorus, needs to be supplemented with proteinaceous and phosphorus rich feeds. The tops are high in oxalates and must be supplemented with calcium.
- Silage of whole sugarcane as well as tops and leaves can be prepared by adding 0.5 % urea and 1.5 % salt.
- Silage of sugarcane is very useful during extreme summer of drought years. *Ureated silage* provides *4.0% of DCP and 48% TDN* on D.M. basis.

Banana:

- The leaves, stem, flowers etc. are available for feeding to the animals. Leaves and flowers have adequate crude protein content and are high in calcium. They also supply carotene.
- The stem, though low in protein content, can provide bulk to the animals. The stem and bulbs are fed after chopping with sharp blades.

Papaya:

- It is cultivated as fruit crop in many parts of the country. Leaves are high in crude protein and calcium.
- The outer skin is removed off the stem and then fed to the animals after cutting into small pieces.

CROP RESIDUES

- These are available from crops of previous years. It can also be available from the non-drought areas. Apart from the known straws and stovers some other less used crop residues are very valuable during scarcity.
- They can be mixed with concentrate in higher proportion so as to minimise the need for roughage. They can also be used upto 30% level in preparing complete feeds.
- Hulls and husks are fibrous materials and provide bulk to the animal feeds during scarcity. Normally they can be used upto filler 5% level in compounded concentrate mixture as filler materials. However, during scarcity their use should be intensified.
- Mustard plant parts (stem + leaves + pod cover) is a potentially useful roughage source for feeding to animals during scarcity. It is richer in protein and calcium than cereal straws.
- During severe scarcity, stalks of cotton, pigeon pea and other similar crops can also provide bulk to the animals in satisfying hunger of large bovine population. They can be fed after grinding and mixing with concentrate and roughage or by incorporating them in complete feeds.
- Crop residues such as straws of wheat and paddy are also not utilized efficiently during normal years. Under normal years, if straws are properly stored in the fodder bank, then they will be very useful during drought.

- Improvement of straw by urea treatment or by supplement of urea will be useful during drought. Straws with thick stems such as sorghum, pearl millet etc. must be chopped before feeding. Chaffing reduces the wastage to the tune of 15 to 20%.
- Some facts and figures about straw
    - Burning of a hectare of straw from a average rice crop of let us say 3000kg paddy results in the loss of
        - 4000kg x 0.6 % N = 24 kg of Nitrogen in the smoke the equivalent of almost 50 kg of urea.
    - Export of the bran results in the loss of 300 kg bran of 10% protein, i.e. 5 kg of nitrogen, leave alone the other nutrients like P and K.
    - If a cow of 300kg body weight can eat approximately 5 kg dry matter of straw per day, the same quantity of 4000 kg straw provides for 800 days animal feed.
    - The quality of particularly slender straws like from rice and wheat is not good enough to keep the animal alive over a long period, but the quantity is large and the value of the straw yield can represent between 10-15% or higher of the total crop value

VEGETABLE CROP RESIDUES

- The vegetable crop residues are grown wherever irrigation facilities are available. The crop residues of vegetables such as cabbage, cauliflower, sweet potato creepers, potato tops and leaves, pod covers of legume crops etc. are available in large quantity. They can be used effectively during scarcity.
- The residues of vegetable crops contain high crude protein (11-20%) and calcium and low in fibre. Being green they also provide carotenes.
- *Cabbage and cauliflower* are high in *molybdenum* content (6.1 and 1.1 ppm respectively) hence they should be fed in limited quantity along with some dry fodder so as to avoid problem of digestive disorders. Before feeding such residues, it is essential to ensure that such feeds are free from harmful level of pesticide residues.

NON-TRADITIONAL PLANTS

- Certain plants which come up with little rains in the beginning of monsoon can be used for feeding animals during severe scarcity periods.
- Cassia tora plants, even when young, are not palatable to cattle and buffaloes. However, silage of cassia tora is quite palatable to the animals. The silage can be prepared by adding 1.5% salt and 1.5 % molasses. Animals can consume daily 20kg of silage.
- Some dry fodders should be given with silage. The silage provides 6.3% DCP and 47.2% TDN on DMB. The silage of cassia tora is very useful during scarcity conditions.
- Cactus has been used as fodder for animals during scarcity in the past. After burning the thorns, cactus can be fed to cattle and buffaloes.
- One kg of cactus is equivalent to 1 kg of grass in DCP and 1.5 kg of grass in net energy on DM basis. Cactus can be fed after chaffing and mixing with wheat straw or feeding it with cotton seed hulls.
- Water hyacinth grows abundantly in ponds and stagnant water. It is high in crude protein but contains high amounts of oxalic acid (3.6%).
- Feeding of fresh leaves causes diuresis and diarrhea. Water hyacinth in hay form is not quite palatable but when mixed with 20% molasses the animals consume the mixture slowly. The hay of water hyacinth has 4.1 DCP and 48.1 % TDN.
- The silage (water hyacinth + 1 part paddy straw and 4.2% salt) provides 5.6% DCP and 40.3% TDN on DMB. There is no adverse effect of feeding of water hyacinth to the animals nor adverse effect on milk flavour noticed.
- However, water hyacinth absorbs heavy metals, it is advisable to feed limited quantity along with dry roughages to the animals.

PLANT ORIENTED WASTES

- Saw dust is one of the important sources of feed during acute scarcity. It is highly lignified and has very low digestibility. However it can provide bulk to the animals.
- Saw dust after cleaning to remove wood pieces will be suitable for animal feeding. Saw dust feeding at the rate of 30% level in high urea-molasses and maize bran ration had no deleterious effects on body weight, digestibility and balance of nutrients. Saw dust thus, is a useful source for short term feeding of animals during acute scarcity atleast for satisfying hunger.
- Paper is also considered as a scarcity fodder. Papers are made up of cellulose. Since they have lower lignin content their digestibility is around 50-60%.
- The stray cattle usually eat paper wastes. In developed countries waste paper are not resaleble. After grinding, paper waste can be used between 20-40% in concentrate mixture. Such mixture improves milk fat content without affecting flavour and quality of milk. The improvement in fat content is attributed to carbon ink used for printing and high crude fibre content of the paper. Paper waste upto 30% level can be used in complete feeds.
- Fallen dry leaves from forest or road side trees can also be used for feeding to the animals. They are especially valuable during scarcity as without disturbing the trees, they can be collected and utilized for animal feeding.
- The dry fallen leaves contain low crude protein than fresh leaves but higher than that of the cereal straws. However, their digestibility is lower than that of cereal straws probably because of higher tannin content. They are also higher in calcium. In order to improve the nutritive value of dry fallen leaves, they can be ground and mixed with molasses, urea, salt, mineral mixture etc. in complete feeds.

AGRO-INDUSTRY WASTES AND OTHER UNCONVENTIONAL FEEDS

- Besides tree leaves as roughages, other byproducts such as flowers, fruits and pods can also be sued as cattle feed. Important trees where byproducts can be exploited are subabul, mango, tamarind etc. The ground pods (Prosopis juliflora) can be used upto 30% level in concentrate of milch cow.
- Mango seed, mango seed kernels (1.1 DCP and 73.7% TDN) are generally available in summer season and can be used upto 10, 20 and 40% in concentrate part of the ration for milk production, growth and maintenance.
- Subabul seeds can be used as part of the ration for feeding the livestock. The seeds have 19.6% DCP and 68.4% TDN on DMB. The seeds contain higher amount of mimosin (3.1%) hence the use should be restricted. Other materials such as tomato waste, neem seed cake, etc. will also be useful during scarcity.
- The importance of utilising the unconventional feeds to augment the existing resources of conventional livestock feed was recognized more than 30 years ago. India is facing a shortage of animal feeds and fodder in terms of nutrients.
- Moreover, this condition aggravates due to natural calamities like drought and flood. Recent studies indicated that quite a large number of agricultural by-products and industrial waste materials could be used for feeding livestock. Some of the unconventional livestock feeds used in India are described below in four groups :
    - Vegetable protein sources
    - Animal protein sources
    - Energy sources
    - Other miscellaneous unconventional feeds

USE OF MOLASSES

- The different types of molasses are similar in feeding value and are available in both liquid and dehydrated forms. Molasses is usually used in rations for cattle, buffaloes, sheep and horses. Advantages of molasses are
    - As a source of energy

- As an appetisor
- To reduce the dustiness of a ration
- As a binder for pelleting
- To stimulate rumen microbial activity
- To supply unidentified factors
- To provide a carrier for NPN and vitamins in liquid supplements
- In the case of cane molasses, to provide trace minerals
- In ruminant rations, molasses is restricted to the level of 10-15% of the ration. Excessive amounts of molasses (greater than 15%) will cause the feed to become messy as well as create digestive disturbance along with disrupted rumen microbial activity.
- Poultry are rather sensitive to molasses as excess levels cause diarrhoea. Levels are restricted to 2-5%.

VEGETABLE PROTEIN SOURCES

- Sunflower Meal
  - Work on Sunflower seed oil meal in India is limited but studies abroad indicate that decorticated sunflower seed oil meal in combination with other protein supplement is good for poultry.
  - Good quality sunflower meal contains about 40-44 per cent high grade protein especially rich in methionine, but that made from unhulled seed has only 20 per cent protein. Sunflower seed meal is a satisfactory substitute to groundnut cake in starter rations and it can replace 100 per cent GNC without any adverse effect on weight gain and feed efficiency. The meal can also be satisfactorily used in layers' ration. Studies indicated that it could be used in total replacement of groundnut cake without any adverse effect on egg production and egg weight.
- Guar Meal
  - Guar is a drought resistant legume, and the meal, a by-product from the preparation of Guar gum, is a potential source of protein. Guar meal is not palatable to cattle since its inclusion at a meagre 5 per cent level itself was refused at the initial phase by cows, although if accustomed, cows can accept rations containing as high as 15 per cent raw guar meal.
  - Higher levels of guar meal may cause, diarrhea, particularly in young calves. It is, therefore, always advisable to incorporate guar meal in the ration very gradually and once accustomed may be used as high as 10-15 per cent level in cows and 5-10 per cent level in calves.
- Niger Cake
  - Niger cake compares well with other oil seed cakes in its chemical composition. It contains about 36 per cent crude protein and 5.98 per cent mineral matter, but contains about 14 to 18 per cent crude fibre.
  - It is suggested that niger cake can completely replace groundnut cake on protein equivalent basis for the growing chicks and the two oil cakes have a complementary effect on chick growth with better efficiency in economics of feeding.
- Karanja Cake
  - Karanja cake is less palatable. It contains probably some polyphenolic compounds which have a deleterious effect on growth and production.
  - Extracted karanja cake can be included in the ration replacing til cake to the extent of 30 per cent on protein equivalent basis in starters and growing chicks (18 week) with distinct economic advantage.
- Neem Cake
  - The potential production of neem seed is estimated at 4.15 lakh tonnes. This can give 3.3 lakh tonnes of cake and 83,000 tonnes of oil every year provided this potentiality is fully utilized .

- Neem cake contains 34 per cent protein while processed cake shows 48 per cent protein. Fibre content is only 4.4 per cent. The amino acid content in terms of lysine and methionine is also comparable to groundnut cake protein.
- It is observed, however, that if this cake is introduced gradually then it can be included in the cattle ration about 15-20 per cent level. A few animals, however, may be reluctant to consume feeds at this level. 1 per cent inclusion, however, is a safe level.

- Rubber seed cake
  - Rubber seed meal contains some cyanogenetic components. A good quality rubber seed cake contains about 30 per cent protein.
  - It can be used in lactating cows at 20 per cent level in concentrate mixture. Rubber seed cake can also be used at a maximum level of 10 per cent in poultry ration without any adverse effect.
- Sunnhemp seed
  - The seed is grown throughout India but in most cases this is used as manure. In some parts, however, this is fed as fodder.
- Dhaincha seed
  - This is a leguminous seed and is excellent in protein quality. It contains 30-33 per cent protein, and 8.32 per cent and 1,019 g / 16 g N lysine and methionine respectively.
  - The seed cannot be used as such, as it contains deleterious factors like gum, trypsin inhibitor and tannin. Enzymic treatment as in the case of guar meal can improve the feeding value of this material.
  - Fermentation by fungi decreases the gum content and trypsin inhibitory activity appreciably and increases the crude protein content of the seed.
  - Studies with dhaincha seed in cattle is limited. However, autocalved dhaincha seed may be used in cattle in limited quantities.
- Cassia tora seed
  - Boiled cassia tora seeds up to the level of 15 per cent in the concentrate ration can safely be fed to milch cows.
- Kapok seed cake
  - It can be used as one of the components of cattle feed concentrate; D.C.P. and T.D.N. being 26 per cent and 69 per cent approximately.
- Corn gluten meal
  - This feed consists chiefly of the dried residue from maize after the removal of the larger part of the starch and bran by the process employed in the wet milling manufacture of maize starch. Occasionally it may include maize oil meal. It contains protein from 50 to 60 per cent.
- Safflower meal
  - The meal is produced after removal of most of the hull and oil from safflower seed. In decorticated form it has about 40-45 per cent protein while the value goes down to about 18-20 if not decorticated.

ANIMAL PROTEIN SOURCES

- Incubator Waste or Hatchery By-product Meal (HBPM)
- Liver Residue Meal
- Frog Meal
- Dried Poultry Manure
- Cow Dung Meal (Cow Manure)
- Shrimp Shell Powder (Prawn Waste)
- Crab Meal
- Poultry By-product Meal
- Hydrolysed Poultry Feathers
- Squilla Meal
- Processed Fish ensilage

ENERGY SOURCES

- Sal Seed Meal
- Cassava (Tapioca) Root
- Tapioca Starch Waste
- Tapioca Thippi
- Tapioca Milk Residue
- Palm Flour
- Tamarind Seed Powder
- Triticale
- Mango Seed Kernel
- Oak Kernel

OTHER MISCELLANEOUS UNCONVENTIONAL FEEDS

- Sea Weed Meal
- Babul Pods (Acacia arabica)
- Rain Tree Pods
- Jack Fruit Waste
- African Payal (Salvinia molesta)
- Sugar Cane Bagasse
- Sugar Beet Pulp
- Sugar Cane Tops
- Papaya
- Petro - Protein

MODULE-10: ENRICHMENT OF CROP RESIDUES AND PROFITABLE UTILIZATION AS ANIMAL FEEDS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - The potential of paddy straw, wheat straw and ragi straw as livestock feed.
  - How to increase the digestibility of straw?
  - How to increase the nutritive value of straw?
  - Advantages of urea treatment.

ENRICHMENT OF CROP RESIDUES AND PROFITABLE UTILIZATION AS ANIMAL FEEDS

Introduction

- Though much of today's livestock in India survives on crop residues, this has not always been so. Early Aryans cultivated crops in the forested Gangetic plains and herd their animals, on grassy areas or in the forest.
- Nowadays little forest is left in those Gangetic plains. In many of the villages in India, we have witnessed that the animals are brought to far off places by the Herdsmen for the purpose of grazing during day times.
- At the end of the day the animals will be again taken back to the place of rearing. Such practice meet the forage requirement of the animals to some extent. However, the same can not be continued for a longer period without any special care given to the grazing resources.

SCOPE OF CROP RESIDUE UTILIZATION

- Changing resource/demand patterns force society to look for other ways to produce. These shifts in resource use (e.g. between grazing- based and straw - based feeding systems) reflect shifts in the relative scarcity of resources used in production.
- This is clearly seen now where rapid increases in agricultural productivity and output in Punjab and Haryana has led to labour shortages and increased wage rates, leading to innovations in labour - saving mechanical technologies (such as tractor ploughing and combine harvesting) and chemical technologies (use of herbicides to reduce weeding labour).
- The same parallels can be applied to the livestock sector where increasing scarcities of common grazing lands led to increased reliance on feeding of crop residues and by-products. In present days it has become difficult to let the animals graze on common grounds, village land and forests.
- There is even a feeling that a cow that used to provide wealth and power, now costs money and feed to maintain. From being a "kamdhenu", i.e. the cow that provides all the needs, livestock are slowly but surely becoming a burden.
- Feed needs now to be purchased and straw has to be stored and kept for feeding, whereas in the past the straw was often left in the field or burned.
- From these examples, it becomes clear that fibrous crop residues (straws) are becoming the basal feedstock for the survival of many village animals. Also in cities the straws become expensive as source of fibre for high producing animals.
- The more valuable crop residues like brans and oilcakes are increasingly being taken to urban centres where they serve as feed for high milk producers or for pigs and poultry. Also, they are exported to other countries, depriving the place of origin from valuable minerals and a possibility to add value.

