**DRAFT STUDY MATERIAL**

# AGRICULTURE (808)

## CLASS – XI

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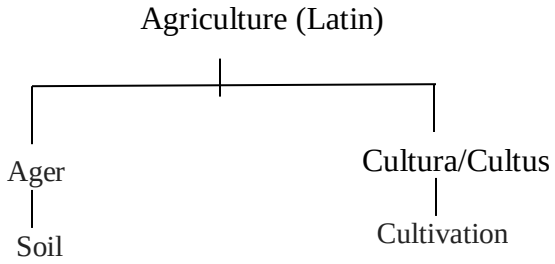
# SECTION – I

# Agriculture and Crop Production

## Unit –I: Scope and Importance

### A. Definition of agriculture and Branches of Agriculture

The term Agriculture is derived from two Latin words ***ager*** or ***agri*** meaning **soil** and ***cultura*** or ***Cultus*** meaning **cultivation**. Agriculture is an applied science which encompasses all aspects of crop productionincluding horticulture, livestock rearing, fisheries, forestry, etc.




**Agriculture is defined as an art, science and business of producing crops and livestock for economic purposes.**

**As an art:-** It embraces knowledge of the way to perform the operations of the farm in a skillful manner,but does not necessarily include an understanding of the principles underlying the farm practices.

**As a science:** Utilizes all technologies developed on scientific principles such as crop breeding, production techniques, crop protection, economics etc. to maximize the yield and profit. For example, new crops and varieties developed by hybridization, Transgenic crop varieties resistant to pests and diseases, hybrids in each crop, high fertilizer responsive varieties, water management, herbicides to control weeds, use of bio-control agents to combat pest and diseases etc.

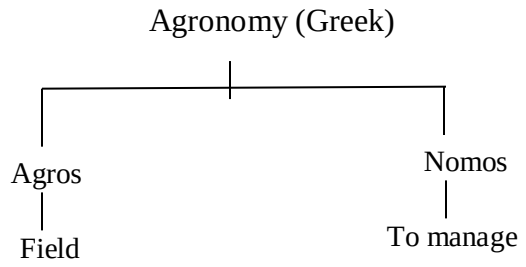
**As the business:** As long as agriculture is the way of life of the rural population production isultimately bound to consumption. But agriculture as a business aims at maximum net return through the management of land labour, water and capital, employing the knowledge of various sciences for production of food, feed, fibre and fuel. In recent years, agriculture is commercialized to run as a business through mechanization.

Agriculture is defined in the Agriculture act (1947), as including 'horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use ancillary to the farming of land for Agricultural purposes".

## Branches of Agriculture

1. Agronomy
2. Horticulture
3. Animal husbandry
4. Forestry
5. Fishery science
6. Agricultural Engineering and
7. Home science

1. **Agronomy** word drive from two Greek word "*Agros*" means field and "*Nomos*" means to manage.

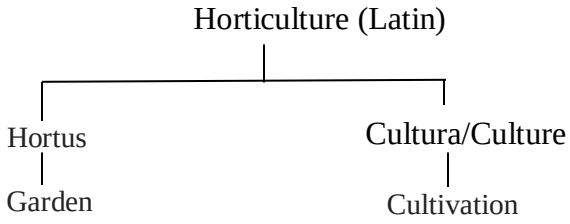



**Definition:-** It is defined as an agricultural science deals with principles and practices of crop production and field management.

or

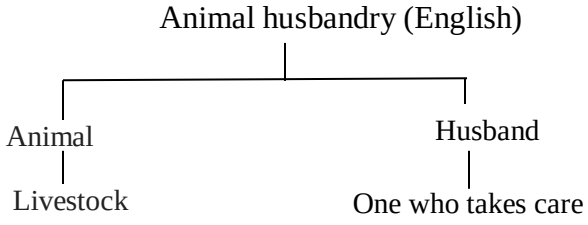
Agronomy is branch of agricultural science, which deals with principles, & practices of soil, water & crop management.

2. **Horticulture** word drive from two Latin word "*Hortus*" means garden and "*cultura/ Cultus*" means cultivation.




**Definition:-** Horticulture is a branch of agriculture in which deal fruit crops, vegetable crops, ornamental plants, commercial flower, medicinal crops, aromatic crops, spices crops, plantation crops, individual tree, shrub, climber and post-harvest management and processing.

3. **Animal husbandry word drive from** "Animal" and "Husband" words. Animal means livestock and husband means one who takes care.



**Definition:-** Animal husbandry is the branch of agriculture concerned with animals that are raised for meat, fibre, milk, eggs, or other products. It includes day-to-day care, selective breeding, and the raising of livestock.

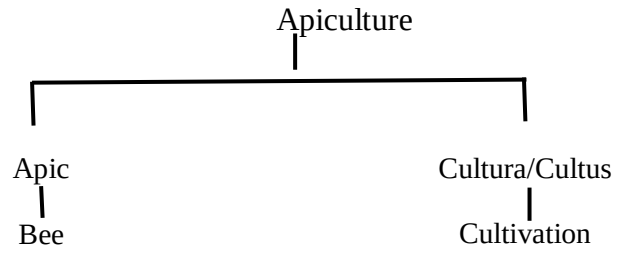
4. **Forestry:-** Forestry word drive from French "Forest" word means wooded country.

   **Definition:-** Forestry is defined as the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources (Anon, 1966). It includes all thinking and all actions pertaining to creation and management of forests, including harvesting, marketing and utilization of all forest products and services. It includes not only management of existing forests but also the creation of new forests.

5. **Fishery science:-** Aquatic and fisheries science is the study of aquatic ecosystems to increase scientific understanding and to apply basic ecological principles to their management, thereby sustaining them for multiple uses.
6. **Agricultural Engineering:-** It is the branch of **engineering** involved with the design of farm machinery, with soil management, land development, and mechanization and automation of livestock farming, and with the efficient planting, harvesting, storage, and processing of farm commodities.
7. **Home Science:-** Home Science can be defined as the multidisciplinary field of study that deals with health, diet, caring child, textile and garment designing, managing resources and other subjects concerned with a ***home.***

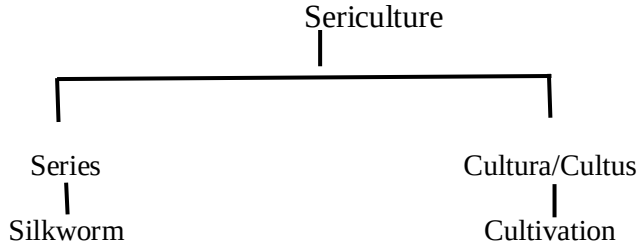
**Other Branches**

8. **Apiculture:-**Apiculture word drive from two Latin words.




**Definition:-** It is a branch of agriculture in which deal study of bee keeping and honey production.

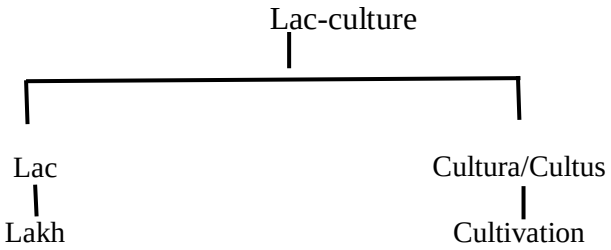
9. **Sericulture:-** Sericulture word drive from two Latin words.




**Definition:-** It is a branch of agriculture in which deal study of Silkworm (*Bombyx mori*) domestication and silk production.

- It is an economically important insect, being a primary producer of silk. A silkworm's preferred food is white mulberry leaves, though they may eat other mulberry (*Morus nigra*) species and even osage orange.

10. **Lac Culture:-** The English word lac synonyms Lakh in Hindi which itself is derivative of Sanskrit word Laksh meaning a lakh or hundred thousand. It would appear that Vedic people knew that the lac is obtained from numerous insects and must also know the biological and commercial aspects of lac industry. It is also worth to mention that a laksh griha would need a lot of lac which could only come from a flourishing lac industry in that period




**Definition:-** It is a branch of agriculture in which deal study of Lac insect (*Laccifer lacca*) domestication and lac production.

**Lac insect Host Plant:-**

1. *Butea monosperma* (Palas)
2. *Zizyphus spp* (Ber)
3. *Schleichera oleosa* (Kusum)
4. *Acacia catechu* (Khair)
5. *Acacia arabica (*Babul)
6. *Acacia auriculiformis* (Akashmani)
7. *Zizyphus xylopyrus* (Khatber- grown in part of M.P. & U.P.)
8. *Shorea talura* (Sal grown in mysore)
9. *Cajanus cajan* (Pigeon-pea or Arhar)
10. *Grewia teliaefolia* (Dhaman preferred in Assam)
11. *Albizzia lebbek* (Siris/Gulwang)
12. *Flemingia macrophylla* (Bholia)
13. *Ficus benghalensis* (Bargad)
14. *Ficus religiosa* (Peepal)

## B. Scope of agriculture in the national economy and employment

**Present status of Agriculture in India**

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP). As per the 2nd advised estimates by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) is expected to be 17.3 per cent of the Gross Value Added (GVA) during 2016-17 at 2011-12 prices.

India is the largest producer, consumer and exporter of spices and spice products. India's fruit production has grown faster than vegetables, making it the second largest fruit producer in the world. India's horticulture output, is estimated to be 287.3 million tonnes (MT) in 2016-17 after the first advance estimate. It ranks third in farm and agriculture outputs. Agricultural export constitutes 10 per cent of the country's exports and is the fourth-largest exported principal commodity. The agro industry in India is divided into several sub segments such as canned, dairy, processed, frozen food to fisheries, meat, poultry, and food grains.

The Department of Agriculture and Cooperation under the Ministry of Agriculture is responsible for the development of the agriculture sector in India. It manages several other bodies, such as the National Dairy Development Board (NDDB), to develop other allied agricultural sectors.

India's GDP is expected to grow at 7.1 per cent in FY 2016-17, led by growth in private consumption, while agriculture GDP is expected to grow above-trend at 4.1 per cent to Rs 1.11 trillion (US$ 1,640 billion). As per the 2nd Advance Estimates, India's food grain production is expected to be 271.98 MT in 2016-17. Production of pulses is estimated at 22.14 MT.

**Scope of Agriculture in India**

Proverbially, India is known as "Land of Villages". Near about 67% of India's population live in villages. The occupation of villagers is agriculture. Agriculture is the dominant sector of our economy & contributes in various ways such as:

**National Economy:-** In 1990 – 91, agriculture contributed 31.6% of the National Income of India, while manufacturing sector contributed 17.6%. It is substantial than other countries for example in 1982 it was 34.9% in India against 2% in UK, 3% in USA, 4 % in the Canada. It indicated that the more the more the advanced stage of development the smaller is the share of agriculture in National Income.

**Total Employment:** Around 65% population is working & depends on agriculture and allied activities. Nearly 70% of the rural population earns its livelihood from agriculture and other occupation allied to agriculture. In cities also, a considerable part of labor force is engaged in jobs depending on processing & marketing of agricultural products.

**Industrial Inputs:** Most of the industries depend on the raw material produced by agriculture, so agriculture is the principal source of raw material to the industries. The industries like cotton textile, jute, paper, sugar depends totally on agriculture for the supply of raw material. The small scale and cottage industries like handloom and power loon, ginning and pressing, oil crushing, rice husking, sericulture fruit processing, etc are also mainly agro based industries.

**Food Supply:** During this year targeted food production was 198 million tons & which is to be increased 225 million tons by the end of this century to feed the growing population of India i.e. 35 corer in 1951 and 100 corers at the end of this century. India, thus, is able to meet almost all the need of its population with regards to food by develop intensive program for increasing food production.

**State Revenue:** The agriculture is contributing the revenue by agriculture taxation includes direct tax and indirect tax. Direct tax includes land revenue, cesses and surcharge on land revenue, cesses on crops & agril income tax. Indirect tax induces sales tax, custom duty and local octri, etc. which farmer pay on purchase of agriculture inputs.

**Trade:** Agriculture plays and important role in foreign trade attracting valuable foreign exchange, necessary for our economic development. The product from agriculture based industries such as jute, cloth, tinned food, etc. contributed to 20% of our export. Around 50 % of total exports are contributed by agril sector. Indian agriculture plays and important role in roads, rails & waterways outside the countries. Indian in roads, rails and waterways used to transport considerable amount of agril produce and agro based industrial products. Agril products like tea, coffee, sugar, oil seeds, tobacco, spices, etc. also constitute the main items of export from India.

# Unit II: Physical Environment

## A. Climate and Weather, Elements of Weather, Rainfall, Temperature, Humidity, Wind, Sunshine.Climate Change, Global warming

**Meteorology**

Meteorology can be defined as the Science of atmosphere which deals with the physics, chemistry and dynamics of atmosphere and also their direct and indirect effects upon the earth surface, oceans and thereby Life in general

**Climatology:-** It is defined as a scientific study of climate. It discovers, describes, & interprets the climate on the basis of cause's processes that generate them.

Or

Climatology is the science which studies average condition of weather or the state behavior of the atmosphere over a place or region for a long period of time.

**Ecology:-** In general ecology is a branch of biology that deals with the relation of living things to their surroundings.

**Weather:-** Weather is the atmospheric condition of any place for a short period of time with respect to its one or more elements such as temperature, pressure, wind, humidity, precipitation, sunshine, cloud cover etc.

The periods of the year which are characterised by particular set of weather conditions are mainly caused by the inclination of the earth's axis and the revolution of the earth around the sun, are known as seasons.

**Climate:-** The average weather conditions, prevalent from one season to another in the course of a year, over a large area is known as climate. The average of these weather conditions is calculated from the data collected for several year (about 35 years) for a larger area. Rajasthan, for example, experiences hot and arid climate, Kerala has tropical rainy climate, Greenland has cold desert climate and the climate of Central Asia is temperate continental. Climate of a region is considered more or less permanent.

**Difference between weather and climate**

| Sr No | Weather | Climate |
|---|---|---|
| 1 | Instantaneous physical state of atmosphere at particular place. | Normal physical state or generated condition of atmosphere or long term average condition of a place. |
| 2 | Weather changes refer to specific instant of time( day or week) | It is generalized over a longer span of time and for a longer area. |
| 3 | It is expressed in terms of numerical values of meteorological elements. | It is expressed in terms of time averages and area averages of meteorological elements. |
| 4 | Weather is measured in observatory. So the observatory must at a place for which weather is to be described. | This is derived information on regional basis. So scripts of observatories extending over a region are necessary. |
| 5 | It provides meteorological information. | It constitutes geographical information in respect of weather. |
| 6 | Weather of two places having same numerical value must be same. | Climate of the two places having the same averages of weather can not be same, because their distribution over the years |

| | | |
|---|---|---|
| | | may be different. |
| 7 | Weather can be categorized as fair, unfair, excellent etc. | Climate is classified as desert climate, marine climate, tropical climate etc. |
| 8 | Weather decides the success or failure of a crop in a particular season. | Climate decides the type of crop suitable for a region, while introducing new crops climate is considered. |
| 9 | Adverse weather results into crop failure or loss and warrants short term contingent planning. | Climate is considered in long terms agricultural planning. |

**Weather forecast:-** Means any advance information about the probable weather in future, which is obtained by evaluating the present and past meteorological conditions of the atmosphere is called weather forecast.