THE POTENTIAL OF STRAWS

- Large quantities of straw are available from cropping, and one hectare yield of rice straw can essentially support the energy needs of one small 350 kg animal for something like a year, though yields and qualities of straw vary.
- Whereas the nutritive value of wheat and rice straw is not good enough to provide maintenance requirements, the use of coarse straws e.g. from maize, millets and sorghum may allow animals to survive and maintain body weight.
- In absence of better feeds, the proper use of crop residues can therefore help to maintain more animals, and to retain more nutrients and income in the village.
- Fortunately, the yield of straw from fertilized and irrigated area may be higher than the yield of fodder from the natural vegetation.
- Unfortunately however, the nutritional value of straws is likely to be less than that of green leaves from forest or grazing.
- As a result, the quality of the feed resources tends to decline. Many ways to overcome these problems are discussed in this lesson.

PADDY STRAW

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- Rice straw is used as feed for ruminants and for many other uses like manure, thatching, paper pulp, alcohol, mats, poultry litter and mushroom production.
- Besides the straw, rice also produces rice polish, rice bran and rice husk. On an average, there is 20% husks, 10% bran, 3% polishings, 1- 17% broken rice and 50-66% polished rice.
- Rice straw is fed to cattle and buffaloes in India since ages. Though rice and wheat straw on average have a similar nutritive value according to laboratory analysis, in some parts of the country like Punjab, Haryana and Western Uttar Pradesh, wheat straw is preferred over rice straw. In rest of the India, paddy straw is fed to animals.

Chemical composition of rice straw (% on dry matter basis)	
Organic matter	82
Crude Protein	4
Crude Fibre	37
Non Fatty Ethers	43
Total ash	18
Calcium	0.14
Phosphorus	0.05
Neutral Detergent Fibre	75
Acid Detergent Fibre	75
Cellulose	54
Lignin	8
Silica	8

- Rice straw is poorly palatable and its intake by animal is low. However , the intake of straw depends on straw type (coarse, fine, long, dwarf, leafy, steamy, fresh, stored, hard , soft), animal species and breed, body weight of animals, other feed in the ration, physiological state, climatic stress etc.
- In general, fine (slender), soft, long, leafy and stores rice straw is preferred by animals.

WHEAT STRAW

- Wheat straw contains on dry matter basis:

Wheat straw contains on dry matter basis	
NDF	72-76%
ADF	44-49%
Hemicelluloses	25-29%
Cellulose	35-43 %
Ash	7-8 %
Crude protein	3-4%
Lignin	6-8%

- Leaves are always better than stems, and straw on the average contains 87-93% dry matter when dry, depending on environmental conditions.
- The digestibility is around 40-43 % and intake is 1.5-8 kg /100 kg body weight in adult and 1.8-2.2 kg/100 kg body weight in growing heifers, of course depending on the level of production.

RAGI STRAW

- Feeding trials on finger millet straw conducted at NDRI (Bangalore), showed considerable variation in chemical composition and in intake.
- The accessions from Indian and African origin differed in organic matter, crude protein and cell wall content, within as well as between origins. Organic matter and cell wall digestibility varied among cultivars.

Chemical composition of Ragi (finger millet) straw	
Chemical composition	**(%)**
Organic matter	89-92
Crude protein	3-5
Crude fibre	34-39
Cell solubles	10-21
Water solubles carbohydrates	3-6
Calcium	0.7 -1.2
Phosphorus	0.05-0.21
Intake (kg DM per 100 kg BW)	
Bullocks	1.6
Heifers	1.7
Milch animals	2.0

ENRICHMENT METHODS

- Large quantities of straw (Rice, Wheat, Ragi, Oats and stovers of Maize, Cumbu, Sorghum) available in India are of poor nutritive value.
- The quality of such straws need to be improved to have a balanced ration to the animals and to supplement the major roughage requirement of the Indian livestock.
- There are three methods of crop residue enrichment
    - Ammoniation
    - Urea molasses mixture
    - Urea enrichment

INCREASE THE DIGESTIBILITY

- The *alkali treatment of straw* increases the digestibility. Alkali dissolves lignin, silica and hemicellulose. However Cellulose is not dissolved by alkali but the Cellulose swell when treated with alkali.
- For the alkali treatment, the straw can be sprayed with NaOH about 3 - 6 grams / 100 grams of straw.

INCREASE THE NUTRITIVE VALUE

- Increase the nutritive value. (Enrichment of Straw or Fortification):
    - Ammoniation

- Urea/Molasses mixture
- Urea enriched paddy straw

AMMONIATION

- Ammoniation is technique by which the poor quality crop residues can be improved and made more palatable. The steps involved are
  - *Chaff the crop residues :* Crop residues are cut into pieces of 2 to 3 cm length.
  - Dig a circular pit on an elevated place.
  - Add 35 to 40% water to moisten the crop residues.
  - Fill the moistened crop residues in the pit and apply 2.5 to 3.0% liquid ammonia.
  - Cover and seal the pit with a plastic sheet.
  - Open the pit after 30 or 35 days by which time the feed is ready for livestock.
  - For daily use, required quantity of the ammonia treated forage can be removed from the pit and kept in the open for over night before feeding. This will help to evaporate excess quantity of ammonia.

UREA-MOLASSES MIXTURE

Required inputs

S. No	Contents	Quantity (in kg)
1	Urea	1.5
2	Water	1.5 to 2
3	Molasses	10
4	Salt	1
5	Mineral mixture	1

Preparation of mixture

- Dissolve 1.5 kg urea in 1.5 kg water.
- Stir well till the urea is dissolved.
- Add 10 kg molasses and mix thoroughly.
- Finally add 1 kg salt and 1 kg mineral mixture and mix thoroughly.
- This mixture should be stored in a covered earthen pot for a period of one month.

Method of feeding

- Take 1/2 kg of the mixture each day and mix it with 2 kg of water. Sprinkle the solution on atleast 5 kg of chopped straw. The urea mixture must be thoroughly and evenly mixed with straw.
- After 20 days the use of mixture may be increased to 3/4 kg and used as above. This mixture can also be used for chopped green fodder (grasses and cereals).

Precautions

- The urea mixture must not be fed to animals less than 4 months old. Animals starts ruminating only after 4 months.
- The mixture must not be kept for more than one month.
- Animals should not be fed more than 3/4 kg of the mixture / day.
- The mixture must be stored in covered earthen pot.

UREA ENRICHED PADDY STRAW

Required inputs

- Paddy straw: 100kg
- Urea: 4kg
- Clean water: 65 litres
- Sprinkler

Steps in the preparation

- For enrichment of 100 kg of paddy straw.
- Dissolve 4 kg urea in 65 litres of water
- Spread a polythene sheet/Gunny bag on the floor. Initially spread 5 kg of paddy straw in layers.
- Using the sprinkler, sprinkle the prepared urea solution over the paddy straw ensuing that all the paddy straw is wet by it.
- Similarly spread another layer of paddy straw over the first layer and repeat the sprinkling of urea solution.
- Repeat the spreading and sprinkling for the entire 100 kg of paddy straw and heap it and cover the straw with polythene sheets to prevent the escape of ammonia liberated from urea. This step facilitates the breakage of lignocellulose bond by ammonia thereby releasing cellulose from lignin bondage for easy digestion and more utilisation.
- After 21 days the urea treated paddy straw is ready for feeding.
- The urea enriched paddy straw, may be left in the open for 5 minutes prior to feeding in order to remove the pungent odour of urea.
- It is advisable to feed the urea treated Paddy Straw for calves above 6 months of age

Advantages of urea treatment

- Total digestible nutrients (TDN) increased from 45 to 60%.
- Crude Protein (CP) increased from 2% to 10%.
- Palatability increased therefore feed intake increases.

MODULE-11: FEED AND FODDER MANAGEMENT FOR INDIVIDUAL ANIMALS

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - Feeding systems generally practiced.
  - Nutritional requirements of cattle and buffaloes.
  - Feeding standards.
  - Formulation of standard ration.
  - Safety aspects in cattle feeds.
  - Performance of Bovines in Traditional pasture vs. Improved pasture
  - All forage diet for Sheep and Goat
  - Efficient feed ration
  - Use of molasses in livestock feeding
  - Daily requirement of green fodder, dry fodder and concentrates for sheep and goat.

FEED AND FODDER MANAGEMENT FOR INDIVIDUAL ANIMALS

Introduction

- In India, system of forage feeding differs from grazing on a poor herbage cover to thick vegetation.
- In larger areas it is mostly seasonal grazing followed by a scarcity period of summer months.
- Pastures and grasslands have reduced considerably in larger parts and also disappeared in many areas leaving behind mango orchards, roadside bunds and river basis for grazing.

FEEDING SYSTEMS

- Feeding on exclusive grazing: Animals are let out for grazing for 6-8 hrs daily.
- Feeding on roughage supplemented grazing: Common in low rainfall areas, where grazing is limited on poor pasture, road sides and canal bunds. The animals are offered dry crop residues (bhusa, straw,etc) during a larger part of the year.
- Feeding on grazing supplemented with concentrates: Grazing of animals followed by feeding of concentrates (grains, grams, oil cakes etc.) to productive dairy animals and working bullocks.
- Stall feeding of all roughage rations: All roughage ration may be of single forage or mixture of 2 or more forages. The combination mostly fall in the following categories
  - *Dry roughages: S*traw, stovers, mixed grass hay, legumious hay, cereal crop hay fed either as long hay or chaffed

- *Green forage feeding:* The feeding of green chaff of cultivated forages is limited to a small period of kharif seasons.
- *Feeding of mixed forage:* The mixture of forages depends on their availability with the farmers and not with the choice for balancing or palatability and feeding value of the forage.

- Stall feeding of forage: Concentrate diets - This system of feeding is common where there is no scope of grazing due to shifting of entire land under the grain and cash crops.
- Feeding of compounded feeds: Feeding of compounded feeds with basal roughage of wheat bhusa or chaffed paddy straw is limited to unorganised and organised daries of towns and cities.

NUTRIENT REQUIREMENTS OF CATTLE

- The first need of animal's life is energy and the central element for this is carbon. Carbon occurs in starches, sugars and other carbohydrates, fats, oils, proteins and even in plant pigments and vitamin compounds. All these are present in forage.
- Depending upon the animal's capacity, the forage is the main source of energy which aids in the support of life, growth, secretion of milk, work performance and reproduction. The portion of the nutrient that is digested and absorbed by the body is called digestible nutrient.
- Some of the nutrients are essential (not synthesized in sufficient quantity) which must be supplied by the diet. Non-essential materials are those that are required by the animal for physiological functions. They can be synthesized by the body tissues or microflora in the digestive tract.
- For example, a young calf with rudimentary rumen must depend on B-Vitamins from the diet. On the other hand, a mature cow can synthesize sufficient B-vitamins to supply her needs. Simple stomached animals depend on the diet for essential vitamins, aminoacids and fatty acids.
- For normal Physiological functions such as respiration, muscular contraction, heart beat, body heat, digesting feeds and body movements energy, proteins, vitamins and minerals are required. Protein is needed daily to replace cells that are broken down.
- To replenish minerals for formation of bones and new tissue cells minerals are needed. If the feed is reduced a dairy cow will use available energy for maintenance and reproduction at the expense of growth and lactation. Therefore, it is important to supply adequate nutrition if normal growth, high milk production and profits are to be obtained.
- Energy: The most important nutrient in the formulation of rations for dairy cattle is energy. The energy values are expresed in different ways.
  - *Total Digestible Nutrients (TDN)* content of a feed is expressed as a percentage. It is estimated in a digestion trial in which feed and faeces are analysed for crude protein (CP) = (N x 6.25), Crude fibre (CF), Nitrogen-free extract (NFE) and either extract(EE) (Fat x 2.25). The data are used to calculate TDN.

    % TDN = (CP + CF+ NFE+(EE X 2.25) X 100) / 100 KG Feed

  - This formula ignores gaseous and urinary energy and losses due to heat production. Extensive TDN data on many feeds are available and long tradition insure its continued use in practice.
- Digestible energy (DE):
  - Gross energy of feed is the total amount of heat liberated when it is completely combusted.
  - The difference between gross energy in the feed and that in faeces is termed digestible energy.
- Fibre and energy:
  - Fibre is necessary in a ration although it is not a nutrient. It controls feed intake, stimulates rumination, maintains pH in rumen and digestion.
  - Lignified fibre is less digestible. It also decreases dry matter intake. The stimulating rumination of fibre is destroyed by reducing particle size in grinding, pelleting or excessive chopping of fodder. An increase in fibre content decreases the energy value.
- Protein:
  - In the animal's diet provides aminoacids for its physiological functions. The cow does not depend on its diet for protein because the rumen is capable of converting nitrogen from the feed and non-protein - nitrogen (NPN) sources into aminoacids.

- The protein requirement of a mature cow depends on the amount of protein in the diet, which is broken down to ammonia by microbial digestion.
- The rumen microbes convert ammonia to microbial protein. All the feed protein sources are not degraded in the rumen to the same extent.
- The optimal ration meets the nitrogen requirements for maximum rumen microbial protein synthesis, avoids losses of excess ammonia from the rumen and provide undegraded protein.
- When microbial synthesis is inadequate to meet protein demands of high production by-pass protein becomes important in lactation. The synthesis depends on feed intake, feed type, protein level, digestibility and feeding method.
- NPN is any compound that contains nitrogen not in the form of amino acid.
- Common NPN compounds fed to dairy cows are feed grade urea, ammoniated straw, mono ammonium phosphate and liquid supplements having molasses, urea, minerals and vitamins. NPN in the ration is cheaper than feed protein sources per unit of nitrogen.
- Urea is limited to 1 percent of grain mixture or 200 g/cow/day. Protein is one the most expensive ingredient of dairy ration and hence overfeeding is avoided.
- Excessive nitrogen intake may affect delayed conception, embryonic death or increased services/conception. Protein requirements for different classes of animals are computed with data available on digestible crude protein.

- Fat:
  - Ruminants ingests and digests large quantities of forages and since fat can be formed from other nutrients, dietary fat needs are nominal.
- Minerals:
  - Inorganic elements are needed for cattle for various physiological functions such as for
    1. Bone and teeth formation,
    2. Enzyme systems,
    3. Maintenance of osmotic relationships and acid-base equilibrium,
    4. Functioning of muscles and nerves and
    5. To serve as constituent of proteins and lipids in muscles, organs, blood cells and soft tissues.
- Vitamins:
  - Dairy cattle require no dietary B vitamins and vitamin K as these are synthesized by microorganisms in the rumen. Vitamin C is synthesized by the body tissue.
  - However, until the rumen of young calves become functional at about 6 weeks of age, the calves need dietary B vitamins. The dietary needs of cattle are vitamins, A,D and E. These vitamins or their precursors are present in natural feeds in varying amounts.
- Digestible crude protein (DCP):
  - From the digestibility coefficient of protein in a feed, the amount of DCP can be determined. For instance suppose an animal consumes 10 kg of a good hay (Guinea grass) containing 7.5% crude protein, then the quantity of crude protein ingested/day is 0.75kg.
  - The animal is found to pass daily 6 kg dung. The moisture content of the dung is 50% so that 3 kg of dry matter is being excreted. If the crude protein content of the dung is 8% on dry basis, the animal excretes daily 0.24 kg of protein as undigested.
  - Therefore from 10 kg hay, only 0.51 kg of protein is being digested giving a digestible protein content 5.1%.
- Total digestible nutrients (TDN):
  - It has been explained before that the major organic nutrients help in producing heat and energy in an animal. Thus, the TDN estimation provides an index of its energy yielding capacity.
  - Suppose a feed like ground nut cake contains 42 kg digestible protein. 12 kg digestible carbohydrate and 8 kg of digestible fat in 100 kg, its TDN will be 42+12+ (8 x 2.25) = 72 kg/100 kg.