**Agricultural weather forecast:-** Forecasting of weather elements viz sunshine hours, occurrence of dew, relative humidity, rainfall, temperature, winds etc. Which are important in agriculture and for farming operations is known as agricultural forecast.

In weather forecasting the advance information of weather elements like distribution of rain fall, warming for heavy rain fall, temperature change important special hazardous weather like if thunderstorm hailstorm, show or frost, sky cover, winds, humidity, dew drought, evaporation rate etc is provided.

**Classification weather forecasting:-** Weather forecasting on the basis of their validity periods or time scale is classified as follows **:**

**1. Short range forecast (SRF):-** It is based on synoptic situation prevailing at the time of forecasting and is valid up to 3 days or 72 hrs and is issued twice a day. It broadcasted from local weather centre.

**2. Medium range forecast (MRF):-** Forecasting of meteorological elements over different agro climatic zones for periods ranging from3-10 days is known as medium range forecast. It is broadcasted from Weather Forecasting Centre, Noida, UP.

**3. Long range forecast (LRF):-** The forecast valid for more than 10 days i.e. a month or a season is knows as long range forecast. It is broadcasted from Indian Metrology Department (IMD), Pune, Maharashtra.

**Facture affecting of Climate:-**

**1. Latitude or Distance from the Equator**

The places near the equator are warmer than the places which are far away from it. This is because the rays of the sun fall vertical on the equator and slanting in the temperate and polar regions. The vertical rays are concentrated over a small area than the slanting one.

Again, the vertical rays pass through a shorter distance in the atmosphere before reaching the earth's surface. Therefore, lower the latitude higher is the temperature and vice versa. Malaysia which is near the equator is warmer than England which is far way from the equator.

**2. Altitude or the Height from the mean sea level**

We all know that mountains are cooler than the plains. Shimla situated on a higher altitude is cooler than Jalandhar, although both are almost on the same latitude. The temperature decreases with the height of a place. For a vertical rise of 165 metres there is an average decrease in temperature at the rate of 1°C. Thus the temperature decreases with increase in height.

**3. Continentally or the Distance from the Sea**

The water is a bad conductor of heat i.e. it takes longer time to heat and longer time to cool. Due to this moderating effect of the sea, places near the coast have low range of temperature and high humidity. The places in the interior of the continent do not experience moderating effect of the sea. These places have extreme temperatures. The places far from the sea have higher range of diurnal (daily) and annual temperatures. Mumbai has relatively lower temperature and higher rainfall than Nagpur, although both are almost situated on the same latitude.

**4. Nature of the Prevailing Winds**The on-shore winds bring the moisture from the sea and cause rainfall on the area through which they pass. The off-shore winds coming from the land are dry

and help in evaporation. In India, the on-shore summer monsoon winds bring rains while off-shore winter monsoon winds are generally dry.

**5. Cloud Cover**

In areas generally of cloudless sky as in deserts, temperature even under shade are very high because of the hot day time sunshine. At night this heat radiates back from the ground very rapidly. It results in a large diurnal range in temperature. On the other hand under cloudy sky and heavy rainfall at Thiruvananthapuram the range of temperature is very small.

**6. Ocean Currents**

Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. Ocean currents are large movements of water usually from a place of warm temperature to one of cooler temperature or vice-versa. The warm ocean currents raise the temperature of the coast and sometimes bring rainfall, while the cold currents lower the temperature and create fog near the coast. Port Bergen in Norway is free from ice even in winter due to warm North Atlantic Drift while Port Quebec in Canada remains frozen during winter months due to chilling effect of the Cold Labrador Current in spite of the fact that Port Quebec is situated in much lower latitude than Port Bergen. The on-shore winds passing over a warm current carry warm air to the interior and raise the temperature of the inland areas. Similarly, the winds blowing over cold current carry cold air to the interior and create fog and mist.

**7. Direction of Mountain Chains**

The mountain chains act as natural barrier for the wind. The on-shore moisture laden winds are forced to rise after striking against the mountain; and give heavy rainfall on the windward side. These winds descending on the leeward side cause very low rainfall. The great Himalayas check the moisture laden monsoon winds from crossing over to Tibet. This mountain chain also checks biting polar cold winds from entering into India. This is the reason for which northern plains of India get rains while Tibet remains a perpetual rain shadow area with lesser amount of rainfall.

**8. Slope and the Aspect**

The concentration of heat being more on the gentler slope raises the temperature of air above them. Its lesser concentration along steeper slopes lowers the temperature. At the same time, mountain slopes facing the sun are warmer than the slopes which are away from the sun's rays. The southern slopes of Himalaya are warmer than the northern slopes.

**9. The Nature of the Soil and Vegetation Cover**

The nature of soil depends upon its texture, structure and composition. These, qualities vary from soil to soil. Stony or sandy soils are good conductor of heat while black clay soils absorb the heat of the sun's rays quickly. The bare surface reradiates the heat easily. The deserts are hot in the day and cold in the night. The forest areas have lower range of temperature throughout the year in contrast to non-forested areas.

**Weather components**

Nearly 50 % of yield is attributed to the influence of climatic factors. The following are the atmospheric weather variables which influences the crop production.

1. **Precipitation:-** Precipitation includes all water which falls from atmosphere such as rainfall, snow, hail, fog and dew.Rainfall one of the most important factor influences the vegetation of a place.
   - Total precipitation in amount and distribution greatly affects the choice of a cultivated species in a place.
   - In heavy and evenly distributed rainfall areas, crops like rice in plains and tea, coffee and rubber in Western Ghats are grown.
   - Low and uneven distribution of rainfall is common in dryland farming where drought resistance crops like pearl millet, sorghum and minor millets are grown.
   - In desert areas grasses and shrubs are common where hot desert climate exists
   - Though the rainfall has major influence on yield of crops, yields are not always directly proportional to the amount of Precipitation as excess above optimum reduces the yields
   - Distribution of rainfall is more important than total rainfall to have longer growing period especially in drylands
2. **Temperature:-** Temperature is a measure of intensity of heat energy. The range of temperature for maximum growth of most of the agricultural plants is between 15 and 40ºC.

- The temperature of a place is largely determined by its distance from the equator (latitude) and altitude.
- It influences distribution of crop plants and vegetation.
- Germination, growth and development of crops are highly influenced by temperature.
- Affects leaf production, expansion and flowering.
- Physical and chemical processes within the plants are governed by air temperature.
- Diffusion rates of gases and liquids changes with temperature.
- Solubility of different substances in plant is dependent on temperature.
- The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature.

| **Crops** | **Minimum temperature ºC** | **Optimum temperature ºC** | **Maximum temperature ºC** |
|---|---|---|---|
| Rice | 10-12 | 30-32 | 36-38 |
| Maize | 8-10 | 32-35 | 40-42 |
| Tobacco | 13-14 | 28-30 | 36-38 |
| Sorghum | 8-10 | 30-32 | 36-38 |
| **Average for Kharif** | **15-18** | **31-37** | **38-47** |
| Wheat | 3-4.5 | 25-27 | 30-32 |
| Barley | 3-4.5 | 20-25 | 38-40 |
| Pea | 1-2 | 30-32 | 35-37 |
| Lentil | 4-5 | 30-32 | 36-38 |
| **Average for Rabi** | **0-5** | **25-30** | **31-35** |

3. **Atmospheric Humidity (Relative Humidity - RH):-** Water is present in the atmosphere in the form of invisible water vapour, normally known as humidity. Relative humidity is ratio between the amounts of moisture present in the air to the saturation capacity of the air at a particular temperature.If relative humidity is 100% it means that the entire space is filled with water and there is no soil evaporation and plant transpiration.

- Relative humidity influences the water requirement of crops
- Relative humidity of 40-60% is suitable for most of the crop plants.
- Very few crops can perform well when relative humidity is 80% and above.
- When relative humidity is high there is chance for the outbreak of pest and disease.

4. **Solar radiation (without which life will not exist):-** From germination to harvest and even post-harvest crops are affected by solar radiation.
    - Biomass production by photosynthetic processes requires light.
    - All physical process taking place in the soil, plant and environment are dependent on light
    - Solar radiation controls distribution of temperature and there by distribution of crops in a region.
    - Visible radiation is very important in photosynthetic mechanism of plants. Photosynthetically Active Radiation (PAR - 0.4 – 0.7µ) is essential for production of carbohydrates and ultimately biomass.
        - ✓ 0.4 to 0.5 µ - Blue – violet – Active

- ✓ 0.5 to 0.6 µ - Orange – red - Active
- ✓ 0.5 to 0.6 µ - Green –yellow – low active

- Photoperiodism is a response of plant for flower inatation to day length. Basis of photoperidism plant classified in 4 gropus.
  1. Short Day Plnt:- If any plant require less than 9 hours day lenght for flower ination is called Short Day Plant. Eg. Rice, lima bean, cluster bean and cotton.
  2. Long day Plants:-If any plant require more than 13 hours day length for flower ination is called Long Day Plant. Eg.Barley, oat, carrot, onion, garlic and cabbage
  3. Day neutral Plant:- If any plant flower inatation is no or less influence on day length. Eg. Tomato, maizerinjal, cucurbits, chilli etc**.**

- Phototropism — Response of plants to light direction. Eg. Sunflower
- Photosensitive – Season bound varieties depends on quantity of light received

**5.Wind velocity:-**

- The basic function of wind is to carry moisture (precipitation) and heat.
- The moving wind not only supplies moisture and heat, also supplies fresh $CO_2$ for the photosynthesis.
- Wind movement for 4 – 6 km/hour is suitable for more crops.
- When wind speed is enormous then there is mechanical damage of the crops (i.e.) it removes leaves and twigs and damages crops like banana, sugarcane.
- Wind dispersal of pollen and seeds is natural and necessary for certain crops.
- Causes soil erosion.
- Helps in cleaning produce to farmers.
- Increases evaporation.
- Spread of pest and diseases.

**5. Atmospheric gases on plant growth**

- Atmosphere Composition:- $CO_2$ – 0.03%, $O_2$ - 20.95%, $N_2$ - 78.09%, Argon - 0.93%, Others - 0.02%.
- $CO_2$ is important for Photosynthesis, $CO_2$ taken by the plants by diffusion process from leaves through stomata
- $CO_2$ is returned to atmosphere during decomposition of organic materials, all farm wastes and by respiration
- $O_2$ is important for respiration of both plants and animals while it is released by plants during Photosynthesis
- Nitrogen is one of the important major plant nutrient, Atmospheric N is fixed in the soil by lightning, rainfall and N fixing microbes in pulses crops and available to plants
- Certain gases like $SO_2$, CO, $CH_4$, HF released to atmosphere are toxic to plants

## Climate Change, Global warming

Climate change, also called global warming, refers to the rise in average surface temperatures on Earth.

Temperature records going back to the late 19th Century show that the average temperature of the Earth's surface has increased by about 0.8C (1.4F) in the last 100 years. About 0.6C (1.0F) of this warming occurred in the last three decades.

Satellite data shows an average increase in global sea levels of some 3mm per year in recent decades. A large proportion of the change in sea level is accounted for by the thermal expansion of seawater. As seawater warms up, the molecules become less densely packed, causing an increase in the volume of the ocean.

But the melting of mountain glaciers and the retreat of polar ice sheets are also important contributors. Most glaciers in temperate regions of the world and along the Antarctic Peninsula are in retreat. Since 1979, satellite records show a dramatic decline in Arctic sea-ice extent, at an annual rate of 4% per decade. In 2012, the ice extent reached a record minimum that was 50% lower than the 1979-2000 average.

The Greenland Ice Sheet has experienced record melting in recent years; if the entire 2.8 million cubic km sheet were to melt, it would raise sea levels by 6m.

Satellite data shows the West Antarctic Ice Sheet is also losing mass, and a recent study indicated that East Antarctica, which had displayed no clear warming or cooling trend, may also have started to lose mass in the last few years. But scientists are not expecting dramatic changes. In some places, mass may actually increase as warming temperatures drive the production of more snows.

The effects of a changing climate can also be seen in vegetation and land animals. These include earlier flowering and fruiting times for plants and changes in the territories (or ranges) occupied by animals.

**Causes of Global Warming**

**Greenhouse Gases**

Some gases in the Earth's atmosphere act a bit like the glass in a greenhouse, trapping the sun's heat and stopping it from leaking back into space.

Many of these gases occur naturally, but human activity is increasing the concentrations of some of them in the atmosphere, in particular:

- ✓ carbon dioxide ($CO_2$)
- ✓ methane
- ✓ nitrous oxide
- ✓ fluorinated gases
- ➢ **$CO_2$** is the greenhouse gas most commonly produced by human activities and it is **responsible for 64% of man-made global warming**. Its concentration in the atmosphere is currently 40% higher than it was when industrialisation began.
- ➢ **Other greenhouse gases** are emitted in smaller quantities, but they trap heat far more effectively than $CO_2$, and in some cases are thousands of times stronger. **Methane** is responsible for 17% of man-made global warming, **nitrous oxide** for 6%.
- ➢ **Causes for rising emission**
- ➢ **Burning coal, oil and gas** produces carbon dioxide and nitrous oxide.
- ➢ **Cutting down forests (deforestation).** Trees help to regulate the climate by absorbing $CO_2$ from the atmosphere. So when they are cut down, that beneficial effect is lost and the carbon stored in the trees is released into the atmosphere,adding to the greenhouse effect.
- ➢ **Increasing livestock farming.** Cows and sheep produce large amounts of methane when they digest their food.
- ➢ **Fertilisers containing nitrogen** produce nitrous oxide emissions.
- ➢ **Fluorinated gases** produce a very strong warming effect, up to 23 000 times greater than $CO_2$. Thankfully these are released in smaller quantities and are being phased down by EU regulation.

## B. Soil texture, Soil structure, Soil types, Soil distribution, Soil area, Soil erosion, Soil conservation

**Definition:-** Soils are natural bodies made from both mineral and organic materials and capable of supporting plants out-of-doors.

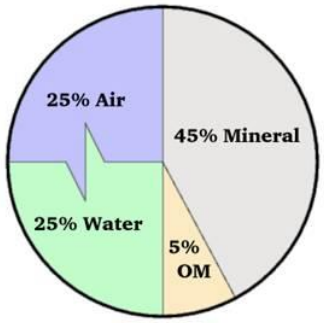
**Jenny (1941):-** Soil is a naturally occurring body that has been formed due to combined influence of climate and living organisms acting on parent material as conditioned by relief over a period of time.

Soil is a three dimensional body having length, breadth and depth. They form a continuation over the land surface and differ in properties from place to place. Its upper boundary is air or water

and lower boundary is the rock lithosphere.

**Composition of soil on volume basis (Soil components)**

- Mineral matter :- 45%
- Organic matter :- 5%
- Soil water :- 25%
- Soil air :- 25%




**Branch of Soil Science**

1. **Pedology:-** Pedology word drive from Greek word *pedon*, means soil or earth and *logos* means to study. Pedology concerned with origin of the soil, its classification, distribution and character (Physical, Chemical and Biological)**.**
2. **Edaphology:-** Edaphology word drive from Greek word *edaphos,* means soilor groundand *logos* means to study. Edaphology is concerned with the influence of soils on living things, particularly plants.