COMMON FEEDING STUFF

- The cattle feeds are classified as concentrates and roughages.

- Concentrates are low in fibre with high TDN. They include cereals, oil seeds, oil cakes and cereal and animal by-products.
- The feeds such as grasses, silage, hay and straws have high fibre are called *roughages*.

FEEDING STANDARDS

- A knowledge of the nutritive value of different feeds is necessary to prepare a balanced ration to the animal. However, before a ration can be formulated for an animal, its requirements are first to be known. The ration is classified as maintenance and production ration.
- The usual practice is to divide the requirements into two parts. The maintenance requirement indicates the amount of nutrients to be supplied to an adult animal so that it may carry out its vital processes without loosing or gaining weight. This requirement depends on the live weight or more precisely on the surface of the body of the animal althoughnot strictly proportional.
- In the case of growing animal or lactating animal or an animal in advanced stage of pregnancy or working animal, extra nutrients have to provided. The excess will depend on the nature and quantity of production. Thus, a cow giving 4% milk fat will require less quantity of extra nutrients than a buffalo of the same body weight giving same quantity of milk but containing 7% milkfat.
- Similarly, a bullock working 8 h/day will require more nourishment than another working 4 h/day. For milk and work production the figures are to be added to the maintenance requirements per day. These figures are based on foreign data and slightly on the higher side. However, it is better to stick to higher figures at least for the valuable cattle.
- In devising production ration, the nature and quantum of production has to be considered. For example a calf growing 0.5 kg/day needs more nutrient than another growing at 0.25 kg/day.
- In this case the nutritive ratio should be narrower than that of maintenance ration. This holds good for milk production where the quantity of milk as well as milk fat percentage needs to be taken together.
- For work production extra protein has to be supplied. For this therefore a supplementary feed with wide nutritive ratio has to be added to the maintenance ration.

FORMULATION OF BALANCED RATION

- The first consideration is the capacity for consumption of food by the animal. Cattle generally eat 2-3 kg dry matter for 100 kg live weight.
- If feed is succulent, the dry matter consumption may be as high as 3.5 kg/100 kg body weight. Buffaloes are slightly more heavy eater than cows. Out of this the dry matter 1/3 may be supplied as concentrates and 2/3 roughages like green grass, silage or hay.

Computing ration for a milch cow

- A cow weighing 400 kg and yielding 8 kg milk/day with 4% milk fat has to be provided a balanced ration. The available feed stuffs for the purpose are jowar silage, wheat bhusa, gram husk, barley, wheat bran and groundnut cake. The animal's capacity of total dry matter consumption is around 10 kg which should be conveniently divided two parts, one for maintenance and the other for milk production. The maintenance requirement is 0.28 kg DCP and 3.4 kg TDN.

Feed	Quantity (kg)	DM (kg)	DCP (kg)	TDN (kg)
Wheat	3.0	2.7	0.00	1.32
Jowar Silage	10.0	3.0	0.07	1.53
Groundnut Cake	0.5	0.5	0.21	0.36
	13.5	**6.2**	**0.28**	**3.21**

COMPUTING RATION FOR A MILCH COW

The requirements for 1 kg milk are 0.048 kg DCP and 0.340 kg TDN. This can be supplied by a mixture of the following composition.

Forage	Parts	DCP (%)	TDN (%)
Barley	5.0	4.02	38.8
Groundnut Cake	10.0	4.17	7.1
Gram Husk	20.0	0.00	11.0
Wheat Bran	20.0	2.12	13.5
1 kg mix		0.10	0.70
Requirement per 2 kg milk		0.10	0.68

- Thus one kg of mix is sufficient for producing 2 kg milk with 4.5% fat. Therefore for 8 kg of milk 4 kg mix should be fed in addition to maintenance quota, providing DCP 0.68, TDN 6.01 and total dry matter 6.2 + 3.6 = 9.8 kg.
- A blend of grasses, green legumes , dry roughages and concentrate feeds is generally suited for milch animals. Providing high quality forages with lucerne berseem or cow pea saves costly concentrate feeds and reduces cost of milk production: such a combination for cow/buffalo providing 8 kg milk/day is indicated below in kg.

Maize Green	20	Berseem Green	25	Maize Silage	30
Cowpea Green	10	Wheat Bhusa	7	Lucerne Green	10
Jowar Hay	7				
	37		32		40

COMPUTING RATION FOR A MILCH BUFFALO

- Suppose a ration is needed for a milch buffalo weighing 450 kg and giving 10 kg milk with 8% milk fat. The available feeds are green maize, wheat bhusa, crushed maize, crushed gram, groundnut cake and wheat bran. The dry matter consumption will be 12 kg. The maintenance requirement will be 0.28 kg DCP and 3.37 kg TDN/day. This can be met as follows.

Feed	Quantity (kg)	DM (kg)	DCP (kg)	TDN (kg)
Green maize	16.0	4.0	0.17	2.7
Wheat Bhusa	3.0	2.7	0.00	1.3
Groundnut Cake	0.25	0.2	0.10	0.7
	19.25	6.9	0.27	4.7

- For the production requirement for 10kg milk with 8% fat an additional requirement of 0.69 kg DCP and 5.53 kg TN is needed. This can be given by 5 kg of concentrate mix with maize 50%, gram 30%, groundnut cake 20% and wheat bran 10%. One kg of mix with have 0.17 DCP and 0.83 kg TDN. Thus,

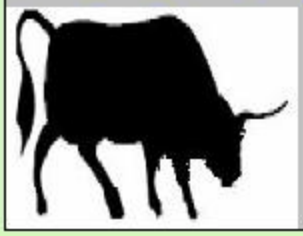
Feed	Quantity (kg)	DM (kg)	DCP (kg)	TDN (kg)
Maintenance ration	19	6.9	0.27	4.7

Concentrate mix	5	4.5	0.85	4.3
Total intake	24	11.4	1.12	9.0
Total requirement		11.5	0.97	8.9

- In urban areas the farmers have no source of getting quality green fodder and hence they are forced to use costly compounded feeds to meet most part of the ration and part of the energy requirements for maintenance and milk production. Such a ration for a 400 kg cow giving 8 kg milk with 4.5% milkfat is shown below:

Feed	Quantity (kg)	DM (kg)	DCP (kg)	TDN (kg)
Wheat Bhusa	7	6.3	0.00	3.01
Concentrate mix	4	3.6	0.64	2.92
Total intake	11	9.9	0.64	5.93
Requirement		10.0	0.65	5.84

DAILY REQUIREMENT

Type of cattle	Stage of the cattle	Green fodder (kg/day/ animal)	Dry fodder (kg/day/ animal)	Concentrates (kg/day/ animal)
Cow (Average weight 250 kg) 	Milk yield 5 litres/day	15.0	5.0	2.0
	Milk yield 5 to 10 litres/day	17.5	5.5	3.0
	Milk yield 10 to 15 litres/day	20.0	6.0	4.0
Cow in gestation	-	15.0	5.0	1.5
Buffalo (Average weight 400 kg) 	Milk yield 5 litres/day	15.0	5.0	2.5
	Milk yield 5 to 10 litres/day	20.0	6.0	4.0
	Milk yield more than 10 litres/day	25.0	7.0	5.0
Bull (Average weight 300 kg) 	During days of work	20.0	7.0	2.0
	During days of no work	15.0	5.5	1.0

SAFETY IN CATTLE FEED

- Environmental pollution is done by the Malaria eradication programme and the team some times unload all DDT/BHC in the sentitive area of cattle sheds, cattle feed stores and rejected places. Their entry into the animal body and transfer to human beings is possible.
- Pesticide residues are a source of head ache for feed producers. Now the use of DDT has been banned. But many other poisonous pesticides available in the market need not to used with utmost care. The preserved feeds must be safe and wholesome.
- The pesticide traffic via cattle feed, fodders and environment or water specifically meant for milch animals and ultimately to milk for human use must be blocked.
- It is safe to use deoiled feed ingredients in cattle feed mixed as the pesticides are fat soluble and the deoiling processes help in eliminating them from cattle feed ingredients.
- The presence of aflatoxins is another limitation in cattle feeds. Groundnut cake suffers a lot in this respect compared with soyabean, sunflower cakes or fish meal.
- As little as 4 mg toxin/kg feed can cause death in cattle. It is desirable to control the moisture content of the feed to around 10-12 percent during storage to reduce spoilage.

- Complete ration is a normal ration where forages, concentrates, minerals and vitamins are blended together. It is a promising method for improving the utilisation of fibrous agricultural poor quality crop residues into a ready made balanced diet in mash or pelleted form for the ruminant.
- Various fibrous agricultural residues like dried mixed grasses; straws from sorghum, paddy, wheat and safflower; sugarcane bagasse; fallen tree leaves; cotton seed hulls and wastes from wood and fruit pulp are amenable for use. This system has been introduced in recent years in developed countries with minimum labour use.
- The concentrate - roughage levels can be varied from diet to diet to meet the optimum nutritional requirement for production. Apart from water and some-wastage and feeding costs; permits consumption of unpalatable portions of the feeding stuff by the animal; causes less digestible upsets in early lactation; reduces eating and rumination time and provides more rest for the animal.
- More frequent feeding is desirable to reduce the load on the rumen and avoids changes in acidity (pH) of the ruminal fluid. Complete ration is very useful for landless, marginal and small farmers who could maintain cattle, buffaloes, sheep and goat in proper condition.

TRADITIONAL PASTURES

- Unmanaged traditional grasslands and pasture contain hardly, legume species of forage. The pastures mostly constitute poor quality feeds supplying 2-3% DCP and 50-55% TDN on DM basis.
- For the optimum utilization of excess energy (TDN) intake by cows and buffaloes through the traditional grasslands it is important to make up the deficiency of protein (DCP) through the feeding of high protein supplements like G.N. cake, till cake, soyabean cake, linseed cake.
- A non-protein nitrogen (NPN) supplement like urea-molasses supplement or urea mixed concentrate mixture can also be fed in limited quantity for the better utilization of excess energy consumed.

IMPROVED PASTURES

- Well managed pastures are periodically renovated and cropped in a manner to maintain the grass legume ratio about 1:1 so that good quality nutritious forage would be available for grazing.
- Improved pastures may supply about 6-7 percent DCP and 50-55% TDN in dry matter.

ALL FORAGE DIETS FOR SHEEP AND GOATS

- Sheep prefer grazing close to the ground whereas goats like browsing on newer leaves of herbs shrubs with variable grass cover. Indian sheep of Northern plains and Southern parts are mostly mutton type.
- A few breeds produce a small amount of rough carpet wool. Sheep in different tropical and sub tropical zones are mostly reared on grazing in semi arid areas or on the stubbles left after harvesting of crops.
- Goats like browsing and some breeds are difficult to adopt for stall feeding Jamunapari goats if not maintained, milk production outside their home tract will further reduce on stall feeding.
- Diversified breeds of goats ranging from the heavy breeds like Janumapari, Beetal and osmana (body weighting 50-80kg adult body weights) to light breeds like black bengal weighting (15-25kg adult body weight) are in existence. (Heavier milk type are mostly born one kid).
- For the optimum utilization of inherent milk production potential of goats it is essential to supplement the grazing, browsing through the feeding of energy rich concentrate mixture. However, on the feeding of palatable forages, goats are capable to consume a large quantity of dry matter (4-5% of body weight).
- Under feeding systems on grazing and browsing lactating goats produce about 0.5 to 2.0 kg milk and male kids grow to 7-12 kg body weight in light breeds and 15-35 kg in large breeds at about 10-12 months of age. At this stage males are marketed for meat and yield good quality carcass providing higher proportion of meat.

EFFICIENT FEED RATION

- In formulating the most efficient and economic ration for livestock, one must select ingredients that supply basic animal requirements - energy, protein, minerals and vitamins to maintain the growth, yield and health of the animals.
- Initially farmers relied almost entirely upon food grains and roughage grown on the farm to feed their livestock. Now it is discovered that the byproducts of milling, meat packing, oil seed processing and other processing industries had considerable feed value as they not only contain substantial amount of protein but also furnish minerals and vitamins lacking in the feed grains and roughages.
- Use of non-conventional raw materials for animal feeding is thought of, which not only helps to reduce the feed cost, but also helps to conserve food grains and other material for human consumption. **eg:** Oil cakes, brans, husks, wastes from dal mills, slaughter houses, etc.
- Usually the ration for the animals consists of green fodder , dry fodder and concentrates. The green and dry fodders can be from cereals or grasses and also legumes.

- Dry fodder refers to the dried crop after removal of the grains such as Paddy straw, Wheat straw, Maize stalk, Sorghum stalk etc., Concentrates are the crop by products such as groundnut oil cake, cotton seed cake, sesamum oil cake etc.
- A concentrate is prepared by mixing different ingredients to meet the animal needs. These would be grains, cakes, some bran and other items along with essentials like mineral mixture, salt, etc.
- Depending on the availability and economics, any one can be chosen. Quantities of green fodder, dry fodder and concentrates to be fed per cattle per day is very important . This is decided based on the type of cattle, its daily nutritional requirements and milk yield.

USE OF MOLASSES IN LIVESTOCK FEEDING

- The different types of molasses are similar in feeding value and are available in both liquid and dehydrated forms.
- Molasses is usually used in rations for cattle, buffaloes, sheep and horses.
    - As a source of energy.
    - As an appetisor.
    - To reduce the dustiness of a ration.
    - As a binder for pelleting.
    - To stimulate rumen microbial activity.
    - To supply unidentified factors.
    - To provide a carrier for NPN and vitamins in liquid supplements.
    - In the case of cane molasses, to provide trace minerals.
    - In ruminant rations, molasses is restricted to the level of 10-15% of the ration.
    - Excessive amounts of molasses (greater than 15%) will cause the feed to become messy as well as create digestive disturbance along with disrupted rumen microbial activity.
    - Poultry are rather sensitive to molasses as excess levels cause diarrhoea. Levels are restricted to from 2-5%.

DAILY REQUIREMENTS

Sl. No	Type of animal	Stage of the animal	Green fodder (kg/day/animal)	Dry fodder (kg/day/animal)	Concentrates (kg/day/animal)
1.	**Goat**	Upto 3 months	0.5	0.4	0.1
		4 - 12 months	1.0	0.6	0.2
		During gestation	2.0	0.8	0.4
		During rest of the period	1.5	0.6	0.3
2.	**Sheep**	Upto 3 months	0.5	0.4	0.1
		4 - 12 months	1.0	0.6	0.2
		During gestation	2.0	0.8	0.4
		During rest of the period	1.5	0.4	0.3

MODULE-12: FODDER PRODUCTION THROUGH INTERCROPPING AND BACKYARD CULTIVATION

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - To know the various intercropping methods.
  - Importance of intercropping legume fodders.
  - Cultivation packages for important intercropping systems.
  - Possible fodder intercropping under rainfed and irrigated situations.
  - Means for intensive fodder production for continuous supply of fodders.

FODDER PRODUCTION THROUGH INTERCROPPING AND BACKYARD CULTIVATION

Introduction

- Presently the Indian farmers are giving much importance to cultivation of grain and commercial crops. The cultivation of crops has become the major enterprise of the farmers where as other enterprises such as dairy/poultry/fishery/piggery/goatery etc. are considered as secondary enterprise.
- This is because of the reason that marginal and small farmers depend on farming for their livelihood and hence produce rice or wheat, being the important staple food crops.
- However this is not the case with the big farmers who are having a larger livestock business. Majority of the farmers do not pay much attention to feed his livestock with green forages.
- The farmer is feeding his livestock with agricultural by products obtained from his farm, like paddy straw, Jowar, Bajra, Maize stover etc., which are having poor feeding value.
- As such the livestock are being fed with poor quality roughages, the yield potentiality of the livestock going down year after year. There is sufficient low cost technology available to feed the livestock of the farmer and improve the yield potentiality. Intercropping and backyard cultivation are important ones.
- For increased fodder production from the available land resources, the cropping has to be intensified in terms of either space or time or both.