**Soil texture:-** Soil texture is the relative proportions of sand, silt, or clay in a soil. The soil textural class is a grouping of soils based upon these relative proportions. Soils with the finest texture are called clay soils, while soils with the coarsest texture are called sands. However, a soil that has a relatively even mixture of sand, silt, and clay and exhibits the properties from each separate is called a loam.

**Piratical size:-**

1. **According to United States Department of Agriculture (USDA)**

| Soil Particle | Diameter (mm) |
|---|---|
| Clay | < 0.002 mm |
| Silt | 0.002 – 0.05 |
| Very Fine Sand | 0.05 – 0.10 |
| Fine Sand | 0.10 – 0.25 |
| Medium Sand | 0.25 – 0.50 |
| Coarse Sand | 0.50 – 1.00 |
| Very Coarse Sand | 1.00 – 2.00 |

2. **According to International Society of Soil Science (ISSS)**

| Soil Particle | Diameter (mm) |
|---|---|
| Clay | < 0.002 mm |
| Silt | 0.002 – 0.02 mm |

| | |
|---|---|
| Fine sand | 0.02 – 0.2 mm |
| Coarse sand | 0.2 – 2.0 mm |

**More than 2mm particle classified as:-**

1. Gravels : 2 – 4 mm
2. Pebbles : 4 – 64 mm
3. Cobbles : 64 – 256 mm
4. Boulders : > 256 mm

**Soil Texture Class:-**

| Sr.No. | Textural Class | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| **1.** | Sandy Soil | 85-100 | 0-15 | 0-10 |
| **2.** | Loamy Sand | 70-90 | 0-30 | 0-15 |
| **3.** | Sandy Loam | 43-80 | 0-50 | 0-20 |
| **4.** | Loam | 23-52 | 28-50 | 7-27 |
| **5.** | Silt Loam | 0-50 | 50-88 | 0-27 |
| **6.** | Silt | 0-20 | 88-100 | 0-12 |
| **7.** | Sand Clay Loam | 45-80 | 0-28 | 20-35 |
| **8.** | Clay Loam | 20-45 | 15-53 | 27-40 |
| **9.** | Silt Clay Loam | 0-20 | 40-73 | 27-40 |
| **10.** | Sandy Clay | 45-65 | 0-20 | 35-45 |
| **11.** | Silt Clay | 0-20 | 40-60 | 40-60 |
| **12.** | Clay | 0-45 | 0-40 | 40-100 |

**Soil structure:-** The arrangement and organization of primary and secondary particles in a soil mass is known as soil structure. Soil structure controls the amount of water and air present in soil.

**Type of Soil Structure:-**

1. **Plate-like (Platy):-** In this type, the aggregates are arranged in relatively thin horizontal plates or leaflets. The horizontal axis or dimensions are larger than the vertical axis. It is generally two types:-
   **i. Platy:-** When the units/ layers are thick they are called platy.

ii. **Laminar:-** When they are thin then it is laminar.

- Platy structure is most noticeable in the surface layers of virgin soils but may be present in the subsoil.
- This type is inherited from the parent material, especially by the action of water or ice.

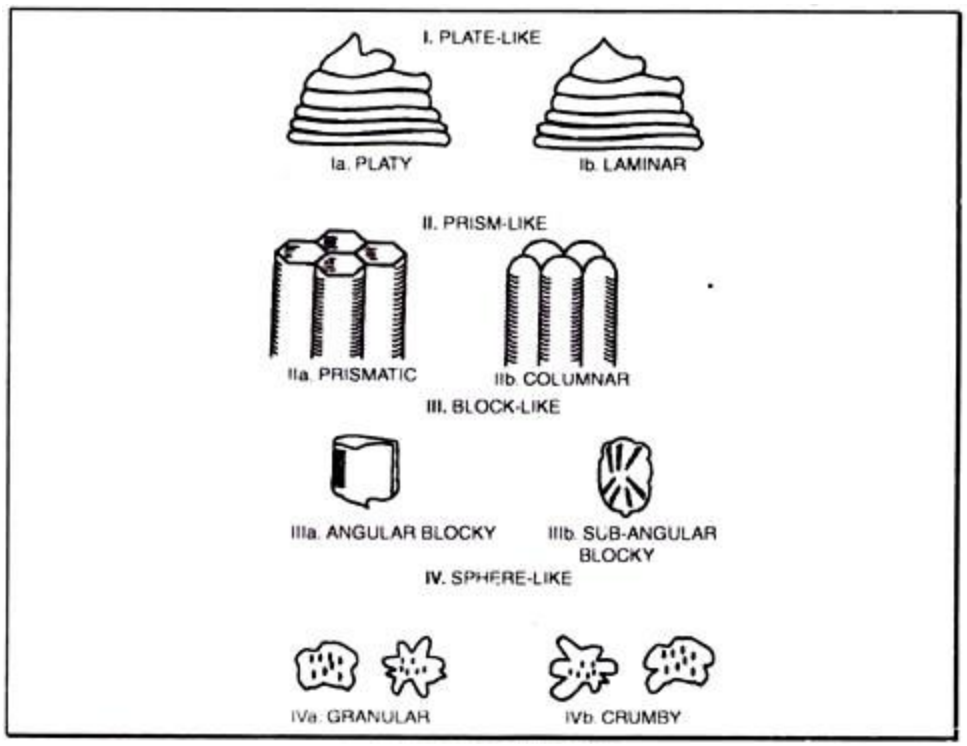
2. **Prism-like:-** The vertical axis is more developed than horizontal, giving a pillar like shape. Vary in length from 1- 10 cm. Commonly occur in sub soil horizons of Arid and Semi arid regions. It is generally two types:-
   i. **Columnar:-** When the tops are rounded, the structure is termed as columnar
   ii. **Prismatic:-** when the tops are flat /plane, level and clear cut than it is known as prismatic.
3. **Block like:-** All three dimensions are about the same size. The aggregates have been reduced to blocks .Irregularly six faced with their three dimensions more or less equal. It is two types:-
   i. **Angular Blocky:-** When the faces are flat and distinct and the edges are sharp angular, the structure is named as angular blocky.
   ii. **Sub-**Angular Blocky:- When the faces and edges are mainly rounded it is called sub angular blocky.

- These types usually are confined to the sub soil and characteristics have much to do with soil drainage, aeration and root penetration.

4. **Spheroidal (Sphere like):-** All rounded aggregates (peds) may be placed in this category. It is two types:-
   i. **Granular:-** If sphere-like structure, infiltration, percolation and aeration are not affected by wetting of soil. The aggregates of this group are usually termed as granular which are relatively less porous.
   ii. **Crumb:-** When the granules are very porous, it is termed as crumb.

- Crumb structure best for cultivation.
- In cultivated land found Spheroidal like structure.

5. **Single Grain Structure:-** Sandy soil always remain without structure so it is called single grain or structure less soil.




## Soil Erosion

Soil erosion is the washing or blowing away (by wind or water) of the top layer of soil (dirt).

**Type of Soil Erosion:-**

1. **Natural Erosion:-** Erosion is a natural process that usually occurs slowly enough that new soil can be made to replace it.
2. **Accelerated Erosion**:- Accelerated erosion is caused by human impact on land use such as over grazing and poor farming practices.

- Erosion decreases soil fertility and this causes a decrease in crop production.
- It takes 20 to 1200 years to form one inch of topsoil.
- In India, nearly 80 million ha area is exposed to the threat of soil erosion, and million ha area is actually affected.
- In states like Madhya Pradesh. Rajasthan, Maharashtra and Punjab, upto 15 per cent of the total land suffers from soil erosion.
- It is reported that the annual loss of fertility by erosion is 20 times faster than what is lost by growing crops.
- Each year, 10,000 hectares area is exposed to erosion. Nearly 145 mHa area in India is in need of conservation measures.

**Factors Influencing Soil Erosion:-**

There are many factors which influence the process of soil erosion; these are discussed below:

**1. Rainfall:-** Precipitation is the most forceful factor causing erosion. Erosion is dependent on the amount, duration, intensity and frequency of rainfall. By the action of dashing rain drops on soil, soil granules are loosened, detached and separated into fine particles. Erosion is greater where the rainfall is not only heavy, but concentrated over short periods.

**2. Slope of Topography:-** The slope accelerates erosion as it increases the velocity of the flowing water.

**3. Vegetation:-** The vegetative cover protects the soil from the beating and dispersing action of the raindrops by forming a canopy over the soil surface. Vegetation also acts as a mechanical obstruction to flowing water, thus reducing its erosive potential. The plant roots help in building a

better structure. They said in opening the soil and thereby accelerating water absorption and reducing surface run-off.

**4. Tillage:-** The infiltration and permeability of the soil is improved by the practice of proper tillage and thereby reducing the chances of erosion. But excess tilling exposes the soil to erosion, especially by wind.

**5. Nature of the Soil:-** Erodability of the soil is influenced by the nature of the soil, particularly its texture, structure, organic matter, amounts and kinds of salts present, presence of hard pan in the soil and presence of high water table.

**6. Soil Moisture:-** The presence of high water table checks the infiltration and permeability, thus allowing more flow of water on the surface, and greater erosion. At the same time, long continuous rainless periods cause loosening of soil and thus expose the soil to erosion by wind.

**7. Wind Velocity:-** Stronger winds have greater erosive potential, thus wind velocity is directly proportional to intensity of erosion.

**Type of Erosion:-**

**Water Erosion:-**

**Following are the types of soil erosion caused by water:-**

**1. Splash Erosion:-** This type of erosion occurs when the falling raindrops splash on the soil, and beat the bare soil into flowing mud.

**2. Sheet Erosion:-** This occurs when soil is removed uniformly in a thin layer from the entire surface area. Movement of soil by splash erosion is the primary cause of sheet erosion.

**3. Rill Erosion:-** This type of erosion takes place when the run-off water, laden with soil flowing along the slopes, forms fingerlike channels. Rill erosion is an intermediate stage between sheet erosion and gulley erosion.

**4. Gully Erosion:-** As the volume of concentrated run-off increases and attains more velocity on slopes, it enlarges the rill into gullies. At an advanced stage, gullies result in ravines, which are sometimes 50 to 100 feet deep. In India ravines cover about 10 million hectares.

**5. Slip Erosion:-** Landslides cause slip erosion big masses of soil and rock slip down, thus damaging the fields in the foothills and causing obstructions in communication. The effect of slip erosion is 19ocalized.

**6. Stream Bank Erosion:-** Streams and rivers change their courses by cutting one bank and depositing the silt loads on the others.

During flash floods, the damage is much accelerated. The Kosi river in Bihar is reported to have changed its course westwards by 100 km within the last 100 years.

**7. Sea Shore Erosion:-** This type of erosion is caused by the striking action of strong waves.

**Wind Erosion:-** Wind erosion is major problem in Rajasthan. Generally wind erosion seen in dry climate area.

**Types of wind erosion:-**

1. **Suspension:-** Fine particles less than 0.1 mm in size are moved parallel to the surface and upward into the atmosphere by strong winds. The most spectacular of erosive processes, these particles can be carried high into the atmosphere, returning to earth only when the wind subsides or they are carried downward with precipitation. Suspended particles can travel hundreds of miles.
2. **Saltation:-** Movement of particles by a series of short bounces along the surface of the ground, and dislodging additional particles with each impact. The bouncing particles ranging in size from 0.1 to 0.5 mm usually remain within 30 cm of the surface. Depending on conditions, this process accounts for 50 to 90% of the total movement of soil by wind.

3. **Soil Creep: -** The rolling and sliding of larger soil particles along the ground surface. The movement of these particles is aided by the bouncing impacts of the saltating particles described above. Soil creep can move particles ranging from 0.5 to 1 mm in diameter, and accounts for 5 to 25% of total soil movement by wind.

**Causes of Soil Erosion in India**: -

1. Rainfall and Flooding
2. Rivers and Streams
2. High Winds
4. Overgrazing, Overstocking and Tillage Practices
5. Deforestation, Reduced Vegetation Cover, and Urbanization
6. Mass Movements and Soil Structure/Composition
7. Overgrazing:- In India number of domestic animals, cattle highest in world and cattle freely graze in open lands making them bare of vegetation. Winds carry away dry soil particles in Rajasthan
8. Bad farming techniques
9. Topography:- North-Eastern parts of India, Shiwaliks and the hilly regions in south India are affected by soil erosion because of steep slopes and heavy rainfall. During heavy rainfall, soils are washed away by running water down the slope.

**Preventing Soil Erosion:-** Some of the following measures can be implemented to prevent soil erosion:

- The use of contour ploughing and windbreaks.
- Leave unploughed grass strips between ploughed lands (strip cropping).
- Make sure that there are always plants growing on the soil, and that the soil is rich in humus.
- Avoid overgrazing.
- Allow indigenous plants to grow along riverbanks.
- Conserve wetlands.
- Cultivate land, using a crop rotation system.
- Minimum or no tillage.
- Encourage water infiltration and reduce water runoff.
- Shifting or Jhuming or slash and burn type of agriculture should be banned.

**Effects of Soil Erosion**:-

- Loss of fertile top soil.
- Lowering of the underground water table and decreasing soil moisture.
- Drying of vegetation and extension of arid lands, increase in the frequency of droughts and floods.
- Silting of river and canal beds, Recurrence of landslides, adverse effect on economic prosperity and cultural development.
- Wind erosion reduces the productive capacity of soil, as most of the nutrients required by the plants are carried by the wind.

## C. Reclamation of problematic soils acidic and alkali

### Acidic Soil

- Soil acidity is an important agricultural problem while evaluating the production potential of most of the crops. Millions of hectares of land lie idle because of strong soil acidity. In India 49 million hectares of land have problems of soil acidity.
- Acid soil is a base unsaturated soil with enough amount of adsorbed exchangeable $H^+$& $Al3^+$ions with the soil pH of <7.0 is called acid soil. An acid soil is actually a mixed H-Al system, i.e. such a soil has both $H^+$ and $Al3^+$ ions as exchangeable ions.
- In the regions of high rainfall, soils are acidic in their reaction because of the facts that soluble basic salts such as those of Ca, Mg, K, Na, are leached away by drainage water and insoluble acidic residues composed chiefly of oxides and silicates of iron, silicon, aluminium are left which accumulate in pretty high amount. These salts are acidic in reaction, hence the soils are acidic.

**Important factors which produce acidity in soil are as follows:**

1. Leaching of bases like Ca, Mg, Na etc., due to heavy rainfall
2. Acidic parent material like granite
3. Use of acid forming fertilizers like Urea and ammonium sulphate
4. Decomposition of organic matter leading to release of various organic acids
5. Continuous cultivation of crops leads to more absorption of basic cations form the soil
6. Acid rains containing sulphate and nitrate ions
7. Aluminium and Iron polymers- One Al species release 3 $H^+$ ions upon step wise hydrolysis and similar reactions are possible with $Fe3^+$ also.
8. Laterization, podzolization and accumulation of undecomposed organic matter under marshy conditions contribute to soil acidity.

**Problems of acidic soil:-**

Soil acidity causes physical, chemical and biological problems in soil.

1. **Physical Problems-**In extreme acid soil, soil will be heavily aggregated and very compact like laterite.

2. **Chemical problems**

a. Acid toxicity

b. Toxicity of different nutrient elements- such as Fe, Al and Mn are more soluble form

c. Nutrient availability is reduced especially N, P, K Ca, Mg, Na,

d. Nutrient imbalances due to fixation of $PO_4$ by Fe, Al and Mn,

e. Boron and Mo availability decreased

3. **Biological problems**:

a. Microbial activity decreases.

b. Bacteria and actinomycetes will not show their activity when the soil pH drops below 5.5.

c. Nitrogen fixation in acid soils is greatly affected by lowering the activity of Azatobacter sp., and Rhizobium species.
d. Fungi can grow well under very acid soils and cause various diseases like Foot rot of Black pepper and blights of potato etc.

**Origin of Acid Soils:**

**Climate:-** In humid regions where evaporation is less than precipitation, chances for the development of acid soils are good.

**Vegetation cover:-** In temperate regions or hilly areas covered with conifers the acid soils can develop easily. Plants found in the coastal regions and marshy places after death and decay produce acids which render the soils acidic.

**Parental rocks:-**

**Topography:-** Sloppy places with good drainage conditions are supposed to be good for the development of acid soils. On hill slopes, the development of acid soils is easy.

**Human interference:-** Continuous efforts by man for developing permanently submerged areas into cultivable land, or for improving drainage in submerged or saline lands, regular use of nitrogen fertilizers like ammonium sulphate which cause acidity in the soils are responsible for decrease of soil pH. In urban areas, industrial wastes containing sulphur or sulphur dioxide also contribute much in the development of acid soils.

**Pools of Soil Acidity:-**

There are three general pools, or sources, of acidity: active, exchangeable or residual.

1. **Active acidity:-** Active acidity is the quantity of hydrogen ions that are present in the soil water solution. The active pool of hydrogen ions is in equilibrium with the exchangeable hydrogen ions that are held on the soil's cation exchange complex. This pool most readily affects plant growth. Active acidity may be directly determined using a pH meter, such as an electron probe.
2. **Exchangeable acidity:-** Exchangeable acidity, refers to the amount of acid cations, aluminum and hydrogen, occupied on the CEC. When the CEC of a soil is high but has a low base saturation, the soil becomes more resistant to pH changes. As a result, it will require larger additions of lime to neutralize the acidity. The soil is then buffered against pH change. (See base saturation discussion.)
3. **Residual acidity:-** Residual acidity comprises of all bound aluminum and hydrogen in soil minerals. Out of all pools, residual acidity is least available.

**Classification of Acid Soils:** According to the intensity of acidity, the acid soils are of the following five types:

(1) Slight acidic (pH range 6.6 to 6.1)

(2) Medium acidic (pH 6.0 to 5.6)

(3) Strong acidic (pH 5.5 to 5.1)
(4) Very strong acidic (pH 5.0 to 4.6)
(5) Extremely strong acidic (pH 4.5 or lower)

**Acid soils occurring in different climatic regions are classified as follows:**

(i) Acid soils of temperate climate including podzol, brown podzol, grey brown podzol, brown forest soils, and grey forest soils.

(ii) Acid soil of tropical and subtropical climates including yellow podzolic soil, lateritic soil and latosols.

(iii) Acid soils of other great soil groups including wet soils (hydromorphic soils), washed peaty soils, mucky, cat-clay (acid sulphate) soils. Cat-clay or acid sulphate soils with pH 3.5 or lower are the soils that abound in organic material as well as $H_2SO_4$.

- According to soil classification system (1970) developed by U.S. Soil Scientists, soils of the world have been classified into 10 soil orders. Among these Aridisols, Vertisols and Mollisols are nonacid soils and the remaining 7 orders contain acid soils.
- Suborders Humox, Humod, Aqualf and Udalf include acid soils.

**Effects of Soil Acidity on Plants:**

Soil acidity affects the plants both directly and indirectly.

**These effects are briefly mentioned below:**

**1. Direct influences.**

**These are as follows:**

(a) Toxic effects of low $H^+$ ion concentrations on root tissues.

(b) Influence of soil acidity on the permeability of the plasma membrane for cations.

(c) Disturbance in the balance between basic and acid constituents through roots.

(d) Affects enzymatic processes since enzymes are particularly sensitive to pH changes. Different crop plants have their specific optimum pH requirement. Rice, oat and linseed can endure a fairly acidic reaction (pH = 5.0) while barley, sugar-beet, lucerne etc. can tolerate a fairly alkaline reaction (pH = 8.0)

**2. Indirect effects.**

**These are listed below:**

(a) Availability of various nutrients, e.g., phosphorous, copper, and zinc are very poor.

(b) High solubility and availability of elements like aluminium, manganese and iron in toxic amount due to high acidity in the soil.

(c) Deficiency of some nutrients such as calcium and potassium due to soil acidity.

(d) Prevalence of plant diseases.

(e) Beneficial activities of soil microbes are adversely affected.

**Reclamation of Acid Soils or Correction of Soil Acidity:**

- Acidity of soil is due to predominance of $H^+$ ions over $OH^-$ ions, the bulk of $H^+$ ions being held in close association with clay-organic colloid complex. Strong acid soils are not much

productive. The soils which are less productive owing to high degree of acidity can be made more productive by liming (application lime).

- When lime is added to moist soil, the soil solution becomes charged with cations and the exchangeable hydrogen and aluminium ions on clay-organic colloid complex as well as the $H^+$ ionsmsoil solution are displaced by calcium ions. Hydrogen combines with $OH^-$ to form neutral water or with $CO_3$ or $HCO_3^-$ to form unstable $H_2CO_3$, which readily dissociates to form $CO_2$ and water.
- Acidity of soil can also be corrected by adding exchangeable $Mg^{++}$ to exchange complex but addition of or $Mg^{++}$ or both to the soil will not necessarily solve the problem of soil acidity.

**Liming materials:**

More than 90 per cent of the lime used in agriculture for reclamation of acid soils is generally in the form of calcium carbonate, some in calcium and magnesium carbonates, and much smaller quantity in the form of calcium oxide or calcium hydroxide.

**The common liming materials used for reclamation of acid soils are as follows:**

(1) Calcic limestone ($CaCO_3$) which is ground limestone.

(2) Dolomite ($CaCO_3$. $MgCO_3$).

(3) Quick lime (CaO) which is burnt limestone.

(4) Hydrated (slaked) lime [Ca (OH) $_2$].

(5) Coral shell lime.

(6) Marl or chalk ($CaCO_3$).

(7) Slags Obtained as by-products from iron and steel plants, slags are used in agriculture for reclaiming acid soils.

(8) Press-mud. It is obtained from carbonation plants of sugar mills. Press mud and some other matters containing calcium are used to decrease acidityinthe soils.

(9) Miscellaneous sources of lime, such as, wood ash, ground oyster shells, by-product lime resulting from paper mills, tanneries, water softening plants, and by product $CaCO_3$ form fertilizer factories using gypsum process.

**Important Roles of Liming Agents in Soils:**

(1) Liming agents reduce soil acidity and stabilize pH of the soils.

Acid-clay + $Ca(OH)_2$ → Ca-clay + $H_2O$

(2) Lime makes phosphorus easily available. This is true mainly because in acid soils phosphorus is fixed by soluble iron and aluminium. Liming reduces the solubility of iron and aluminium and therefore less phosphorus is held in these insoluble and unavailable forms.

(3) Lime makes potassium more efficient in plant nutrition. When K is in sufficient amount in soil plants absorb more potassium than is actually needed but at the same time when lime is available in plenty, plants take up more calcium and less potassium. Economically liming is more desirable because plants absorb more cheap Ca. than expensive potassium.

(4) Lime enhances the decomposition of organic matter, thereby increases the availability of nitrogen and other nutrients locked up in complex forms to plants.
(5) Lime promotes beneficial activities of soil bacteria.
(6) Liming programme extended over a period of years improves the physical conditions of the soil by causing granulation of soil particles, decreasing its bulk density, and increasing its infiltration rate.
(7) Ca and Mg found in liming agents, particularly in Dolomite act as essential elements in the nutrition of plants.
(8) Lime converts toxic elements such as aluminium, Mn, Fe of the soil in insoluble and harmless compounds.

**Acid Tolerance Crops:-** Oat, Potato, Rice, Rye, Strawberry, Plum, Tea, Pineapple etc.
**High Lime Requirement:-** Barely, Beans, Cotton, Pea, Soya bean, Sugerbeet and Sunflower.
**Low Lime Requirement:-** Oat, Potato, Rice, Rye etc.
**Very Low Lime Requirement:-** Tea and Pineapple.

**Saline and Alkaline Soil**

The presence of an excess of sodium salts and the predominance of sodium in the exchangeable complex are divided into the two main groups:
(1) Saline soils and
(2) Alkaline soils.

**(1) Saline Soils:-** Saline soils contain an excess of sodium salts, but its colloidal material is not yet sodiumised.

When the soil contains excess of sodium salts and clay complex still contains exchangeable calcium, the soil is known as saline soil or white alkali or brown alkali soil. The process of accumulation of salts leading to the formation of soils is known as salinization.

(i) Saline soils contain usually chloride, sulphate, bicarbonates and sometime nitrates of sodium. The presence of chloride and sulphate of sodium gives a white colour on the soil surface. When nitrates are in excess they give a brown colour to the soil.
(ii) Exchangeable sodium percentage (ESP) is very low, being less than 15% of the total cation exchange capacity (C.E.C.).
(iii) As a consequence of low ESP, generally pH varies between 7.5 and 8.5.
(iv) Total soluble salt content is more than 0.1%. it is high enough to interfere with normal growth of most plant species.
(v) Electrical conductivity (E.C.) of solution extract (saturated soil) is 4 or more m mhos/cm.
(vi) Saline soils remain in a flocculated condition (granulated). It is permeable to water and air.
(vii) Saline soils usually have a surface crust of white salts, especially in the season when the net movement of soil moisture is upward. Salts dissolved in the soil water move up to the surface, where they are left as a crust when the water evaporates.

**(2) Alkali Soils:-** In the case of alkali soils, the exchange complex contains appreciable quantities of exchangeable sodium. Such soils may or may not contain excess salts.

**Alkali soils may be divided into following groups:**

**(a) Saline-alkali soils:-** When they contain soluble salts in excess they are known as saline-alkali soils. The characteristic features are the presence of collodial complex that is saturated with exchangeable sodium, and the absence of appreciable quantities of soluble salts. These soils are often called 'black alkali' soils, because they are black, owing to the effect of the high sodium content which causes the dispersion of the organic matter. These soils are also called typical usarsoils. These soils contain sodium carbonates ($Na_2 CO_3$) in abundance.

(i) Exchangeable sodium percentage is greater than 15%.

(ii) Consequently pH ranges from 8.5 to 10 (strongly alkaline).

(iii) Total soluble salt (sodium) content is less than 0.15.

(iv) Electrical conductivity (EC) is usually less than 4 mmhos/cm.

(v) Colloidal complex is deflocculated and dispersed. The clay swells and chokes the soil pores. Hence, permeability to water and air is poor (or infiltration and aeration is slow).

(vi) The presence of free sodium carbonate has a toxic effect on plant roots. Also, the high pH and poor physical condition of soil adversely affect plant growth.

(vii) Sodium carbonate absorbs organic matter, so there is great depletion of organic matter. Therefore, these soils are almost barren (Usar).

**(b) Non-saline-alkali soils (Alkali soil):-**When they do not contain soluble salts, they are called non-saline-alkali soils.

These soils are both saline and alkali. There can be all stages in transition with varying degree of dominance of salt content and pH. According to movement of soluble salts, formation of saline-alkali and non-saline alkali soils depends. Soil contains Na-clay as well as excess soluble salts.

If the soluble sodium salts are not leached out due to the insufficiency of rain water, they remain in the soil. The soil thus contains Na-clay and excess soluble, salts in solution. Such soils are known as saline-alkali soils. They are thus, developed as a result of the combined process of salinization and alkalization. In spite of the presence of sodium clay (Na-clay) the soil remains friable and possesses aggregate (flocculated). This is because the presence of sodium salts does not allow the sodium clay to get dispersed and keeps it flocculated.

Thus, this soil behaves more or less like saline soils. If due to much water soluble salts are leached down, and soil contains Na-clay only. Thus, this soil behaves more or less as non-saline-alkali soil. Therefore, the soil structure becomes un-favourable for the entry and movement of air and water.

(i) Exchangeable sodium is more than 15%.

(ii) A variable pH, usually above 8.5, depending upon the relative amounts of exchangeable sodium and soluble salts. When soluble salts are leached downward, the pH will rise above 8.5, but when the soluble salts again accumulated, the pH again falls to 8.5.

(iii) Generally soluble salts content is more than 0.1%.

(iv) Electrical conductivity is greater than 4 mmhos/cm.

**(c) Degraded alkali soils:-** Under certain circumstances the clay complex of some alkali soils is broken down to give rise to degraded alkali soils.

The soil does not contain free calcium carbonate ($CaCO_3$). As a result of prolong leaching under this condition, Na-clay hydrolyses NaOH which combines with $CO_2$ or soil air and forms sodium carbonate (Alkaline condition).

$$\underset{\text{Acidic Soil}}{\text{Na-Clay}+H_2O \leftrightharpoons \text{H-Clay}+NaOH}$$

$$\underset{\text{Alkali Soil}}{2NaOH+CO_2 \rightarrow Na_2CO_3+H_2O}$$

Sodium carbonate ($Na_2\,CO_3$) dissolves humus. Humus (organic matter) is deposited in the lower layer. The lower layer thus, acquires a black colour. At the same time, a part of exchangeable sodium of the surface layer is replaced by hydrogen. H-clay (acid soil) formed in this way does not remain stable. The process of break-down of H-clay under alkaline condition is known as solodization and the soil as formed is called Solod, Soloth or degraded alkali soil.

(i) The soil reaction of the surface layer is acidic (pH 6.0). This layer is usually very thin, hardly a few inches in depth.

(ii) The lower layer which constitutes the main soil body has a high pH (more than 8.5).

(iii) ESP is greater than 15%.

(iv) EC less than 4 mmhos/cm.

(v) The lower layer has black colour.

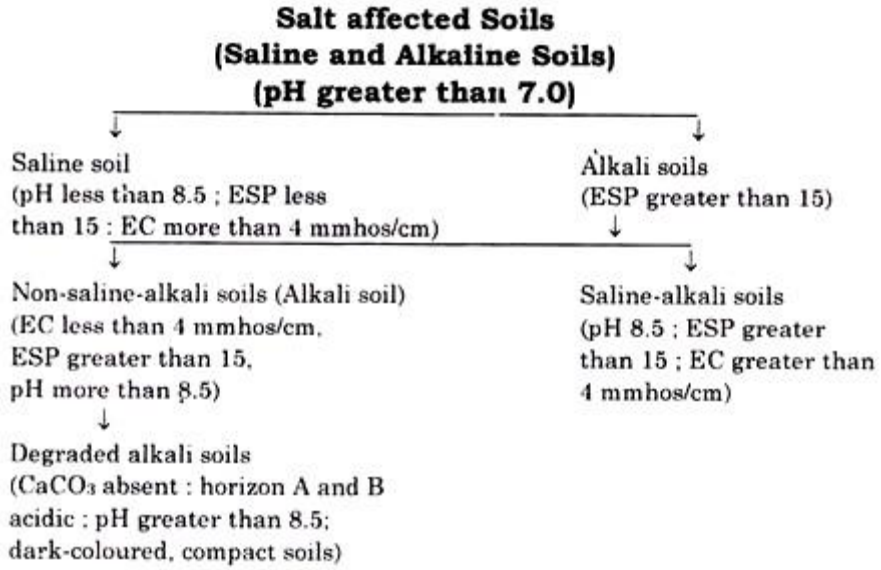
(vi) It develops columnar (prism-like) structure.