TYPES OF 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 atleast for part of their life cycle. There are different systems of intercropping.
- *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. Eg. Sorghum + cowpea + cucumber

- *Row intercropping:* Owing 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. Eg. Sorghum + cowpea, Maize + cowpea etc.
- *Strip intercropping:* The systems of sowing two or more crops in alternate strips (slightly larger ratios such as 10:10 or so) is termed as strip cropping. Eg. Stylosanthes sp. + guinea grass
- *Relay cropping:* Usually a legume and a non -legume are sown together in the above systems. 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. Eg. Rice - sunnhemp, Rice - Pillipesara etc. (Food crop followed by fodder crop).
- *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. Depending on the number of crops grown in one year, the systems are called as *double cropping*, *triple cropping* , *quadruple cropping*, etc. If the same crop is grown season after season or year after year, it is termed as *monoculture* and if different crops are grown, it is termed as *crop rotation*,
    - **Examples:**
        - Maize - Berseem
        - Sorghum - Oats - Maize
        - Maize - Cowpea - SSG 59-3 (multicut sorghum)
- Availability of irrigation water is more important to adopt sequential cropping systems

WHY LEGUME IS INTERCROPPED?

- There are many advantages due to inter cropping a legume and non-legume crop. This system helps in economizing the fertilizer use, improves the forage quality and at times may even increase the biomass production. This is illustrated through the following example.

System	Fertilizer used Kg/ha		Forage yield t/ha		Crude Protein (Kg/ha)
	N	P_2O_5	Green	Dry	
Sorghum (pure crop)	120	50	49.0	10.18	680
Sorghum + Cowpea	70	55	49.3	10.10	1024

- These inter cropping systems aim at production of green forages with the existing resources (land, labor, capital, water and other inputs) available with the farmer without foregoing the regular cultivation of grain and commercial crops in the farm.

COMMON FODDER INTERCROPPING

- Common intercropping system recommended

1.	Cumbu Napier grass	3 rows	+	Hedge Lucerne	1 row
2.	Fodder sorghum var Co.27	2 rows	+	Soyabean var Co.1	1 row
3.	Fodder maize var African Tall	1 row	+	Cowpea var Co.5	1 row
4.	Buffel grass	1 row	+	Stylo	1 row

- Apart from these, Lucerne is considered a good intercrop as well an ideal strip crop in north indian conditions where the temperature is cooler. Some images where lucerne is used for intercropping is given below:

- 


CUMBU NAPIER GRASS AND HEDGE LUCERNE

- Both Cumbu Napier grass and Hedge lucerne can be grown in intercropping in 3 : 1 ratio.

Seed rate	Grass 30,000 slips/ha, Velimasal 2 kg/ha
Spacing	Cumbu napier - 50 x 50 cm, Velimasal - continuous row in between
Fertilizer	FYM 25 t/ha, N:50, K:40 kg/ha
Top dressing	100 kg N after every harvest
Irrigation	Once in 10 to 15 days
Harvest	First harvest after 80 days of sowing subsequent harvest every 45 days
Yield	250 to 300 tonnes/ha/year

SORGHUM AND SOYABEAN

- Sorghum variety Co 27 and Soyabean variety Co.1 can be intercropped in 2 : 1 ratio.

Seed rate	Sorghum 27 kg/ha, Soyabean 10 kg/ha
Spacing	25 x 10 cm
Fertilizer	FYM 25 t/ha, 30:40:20 kg NPK/ha
Top dressing	30 kg N to be applied at 30 days after sowing
Irrigation	Once in 10 days
Harvest	at 50% flowering
Yield	40 t/ha green fodder

FODDER MAIZE AND COWPEA

- Fodder maize var. African Tall and Cowpea Co.5 can be intercropped in 1 :1 ratio.

Seed rate	Maize: 20 kg/ha, Cow pea 20 kg/ha
Spacing	30 x 10 cm
Fertilizer	FYM 25 t/ha, 30:50:20 kg NPK/ha

Top dressing	30 kg N to be applied at 30 days after sowing
Irrigation	Once in 10 to 15 days
Harvest	at 50% flowering
Yield	34 to 35 t/ha green fodder

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BUFFEL GRASS AND STYLO

- Buffel grass and Stylo can be grown together in the ratio 3 : 1.

Seed rate	Buffel grass: 6 kg/ha, Stylo: 3 kg/ha
Spacing	50 x 30 cm
Fertilizer	FYM 10 t/ha, 24:45:19 kg NPK/ha

Top dressing	25 kg N to be applied after each harvest
Harvest	Buffel grass can be harvested 3-4 times in an year Stylo is harvested first on 75 days and subsequently at 40-45 ays interval
Yield	Grass:15-22.5 t/ha, Stylo: 7.5-8.5 t/ha

MODULE-13: RECYCLING OF ANIMAL WASHINGS AND WASTES

LEARNING OBJECTIVES

- The major objectives of this module are to make the user to learn the following:
  - Manurial value of livestock wastes - Farm Yard Manure.
  - Energy value of livestock wastes - Gobar gas.
  - Value addition of livestock wastes - Vermicompost and Panchakavya.

UTILIZATION OF ORGANIC WASTES

MANURIAL VALUE

- Proper collection and preservation of dung, urine, leftover fodder and other farm wastes is important, as they can be converted into valuable manure.
- At present, more than 50% of the cattle dung produced in the country is utilised as fuel without realizing its manurial value. The urine which is a rich source of K, N and S is also not utilised properly due to improper methods of collection.
- Cattle Manure or Farm Yard Manure (FYM) is the decomposed mixture of dung and urine of farm animals along with leftover feed material and bedding material.
- FYM is a bulky organic manure and it has long lasting effects on crop production and soil productivity, when properly used.
    - FYM contains all the essential elements required for crop growth.
    - These nutrients are present in small quantities (Average N.P.K content on dry weight basis is 1.0, 0.5 and 1.0 % , respectively), but they are not easily lost from the soil because they are in organic form.
    - There are no ill-effects or pollution effects because of the use of FYM.
    - FYM is cheaper compared to the cost of commercial fertilisers. It can be locally prepared with indigenous technology
    - Application of FYM improves the physical properties of soil such as structure, pore space, water holding capacity, etc.
    - It also improves the soil chemical properties because organic matter (humus) has the highest cation exchange capacity (CEC).
    - FYM is the main source of food for all the useful micro-organisms living in the soil. Soil is biologically improved because of the application of FYM.
- In view of the numerous advantages, animal wastes should be properly collected and converted into manure.
- The floor of the cattle shed is prepared in such a way that the urine is either collected at one point because of the slope and hard and rough surface of the flooring, or is collected (absorbed) by using different types of bedding material like paddy husk, saw dust, groundnut shells, chopped straw, etc. The dung , urine (with or without bedding material) and left over feed (mainly roughages) are collected properly.
- There are different methods of storage to prepare FYM.

Heap method

- In this system, the manure is heaped on the ground in an open land exposed to sun and rain. There is heavy loss of nutrients in this system due to volatilization and/or leaching. The loss can be minimized by heaping underneath the shade of a tree and by covering with earth or polythene sheet.

Pit method

- This is better than heap method. The bottom and sides of the pit are plastered with non-absorbants and as there is no direct exposure to sun or rain, the nutrient losses are minimum.

Covered Pit method

- The opening of pit is covered and so, it is the best method for FYM preparation.
- Cattle and buffalo manure is available in plenty in our country which needs to be utilized properly. Pig manure is a rich source of N and P (3.7 and 3.3%), which should also be utilized more effectively.

ENERGY VALUE -BIOGAS PRODUCTION

- Biogas will make a convenient alternative to alleviate the energy crisis in the farm sector including farmers' households, apart from providing a good quality manure devoid of viable seeds of weeds.
- Biogas is generated through the anaerobic digestion of organic wastes mainly cattle dung. An average Indian farm family normally has two or three cattle for basic agricultural operations.
- The dung from these animals can be efficiently used. Increased popularization of biogas plants has led to about 16 lakh family - type biogas plants in India, starting from a meagre 1000 plants approximately in 1972-73. In Tamil Nadu state alone there are about 1. 5 lakh number of biogas plants.

Availability of dung and scope of bio gas plants in Tamil Nadu

Type of animal	No. in Million	Dung / day/animal (kg)	Total (million kg/day)	Gas Production	
				Rate m3/kg	Million m3/kg
White cattle	13.6	10	136.0	0.04	5.44
Black cattle	3.2	15	48.0	0.04	1.92
Sheep	5.5	2	11.0	0.04	0.44
Goat	5.2	2	10.4	0.04	0.42
Pigs	0.7	1.5	1.0	0.07	0.07
Poultry	18.2	0.1	1.8	0.06	0.11
			208.2		8.40

- In Tamil Nadu alone, from about 208 million kg of dung available every day, it is possible to produce about 8.40 million m3 of biogas per day. But only 7% dung is utilised for biogas production by about 1.5 lakh biogas plants of 4 m3 capacity each requiring 100 kg of dung per day.
- There is a lot of scope for more bio gas plants and as such, the Department of Non-Conventional Energy Sources of the Union Government is encouraging the Indian house holds particulary in the rural areas to install the bio gas plants.
- Apart from cattle dung, wastes from poultry, piggery, sericulture, goat -husbandry, crop and field wastes and nightsoil are yet to be used in large quantities.

VALUE ADDITION - PANCHAKAVYA

- The Sanskrit word Panchakavya means “mixture of five products” and it has been used in traditional Hindu rituals throughout history. In recent years panchakavya has found a prominent position in the context of organic farming.
- Panchakavya is a concoction prepared by mixing five products of cow. The three direct constituents are dung, urine and milk; the two derived products are curd and ghee. These are mixed in proper ratio and then allowed to ferment and used.
- Panchakavya is said to have miraculous effects on plants, animals and human beings. It can act as growth promoter and immunity booster. It enhances the shelf life of vegetables, fruits and grains but also improves the taste.
- The present form of Panchakavya is an organic input , which acts as a growth promoter and immunity booster. The ingredients include

Ingredients	Quantities
Gobar gas slurry	4 kg
Fresh cowdung	1kg
Cow’s urine	3 litres
Cow’s milk	2 litres

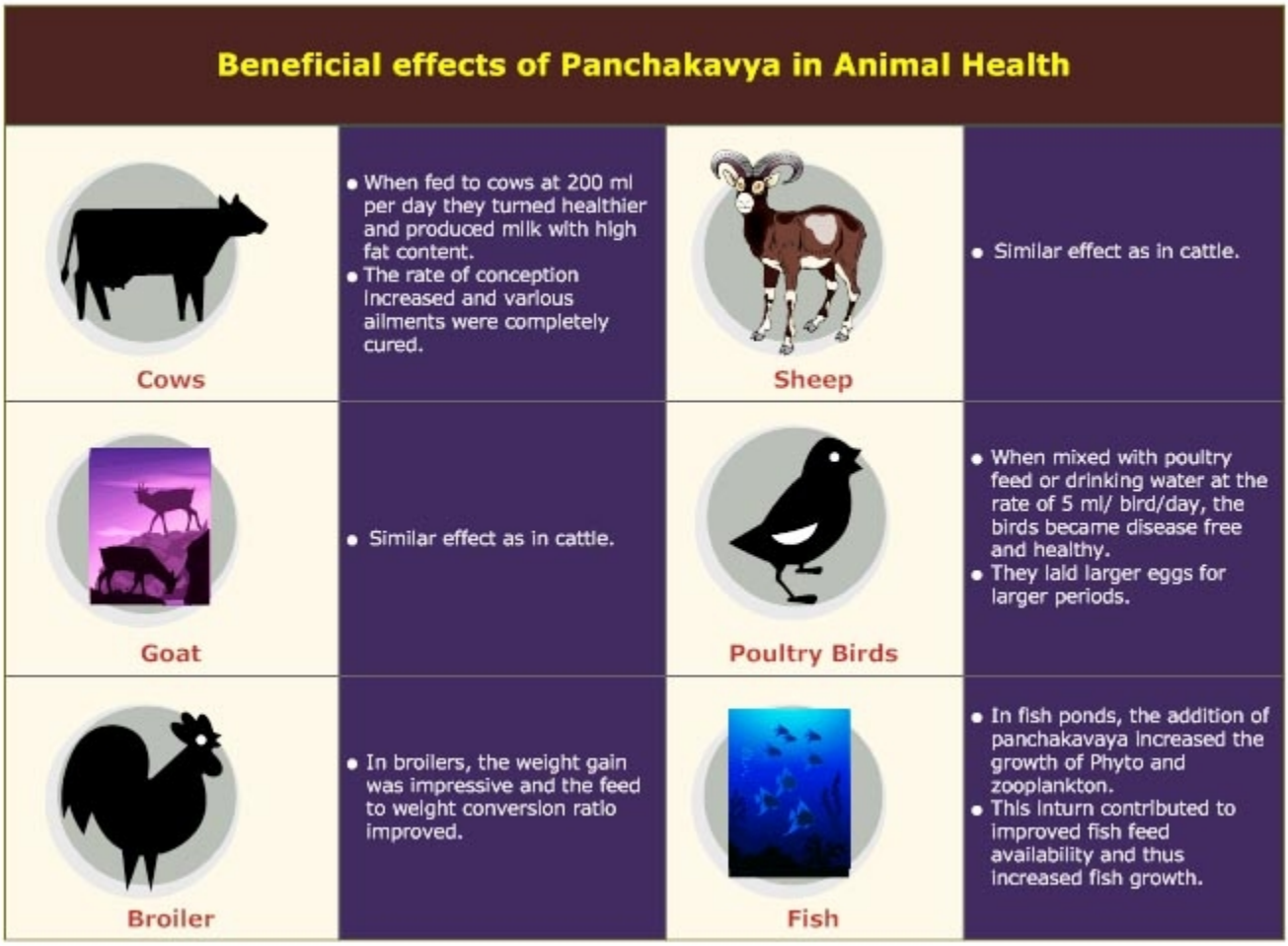
Cow’s curd	2 litres
Cow’s ghee	1kg
Sugarcane juice	3 litres
Ripe bananas	12 nos.
Tender coconut water	3 litres
Toddy (if available)	2 litres

- This will make about 20 litres of Panchakavya . The concoction is stored in a wide mouthed earthern pot or concrete tank kept covered with a cotton cloth and placed in an open area.
- Sufficient shade should be provided and the contents should be stirred twice a day both in the morning and in the evening.
- The methane gas likely to generate inside gets released while stirring. In seven days, the modified Panchakavya will be ready. Panchakavya is diluted to 3% and sprayed on crops to get the best results.

BENEFITS OF PANCHAKAVYA IN AGRICULTURE

- In the preliminary research conducted by Rural Community Action Centre, headed by Dr. K. Natarajan, it is said that the following benefits were realised by the use of Panchakavya. His findings have been validated by some of the research institutes in the country.
- Seeds can be soaked and seedlings can be dipped in *3% solution* of Panchakavya for about 30 minutes before sowing to get good results from the crops.
- Various cereal crops, such as rice, maize, vegetables such as brinjal, bhendi, fruit crops like mango, banana, guava, cash crops like sugarcane, turmeric, jasmine and moringa and plantation crops have responded extremely well to application of Panchakavya.
- Earth worms grow faster and produced more *Vermi compost* when treated with this solution.
- When sprayed with Panchakavya the plants produce larger leaves and develop a denser canopy. The stem produces lateral shoots and sturdy branches to bear heavy yields.
- The rooting is profuse and penetrates rates deeper, helping the plants with stand drought condition. Roots helps in better in take of nutrients and water.

BENEFITS OF PANCHAKAVYA IN ANIMAL HEALTH



SCIENTIFIC ANALYSIS OF PANCHAKAVYA

- Presence of growth regulatory substances such as IAA, GA and cytokinin, essential plant nutrients, naturally occurring, beneficial effective micro organizations predominately lactic acid bacteria, yeast, actinomycetes, phyto synthetic bacteria and certain fungi besides beneficial and proven bio-fertilizers such as Acetobacter, Asospirillum and phosphobacterium and plant protection substances can be detected in Panchakavya .

Sl. No.	Contents (in ppm)	Panchakavya
1	Total sugars	345
2.	Reducing sugars	121
3.	Protein	66
4.	IAA	8.5
5.	GA	3.5
6.	Total Nitrogen	238
7.	Total Phosphorus	995
8.	Total Potash	1540
9.	Total Sodium	218

10.	pH	3.76
11.	EC (dSm^{-1})	8.25

VALUE ADDITION - VERMI COMPOST

- Vermicompost is the castings of earthworms. Organic waste gets decomposed by micro-organizms and is consumed by earth worms. The castings of these worms is popularly known as vermicompost.
- Vermicompost can be prepared easily. The essentials are space, cowdung, organic wastes, and Epigeic phytophagous earthworms.
- Vermicompost is a good organic manure as it improves soil quality. Conversely, over time, inorganic fertilisers can deprive the soil of fertility.

REQUIREMENTS OF VERMICOMPOST

Housing:

- Sheltered culturing of worms is recommended to protect the worms from excessive sunlight and rain.
- All the entrepreneurs have set up their units in vacant cowsheds, poultry sheds, basements and back yards.

Containers:

- Cement tanks were constructed. These were separated in half by a dividing wall. Another set of tanks were also constructed for preliminary decomposition.

Bedding and feeding materials:

- Cowdung is used in the bedding material in order to breed sufficient numbers of earthworms.
- Once the earthworm multiply in sufficient numbers, one can start using all kinds of organic waste.

PROCESS OF VERMICOMPOSTING

- The bedding and feeding materials are mixed, watered and allowed to ferment for about two to three weeks in the cement tanks. During this period the material is overturned 3 or 4 times to bring down the temperature and to assist in uniform decomposition.
- When the material becomes quite soft, it is transferred to the culture containers and worms ranging from a few days to a few weeks old are introduced into them.
- A container of 1 metre by 1 metre by 0.3 metres, holds about 30-40 kgs of the bedding and feeding materials. In such a container, 1000 - 1500 worms are required for processing the materials. The material should have 40 to 50 percent moisture, a pH of 6.3 to 7.5, and a temperature range of 20 to 30 degree celsius.
- The earthworms live in the deeper layers of the material. They actively feed and deposit granular castings on the surface of the material. The worms should be allowed to feed on the material until it is converted into a highly granular mass.
- The earthworms take 7 weeks to reach adulthood. From the 8th week onwards they deposit cocoons. One mature worm can produce two cocoons per week.
- Each cocoon produces 3-7 young after an incubation period of 5-10 days depending on the species of worms, quality of feed, and general conditions. The resulting increase is about 1200-1500 worms per year. The population doubles in about a months time.

HARVESTING OF VERMICOMPOST

- The harvesting of vermicompost involves the manual separation of worms from the castings. For this purpose, the contents of the containers are dumped on the ground in the form of a mound and allowed to stand for a few hours.
- Most of the worms move to the bottom of the mound to avoid light. The worms collect at the bottom in the form of a ball. At this stage, the vermicompost is removed to get the worms. The worms are collected for new culture beds.
- The vermicompost collected is dried, passed through a 3 mm sieve to recover the cocoons, young worms, and unconsumed organic material.
- The cocoons and young worms are used for seeding the new culture beds. The vermicompost recovered is rich in macro-nutrients, microbes such as actinomycetes and nitrogen fixers, and is used as a manure.

PESTS AND PREDATORS

- Earth worms have a large number of predators, including: birds, fowl, rodents, frogs, toads, snakes, ants, leeches, and flat worms such as bipalium.
- To avoid attacks of these predators vermiculture should be practised in protected places.

BENEFITS OF VERMICOMPOST

- By establishing vermiculture units entrepreneurs can recycle their own resources and create an effective fertiliser in the process. The extra worms that are produced can be used as feed for poultry and fish. The advantages of this technology include:
    - Recycling of organic wastes.
    - Production of energy rich resources.
    - Reduction of environmental pollution.
    - Provision of job opportunities for women and jobless people.
    - Improvement of soil pH. (vermicompost acts as a buffering agent).
    - Improvement in the percolation property of clay soils (from the compost's granular nature).
    - Improvement of the water holding capacity in sandy soils.
    - Release of exchangeable and available forms of nutrients.
    - Increase of oxidizable carbon levels, improving the base exchange capacity of the soil.
    - Improvement of the nitrate and phosphate levels.
    - Encouragement of plant root system growth.
    - Improvement in the size and girth of plant stems.
    - Early and profuse plant flowering
    - Creation of a substitute protein in poultry and fish feed.
- One disadvantage of this technology is that pesticides and heavy metals accumulate in the bodies of the worms that are raised on contaminated organic wastes. If such worms are used as protein source in animal feeds, health hazards may result.

MODULE-14: SOIL AND MOISTURE CONSERVATION METHODS FOR FODDER PRODUCTION

LEARNING OBJECTIVES

- At the end of this module the user can learn the following:
  - Types of soil erosion
  - Methods to prevent soil erosion
  - Methods to prevent water erosion
  - Methods to conserves soil and water

SOIL AND MOISTURE CONSERVATION METHODS FOR FODDER PRODUCTION

Introduction

- Soil conservation is using and managing land, based on the capabilities of the land itself, involving the application of the best practices to result in greatest profitable production without damaging the land. This is accomplished by
  - Land use based on its capability
  - Conservation of soil and moisture to avoid damage to the soil
  - Use of the best soils and crop management practices, correction of acidity, alkalanity and drainage etc.
- Soil conservation is adopted to prevent the soil from soil erosion.

SOIL EROSION

- Soil erosion is the process of detachment of soil particles from the parent body and transportation of the detached soil particles by wind and or water. The agents causing erosion are wind and water. (Click here for an animated illustration of the surface movement of water)
- The detaching agents are falling raindrops, channel flow and wind. The transporting agents are flowing water, rain splash and wind. Depending on the agents of erosion, it is called as water erosion or wind erosion or wave erosion.

Water erosion

- Water erosion causes several types of damages by removing soil gradually. Sheet erosion, rill erosion, gully erosion, ravines and land slides are the types of soil losses caused by water erosion.
- The rate of erosion depends on intensity of rainfall, slope of the land, characteristics of soil and type of vegetation.
- The soil erosion due to rainfall in bare soil ranges from 1.9 t/ha to 16.6 t/ha, depending on the intensity of rainfall, soil type etc.
- The water erosion is negligible in soils with plant cover.
- Losses due to water erosion
  - *Loss of rain water:* Loss of rain water is through run off
  - *Loss of fertile top:* Loss of top soil is about 16.35 t/ha annually in India
  - *Nutrient losses:* Soluble forms of nutrients in the top soil is lost through run off, exchangeable and fixed forms of nutrients are lost through sediments.

- *Silting of reservoirs:* Flow velocity is reduced, and sediments settles on the floor of the reservoir which reduce the depth of the reservoir

Wind erosion

- Wind erosion is a serious problem in areas where land is bare and devoid of vegetation and is a natural phenomena in arid and semi arid zones.
- Factors affecting wind erosion are wind velocity, temperature, rainfall, soil texture, structure, cohesiveness, bulk density, organic matter, moisture content, surface roughness, height and density of vegetative cover and type of vegetation.
- Losses due to wind erosion
  - Loss of fertile top soil
  - Drifting of sand by wind and deposit on the good fertile land
  - Damage to crops due to abrasive action.

Wave erosion

- Wave erosion is caused by the combined action of wind and water.
- Wave erosion mainly occurs in rivers and canals. Lining the canals mainly controls wave erosion.

MEASURES TO CONSERVE SOIL DUE TO WATER EROSION

- Measures to prevent erosion are broadly classified as
  - Agronomic measures
  - Mechanical measures
  - Forestry measures and
  - Agrostological measures

AGRONOMIC MEASURES

- Agronomic measures are mostly adopted in dryland areas where slope is gentle i.e. less than 2% when one or more agronomic measures are combined, erosion can be reduced even if the slope is more than 2%.
- Following are the commonly adopted agronomic measures
  - Contour cultivation
  - Tillage
  - Mulching
  - Cropping systems
  - Strip cropping
  - Use of chemical and
  - Others
- Contour cultivation
  - Contour cultivation includes contour ploughing, contour sowing and other intercultural operations. By ploughing and sowing across the slope, each ridge of plough furrow and each row of the crop act as an obstruction to run off and provide more time for water to enter into the soil and reduce soil loss.
- Tillage
  - Conservation tillage is disturbing the soil to minimum extent necessary and leaving crop residues on the soil. Mostly adopted conservation tillage system is zero and minimum tillage, and this can reduce the soil loss to an extent of 50% over conventional tillage.
- Mulching
  - Mulching with plant materials reduces soils loss upto 43 times compared to bare soil and 17 times compared to cropped soil without mulches. Mulches covers more soil surface and protects it from rain drop impact, thus reducing the run off loss. When the crop residues are pressed down into

narrow continuous slots of 5 to 10 cm width and 20 to 25 cm depth, the infiltration capacity is increased.

- Cropping systems
  - Pasture land has faced negligible run off and sediment losses. Growing a crop with maximum vegetative cover reduces run off and soil loss. In multiple cropping systems, where the soil is covered with crops throughout the year, the soil loss is minimum as the falling rain drops are interrupted by the crop.
- Strip cropping
  - Strip cropping is a system of crop production in which long and narrow strips of erosion resisting crops (close growing crops) are alternated with strips of erosion permitting crops (erect growing crops) across the slope. Groundnut, moth bean, horsegram, is some of the erosion resistant crops and erosion permitting crops are sorghum, maize and millet.
- Use of chemicals
  - Aggregate stability can be increased by spraying chemicals like polyvinyl alcohol at 480 kg/ha, the rate however depending on the type of soil. Bitumin application also increases the water stable aggregates and infiltration capacity of the soil.
  - Application of organic matter, farmyard manure, crop residues and green manure increases the aggregate stability and thereby reduces the runoff and soil losses.
- Other agronomic practices
  - Application of manures and fertilizers provides early crop cover due to quick growth and thereby reduces the soil loss. Formation of dead furrows with closed ends at 3.6m interval after emergence of the crop sown across the slope, reduces the length of the run off water, hold water and increases the time for infiltration.

MECHANICAL MEASURES

- Mechanical measures are supplemented with agronomical measures when the latter, alone is not sufficient. Some of the mechanical measures are
  - Contour bunding
  - Graded bunding
  - Bread base terrace
  - Bench terracing
  - Trenching
  - Vegetative barriers
  - Grassed waterways and
  - Gully control.
- Contour bunding
  - The contour bunds are formed at all lines of the greatest slope and this ensures uniform water depth and distribution throughout its length and enables better possible cultivation than any other type of bund.
  - As the bunds are at regular intervals, they intercept the run off from attaining erosive velocity and causing erosion. Contour bunds are adopted in areas with rainfall of less than 1500 mm and the slope of upto 6%.
- Graded bunding
  - This is recommended where the rain water is not readily absorbed either due to high rainfall or low intake of the soil. The graded bunds are designed for conveying the peak rate of the inter bunded run off at non scouring and no silting velocity.
- Broad base terrace
  - This is a combination of ridge and channel built across the slope on a controlled grade and has a wide base and low height of ridge. Suitable for deep black soils.
- Bench terracing
  - Usually practiced on slopes ranging from 16 to 33%. Bench terracing consists of principally transforming relatively steep land into a series of level strips or platforms across the slope of the land. It reduces the slope length and consequently erosion.
- Trenching

    - Contour trenches are made in non - agricultural land for providing adequate moisture conditions in order to raise tree and grass species. Size of the trench varies with slope, rainfall and depth of soil available.
    - Trenches are formed at an interval of 60m. The trenches are half refilled diagonally with excavated material and remaining half of the soil forms the spoil bank.
- Vegetative barriers
    - These are closely spaced plantation, usually a few rows of grasses or shrubs, grown along contours. Act as a barrier, to check the velocity of overland flow entrapment of silt load behind them. Eg. Khus (*Vettiveria zelanica*)
- Grassed waterways
    - Grassed waterways are drainage channels developed either by shaping the existing drainage ways or constructed separately to agricultural lands.
    - Used to handle run off discharge from graded bunds, broad base terraces, bench terraces etc. Suitable perennial grass, deep rooted and spreading type such as *Panicum repens*, *Brachiaria mutica*, *Cynodon plectostachyus*, *Cynodon dactylon* and *Paspalum notatum* may be established for the stability of the waterways.
- Gully control
    - Gullies are controlled by diverting run off by adoption of agronomical measures and stabilizing the gully sides and bed by establishing vegetation and reducing the gradient of the channel to maintain velocities below erosive level by temporary and permanent structures such as check dams, drop spillways and chutes.

FORESTRY MEASURES

- In forest lands, slopes are steep, uneven, soil is less stable, highly erodable and precipitation is high.
- The vegetation and dried leaves on the floor intercept the rain and reduce the impact of rain drops.
- Due to overgrazing and felling of trees, most of the hills and hillocks became naked and barren.
- Re-establishment is essential to avoid erosion and to maintain ecological balance.
- Afforestation by adopting contour trenching helps in reducing the soil erosion and increases the infiltration rate.

AGROSTOLOGICAL MEASURES

- Grasses are used to prevent soil erosion by intercepting rainfall, binding the soil particles and by improving soil structure.
- Grasses should be perennial, drought resistance, rhizomniferous, develop good canopy, deep root system, prostrate in habit and useful for cottage industries. **Eg.** *Chloris gayana*, *Dicanthilum annulatum*, *Heteropogon contortus* etc.
- Grass legumes association is ideal for soil conservation. Legumes build up soil fertility by fixing atmospheric nitrogen.
- Grasses are used to stabilize the surface of waterways, contour bunds, bench terraces etc.
- Further, grasses improve, the soil structure, porosity, infiltration and also add organic matter to the soil.

A good example of grass–legume association is *Cenchrus ciliaris* + *Stylosanthes hamata*.

MEASURES TO CONTROL WIND EROSION

Should aim at reducing the wind velocity and altering soils characteristics.

Reducing wind velocity

- Adopting vegetative measures or tillage measures or mechanical measures can reduce wind velocity.

- Vegetative measures
  - A long barrier of a several rows of trees planted across wind direction is called as shelter belts and is useful for soil and moisture conservation as it filters the wind and at the same time lift it from the surface.
  - Some of the commonly used tree species are *Prosopis specigera*, *Albizzia amara*, *Tamarindus indica*, Eucalypthus species etc. Close growing crops like ground nut, green grass are more effective.
- Tillage measures
  - Rough and clody surface resists the force of wind from causing erosion. Stubble mulching reduces wind velocity and also trop the eroding soil.
- Mechanical measures
  - Physical obstructions such as fences, terraces known as wind breaks reduces the wind velocity.

Altering soil factor

- Bigger the size of the aggregates, lesser will be the effect of wind on soil erosion. Soil aggregates can be improved by increasing the organic matter content.

MOISTURE CONSERVATION PRACTICES

- Since water is the predisposing factor for the successful crop production in dry land areas, the job of an efficient farmer starts right from the time rain falls on the earth till it is efficiently utilized by the plant.
  - Arresting Maximum Amount of Rainfall at the site of Occurrence
  - Maximizing soil Moisture storage
  - Reducing soil Moisture Losses
  - Overcoming Soil-Physical Constraints
  - Antitranspirants

ARRESTING MAXIMUM AMOUNT OF RAINFALL AT THE SITE OF OCCURRENCE

- Mechanical practices like levelling, bunding, terracing, contour furrowing, trenching, ridging, etc. help arrest the rainfall at the site of occurrence and provides more time to the rain water to soak into the soil.
- Levelling and grading
  - It is the process of the reshaping land surface to a planned grade which usually requires cutting of high areas and filling of low sports to remove surface irregularities and unevenness.
  - It reduces erosion, controls water flow and improves surface drainage.
- Contour bunding
  - Contour bunds are constructed to intercept the run-off. Contour bunds are usually less than one metre in height.
  - They are followed in low to medium rainfall area and relatively permeable soils.
  - In areas having rainfall more than 500 mm graded bunds are preferred to remove the excess water.
- Bench terracing
  - These are followed in areas of steep slopes (10-30%).