(vii) Soils become compact and has low infiltration, and permeability.

**The various types of alkaline soils are shown diagrammatically as under:**

**Table : Characteristics of salt affected soils (Saline and Alkaline soils)**

| Nature of Soil | Soil characteristics | | ESP |
|---|---|---|---|
| | pH | EC | |
| Saline | < 8.5 | > 4 mmhos/cm | < 15 |
| Alkali | > 8.5 | < 4 mmhos/cm | > 15 |
| Saiine – Alkali | 8.5 | > 4 mmhos/cm | > 15 |




| Sr. No. | State | Saline and Alkaline Affected area |
|---|---|---|
| 1. | UP | 12.95 Million Ha |
| 2. | Gujarat | 12.14 Million Ha |
| 3. | West Bengal | 8.50 Million Ha |
| 4. | Rajasthan | 7.28 Million Ha |
| 5. | Punjab | 6.89 Million Ha |
| 6. | Maharashtra | 5.34 Million Ha |
| 7. | Haryana | 5.26 Million Ha |
| 8. | Total Area in India | 69.49 Million Ha |

**Formation of Saline and Alkaline Soil:**

**(i) Arid and Semi-Arid Climate:-** Alkalinity is due to sodium salts in soil solution or the presence of sodium clay or both. They are formed in arid and semi-arid regions which have very low rainfall and high evaporation.

The low rainfall in these regions is not sufficient to leach out the soluble products of weathering and hence, the salts accumulate in the soil. During rain, the salts dissolve in rain water and move down in the lower layers. However, due to the limited rainfall, the downward movement is restricted to a short distance only. In dry weather, the salts move up with the water and are brought up to the surface where they are deposited as the water evaporates.

**(ii) Poor Drainage of Soil:-** During the periods of high rainfall, the salts are leached from the upper layer and, if the drainage is impeded, they accumulate in the lower layer. When water evaporates, the salt is left in the soil. Such soils are generally developed in low-lying areas or in basin shaped areas.

**(iii) High Water Table:-** The ground waters of arid regions usually contain considerable quantities of soluble salts. If the water table is high, large amounts of water move to the surface by capillary action and the evaporated, leaving soluble salts on the surface.

**(iv) Overflow of Sea Water over Lands:-** Low lying areas near the sea which get sea water during tides. Salt water accumulates and enrich the soils with salts.

**(v) Introduction of Irrigation Water:-** The ground water of arid regions are generally saline in nature. With injudicious irrigation the percolating water may get linked with the saline ground water. During dry weather the soluble salts of the ground water may, thus, get carried to the surface and increase the salinity of the land. The irrigation water may be itself rich in soluble salts and add to the salinity of the soils.

**(vi) Salts Blown by Wind:-** In arid regions near the sea, lot of salt is blown by wind year after year and get deposited on the lands. Due to low rainfall they are not washed back to sea and thus, add salinity to the land. The salinity of Rajasthan has developed to a great extent, due to this reason.

**(vii) Saline Nature of Parent Rock Materials:-** If soils develop from saline nature of parent rock materials, soil would be saline.

**(viii) Excessive Use of Basic Fertilizers:-** Use of alkaline fertilizers like sodium nitrate, basic slag etc., may develop alkalinity in soil.

**(ix) Humid and Semi-Humid Regions:-** Alkaline soils develop in other areas also, e.g., in semi-humid and temperate regions, especially in depressions where drainage is defective and where the underground water table is high or close to the surface. There are three distinct stage in the evolution of saline and alkali soils.

**They are as follows:**

**1. Saline soils (Salinization):-** Soil contains excess of sodium salts while the clay- complex (soil-colloid) still contains exchangeable calcium and magnesium. In these soils the colloids are not damaged by sodium.

**2. Saline-alkali soils:-** When soluble sodium salts accumulate in a soil over a prolong period, form sodium clay (sodium becomes the predominant cation in soil solution). If the soluble salts (sodium) are not leached out due to the insufficiency of rain, they remain in the soil. They are thus, developed as a result of the combined process of salinization and alkalization. Sodium salts keep soils in flocculated conditions.

$$\text{Ca-Clay} + \text{Na-Salt} \leftrightharpoons \text{Na-Clay} + \text{Ca-Salts}$$

**3. Alkalinization (non-saline-alkali soils):-** When soluble salts (from saline-alkali soils) are removed by leaching as a result of the increase in rainfall, it gives rise to non- saline-alkali soil (only Na-clay in the soil colloids). Calcium carbonate ($CaCO_3$) reacts with Na-clay and give rise to Ca-clay and sodium carbonate ($Na_2CO_3$). Due to low $CaCO_3$,$Na_2CO_3$ converts Ca-clay into Na-clay. The clay is thus sodium saturated.

$$\text{Na-Clay} + CaCO_3 \leftrightharpoons \text{Ca-Clay} + Na_2CO_3$$

If $CaCO_3$ is absent, it forms degraded alkali soils. Na-clay hydrolyses (during leaching) and liberates NaOH which combines with the $CO_2$ and forms sodium carbonate.

$$\text{Na-Clay} + H_2O \leftrightharpoons \text{H- Clay (acid)} + NaOH$$

$$2NaOH + CO_2 \leftrightharpoons Na_2CO_3 + H_2O$$

**Detrimental Effects of Soil Salinity and Alkalinity:**

**Saline Soils:**

**(i) Absorption of water and nutrients:-** Excessive salts in the soil solution increase the osmotic pressure of soil solution in comparison to cell sap. This prevents absorption of moisture and nutrients in adequate amounts by the roots.

**(ii) Salt toxicity:-** When the concentration of soluble salts increase to high level then it produces toxic effect directly to plants. Saline soils are usually barren but potentially productive soils.

**Alkaline Soil:**

**(i) Dispersion of soil particles:-** Under alkali soil conditions, the damage is not due to salt concentration. The sodium adsorbed by clay and colloids causes dispersion of clay which results in a loss of desirable structure and development of compact soil.

**(ii) Physical properties affected:-** Due to compactness of soil, aeration, permeability, drainage and microbiological activity are reduced.

**(iii) Availability of plant nutrients reduced:-** The high pH in alkali soil causes a reduction in the availability of plant nutrients such as phosphorus, calcium, nitrogen, iron, copper, manganese and zinc. Under saline-alkali conditions there may be actually transitional stages, from high salinity-low alkalinity to low salinity-high alkalinity. Under such conditions, the crops may suffer due to high salinity as well as to un-favourable effects of alkalinity.

**I. Saline Soil Reclamation and Management:**

**(A) Mechanical Methods:**

**(i) Flooding and leaching down of the soluble salts:-** The leaching can be done by first ponding the water on the land and lowering it to stand there for a week. Most of the soluble salts would leach down below the root zone. After a week, standing water (dissolved with soluble salts) is allowed to escape. Such, 2 to 3 treatments are given to reclaim highly saline soils. Sometimes gypsum is also added to flood water when the soluble salts are low in calcium to check development of alkalinity.

**(ii) Scrapping of the surface soil:-** When the soluble salts accumulate on the soil surface, scrapping helps to remove salts. This is a temporary cure and salinity again develops on such lands.

**(B) Cultural Methods (Crop, Soil and Water Management):**

**(i) Providing proper drainage:-** If the soil is not free draining, artificial, drains are opened or tile drains laid underground to help wash out the salts.

**(ii) Use of salt free irrigation water:-** Salt free good quality of irrigation water should be used.

**(iii) Proper use of irrigation water:-** It is known that as the amount of water in the soil decreases the concentration of salts in the soil solution increases, thus, moisture should be kept at optimum field capacity.

**(iv) Planting or sowing of seeds in the furrow:-** The salt concentration even in smaller amounts is most harmful to the germinating seedlings. Water generally evaporates from the highest surface by capillarity and hence, these points have maximum salt concentrations. If the seeds or seedlings are planted inside the furrows, they escape the zone of maximum salt concentrations and thus, can germinate and develop properly during their early growth stage.

**(v) Use of Acidic Fertilizer:-**In saline soil, acidic nature of fertilizers (e.g., Ammonium sulphate) should be used.

**(vi) Use of organic manures:-**The organic manures have very high water-holding capacity. When sufficient amount of these manures are added the water-holding capacity of soil increases and as a result the conductivity of the soil solution decreases.

**(vii) Ploughing and leveling of the land:-**Ploughing and leveling of the land increases the infiltration and percolation rate. Therefore, salts leach down to the lower levels.

**(viii) Retardation of water evaporation from soil surface:-**Water may be conserved in the soil retarding the water evaporation. Thus, salts may remain in the lower level with the water.

**(ix) Growing of salt tolerant crops:**

**(a) High salt tolerant crops:-** Para grass, barley, sugar beet, Spinach, Palak, Date Palm, Beal, Aonla, Coconut, Cashewnut, Ber, Pomegranate etc.

**(b) Moderately salt tolerant crops:-** Wheat, sorghum, maize, flax etc.

**(c) Low salt tolerant crops:-** Beans, radish, white clover etc.

(**d) Sensitive crops:-** Tomato, potato, onion, carrot etc.

**II. Reclamation and Management of Alkali (Saline-alkali and non-saline-alkali) Soils:**

Alkali soils cannot be reclaimed by mere flooding the land. In the case of saline-alkali soils, flooding is likely to do more harm. Leaching (flooding) down of soluble salts make the soil alkaline (only Na-clay remain in the soil). Soils get dispersed and become compact (impervious).

In alkali (non-saline-alkali) soils, exchangeable sodium Na-clay is so great as to make the soil almost impervious to water. But even if water could move downward freely in alkali soils, the water alone would not leach out the excess exchangeable sodium. The sodium-cation must be replaced by calcium-cation and then leached downward.

**Following chemical methods are used for reclaiming the alkali soils:**

**(A) Chemical Methods:**

**(i) Application of gypsum:-** By cationic exchange, calcium is often used to replace sodium in alkali soil. If the soil has no reserve of calcium carbonate, the addition of gypsum (calcium sulphate) is necessary. When gypsum is used as a reclaiming agent, calcium replaces the exchangeable sodium and converts the clay back into calcium-clay (Ca-clay).

$$Na^+ \text{ CLAY COMPLEX } Na^+ \text{ (Alkali soil)} + \underset{\text{Gypsum}}{CaSO_4} \rightleftharpoons \underset{\text{Normal}}{Ca^{++}} \text{ CLAY COMPLEX} + \underset{\text{Leachable}}{Na_2SO_4 \downarrow}$$

$$Na_2CO_3 + CaSO_4 \rightleftharpoons CaCO_3 + Na_2SO_4 \downarrow$$

Sodium sulphate goes into solution and is then removed by washing it out with water or leaching down with water with the help of artificial drains. Addition of gypsum improves physical conditions of soil. Soils become flocculated and drainage improves. pH is lowered down to a desirable level.

**Gypsum equivalents of some such materials are given below:-**

| Sr. No. | Amendment | Gypsum equivalent |
|---|---|---|

| | | |
|---|---|---|
| 1. | Gypsum ($CaSO_4.2H_2O$) | 1.00 |
| 2. | Sulphur (S) | 0.19 |
| 3. | Sulphuric Acid ($H_2SO_4$) | 0.57 |
| 4. | Iron Sulphate ($FeSO_4.7H_2O$) | 1.62 |
| 5. | Iron Pyrite ($FeSO_2$) | 0.63 |

**(ii) Use of sulphur:**

## D. Tillage definition and types Concept of conservation and tillage.

**Tillage**

Tillage operations in various forms have been practiced from the very inception of growing plants. Primitive man used tools to disturb the soils for placing the seeds. The word tillage is derived from 'Anglo-Saxon' words *Tilian* and *Teolian*, meaning 'to plough and prepare soil for seed to sow, to cultivate and to raise crops'. **Jethrotull,** who is considered as father of tillage suggested that thorough ploughing is necessary so as to make the soil into fine particles.

**Tillage** is the mechanical manipulation of soil with tools and implements for obtaining conditionsideal for seed germination, seedling establishment and growth of crops.

**Tilth** is the physical condition of soil obtained out of tillage (or) it is the result of tillage. The tilthmay be a coarse tilth, fine tilth or moderate tilth.

**Objectives of tillage**

The main objectives of tillage are,

- To prepare a good seed bed which helps the germin ation of seeds.
- To create conditions in the soil suited for better growth of crops.
- To control the weeds effectively.
- To make the soil capable for absorbing more rain water.
- To mix up the manure and fertilizers uniformly in the soil.
- To aerate the soil.
- To provide adequate seed-soil contact to permit w ater flow to seed and seedling roots.
- To remove the hard pan and to increase the soil d epth.
- To achieve these objectives, the soil is disturbed / opened up and turned over.

**Types of tillage:** Tillage operations may be grouped into

1. On season tillage 2. Off-season tillage

**1. <u>On-season tillage</u>**

Tillage operations that are done for raising crops in the same season or at the onset of the crop season are known as on-season tillage. They may be preparatory cultivation and after cultivation.

**A. Preparatory tillage:**This refers to tillage operations that are done to prepare the field for raisingcrops. It consists of deep opening and loosening of the soil to bring about a desirable tilth as well as to incorporate or uproot weeds and crop stubble when the soil is in a workable condition.

**Types of preparatory tillage**

a. Primary tillage
b. Secondary tillage

**Primary tillage:-** It constitutes the initial major soil working operation. It is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. The operations performed to open up any cultivable land with a view to prepare a seed bed for growing crops is known as primary tillage. Animal drawn implements mostly include indigenous plough and mould-board plough. Tractor drawn implements include mould-board plough, disc plough, subsoil plough, chisel plough and other similar implements.

**Secondary tillage:-** Tillage operations following primary tillage those are performed to create proper soil tilth for seeding and planting are secondary tillage. These are lighter and finer operations, performed on the soil after primary tillage operations. Secondary tillage consists of conditioning the soil to meet the different tillage objectives of the farm. The implements include different types of harrow, cultivators, levellers, clod crushers etc.

**B. After cultivation (Inter tillage):-**The tillage operations that are carried out in the standing cropafter the sowing or planting and prior to the harvesting of the crop plants are called after tillage. This is also called as inter cultivation or post seeding/ planting cultivation. It includes harrowing, hoeing, weeding, earthing up, drilling or side dressing of fertilizers etc. Spade, hoe, weeders etc. are used for inter cultivation.

2. **Off-season tillage:**Tillage operations done for conditioning the soil suitably for the forthcomingmain season crop are called off-season tillage. Off season tillage may be, post-harvest tillage, summer tillage, winter tillage and fallow tillage.

**Special purpose tillage:** Tillage operations intended to serve special purposes are said to be specialpurpose tillage. They are,

**a. Sub-soiling:** To break the hard pan beneath the plough layer, special tillage operation (chiseling)is performed to reduce compaction. Sub-soiling is essential and once in four to five years where heavy machineries are used for field operations, seeding, harvesting and transporting. Advantages of sub-soiling are, greater volume of soil may be obtained for cultivation of crops, excess water may percolate downward to recharge the permanent water table, reduce runoff and soil erosion and roots of crop plants can penetrate deeper to extract moisture from the water table.