MAXIMIZING SOIL MOISTURE STORAGE

- Rapidity of water infiltration and higher moisture storage capacity of soil are desired for successful crop production under dry land farming.
- An improvement in both these essential may be brought about by making sub-soil pervious and improving structure of surface soil.

- The practices like hot weather cultivation, deep ploughing, sub-soiling, chiselling, growing of legumes and grasses and other deep rooted crops have been round to make the soil pervious to hold larger quantities to rain water which ultimately result in increased yield of crops.
    - Off- season tillage
        - Any tillage that is carried out between two crop periods is termed as off-season tillage. This aims at keeping the soil open for more water to soak into the soil and to control weeds.
    - Primary deep tillage
        - This aims to get weed-free seedbed with good water intake capacity so as to get more time for seeding and better germination.
    - Chiselling
        - This refers to breaking and loosening of compact soil or sub-soil with a chisel so as to increase root penetration.
    - Addition of organic matter
        - Organic matter improves soil structure consequently to more water holding capacity apart from improved soil fertility and better physical condition of soil, which results in higher yields.
        - Growing of deep rooted crops with particular reference to legumes also help to improve soil permeability and water storage in soil.

REDUCING SOIL MOISTURE LOSSES

- Surface evaporation and weeds are the two most important unwanted sources of the loss of soil water under dryland conditions, an effective control of which is of great concern to the dryland farmer.
- It has been estimated that surface evaporation is responsible for 30-40% of available soil moisture and if weeds are not kept under control the magnitude of loss increases upto 60-80%.
- Intercultivation by khurpi, hoe, harrow, cultivator, etc. in between the crop rows remove weeds and help check evaporation losses by forming a sort of dust mulch on the soil surface.
- Applications of mulches (organic, chemical, polyethylene etc.) antitranspirants, chemical weed control are other ways to reduce unproductive water losses through evaporation, transpiration and weed growth.

Mulches

- Organic mulches such as crop residues like rice straw sugarcane trash, maize stubbles, dry grasses etc., on soil surface in between the crop row is an effective way to check weed growth and to reduce soil moisture losses.
- Apart from this, it minimizes temperature fluctuation, improves physico –chemical properties of soil, adds to soil fertility and ultimately increases crop yields.
- Chemical mulches and polyethylene mulching are also used but done to their higher cost their use is generally prohibitive.

OVERCOMING SOIL - PHYSICAL CONSTRAINTS

- Dryland farmer may confront with one or more of the following soil physical constraints.
- Surface crusting
    - The problem is experienced in light soils where seeding emergence is hampered. Incorporation of stubble of crop residues minimizes crusting.
    - Set line cultivation, seeding on ridges also minimises the effect of crusting. In case where crusting has occured, passing of thorny branches on the surface reduces crusting.
- Soil cracking

- This is a serious problem of heavy textured soils. Intercultivation, mulching and selection of short duration varieties, which may complete the life cycle before the cracks develop can tackle this problem.

- Textural profiles and hard pans
  - Deep ploughing, chiselling and growing of deep rooted crops help to over come these problems.

ANTITRANSPIRANTS

- Antitranspirants are generally used to reduce the photosynthesis activity in the crops, therefore, their use is limited to save the crops under nurseries only.
- Antitranspirants are the following types :
  - *Growth retardants:* Such hormones are reduce shoot growth and increase root growth and also enhance female flower ratio, thus increase the production and resist to drought.
  - *Stomata closing type:* Such chemicals reduce water loss through stomatal closing.
  - *Film farming type:* Retard moisture loss due to formation to thin films as physical barrier.
  - *Reflecting type:* Such materials reflect the radiation and thus reduce leaf temperature and vapour pressure gradient from leaf to atmosphere and ultimately transpiration is reduced.

MODULE-15: METHODS OF IRRIGATION AND DRAINAGE FOR FODDER PRODUCTION

LEARNING OBJECTIVES

- At the end of this module the user can learn the following:
  - Meaning of irrigation and drainage
  - What are the various methods of irrigation?
  - What are the various methods of drainage?
  - Possible methods of irrigation for fodder cultivation.

METHODS OF IRRIGATION AND DRAINAGE FOR FODDER PRODUCTION

Introduction

- Water is essential for human, animal and plant life. It is a part of all organisms and some of the organisms contain more than 90% of water. It is an essential part of protoplasm and photosynthesis. Water is also required for translocation of nutrients and dissipation of heat.
- About 400 to 500 litres of water is necessary for the production of a kilo of plant dry matter. Biomass (Plant dry matter) production is vital for increasing green fodder productivity.
- Soil water is depleted due to evaporation from soil surface, transpiration through the plant and deep percolation into the soil beyond the root zone. Water availability to crops is reduced gradually and plants are subjected to moisture stress. Root growth is reduced due to high mechanical resistance of dry soil. In order to favour root plant growth, water should be supplemented through irrigation.
- Irrigation is the artificial application of water to soil to supplement rainfall for crop production.

WATER REQUIREMENT OF CROP

- Water requirement of a crop is the quantity of water regardless of source, needed for normal crop growth and yield in a period of time at a place and may be supplied by precipitation or by irrigation or by both.
- Water is needed mainly to meet the demands of evaporation (E), transpiration (T) and metabolic needs of plants, all together known as consumptive use.
- Water is currently the most limiting resource for crop production and is recognized as the most critical resource for future developments.
- Water use efficiency can be increased through introduction of short duration and drought tolerant crop cultivars, mulching to reduce evaporation, land leveling to reduce water requirement and optimum irrigation regime.
- Water use efficiency is defined as the yield of marketable crop produced per unit of water used in evapotranspiration.

DIFFERENT APPROACHES FOR IRRIGATION SCHEDULING

- Soil moisture depletion approach
- Climatological approach
    - IW / CPE approach
    - Can evaporimetry method
    - Combination approach
- Critical stage approach

Soil moisture depletion approach

- When the soil moisture in a specified root zone depth is depleted to a particular level, it should be replenished by irrigation.
- **Eg.** Irrigation can be scheduled at 25% depletion of soil moisture for crops like maize, wheat etc. and at 50% depletion of soil moisture for crops like sorghum, pearl millet, finger millet etc.

Climatological approach

    - This is mainly based on evapotranspiration. Based on the climatic data different methods are employed.
- IW/ CPE approach
    - A known amount of irrigation water is applied (IW) when the cumulative pan evaporation reaches a predetermined level.
- Can evaporimetry
    - Small cans of one litre capacity painted white and covered with 6/20-size mesh are used to indicate evaporation from the cropped field.
    - An indicator point is fixed at 1.5 cm below the brim. When irrigation is given bringing the soil to field capacity, the can is filled up with water to pointer level and kept to the crop height.
    - Evaporation from can is directly related to crop evapotranspiration. Irrigation is scheduled when the water level in the can falls to a predetermined level and can is again filled to the pointer level.
- Combination approach
    - This is based on soil moisture depletion and climatological approach for sufficient and deficit irrigation water conditions.

Critical stage approach

- In each and every crop, there are certain growth stages at which moisture stress leads to irrevocable yield loss and these stages are known as critical period or moisture sensitive period. This is highly suitable under

limited water supply conditions. Here the irrigation is scheduled at moisture sensitive stages and irrigation is skipped at non-sensitive stages.

- For higher water use efficiency by a crop, application efficiency, storage efficiency and distribution efficiency, different methods of irrigation can be followed based on land slope, amount of water and equipment available, crop and method of cultivation of crop.

IRRIGATION METHODS

- Surface irrigation
- Sub surface irrigation
- Over head or sprinkler irrigation
- Drip irrigation methods

Surface irrigation methods

- The common surface irrigation methods are flooding, check basin, border strip and furrow methods.
    - Flooding
        - Exclusive for lowland cultivation
    - Check basin method (View animation)
        - Mostly adopted method of irrigation. Suitable for closely growing crops. Here, field is divided into small plots surrounded by bunds or all the four sides.
        - Water is impounded in the basins and the bunds prevent water flow from one basin to the adjacent. Suitable for forage crops, which are tolerant to standing water, usually ranging from 12-24 hours.
    - Basin method (View animation)
        - This is highly suitable for fodder tree crops. Basins are formed around the trees and the basins alone are irrigated which are interconnected by an irrigation channel.
    - Border strip method (View animation)
        - The field is laid out into long, narrow strips, bordering with small bunds. Mostly the strips are about 30 to 50m in length and 3 to 5 m in width.
        - Suitable for medium to heavy textured soil with close growing crops.
    - Furrow irrigation (View Straight and Contour furrows animation)
        - Furrow irrigation is adapted to crops grown with ridges and furrows. The size and shape of the furrow depends on the crop grown and the spacing adopted for the crop.
        - Commonly grown crops with furrow irrigation are cumbu napier hybrid grass and guinea grass.

TOP

Sub surface irrigation

- Water is applied to the subsurface soil through underground-perforated pipes. Here, the surface soil is dry even though the root zone is wet. Suitable, where water table is shallow.

TOP

Sprinkler irrigation

- Water is applied as spray or as rain drops over the crops. Water is pumped through a system of pipes under pressure in the pipeline system to sprinkle water over the crops.
- Small quantities of irrigation water can be applied with sprinkler irrigation. This is highly suitable for pasture crops, and in dry areas where water is the limiting factor.

Click here for video...

TOP

Drip irrigation

- Drip irrigation is defined as the precise, slow application of water in the form of discrete or continuous or tiny streams or miniature sprays through mechanical devices called emitters or applicators located at selected points along with delivery lines.
- Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops such as coconut, grapes, banana, surgarcane, brinjal, cotton, maize etc.

Irrigation for fodder crops

- Irrigation water is an expensive input and has to be used very efficiently. Irrigation efficiency at the field level can be increased by selecting suitable method of irrigation, adequate land preparation and engaging an efficient irrigator. At the project level, it can be increased by proper conveyance and distribution system.
- Forage crops are usually grown as rainfed crop. In some cases, where the dairy farming is predominant, it is grown in irrigated upland situation. Most of the crops grown in irrigated upland situation are fairly drought tolerant, and it can withstand a drought period of upto five weeks, and thereafter is very susceptible.
- Irrigation is required on the day of sowing and subsequently once in 10-15 days interval or based on the soil moisture availability. Eg. Maize, cumbu napier hybrid grass, sorghum etc. Usually rainfed crops are sown as pre monsoon sowing. Once the rain occurs it utilizes the available moisture for its growth. Eg. Cenchrus, stylosanthes.
- Some of the crops are susceptible to water logging and in such cased provision of drainage channel is a must. **Eg.** Maize.

DRAINAGE

- Agricultural drainage is the provision of a suitable system for the removal of excessive irrigation or rain water from the land surface so as to provide suitable soil conditions for better plant growth.

Advantages of drainage

- Facilitates early sowing of crops.
- Land can be used for a long time without any deterioration due to damaged soil structure and salt concentration
- Lowers underground water table so as to facilities increased root zone depth.
- Improves soil aeration and increases soil temperature

METHODS OF DRAINAGE

- Surface drainage
- Subsurface drainage

Surface drainage

- Simplest and commonly adopted method is India. Drainage is achieved by digging open drains at suitable intervals and depth. Irrigation channels also serve as drainage channel.
- Surface drainage may be needed to prevent or modify saline-alkali condition in a soil by leaching. If the land is not naturally well drained, artificial drainage must be established at the same time, the irrigation system is installed.

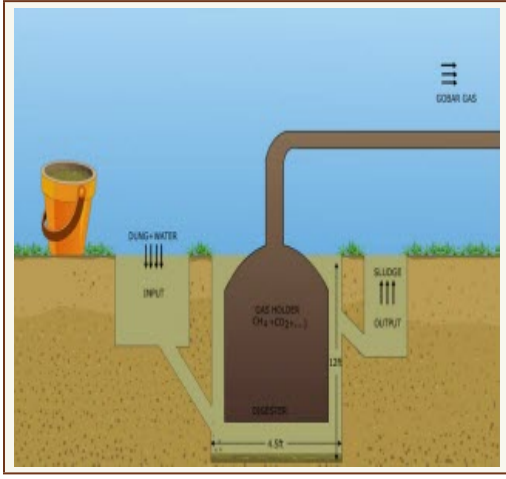
- See page from over irrigated areas at higher elevations and irrigation canal can damage lands in the low-lying areas. Interceptor drains may be necessary at the upper boundaries of the low-lying area to divert the seepage and to prevent water logging. Integrated irrigation and drainage planning is often necessary for laying out a farm area for efficient water use.
- Different methods of surface drainage are adopted, depending on the topography of the land, soil characteristics and crops that are proposed to be grown.
    - Random field ditch method
        - Standing water may be present in the field at several places distributed randomly. These depressions or micro ponds are connected by means of shallow channels or ditches and these are led into an outlet.
    - Land smoothing
        - The elevated areas are cut off and excess soil is spread over lower areas, so that the surface is even with uniform slope. Excess surface run off is collected and conveyed into the field ditches provided at the lower end of the field.
    - Bedding
        - Small furrows are formed at known intervals parallel to the slope for draining out water and known as dead furrows. The land between these furrows is known as beds. Small ridge or bund is made at the centre of the bed with gradual slope to drain water into the dead furrows.
    - Parallel field ditch system
        - Almost similar to bedding system except for deep drains and uneven interval between drains.
    - Broad bed and furrow method
        - The field is laid out into 1.05 m beds and 45 cm wide furrows across the slope. About 0.5% slope is provided for the furrows for free drainage.
        - Crops are sown on the beds and furrows help in drainage of water when there is excess rain.

TOP

Subsurface drainage

- When surface drainage is not possible due to subsoil conditions, water table and topography, subsurface drainage is resorted to remove ground water, or to lower water table.
- Unlike open drainage, land is not wasted and there is no interference to farming operations by subsurface drainage. However, this requires less maintenance and high investments.

MODULE-16: FARM POWER AND AGRO ENERGY
SOURCES, MERITS AND DEMERITS



LEARNING OBJECTIVES

- User can learn the following in this module:
    - Differet forms of farm power
    - Units of power
    - Agro energy
    - Biogas, wind mill and solar energy sources

FARM POWER AND AGRO ENERGY - AN INTRODUCTION

Power

- In physics, **power** (symbol: *P*) is the rate at which work is performed or energy is transmitted, or the amount of energy required or expended for a given unit of time. As a rate of change of work done or the energy of a subsystem, power is:

P=W/t

- where *P* is power, *W* is work and *t* is time.

Units of power

- Generally, it refers to the units of energy divided by time. The SI unit of power is the watt (W), which is equal to one joule per second. Non-SI units of power include ergs per second (erg/s) or horsepower (hp).
- One unit of horsepower is equivalent to 33,000 foot-pounds per minute, or the power required to lift 550 pounds one foot in one second, and is equivalent to about 746 watts. (one pound = 0.453 kg)

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SOURCES OF FARM POWER

- There are different sources of farm power in India which are classificatied as
  - Human power
  - Animal power
  - Mechanical power (Tractors + Power tillers + Oil engines)
  - Electrical power
  - Renewable energy (Biogas + Solar energy + Wind energy)

Human power

- Human power is the main source for operating small implements and tools at the farm. Stationary work like chaff cutting, lifting, watering, threshing, winnowing etc are done by manual labour.
- An average person can develop maximum power of about 0.1 hp for doing farm work.

Animal power

- Power developed by an average pair of bullocks is about 1 hp for usual farm work. Bullocks are employed for all types of farm work in all seasons.
- Besides bullocks, other animals like camels, buffaloes, horses, donkeys, mules and elephants are also used at some places. The average force a draft animal can exert is nearly one-tenth of its body weight.

Mechanical power

- Broadly speaking, mechanical power includes stationary oil engines, tractors and power tillers. Internal combustion engine is a good device for converting fuel into useful work. These engines are two types
  - Diesel engine and

- Petrol or Kerosene engine.