**b. Clean tillage:** It refers to working of the soil of the entire field in such a way no living plant is leftundisturbed. It is practiced to control weeds, soil borne pathogen and pests.

**c. Blind tillage:** It refers to tillage done after seeding or planting the crop (in a sterile soil) either atthe pre-emergence stage of the crop plants or while they are in the early stages of growth so that crop plants (sugarcane, potato etc.) do not get damaged, but, extra plants and broad leaved weeds are uprooted.

**d. Dry tillage:** Dry tillage is practiced for crops that are sown or planted in dry land condition havingsufficient moisture for germination of seeds. This is suitable for crops like broadcasted rice, jute, wheat, oilseed crops, pulses, potato and vegetable crops. Dry tillage is done in a soil having sufficient moisture (21-23%). The soil becomes more porous and soft due to dry tillage. Besides, the water holding

capacity of the soil and aeration are increased. These conditions are more favourable for soil micro-organisms.

**e. Wet tillage or puddling:** The tillage operation that is done in a land with standing water is calledwet tillage or puddling. Puddling operation consists of ploughing repeatedly in standing water until the soil becomes soft and muddy. Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seed bed for planting rice. Puddling is done in both the directions for the incorporation of green manures and weeds. Wet tillage destroys the soil structure and the soil particles that are separated during puddling settle later. Wet tillage is the only means of land preparation for transplanting semi-aquatic crop plant such as rice. Planking after wet tillage makes the soil level and compact. Puddling hastens transplanting operation as well as establishment of seedlings. Wet land ploughs or worn out dry land ploughs are normally used for wet tillage.

**Depth of ploughing**

The desirable depth of ploughing is 12 to 20 cm for field crops. The ploughing depth varies with effective root zone of the crop. The depth of ploughing is 10-20 cm for shallow rooted crops and 15-30 cm for deep rooted crops.

**Number of ploughing**

Number of ploughing depends on soil conditions, time available for cultivation between two crops and type of cropping systems. Zero tillage is practiced in rice fallow pulses. Minimum number of ploughing is taken up at optimum moisture level to bring favourable tilth depending on need of the crop.

**Time of ploughing**

The optimum soil moisture content for tillage is 60% of field capacity.

**<u>Modern concepts in tillage:</u>**

Conventional tillage involves primary tillage to break open and turn the soil followed by secondary tillage to obtain seed bed for sowing or planting. With the introduction of herbicides in intensive farming systems, the concept of tillage has been changed. Continuous use of heavy ploughs create hard pan in the subsoil, results in poor infiltration. It is more susceptible to run-off and erosion. It is capital intensive and increase soil degradation. To avoid these ill effects, modern concepts on tillage is in rule.

1. **Minimum tillage:** It aims at reducing tillage operations to the minimum necessity for ensuring agood seed bed. The advantages of minimum tillage over conventional tillage are,

- The cost and time for field preparation is reduced by reducing the number of field operations.
- Soil compaction is comparatively less.
- Soil structure is not destroyed.
- Water loss through runoff and erosion is minimum.
- Water storage in the plough layer is increased.

**Tillage can be reduced in 2 ways**

1. By omitting operations which do not give much benefit when compared to the cost.
2. By combining agricultural operations like seeding and fertilizer application.

The minimum tillage systems can be grouped into the following ategories,

**a. Row zone tillage:-** Primary tillage is done with mould board plough in the entire area of the field; secondary tillage operations like discing and harrowing are reduced and done only in row zone.

**b. Plough plant tillage:-** After the primary tillage, a special planter is used for sowing. In one run over the field, the row zone is pulverized and seeds are sown by the planter.

c. **Wheel track tillage:-** Primary ploughing is done as usual. Tractor is used for sowing; the wheels of the tractor pulverize the row zone in which planting is done.

- In all these systems, primary tillage is as usual. However, secondary tillage is replaced by direct sowing in which sown seed is covered in the row zone with the equipment used for sowing.

**2. Zero tillage (No tillage):** This concept is given by Jethrotull**.** In this, new crop is planted in the residues of the previous crop withoutany prior soil tillage or seed bed preparation and it is possible when all the weeds are controlled by the use of herbicides. Zero tillage is applicable for soils with a coarse textured surface horizon, good internal drainage, and high biological activity of soil fauna, favourable initial soil structure and an adequate quantity of crop residue as mulch. These conditions are generally found in *Alfisols*, *Oxisols* and *Ultisols* in the humid and sub-humid tropics.

**Till planting:-** Till planting is one method of practicing zero tillage. A wide sweep and trash bar clears a strip over the previous crop row and planter opens a narrow strip into which seeds are planted and covered. Here, herbicide functions are extended. Before sowing, the vegetation present has to be destroyed for which broad spectrum non selective herbicides like glyposate, paraquat and diquat are used.

**Advantages**

- Zero tilled soils are homogenous in structure wit h more number of earthworms.
- Organic matter content increases due to less mineralization.
- Surface run-off is reduced due to presence of mulch.

**Disadvantages**

- Higher amount of nitrogen has to be applied for mineralization of organic matter in zero tillage.
- Perennial weeds may be a problem.
- High number of volunteer plants and buildup of pests.

**3. Stubble mulch tillage or stubble mulch farming**

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

Two methods for sowing crops in stubble mulch tillage are,

A. Similar to zero tillage, a wide sweep and trash bars are used to clear a strip and a narrow planter shoe opens a narrow furrow into which seeds are placed.
B. A narrow chisel of 5-10 cm width is worked through the soil at a depth of 15-30 cm leaving all plant residues on the surface. The chisel shatters the tillage pans and surface crusts. Planting is done with special planters.

**Disadvantages of stubble mulch farming**

- The residues left on the surface interfere with seed bed preparation and sowing operations.
- The traditional tillage and sowing implements or equipments are not suitable under these conditions.

**4. Conservation tillage:-**

Conservation tillage is a tillage system that creates a suitable soil environment for growing a crop and that conserves soil, water and energy resources mainly through the reduction in the intensity of tillage, and retention of plant residues.

**No-till/strip-till:-** No-till means leaving the residue from last year's crop undisturbed until planting. Strip-till means no more than a third of the row width is disturbed with a coulter, residue manager or specialized shank that creates a strip. If shanks are used, nutrients may be injected at the same time.

**Ridge-till:-** 4-6" high ridges are formed at cultivation. Planters using specialized attachments scrape off the top two inches of the ridge before placing the seed in the ground.

**Mulch-till:-** This full-width tillage system usually includes only one or two tillage passes. Yet, after planting, at least a third of the surface remains covered with residue.

**Reduced-till and intensive-till:-** Full-width tillage systems like these are not considered conservation tillage. After planting, field residue covers less than a third of the soil.

**Conservation tillage system management.**

Managing a conservation tillage system is an important part of the overall farm management strategy. It includes planning crop rotation; analyzing soil conditions; keeping tabs on soil temperature and moisture; adjusting nutrient and weed management approaches; and selecting the equipment and attachments to match your farming system.

**Crop rotation:-** The previous crop will, in many ways, dictate the amount of tillage (if any) that can be done and still leave around a third of the soil's surface covered with crop residue.

Corn, wheat and sorghum produce high levels of residue after harvest. Thus, you can either plant directly into these residues (no-till/strip-till) or use one or two low-disturbance tillage passes (mulch-till) and still leave approximately a third of the soil covered.

Soybeans and cotton produce much less crop residue. Thus just one tillable pass may not leave enough cover after planting.

**Soil condition:-** While compaction, drainage and low fertility levels are important to correct in any tillage system, they are especially important to correct prior to the adoption of a conservation tillage system. Improved soil structure and higher organic matter levels may reduce the necessity to repeat these corrective measures.

**Equipment selection and adjustment:-** To assure good seed-to-soil contact when planting, equipment must be selected and adjusted to match your system, soils, yields and size. For instance, your combine needs to have a chaf spreader so the crop's residue is evenly spread across the full width of the combine. If your equipment is extremely old, you'll need to modify and strengthen it to handle high residue and more strenuous field conditions. In some regions residue managers, coulters and other planter attachments may be needed. Special equipment–like strip-till equipment–may be needed for sensitive crops (corn and cotton) in climates where moisture keeps soil cool at planting time. Row width will also need to be analyzed.

**Weed control:-** Weed control strategies may need to be modified. While weed pressure often seems to increase the first few years, over time weed pressure may decrease. A different array of weeds may prefer different tillage systems. For instance, weed species commonly found in intensive tillage systems often differ from those commonly found in a no-till system.

**Nutrient management:-** Your approach to nutrient management will also change to optimize production in a conservation tillage system. For instance, crops that require nitrogen to be added to the soil usually do best if your nutrient management program includes a starter fertilizer applied with the planter.

**Bottom line:-** If you properly manage these factors–crop rotation, soil conditions, equipment selection and adjustments, plant nutrients and weed control–conservation tillage will help improve your bottom line. It's also a critical step in maintaining–and even improving–soil productivity.

Best of all, conservation tillage helps keep topsoil, nutrients (particularly phosphorus) and crop protection products on your fields and out of creeks, streams and lakes.

In fact, scientific evidence indicates approximately 80% of environmental issues that result from cropland can be corrected by integrating conservation tillage, conservation buffers, nutrient management and weed and pest management (IPM) systems into your farm management approach.

**Advantage of Conservation tillage**

- Yields are as good
- Optimizes soil moisture
- Saves time
- Reduces fuel consumption
- Reduces machinery wear
- Reduces soil erosion
- Increases organic matter
- Improves water quality

## f. Importance of farm implements and there maintenance.

**Pick Axe:-** The pointed edge is most often used to break up rocky surfaces or other hard surfaces such as concrete or hardened dried earth. The large momentum of a heavy pickaxe on a small contact area makes it very effective for this purpose. The chiseled end, if present, is used for purposes including cutting through roots.

**Pronged Hoes:-** Designed for weeding and furrowing.

**Spade:-** It is a digging tool. In farm, a spade is a hand tool used to dig or loosen ground, or to break up lumps in the soil.

**Fork:-** It is used for digging, hoeing and compost handling.


**Hoe-Cum-Fork:-** It is use for digging, hoeing, earthing, levelling and collecting weeds.

**Shovel:-** It is use for placing dug-out soil from one place to another.

**Garden Rake:-** It is a broom for outside use; a horticultural implement consisting of a toothed bar fixed transversely to a handle, and used to collect leaves, hay, grass, etc., and, in gardening, for loosening the soil, light weeding and levelling, removing dead grass from lawns, and generally for purposes performed in agriculture by the harrow.

**Hand Leveller:-** It is use in small beds and nursery for levelingn land and covering the seed after sowing. It is also used for evenly distributing the applied manure.

**Trowel:-** It is used for breaking up earth, digging small holes, especially for planting and weeding, mixing in fertilizer or other additives, and transferring plants to pots.


**Axe:-** It is used for felling trees and cutting branches.

**Bill Hook:-** The billhook is a traditional cutting tool used widely in agriculture and forestry for cutting smaller woody material such as shrubs and branches and is distinct from the sickle. It is very common in the wine-growing countries of Europe.

**Budding Knife**:- In this knife the apex of the blade is slightely curved which is used for making incision for inserting bud on rootstock. In some knives, in rare side, brass blade is proved. It is termed as budder. The blade is used for opening bark of rootstock for placing bud.

**Grafting Knife:-** It is used for separating scion shoot, defoliation scion shoot and making incision on rootstock.

**Budding and Grafting Knife:-** It is knife having combined blade for budding and grafting. It serves both the purpose of budding and grafting.

**Pruning Knife:-** It is use for cutting small shoots for pruning.

**Secateurs:-** It is used in pruning for cutting twigs and shoot.

**Pruning Saw:-** A pruning saw is normally made out of a medium length blade which is either straight or a curved blade, attached to a secure handle. At times the handle is also curved so that it allows better angle for cutting curved thick branches. Nowadays pruning saws have very sharp blades so that you can cut through large branches very easily. Pruning saws are used mainly for trees or even tough thick bushes.

**Hedge Shear:-** It is used pruning hedge to maintain them in proper shape.

**Tree Pruner:-** It is used for pruning trees in which the high up branches remain out of reach from the ground level.

**Lopping Shear:-** It is used for pruning trees from ground. Due to its long handle the operator can prune the tree from ground level which cannot be pruned otherwise with simple hedge shear.

**Grass Shear:-** It is used for uniform cutting of grasses. It is also used for side dressing of lawn grass and cutting other shoots.

**Flowers Scissor:-** It is used for cutting flowers and removing flower parts.

**Khurpi:-** A khurpa is a short handled cutting tool with a flat blade used for digging soil and weeding in small gardens or vegetable farms. It is commonly use in small farms or in ridges or rows of vegetables to hoewing or earth up the weeds.

**Straight Blade Hand Hoe:-** It is used for removing weeds from the rows of the standing crops.


**Dutch Hoe:-** It work similar to straight blade hand hoe.

**Three Tined Hand Hoe:-** It is used for weeding purpose in line sown crops in standing position.

**Hand Cultivator:-** A hand cultivator is a gardening tool that is used to turn the soil where you plan on planting and for removing weeds. In small flower or vegetable gardens, it can also be used like a small plow to dig the planting rows.

**Push-Pull Weeder:-** It is used for weeding in the field in the line sown crops.

**Knap-Sack Sprayer:-** It is a spraying apparatus consisting of a knapsack tank together with pressurizing device, line, and sprayer nozzle, used chiefly in fire control and in spraying fungicides or insecticides

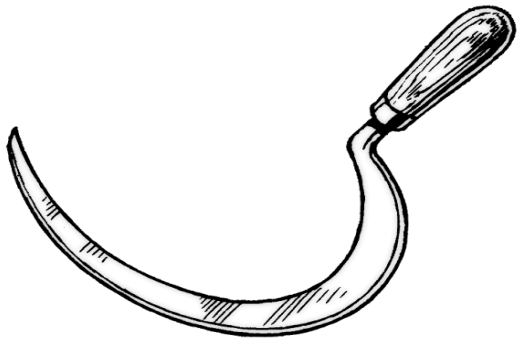
**Rocker Sprayer:-** Its require two workers. It is suitable both for small & large scale spraying on field crops, orchards, tea, coffee & rubber plantations. It develops maximum pressure with less number of strokes. It is used for effective & economical spraying of insecticides & pesticides.


**Foot Sprayer:-** It is also require two worker for operation. One operate the pump and other operates the nozzle. The spray liquid is filled in another container which passes through the pump to the nozzle. It is suitable for spraying in the field as well as on the trees in the garden.

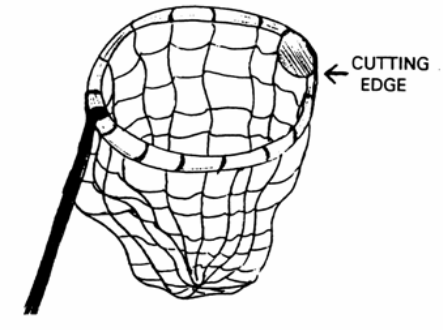
**Hand Sprayer:-** It is used for spraying pesticide in small beds of vegetables, flowers, nursery etc.

**Hand Rotary Duster:-** It is used for dusting the pesticidal dust.


**Sickle:-** A sickle, or bagging hook, is a hand-held agricultural tool designed with variously curved blades and typically used for harvesting, or reaping, grain crops or cutting succulent forage chiefly for feeding livestock, either freshly cut or dried as hay.



**Mango Harvester:-** It consist of two blades, net basket and a long handle. The blade is spring operated. The harvested mango is collected in the net basket. Due to long handle, the fruit is harvested easily.



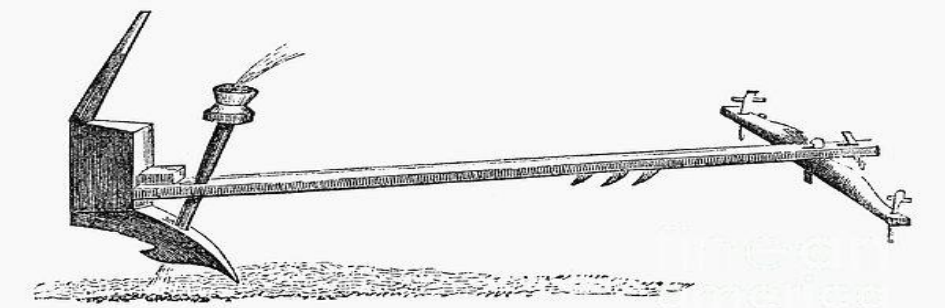

**Lawn Mower**:- A lawn mower (mower) is a machine utilizing one or more revolving blades to cut a grass surface to an even height. Two main styles of blades are used in lawn mowers.

**Hedge Cutter:-** A hedge trimmer, shrub trimmer, or bush trimmer, is a gardening tool or machine used for trimming (cutting, pruning) hedges or solitary shrubs (bushes). Different designs as well as manual and powered versions of hedge trimmers exist.

**Wheel Barrow:-** It is used for carrying nursery plants, compost, fertilizer, leaf litter etc one place to another place in horticulture operation.

**Ladders:-** It is used for harvesting of  fruits and also for pruning of large tree.

**Plough:-** It is use of preparation of bed for sowing and planting. Its basic functions such as soil broking, and soil turning.



Indian Plough.

**Mould Board Plough**:- t is designed to work in all types of soil for functions such as soil breaking, soil raising and soil inversion. The plough has special wear-resistant steel bottoms with points for toughest ploughing jobs. It can handle the toughest ploughing job with excellent penetration performance. Hydraulic turnover mechanism.

**Disc Plough:-** Disc Plough used for deep ploughing in root-infested, sticky, stony, and hard soils. Mixes remains of crops and weeds throughout the depth of ploughing, hence it is ideal for rain-fed areas for checking soil erosion by water and wind.

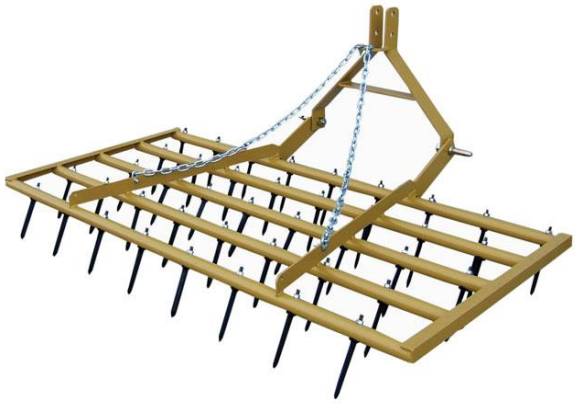

**Chesal Plough:-** The chisel plough is a common tool to get deep tillage (prepared land) with limited soil disruption. The main function of this plough is to loosen and aerate the soils while leaving crop residue at the top of the soil. This plough can be used to reduce the effects of compaction and to help break up the ploughpan and hardpan. Unlike many other ploughs the chisel will not invert or turn the soil.


**Rotavator:-** Rotavators use a set of blades or rotors which spin and break though the soil. This improves drainage, levels the area and makes the ground perfect for growing vegetables and crops.

**Sub-Soiler:-** A subsoiler can break up soil deep beneath the surface, helping eliminate standing water.

**Cultivator:-** Cultivators are used to break up soil and feribale of soil. It is secondery tillage empliments.

**Harrow:-** A harrow is a farm tool. It is an implement for breaking up and smoothing out the surface of the soil. In this way it is different from a plow, which cuts deeper into the soil. A plow also lifts up the soil and tips it over, but a harrow works mostly by cutting into the soil and breaking it up.



**Disc Harrow:-** A disc harrow is a farm implement that is used to till the soil where crops are to be planted. It is also used to chop up unwanted weeds or crop remainders.

**Leveller:-** It is used for level the land.

**Bund Former:-** It is use for bund making.

**Thresher:-** A threshing machine or thresher is a piece of farm equipment that threshes grain, that is it removes the seeds from the stalks and husks.

**Crop Reaper:-** A reaper is a farm implement or person that reaps crops at harvest, when they are ripe.

**Seed Drill:-** It is a Machin that is sows the seeds at equal distances and proper depth, ensuring that the seeds get covered with soil and are saved from being eaten by birds.

# UNIT III: Agriculture Economics and Crop Production

## A. Agricultural economics, Cooperative system in Agriculture, Crop Insurance, Kissan Credit Cards, Marketing of Agricultural Products (supply chain, retailing, wholesale), haats.

**Agriculture Economics:-**

Economics is the science of the administration of scarce resources (land, labor, capital and management), which are needed in order to produce goods and services that satisfy human wants.

The field of agricultural economics is delineated by the application of economic science tools to the agricultural sector.economic science tools to the agricultural sector.

Agricultural economics refers to all economic activities connected with the control of living organisms, such as plants and animals.

These economic activities gravitate around the production of food, and they involve many different economic actors at different production and transformation stages.

**Cooperative Agriculture system/Cooperative Farming**

A voluntary form of organization in which farmers and landless cultivators pool their uneconomic holdings and other resources with a view to facilitate the rational use of resources, economies of scale, and adopt scientific methods of cultivation.

**History of cooperative farming:-**

- 1944- Cooperative farming was introduced in India through action plan launched by Bombay Government.
- 1945- Cooperative Planning committee suggested four types of cooperative farming societies.
- 1947- Economic Program Committee recommended a Pilot schemes for cooperative farming.
- 1949- Congress Agrarian Reforms Committee recommended the states to promote cooperative farming.

**Features of Cooperative Farming**

- Members pool their land, man-power and other resources into a single unit.
- Ownership of land continues to be with the individual members.
- The society is formed voluntarily and is run on co-principles.
- Members receive remuneration according to the work done and the land contributed for joint cultivation.
- Members will have the option to leave the organization.

**Classification of Cooperative Farming**

The Cooperative Planning Committee envisaged four types of co-operative farming :

1. **Better-farming Society:-** The better-farming society could be said to form the basis of the co-operative farming programme. The main object of it is to educate and to prepare the farmers to accept the new system of farming. For this, they organise demonstrations of improved methods of agriculture. Use of improved seeds, manures and implements is the most common activity undertaken by these societies. Besides this, a number of other activities such as disposal of farm produce at reasonable prices, purchase of occupational requisites, etc., are also undertaken. Under this type of co-operative farming, the ownership and management of land rest with the individual.
2. **Co-operative Tenant Farming Society:-** The co-operative tenant farming society provides its members with facilities such as finance, implements, seed, etc. The society owns land or gets it on lease, but it does not undertake farming. Land is divided into blocks and each block is given on rent to a cultivator who cultivates according to the plan laid down by the society.
3. **Co-operative joint Farming Society:-** The joint-farming societies are suitable to solve the problem of fragmentation of land and the cultivation of uneconomic holdings. The land of small owners is pooled together increasing thereby the size of the unit of cultivation.

   The members of the society work jointly on the pooled land according to the programme of the society. The cultivators who work on the farm receive wages for their labour. As against the proprietorship of land, the owner cultivators get dividend or rent in proportion to the value of the land. The common functions of these types of societies are planning of crop programmes, joint purchase of farm requisites, joint cultivation, raising of funds for the improvement of land and joint sale of farm produce. The small owners of land are encouraged to pool their land so as to form a large unit of cultivation. The society can also purchase or take on lease land for cultivation. Out of the proceeds received from the disposal of the produce, all the expenses of cultivation including payment for the use of land, wages and cost of management are met first. Provision for interest on borrowings, depreciation of wasting assets, previous losses and for reserves and other funds is also made. The residue is then shared by members in proportion to the wages earned by each after utilising a part thereof towards the payment of bonus to the salaried staff.
4. **Co-operative Collective Farming Society:-** The society owns land or gets it on lease and it is collectively cultivated by its members. Most of these societies are organised on Government waste lands. Members get wages for their work and in the case of profits a bonus is paid in proportion to their wages. No dividend is paid on the share capital. The members of the collective farming society do not have any ownership or proprietary rights in the land.

**Advantage of Cooperative farming:-**

1. Serves as an instrument for planning.
2. Development of democratic spirit.
3. Reduces the cost of production.
4. Increases agriculture production.
5. Achieves the economies of scale.
6. Accessibility of services and technology.

**Status of cooperative farming in India:-**

- 200 cooperative farming societies functioning in India
- The government of Andhra Pradesh prepared a draft policy on cooperative tenure farming.
- The government of Kerala is promoting cooperative farming through Kudumbasree project.
- The phud system of joint farming is widely practiced in the Kolhapur region of Maharashtra.

**Crop Insurance**

Crop insurance is an insurance arrangement aiming at mitigating the financial losses suffered by the farmers due to damage and destruction of their crops as a result of various production risks.

The Central government introduced the PMBFY (Pradhan Mantri Fasal Bima Yojana) in Kharif season 2016, and restructured Weather Based Crop Insurance Scheme by replacing previous schemes.

**Objectives of Crop Insurance:-**

- To provide insurance coverage and financial support to the farmers in the event of prevented sowing & failure of any of the notified crop as a result of natural calamities, pests & diseases
- To encourage the farmers to adopt progressive farming practices, high value in-puts and higher technology in Agriculture
- To help stabilize farm incomes, particularly in disaster years.

**Kisan Credit Card**

Kisan Credit Card scheme was introduced by NDA Government in August 1998 with the aim to provide adequate and timely short-term credit needs of farmers during the cropping season. It was first proposed in the Budget 1998-99 by then Finance Minister Yashwant Sinha. Consequent to this, NABARD had prepared a Model Kisan Credit Card Scheme in consultation with the Major Banks on the basis of R V Gupta Committee.

**Objective & Rationale behind Kisan Credit Card Scheme**

Due to lack of awareness among farmers and unnecessary delays, cumbersome procedure and improper practices adopted by institutional lending agencies; a large number of Farmers heavily depend on non-institutional sources of credit for their frequent needs to purchase farm inputs such as seeds, fertilizers, pesticides etc. The non-institutional credit is not only expensive but also counter-productive. The Kisan Credit Card scheme was launched to provide adequate, timely and cost effective institutional credit from the banking system to the farmers for their cultivation needs. Farmers can not only purchase inputs but also can withdraw cash from this credit card for their input needs.

**How Kisan Credit Card Scheme works?**

Kisan Credit Cards are issued to the farmers on the basis of their land holdings and other criteria such as timely payment of past credits etc. Farmers covered under the Kisan Credit Card scheme are issued with a credit card and a pass book or a credit card cum pass book incorporating the name, address, particulars of land holding, borrowing limit, validity period, a passport size photograph of holder etc., which may serve both as an identity card and facilitate recording of transactions on an ongoing basis.

**Salient Features of the Scheme**

The Kisan Credit Card scheme is implemented by public sector commercial banks, RRBs and cooperative banks. It was launched to provide short term loans in the form of production credit. However, later its scope was extended to term loans for agriculture and allied activities and reasonable component for consumption loan. Thus, currently this scheme provides:

- Production credit
- Working capital requirements for allied activities
- Ancillary credit requirements related to crop production
- Contingent needs and
- Accidental insurance of KCC borrowers.

Crop loans disbursed under KCC scheme for notified crops are covered under National Crop Insurance scheme. The purpose of the scheme is to protect the interest of farmers against crop loss caused by natural calamities, pest attacks etc.

**Benefits of Kisan Credit Card Scheme**

- Simplifies disbursement procedures.
- Removes rigidity regarding cash and kind.
- No need to apply for a loan for every crop.
- Assured availability of credit at any time enabling reduced interest burden for the farmer.
- Helps buy seeds, fertilizers at farmer's convenience and choice.
- Helps buy on cash-avail discount from dealers.
- Credit facility for 3 years – no need for seasonal appraisal.
- Maximum credit limit based on agriculture income.
- Any number of withdrawals subject to credit limit.
- Repayment only after harvest.
- Rate of interest as applicable to agriculture advance.
- Security, margin and documentation norms as applicable to agricultural advance.
- Access to adequate and timely credit to farmers.
- Full year's credit requirement of the borrower taken care of.
- Minimum paper work and simplification of documentation for drawal of funds from the bank.
- Flexibility to draw cash and buy inputs.
- Assured availability of credit at any time enabling reduced interest burden for the farmer.
- Flexibility of drawals from a branch other than the issuing branch at the discretion of the bank.

**Features of Kisan Credit Card Scheme**

- Farmers eligible for production credit of Rs. 5000 or more are eligible for issue of Kisan Credit Card.
- Eligible farmers to be provided with a Kisan Credit Card and a pass book or card-cum-pass book.
- Revolving cash credit facility involving any number of drawls and repayments within the limit.
- Limit to be fixed on the basis of operational land holding, cropping pattern and scale of finance.
- Entire production credit needs for full year plus ancillary activities related to crop production to be considered while fixing limit.
- Sub-limits may be fixed at the discretion of banks.
- Card valid for 3 years subject to annual review. As incentive for good performance, credit limits could be enhanced to take care of increase in costs, change in cropping pattern, etc.
- Each drawals to be repaid within a maximum period of 12 months.
- Conversion/re-scheduling of loans also permissible in case of damage to crops due to natural calamities.
- Security, margin, rate of interest, etc. as per RBI norms.
- Operations may be through issuing branch (and also PACS in the case of Cooperative Banks) through other designated branches at the discretion of bank.
- Withdrawals through slips/cheques accompanied by card and passbook.

**Benefits to Banks**

- Reduction in work load for branch staff by avoidance of repeat appraisal and processing of loan papers under Kisan Credit Card Scheme.

- Minimum paper work and simplification of documentation for drawal of funds from the bank.
- Improvement in recycling of funds and better recovery of loans.
- Reduction in transaction cost to the banks.
- Better Banker – Client relationships.

**Insurance under KCC**

Kisan Credit Card holders are covered by a personal accident insurance. This cover is available when the person enters the scheme. The cover is as follows:

- Death : 50,000
- Disability: 25000
- Maximum Age to enter : 70 years

**How farmers use Kisan Credit Cards?**

Under KCC scheme, the loan amount is disbursed in cash through drawings made via withdrawal slips accompanied by KCC-cum-passbook. Cheque books are also issued to literate KCC holders enjoying KCC limit of Rs. 25000 and above.