- The thermal efficiency of diesel engine varies from 32 to 38 per cent whereas that of petrol engine varies from 25 to 32 per cent.
- In modern days, almost all the tractors and power tillers are operated by diesel. Oil engines are used for pumping water, flour, mills, oil ghanis, cotton gins, chaff cutter, sugarcane crusher, threshers, winnowers etc.

Electrical power

- Electrical power is used mostly in the form of electrical motors on the farms. Motor is a very useful machine for farmers. It is clean, quest and smooth running. Its maintenance and operation needs less attention and care.
- The operating cost remains almost constant throughout its life. Electrical power is used for pumping sets, diary industry, cold storage, farm product processing, fruit industry and many similar things.

Renewable energy

- It is the energy mainly obtained from business sun and wind. Biogas energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices.
- It can be used for lighting, cooking, water heating, space heating, water distillation, food processing, water pumping, diesel engine operation anmd electric generation. This type of energy is inexhaustible in nature.

DIFFERENT FORMS OF POWER AND THEIR ADVANTAGES

Merit		Demerit	
Human Power			
1.	Easily available.	1.	Costliest power compared to all other forms of power.
2.	Used for all types of work.	2.	Very low efficiency.
		3.	Requires full maintenance when not in use.
		4.	Affected by weather condition and seasons.
Animal Power			
1.	Easily available.	1.	Not very efficient.
2.	Used for all types of work.	2.	Seasons and weather affect the efficiency.
3.	Low initial investment.	3.	Cannot work at a stretch.
4.	Supplies manures to the field and fuels to farmers.	4.	Requires full maintenance when not in use.
5.	Lives on farm products.	5.	Creates unhealthy and dirty atmosphere near the residence.
		6.	Very slow in doing work.
Mechanical Power			
1.	Efficiency is high.	1.	Initial capital investment high.
2.	Not affected by weather.	2.	Fuel is costly.
3.	Cannot run at a stretch.	3.	Repairs and maintenance needs technical knowledge.
4.	Requires less space.		
5.	Cheaper form of power.		
Electrical Power			
1.	Very cheap form of power.	1.	Initial capital investment high.

2.	High efficiency.	2.	Requires good amount of technical knowledge.
3.	Can work at a stretch.	3.	If handled carelessly, it causes great danger.
4.	Maintenance and operating cost is very low.		
5.	Not affected by seasons.		

AGRO ENERGY

- Biogas energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices.
- It can be used for lighting, cooking, water heating, space heating, water distillation, food processing, water pumping, diesel engine operation and power generation.

BIOGAS

- Plant matter created by process of photosynthesis is called biomass. It includes all plant life, trees, agricultural plants, bush, grass, algae and livestock wastes.
- Photosynthesis is a naturally occurring process which derives its energy requirement from solar radiation. In its simplest form the reaction of this process can be represented by $H_2O + CO_2$ à CH_2O+O_2.
- It is seen that in this process, water and carbon dioxide are converted into organic material. The gas produced by biomass is called biogas.
- Biogas is obtained through the fermentation of animal waste and other biomass in a digestion chamber. Biogas is a mixture of methane (45 to 70 per cent) and carbon dioxide.
- The production of biogas is of particular significance for India because of its large cattle population.

History of Biogas

- History of biogas in India is petty old. Sri.S.V.Desai of Indian Agricultural Research Institute, New Delhi was a pioneer man in India who worked extensively on this subject in 1937. After that, contribution of Prof.N.V.Joshi of I.A.R.I. in 1964 is of great significance, Sri Satish Chandra Das Gupta had studied in detail the different aspects of biogas in the year 1952. Besides these, a large number of persons worked on different aspects of biogas at different places. Khadi and Village Industries Commission (KVIC) started a project on biogas in a big way in 1962.

Biogas Plant

- It is a composite unit consisting of : (1) Digester and (2) Gas holder. The gas holder floats on the top of digester in conventional designs (Fig.2.1.). In KVIC design the gas holder is a fixed type unit.

Digester

- It is a chamber containing the animal waste in the form of slum. It is normally situated below the ground level. It is made of masonry work.
- There is a partition wall in the middle of the digester which divides the digester into semi-circular compartments.
- Two slanting pipes are fitted to reach the bottom of the well on either side of the partition wall. There is one inlet pipe and another outlet pipe for the system. Outlet opening is lower than the inlet opening.
- The diameter of the digester ranges from 1.2 to 6 metres while its depth ranges from 3 to 6 meters.

Gas Holder

- It is a drum like structure of mild steel sheet in conventional designs. It is like a cap on the mouth of the digester where it dips in the slurry and rests on suitable base inside the digester.
- Gas holders may be made of mild steel sheet, fibre glass, reinforced plastic (RFP) and high density polythelene (HDP). In some designs there is fixed type gas holder.

Gas generation process

- The gas generation process occurs in two stages. In the first stage the organic substance contained in the waste are acted upon by certain kind of bacteria called acid formers.
- The material is broken up into small chain simple acids. On the second stage, these acids are acted upon by another kind of bacteria which produce methane and carbon dioxide. The biogas contains about 55% methane (CH_4) and about 45% carbon dioxide (CO_2).

Feeding process of slurry

- Cattle dung is mixed with water in the proportion of about 4:5 ratio and fed through inlet opening. Cattle dung can be obtained from buffaloes, bullocks, cows and calves.
- Buffaloes give about 15kg dung per day, bullocks or cows give about 10kg dung per day and calves give about 5kg dung per day.

Gas Plant Capacity

- Gas plants are available in nearly 20 sizes ranging from 2 to 150 cubic metre. Smallest plant may be 2 cubic meter size where 2 to 3 animals are required.
- Gas production may be 0.037m^3 per kg of wet dung.
- For cooking purpose 0.227 m^3 gas per day per person may be required.
- For lighting purpose 0.127 m^3 gas per lamp of 100 candle power may be required.
- For a 5 hp engine, 18 m^3 gas may be required for 8 hours.

Condition for gas production

- Suitable condition for gas production is when the pH of the slurry is between 7 to 8 in the digestion chamber. Bacteria dies when the pH is above 8 in the digestion chamber.
- Gas production is at higher rate when the temperature inside the chamber is around 35°C. The process is retarded very much below 15°C.

Utilization

- Gas is used for : (i) cooking purpose (ii) lighting (iii) running of diesel engine (iv) fertilizer supply. The sludge which comes out from the gas plant retains all the nitrogen, phosphorus and potassium, so it is an excellent fertilizer at the farms.

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WIND ENERGY

- Air in motion is called wind. Contrast in temperature causes pressure difference which generates wind. Energy derived from wind velocity is wind energy.
- It is a non-conventional type of energy which is renewable with suitable devices. This energy can be used as a perennial source of energy.
- Wind energy is obtained with the help of wind mill. The minimum wind speed of 10 km/hr is considered to be useful for working wind mills for agricultural purpose.
- Along the sea coast and hilly areas, wind mills are likely to be most successful in Karnataka, Maharastra and Gujarat State.

Function of wind mill

- Wind mill extracts energy from the wind and produces mechanical energy. This energy may be converted into electrical energy.
- A minimum wind speed of less than 10 km/hr is not suitable to operate a wind mill on economical basis .

Types of wind mill

- Wind mill may be of two types :
    - Horizontal axis rotor

- Vertical axis rotor

Horizontal axis rotor

- Horizontal axis (or wind axis) rotor is an unit whose axis of rotation is parallel to the direction of the wind. This rotor has three types of blades :
  - Multiblade unit
  - Sail type unit and
  - Propeller type unit.
- Multiblade type rotor
  - It is very widely used in wind mills. It has usually 12 to 20 blades fixed over it. The blades are made by suitably shaping the metal sheets. It runs at speed of 60 to 80 revolutions per minute .
- Sail type unit
  - It has three blades made by stretching out triangular pieces of canvas cloth. It runs at 60 to 80 revolutions per minute.
- Propeller type unit
  - It has 2 or 3 aerofoil blades and runs at speeds of 300 to 400 revolutions per minute.

Advantages

- Wind power has many advantages:
  - Zero pollution
  - Provides extra income for rural farmers by renting land for turbines
  - Creates more jobs per GW of electricity generated than coal power stations
  - Renewable source of electricity
  - Sustainable source of electricity

SOLAR ENERGY

- Sun is the biggest fusion reactor known to mankind which supplies to the earthy daily about 10,000 times energy needed by the world population.
- Apart from being the source of life, sun happens to be the source of all energy except nuclear energy and geothermal energy. Sun radiates energy in the form of electromagnetic radiation.
- In order to obtain solar energy, a dark surface is exposed to solar radiation so that radiation is absorbed. A part of the absorbed radiation is then transferred to a fluid or air.

Collection of solar radiation

Collection of solar radiation can be done in three ways :

- By flat plate collector.
- Focussing or Concentrating collector
- Photovoltaic cell.

Application of solar energy

- Solar water heating
- Space heating
- Space cooling
- Thermal electric conversion
- Photovoltaic electric conversion
- Solar distillation
- Solar pumping

- Agricultural and Industrial process heat
- Solar furnace
- Solar cooking
- Solar production of hydrogen
- Solar green house

MODULE-17: FARM MACHINERY AND EQUIPMENTS

LEARNING OBJECTIVES

- After this module the user would know the following:
  - What is tillage?
  - What are the various tillage implements?
  - What are the various sowing implements?
  - What are the various intercultural implements?
  - What are the various plant protection equipments?
  - What are the various types of spraying?

FARM MACHINERY AND EQUIPMENTS

Introduction

- Use of machines in agricultural production has been one of the outstanding developments all over the world during the past century.
- The farm machines have reduced the burden and human drudgery of farm work to a great extent. Various types of farm equipments that are important and commonly used are listed into *four broad categories*:
  - Tillage implements
  - Sowing equipments
  - Interculture equipments
  - Plant protection equipments
  - Harvesting equipments

TILLAGE IMPLEMENTS

Tillage

- Tillage is the preparation of soil for sowing seeds and the process of providing favourable conditions in the soil by improving the soil tilth for good crop growth. Tillage is the preparation of soil zone (about 100 to 900 mm of the top soil layer) for crop production.

Objectives of tillage

- The tillage has the following objectives:
  - To obtain a seed bed of good tilth.

- To add humus and fertility to the soil by covering the crop residues.
- To increase soil aeration.
- To improve the moisture retaining capacity of the soil.
- To destroy soil insects and their breeding places.
- To destroy the competitive weeds.
- To improve physical conditions of soil so as to reduce soil losses due to water and wind erosion.

COUNTRY PLOUGH

- Country plough or indigenous plough is the *most commonly used* plough in India. The shape and size of the country plough varies from place to place depending on the type of soil and tillage requirements.
- The main parts of the plough are body, shoe, share, beam and handle. All the parts except share are made of wood. Share is made of mild steel. The share makes an angle of 10° to 30° with ground level.

MOULD BOARD PLOUGH

- The mould board plough was imported to India during the British rule. The mould board plough does the following functions:
  - Cutting
  - Lifting
  - Turning and
  - Pulverisation

DISC PLOUGH

- Disc plough is used in the following conditions:
  - Clayey and sticky soils where mould board plough does not scour well.
  - Soil having hard pan or plough sole below regular ploughing depth.
  - Dry and hard land which are difficult to plough with mould board plough.
  - Stony and stumpy soils which are likely to cause damage to mould board plough.
- Disc plough is capable of ploughing at more depth than mould board plough. Disc plough does not completely invert the soil. A disc plough consists of 2 or 3 discs, cross shaft, frame, disc bearing

brackets, scrapers, land wheel and furrow wheel. Diameter of steel concave discs varies from 600 to 900 mm.

- Furrow wheel is attached at the rear of disc plough. This is provided to counter act the soil side thrust force exerted on the discs during ploughing. Scrapers are used to keep the disc surfaces clean. Discs are set at an angle to the direction of travel and also to vertical line.

METHODS OF PLOUGHING

- To form furrows at the right hand side of the plough all the times, following methods are followed for ploughing the fields.
  - Round and round ploughing
    - In this method, plough moves around a field strip. Ploughing can be started either from the center of field or from the field boundary.
  - Gathering
    - When a plough works round a strip of ploughed land, it is said to be gathering.
  - Casting
    - When a plough works round a strip of unploughed land, it is said to be casting.
  - Continuous ploughing
    - This method consists of gathering and casting alternately so that idle runs are minimised. Field is divided into strips of equal width. Each strip is divided into two parts in the ratio of 3:4. Casting is started at the first strip leaving 1/3 of the strip at the middle.

CULTIVATOR

Cultivator

- Cultivator is a secondary tillage implement used to stir the ploughed land for shallow depth prior to sowing. It is popularly known as tiller. When soil has sufficient moisture, cultivator is directly used as primary tillage implement. It is the only implement that can be used for tilling the soil in between standing rows of crops.

Functions of cultivator

- It breaks the clods.
- It does weeding and intercultural operations in between standing rows of crops.
- It aerates the soil.
- It conserves soil moisture by preparing soil mulch.
- It sows seeds when provided with sowing attachment.

- Cultivator consists of 9 or 11 tynes attached to a rectangular frame. The tynes are staggered in two rows one behind the other. Spacing in between the tynes is adjustable. The bottom of the tynes are fitted with shovels, which are replacable and reversible.
- The cultivator has two heavy coiled springs fitted with each tyne. The spring loaded tynes deflect when the tynes hit obstacles in the field infested with stones and root stumps. It covers 0.40 ha/h.

HARROWS

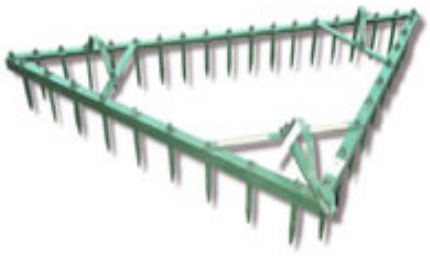
Harrows

- Harrows are used to break the clods, to stir the soil and to destroy weeds after ploughing.

Type of harrows

  - Disc harrows
  - Spike tooth harrow
  - Spring tooth harrow
  - Triangular harrow
  - Blade harrow
  - Power harrow
- Disc harrow is a tractor drawn secondary tillage implement which has concave steel discs of 400 to 600 mm diameter mounted on long gang bolts. The discs are spaced at a distance of 150 to 250 mm by means of spacers. Each disc is provided with a scraper to remove soil sticking to the disc. Cut-away or notched discs are provided in the front gang to cut the crop residues in the field. Disc angle of the discs in a disc harrow is less than 25°.
- The angle between gang bolt and the direction of travel is called gang angle. Width of operation by the disc harrow is changed by altering the gang angle. The center line of the implement is offset to the center line of the tractor and therefore it is called offset disc harrow. Two gangs are provided one behind the other. The discs in the front gang and rear gang face opposite direction. The offset disc harrow is suitable for tilling orchards.



LEVELLER

- Levelling of agricultural land is necessary for
    - Effective application of irrigation water.
    - Reducing water logging and
    - Controlling soil erosion.
- Tractor drawn leveller is also known as blade terracer. The leveling board is attached to the three point linkage of the tractor and controlled by the tractor hydraulic system. Land levelling is essential when areas under forests are converted to farm lands.
- The leveller is used in ploughed fields to collect top soil from high spots and to dump the soil in depressions. It is used in irrigated fields for precision levelling. Crawler tractor or chain type tractor fitted with leveling board at the front is known as bulldozer or simply dozer.

RIDGER

- The ridger is useful in forming ridges and furrows in garden land to facilitate sowing of seeds. Ridger is also known as ridge plough or double mould board plough. The ridger has a wedge shaped share and two mould boards fitted to the share.
- Distance between the mould boards can be adjusted at the back according to the size of furrow desired in the field. Ridger is also used for earthing up operation in row crops like sugarcane. Distance between ridger bottoms can also be altered according to the crop row spacing.

BUND FORMER

- It makes bunds by gathering the top soil Bunds are formed in the field to prevent water run – off and to reduce soil erosion. Two bund forming boards are fitted to a frame.
- Distance between the bund forming boards is more at the front than at the back. Size of bund former is specified by the maximum horizontal distance between the two bund forming boards at the rear end. If two bund formers are used side by side, an irrigation channel is formed. Bund former is
- also used to form field boundaries . In dry land, bunds are formed across the slope to conserve soil moisture. In some bund formers the size of the bund is adjustable.

MELUR PLOUGH

- It is used for *shallow ploughing*. The cast iron shares made in Melur, near *Madurai in Tamil Nadu*. It is also known as *Bose plough*. In some areas double Melur plough bottoms are used. Except the share, all other components viz., frame, beam and handle are made of wood.
- It is an alternative to the country plough. When the share happens to encounter root stumps or roots, the share will break. The broken share can be easily replaced.

CHISEL PLOUGH

- The chisel plough cuts a furrow of an average depth of 300 mm with an average draft of 110-130 kg. The chisel plough is operated at a spacing of 300 to 450 mm.
- It helps to conserve the soil moisture and 16 per cent yield is increased. The tyne is 30 mm thick and 700 mm wide. It is used to break hard pan once in three years. It needs a pair of heavy sized bullocks. It will not pulvarise soil. It improves air permeability of the soil.

BASIN LISTER

- It is a soil conservation equipment especially useful in dry farming areas receiving meagre rainfall. The equipment has one to three plough bottoms with ground wheels.
- The plough bottoms are lifted often during operation by the cam arrangement and by this furrows are formed in the field intermittently. The precipitated water is retained in the furrows, thus reducing the top soil erosion and conserving moisture.
- Several versions of basis listers are now available in India such as tractor drawn and power tiller drawn basin listers. An offset disc harrow drawn by tractor can be converted to a basin lister by shifting the center of rotation of the dics to one side. Seeds are sown in between the staggered pits.

PUDDLER

- Puddler is a wetland implement used for the preparation of paddy fields in standing water of 50 to 100 mm depth after ploughing. It breaks the clods and churns the soil to a homogeneous mixture.
- The purpose of puddling is to minimise water leaching, to destroy weeds by burying and decomposing them and to facilitate transplanting of paddy seedlings by making the soil softer.
- High yielding varieties of paddy respond well to good quality puddling. The puddlers are operated by bullock, power tiller or tractors. Some of the bullock drawn puddlers available in India are
    - Open blade puddler
    - Straight blade puddler
    - Helical blade puddler

GREEN MANURE TRAMPLER

- This implement is used to trample and press the green manure crops the paddy field.
- There are *two types of tramplers* viz.,
    - *Slat type* and
    - *Disc type*
- In slat type trampler long radical slats of flats are fitted to a central axle through supporting discs.
- In disc type trampler, flat discs are fitted to a central axle with intermediate spacing.

SOWING EQUIPMENT

- Sowing refers to placing seeds into the soil in accepted pattern under optimum soil moisture and at optimum row to row and plant to plant spacing. To get high yield, the right amount of seed should be placed at the right time at a predetermined depth and spacing in the soil.
- The operational requirement of a sowing equipment are as follows:
    - Provision to change the seed rate.
    - Placing of seeds at an appropriate depth and their covering with soil layer.
    - Seeds should not be exposed to injury by the seeding devices.
    - Operating efficiency of the seed drill should not be dependent on field undulations and travel speed (6-15 km/h).

METHODS OF SOWING THE SEEDS

- The methods of sowing seeds include broadcasting, dibbling, drilling, hill dropping, planting, check row planting and transplanting.
- Broadcasting
    - It is the process of scattering of seeds at random on the prepared seed bed. It is usually done with manual labour, seed rates are generally higher in this method. After the seeds are broadcast they are covered by planking.
- Dibbling
    - It is the method of placing the seeds into the holes made on prepared seed bed at predetermined depth and at fixed spacing. The seeds are then covered by physically manipulating the soil. For dibbling, dibber is used in kitchen gardens and vegetable plots. This method is not suitable for small seeds.

- Drilling
  - It consists of dropping seeds along with rows of furrows in a continuous steam and covering them. Seeding behind the country plough is a manual seed drilling process. Mechanical seed drilling machines are called seed drills.
- Hill dropping
  - Seeds are dropped in the furrows as in the case of drilling. But in one hill move than one seed is dropped with fixed spacing between hills.
- Planting
  - Individual seeds are dropped with a fixed seed to seed spacing.
- Check row planting
  - In this method spacing between rows is equal to the spacing between seeds. This facilitates weeding and interculturing operations in both the directions.
- Transplanting
  - Seeds are broadcast in prepared nursery bed. The grown up seedlings are plucked from the nursery field and transplanted in the main field. It is suitable for *paddy*, *vegetables* and flower *crops*. Transplanting requires less seed rate.
  - Seedlings can be selected before transplanting and hence uniform crop stand can be obtained. Weeds are buried at the time of puddling. Plant protection measures can be effectively done in the nursery field.

HAND OPERATED SEED BROADCASTING DEVICE

- The main disadvantage of broadcasting by hand is the non-uniformity of distribution. This causes uneven crop growth which results in poor yield.
- The hand operated broadcasting device consists of a plastic hopper with agitator, a rotating disc made of aluminium sheet with projections and a handle. By rotating the handle the disc is made to rotate at a speed of 500 rev/min.
- The hand operated broadcasting device spreads the seeds 50 per cent more uniformity with respect to hand broadcasting. The device is hung infront of the operator. The material is spread, over a width of 3.5 to 10 metre. The unit weighs only 3.6 kg and costs about Rs.1500/-.
- The seed rate can be varied by changing the opening area at the hopper bottom. The device is capable of covering one hectare per hour.

SEED DRILL

- The typical functions of a seed drill are:
  - It holds and carries the seeds.
  - Opens furrow to a uniform depth.
  - Meters the seeds at a predetermined seed rate.
  - Drops seeds into the opened furrows and
  - Covers the seeds and compacts the soil around them.
- Country seed drill
  - The simple seed drill otherwise known as **‘Gurru’** has a wooden bowl with holes at the bottom Seed tubes are inserted in the holes. T
  - he other end of seed tubes are connected to the country plough bottom like furrow openers. Uniformity of seed distribution in this drill depends mainly on the skill of the operator dropping the seeds in the bowl.
  - A three bottom gorru can cover one hectare in a day.
- Seed Planter
  - Seed planters are meant for sowing the seeds in rows with specific seed to seed spacings. All the components of a seed planter are the same as in the case of seed drill except the seed metering device.
  - The seed planters are suitable for till dropping, planting and check row planting. A seed planter has a seed hopper for each row.

INTERCULTURE EQUIPMENT

- Interculturing is described as breaking the upper surface of the soil, uprooting the weeds, aerating the soil, thereby promoting the activities of soil microorganisms and making a good mulch so that the soil moisture is conserved. Control of weeds has always been one of the greatest time and labour consuming operations in the production of crops.
- In India Rs. 4200 million is being lost every year due to the competitive weeds in the produce of major agricultural crops (Natarajan,1987). In an average the cost of weeding comes to Rs. 945/ha, out of the total cost of cultivation of Rs. 3000/ha for agricultural crops.

WEEDERS

- There are several types of weeders available in India.
    - Paddy weeder
    - Dryland weeder
    - Cono weeder
    - Power weeder

Manual weeder

Power weeder

Dryland weeder

- It has a long handle, a roller with star shaped projections and a scraper blade at the rear. The weeder is suitable for weeding in groundnut, vegetable and similar crops.The weeder is capable of weeding 0.05 hectare in a day of 8 hours. The rear blade cuts the roots of the weeds and leaves behind a soil mulch.
- The weeder is operated by one person. For best results, the operator has to give push – pull movements to the handle and walk behind in the field. Dry land weeder is used for removing weeds in between line sown crops in rainfed and garden lands.
- It is suitable for removing shallow rooted weeds in the lands not too thickly infested with weeds. The weeding blade can be adjusted to the desired angle and depth. The operator need not kneel not bend down while weeding. He does weeding operation in standing position.

MINI POWER TILLER FOR WEEDING AND INTERCULTURE

- Weed control is one of the most expensive operations in Indian crop production. Majority of Indian farmers use hand-hoe for weeding which requires 40 – 60 manual labourers for one hectare.
- An engine operated mini power-tiller has been developed for weeding and interculture in between rows of crops such as maize, tapioca, cotton, pulses, sugarcane and grape.
- Two types of weeding tools viz.,
    - Sweep blade and
    - Rotary blades have been developed as attachments to the mini power – tiller.

ROW - CROP CULTIVATORS

- The main reason for row-crop cultivation is to promote plant growth by eradicating weeds. Additional functions in irrigated areas are to prepare the land for the application of irrigation water and to improve water penetration.
- In certain crops, preparation of the field for harvesting operation is an important consideration.

GUNTAKA

- Guntaka is an improved type of blade harrow.
- Junior hoe is a bullock drawn cultivator.
- The spacing between the tynes is adjustable.

PLANT PROTECTION EQUIPMENT

- On an average, 20 % of the total cost of cultivation goes to plant production activities for majority of the food crop production.
- In India, the total annual losses in crop production has been estimated to be in the order of Rs. 60,000 million.
- The percentage contribution of pests in the above loss is as follows:

Weeds	33%
Diseases	26%
Insects	20%
Rodents	8%

Birds	2%

- Fodder crops do not generally report pest infestation in the Country. However, pests and diseases in could be noticed in the case of fodder seed production and storage. This would make spraying and dusting necessary at times.
- Different types of sprayers and dusters are used for spraying insecticides, pesticides, fungicides and herbicides. Control of these pests is accomplished by chemical and non-chemical means.
- Combinations of these is known as Integrated Pest Management(IPM). IPM strives for pest control using biological, chemical and physical means that are effective, economical and environmentally friendly.

TYPES OF SPRAYERS

- Hand atomizer
- Compression sprayer
- Bucket sprayer
- Rocker sprayer
- Lever operated backpack sprayer or knapsack sprayer
- Power knapsack sprayer or mist blower cum duster
- Tree sprayer
- Tractor mounted boom sprayer
- Air craft sprayer

HAND ATOMIZER AND COMPRESSION SPRAYER

- Hand atomizer
  - This is the smallest type of manually operated sprayer used in kitchen gardens. In this sprayer air is compressed by means of a hand pump.
  - The compressed air is allowed to pass over the end of a tube. The other end of the tube is dipped into the spray liquid kept inside a tank. The outgoing air sucks the spray liquid from the tank through the tube and blows out off the nozzle.

- Compression sprayer
  - An air pump is mounted on the top of an air tight tank which is filled with spray liquid upto ¾ level.
  - The air pump builds up pressure in the space above the liquid. When the nozzle is opened, spray liquid is forced out through the nozzle opening by the compressed air.
  - Frequent pumping has to be done to maintain pressure inside the tank. Pressure is developed by pumping air into the tank and the spray is forced out under pressure. Frequent pumping is to be done to maintain pressure.

BUCKET SPRAYER AND ROCKER SPRAYER

- Bucket sprayer
  - It consists of a pump kept into a bucket containing spray solution. The pump delivers the spray liquid through a spray lance. It consists of a single or double acting pump which is placed in a bucket containing spray solution. It is light and easily handled and develops sufficient pressure to spray small gardens and low trees.
- Rocker sprayer
  - It consists of a plunger pump, spherical air pressure chamber, handle, spray lance and hose . Air chamber helps to have uniform spray. The lance has nozzle and cut off value. By using the sprayer using two persons, 1.5 ha can be sprayed in a day. This is a high volume sprayer i.e., it sprays more than 400 litre/ha.
  - The suction hose and delivery hose are fitted to the pump barrel. Spray gun is connected to the outlet opening of the pump through a plastic hose. This sprayer needs two operators, one to operate or rock the handle and another to hold the lance and spray. It is suitable for spraying on medium height trees like mango.

KNAPSACK SPRAYERS

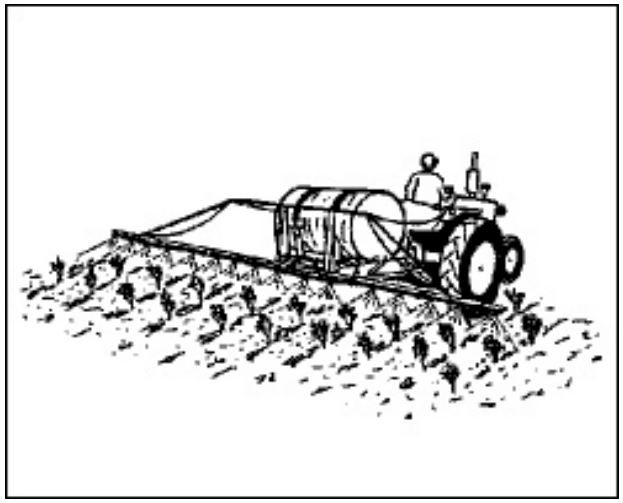
- Lever operated backpack sprayer or knapsack sprayer
  - The sprayer is taken on the back of the operator. It consists of a spray tank of 10 litre capacity, pump, handle, air chamber fitted inside the tank, delivery line and nozzle. The operator operates the handle by left hand and sprays by right hand. The spray application rate by the sprayer is 225 l/ha.
  - It is provided with a pump and a large air chamber mounted in a tank. The handle of the pump extending under the arm of the operator makes it possible to pump with one hand and spray with the other hand.

- It is useful for spraying small trees, shrubs and row crops. A uniform pressure can be maintained by keeping the pump in operation. One man can spray 0.4 ha in a day.

- Power knapsack sprayer or mist blower cum duster
  - Power knapsack sprayer or mist blower cum duster is the most commonly used sprayer in India. It consists of an engine, petrol tank, spray tank, carburetor, spark plug, blower, spray boom, cut off valve, throttle and frame. The engine used is 1.2 to 1.7 hp petrol engine.
  - The engine rotates at a maximum speed of 6000 rev/min. The engine drives the blower. The spray liquid is made to drop from the end of a spray tube. The blower blows air at a speed of 500 km/h. This blast of air breaks the spray liquid into spray droplets. The spray tank is of 10 L capacity.
  - Power sprayer comes under low volume spraying (150 l/ha spray application rate). Power knapsack sprayer is available per tank basis on custom hiring.

TREE SPRAYER AND TRACTOR MOUNTED BOOM SPRAYER

- Tree sprayer
  - Engine operated portable sprayers are used for spraying tree crops. The sprayer is carried by four labourers. A blower is attached to the engine.
  - The blast of air carries upwards the spray liquid up to 9 m height.
- Tractor mounted boom sprayer
  - A tractor mounted boom sprayer consists of pump, tank, agitator, pressure regulator, boom, nozzles, pressure gauge, filters.
  - The spray tanks are mounted on the side or front of the tractor.



AIR CRAFT SPRAYER

Air craft spraying is meant for larger farms. Areal spraying is affected by wind. Atomising devices use one or more of the following principles to break the liquid into droplets.

- Pressure or hydraulic atomization, which depends on liquid pressure to supply the atomizing energy.
- Pneumatic or gas atomisation in which the liquid is broken up by a high velocity air stream.
- Centrifugal atomisation in which the liquid is fed under low pressure at the centre of a high speed rotating disc or cup. The liquid is broken up by centrifugal force as the liquid leave the periphery of the disc or cup.

TYPES OF SPRAYING

- Based on the spray application rate there are **three types of spraying**
  - High volume spraying: More than 150 l/ha of spray liquid is applied. This technique is biologically effective but economically expensive, time as well labour consuming. With high volume spraying the drops are larger, complete coverage of crop canopy is achieved, excessive run off occur and less danger of damage from spray drifting to the neighbouring crops. Insecticides, fungicides and herbicides are sprayed by this technique. Lever operated knapsack sprayer and tractor mounted boom sprayer come under this category.
  - Low volume (LV) spraying: Spray volume ranges from 10 to 150 l/ha. Sprayers designed for low volume work is relatively light and cheap, require less amount of water, have high rate of work and low labour cost. Insecticides and fungicides are sprayed by this method. Motorised knapsack sprayer and aircraft sprayer are low volume sprayers.
  - Ultra low volume (ULV) spraying: Less than 10 l/ha is applied. The chemical is undiluted or in more concentrated form.