**Interest and other charges on Kisan Credit Cards**

The interest rates on Kisan Credit Cards varies from bank to bank and also on borrowing limits. Generally, 9% per annum interest rate is charged for KCC borrowing limit up to Rs. 3 Lakh. However, central government provides interest subvention to the financing institutions. If the track record of the card holder is good; a further 2% interest subsidy is provided. After three years sound track record, a card holder can also get the credit limit enhanced.

Apart from that there are some overhead costs for borrowing under KCC. These include processing fee, charges on land mortgage deed, passport photo charges, insurance premium etc.

## Agriculture Marketing

The agricultural sector has been one of the most important components of the economy. The increasing trend of agricultural production has brought new challenges in terms of finding market for the surplus. There is also a need to respond to the challenges and opportunities, that the global markets offer in the liberalised trade. To benefit the farming community from the new global market access opportunities, the internal agricultural marketing system in the country needs to be integrated and strengthened. Agriculture and agricultural marketing need to be re-oriented to respond to the market needs and consumer preferences.

**Marketing**. Marketing means working with markets, which in turn means attempting to actualize potential exchanges for the satisfying human needs and wants. Thus we return to our definition of marketing as human activity directed at satisfying needs and wants through exchange processes.

**Farm's marketing**. Activities related to the marketing and production of agricultural products produced by an organization or individual farmer. Such activities in the process of farm's marketing include packaging, selection of brands name, promotional strategies, price policies, marketing channels and other policies.

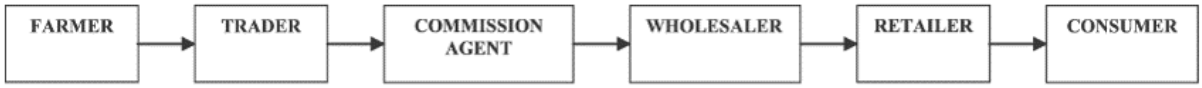
**Agricultural marketing**. Agricultural marketing generally means the marketing of agricultural products to the first handler. In macro (social) perspective, is the performance of all business activities involved in the forward flow of food and fiber from farm producers to consumers. It includes all the activities associated with agricultural production and with food, feed, and fiber assembly, processing, and distribution to final consumers, including analyses of consumer's needs, motivations, and purchasing and consumption behavior.

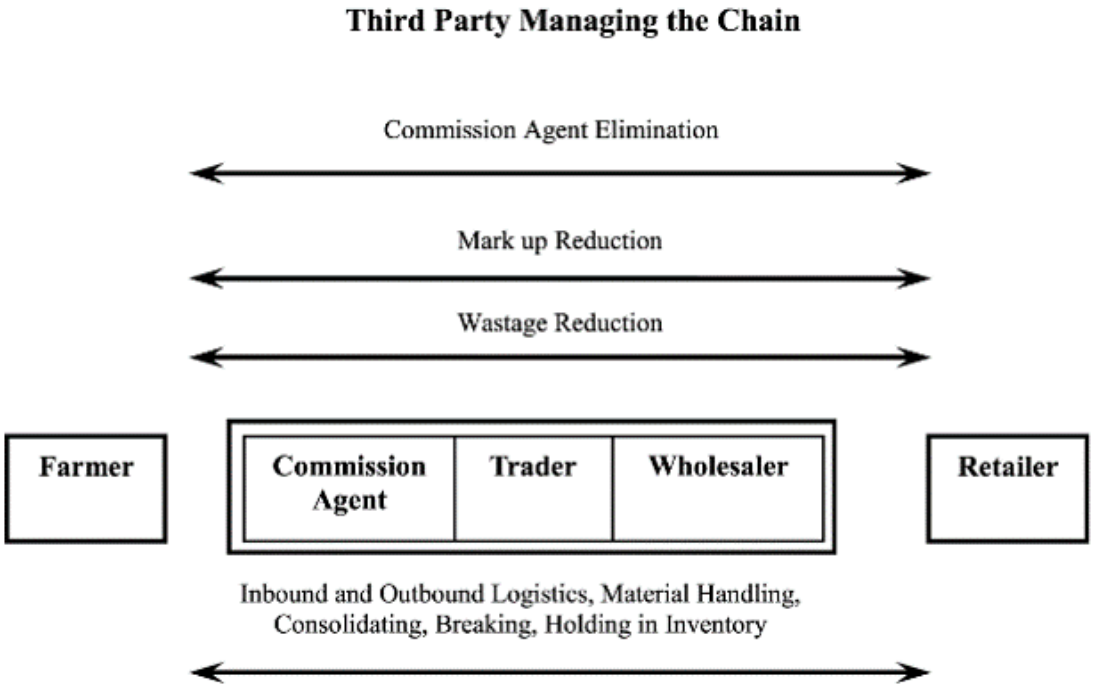
**Agricultural marketing circle**. It consists of;

- **First circle**. Refers to the final consumer or targeted customer.
- **Second circle**. Factors that can be controlled known as marketing mix (product, price, place, and promotion).

- **Third circle**. Environmental factors that cannot be controlled (political and legal, economic, law and regulation, social & culture, technologies, & demographic).

**Agriculture supply chain:-** In other words, supply chain management is the integrated process of producing value for the end user or ultimate consumer. The supply chains of different agricultural commodities in India, however, are fraught with challenges stemming from the inherent problems of the agriculture sector.




**Haats:-** A haat bazaar, most often called only haat, is an open-air market that serves as a trading venue for local people in rural areas and some towns of Nepal, India and Bangladesh.

Haat bazaars are conducted on a regular basis, i.e. once, twice, or three times a week and in some places every two weeks. At times, haat bazaars are organized in a different manner, to support or promote trading by and with rural people.

## B. Package & practices like- Important varieties, Seed rate, Sowing time, Intercultural operations, Yield and marketing of Rice, Wheat, Maize, Mustard, Sunflower, Soybean, Groundnut, Black gram, Red gram, Pea, Jute, Sugarcane, Sorghum, Pearl millet, Finger millet.

### Rice

**Botanical Name:-** *Oryza sativa*
**Family:** - Poaceae.
**Origin:-** Indo-Burma (South-eastern Asia)
**Inflorescence:** - Spike
**Type of fruit:-** Caryopsis

**Leading states in India:-** West Bengal, Uttar Pradesh.
**Percentage of carbohydrate: -** 78.2 %.
**Percentage of protein:-** 2.2-2.5%.

- India is the second largest producer of rice after China but first in rice area among world.
- India produces 19% of the world's rice.
- Highest production of rice in India is in West Bengal and productivity is of Punjab.
- Wheat is $C_3$ and SDP (Long Day Plant).
- Rice is self-pollinated crops.
- Orizene proteins is found in the rice.
- Protein content in rice is 6-7% that is lowest among cereal crops.
- Chhattisgarh state of India known as "*Bowl of rice*".
- Rice with husk is known as brown rice and without husk rice is known as white rice.
- Rice is stable food of India 65% population.
- The rice dwarfing gene is "Dee Gee Woo".
- Test weight of rice seed is 25 grams and Basmati rice is 21gm.
- Asia produce 90% of total rice of world.
- 24 rice species found in around the world.

1. ***Oryza sativa:-***It is mostly cultivated in Asia. It has three sub species.

i. *Oryza sativa var. indica:-* It is cultivated in tropical and subtropical belt. In India and Asia, this species is grown at maximum area.
ii. *Oryza sativa var. japonica:-* It is mostly grown in temperate region. It is cultivated in Japan.
iii. *Oryza sativa var. javanica*:- It is mostly cultivated in Indonesia.

2. *O. glaberrima:-* It is cultivated in Africa.
   - Only two species of rice are cultivated other are wild.

**Climate:-**In India rice is grown under widely varying conditions of altitude and climate. Rice cultivation in India extends from 8 to35ºN latitude and from sea level to as high as 3000 meters. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37º C. Maximum temp which the crop can tolerate $40^{o}$C to $42^{o}$C.

- Suitable temperature for growth:- 25-30ºC.
- Suitable temperature for maturity:- 20-25ºC.

**Soil:-** Clay to silt loam soil good for rice cultivation. Rice can be cultivated in acidic soil. Suitable pH range of soil for rice cultivation is 5.5-6.5.

**Sowing time of Rice**

| **Crop** | **Sowing Time** | **Harvesting Time** | **Remark** |
|---|---|---|---|
| Aman/Rainy season | July-August | Nov-Dec | It is grown at 84% area of Total area. |

| | | | |
|---|---|---|---|
| Boro/Winter season | Nov-Dec | March-April | It is grown at 9% area of Total area. |
| Aus/Autum rice | April-May | Sep-Oct | It is grown at 7% area of Total area. |

**Seed Rate:-**

1. **Broadcasting Method:-** 100kg/ha.
2. **By Seed drill:-** 60kg/ha.
3. **By nursery:-** 30-40kg/ha.
4. **For IR-8 and Jaya:-** 40-45kg/ha.

**Cultivation Methods in Rice Farming:-**

There are 4 methods of cultivation practiced in paddy farming.

1. **Broadcasting method:-** In this method, seeds are sown by hand and this method is suitable in areas where the soil is not fertile and lands are dry. This requires minimum labour and inputs. This method produces very less yield when compared to other sowing methods.
2. **Drilling method:-** In this method, Ploughing of land and sowing of seeds can be carried out by 2 persons. This sowing method is mostly confined to peninsular of India.
3. **Transplantation method:-**

**a. Wet-Bed Method:-** The wet-bed nursery is mainly used in areas where there is enough water. Pre-germinated seeds are broadcast on a soil that is thoroughly puddled and leveled. Drainage canals for proper removal of water must be constructed. Addition of organic manure (decomposed) and small amount of inorganic fertilizer as basal dressing will increase easiness of uprooting of seedlings and seedling vigour.

Total seed bed area is about 1/10 (1000$m^2$) of the area to be transplanted and about 40 kg of seed are required to transplant 1 hectare.

The best seedling age for transplanting is about 15-21 days.

Nurseries should be free from weeds, any pest or disease incidence and nutrient deficiencies. If such conditions occur it must be treated at the nursery level.

**b. Dry-bed method:-** The nursery is prepared in dry soil conditions. Seed beds of convenient dimensions are prepared by raising the soil to a height of about 5-10 cm. A layer of half burned paddy husk could be distributed on the nursery bed to facilitate uprooting.

The site should be free of shade and with adequate irrigation facilities. Total seed bed area is also about 1/10 (1000$m^2$) nof the area to be transplanted but about 80 kg of seed are required to transplant 1 hectare (germination is lower). Uprooting of seedlings should be done between 15 - 21 days after germination. Nursery should be maintain without any moisture stress. A basal fertilizer mixture can be applied and incorporated between rows if the soil nutrient supply is low.

The advantage of the dry-bed method is that seedlings are short and strong, with a longer root system compared with the wet-bed method. The seedlings can be raised even during periods of heavy rains.

A disadvantage is however that roots may get damaged during pulling. Seedlings of upland nurseries may also get infected with blast and are more prone to pests such as rodents etc.

**c. Dapog method (mats):-** It is doveloped by IRRI, Philippines.Dapog nurseries can be located anywhere on a flat firm surface but water supply/control should be very reliable. The area needed is about 100 $m^2$/ha or 1% of the transplantable land which is much smaller than conventional nurseries.

Another advantage of the "dapog" over wet/dry-bed nurseries is that the cost of uprooting of seedling is minimal. But, because the seedlings are small, transplanting can be more difficult. Very young seedlings from dapog nurseries suffer less from the transplanting shock compared with other nurseries, thus the seedlings are more suitable for short duration varieties. Irrigation is obligatory to prevent water stress. Seed rate require 3kg/$m^2$. The seedling are ready in 11-13 for transplanting.

d. **Preparing the Nursery and Starting Seedlings (System of Rice Intensification):-** Rice seeds should first be soaked in temperate water for 24 hours. Any that are irregular or float should be discarded.

1. Next, put the seeds in a sack (burlap or other) and place it in a warm compost pile or in a hold in the ground that has been warmed by fire. Cover the sack completely with either compost or soil and leave it for 24 hours for slow warming of the seeds.
2. The seedbed should be prepared as closely as possible to the field that will be planted, so as to minimize transport time between seedlings' removal from the seedbed and their transplanting in the field.
3. Compost should be mixed into the soil of the seedbed at a rate of 100 kg per are (10 m x 10 m). Prior to seeding, lay down a fine layer of "ripe" compost or black soil in the seedbed to give the seeds good nutrient-rich material to begin their growth in. Farmers in Sri Lanka have found that building up the seedbed, about 10 cm, with lengths of bamboo, putting in compost or animal manure (chicken manure is very good) along with soil, gives the seedlings an excellent start and makes them easy to remove. Also, the organic nutrients are contained within the seedbed better this way.
4. Broadcast the pre-germinated seeds onto the bed at a rate of about 200 grams for every 3 square meters, and then cover the seeds with a fine layer of soil.
5. Water the seedbed every day in the late afternoon, or as often as needed to maintain a moderate level of soil moisture. The soil should not be saturated or kept continuously wet. If there has been rain during the day, no watering may be needed. How much to add to the bed depends on whether the soil has become dry. Transplanting should be done when the seedlings have just two leaves -- and before they have more. This usually occurs between 8 and 15 days.
6. Seeds should not be sown all at the same time. Rather, appropriate batches of seed should be sown on successive days, so that the plants when they are put into the field can be all a uniform age, all between 8 and 12 days.

4. **Japanese method:**- High yielding varieties can be included in this method and which requires heavy dose of fertilizers. Seeds should be sown on raised nursery beds and should transplant the seedlings in rows. Weeding and fertigation should be carried out as per schedule. This method is successfully adopted for high yielding hybrid crops.

**Seed Treatment in Rice Cultivation:-** The paddy seeds should be treated with Agrosan @ 100 gm/50 Kg of seeds to prevent seed-borne diseases. The untreated high yielding varieties of rice should be soaked for 12 hours in a solution of wettable ceresan (0.1%). After this, make sure to thoroughly dry in shade before sowing in the field or nursery bed.

**Land Preparation, Sowing in Rice Cultivation:-** The main systems followed in rice cultivation are ‘dry’, ‘semi-dry’ and ‘Wet’. Basically, the dry and semi-dry systems of cultivation depends on rains and do not have supplementary irrigation facilities whereas in wet cultivation system, the rice crop is grown with assured and abundant water supply either by rain or by irrigation.

Dry and Semi-dry system: for this system of rice crop the field should have good tilth that can be achieved by giving couple of ploughings & harrowing. Filed should be supplemented with farm yard manure (FMY)/compost distributed uniformly 2 weeks to 4 weeks before sowing or planting. The seeds should be sown either by broadcasting or drilling method and line sowing would help in weeding and intercultural operations. The row to row spacing in case of drill sowing method is 20 cm to 25 cm.

Wet system: When following this system of cultivation method, the land should be ploughed thoroughly and puddled with 3cm to 5 cm of standing water in the field. The ideal depth of puddling is found to be around 10 cm in clay soils and clay-loamy soils. The land should be levelled after puddling to facilitate a uniform distribution of water and fertilizers. Paddy seeds should be sown after sprouting or the seedlings of rice should be transplanted in the main field.

**Verities:-**

1. **TN-1:-** It is first dwarf variety of rice. It is introduce in India from Taiwan.
2. **IR**-8:- It is developed by IRRI, Philippines. It is first high yielding variety. It is resistant to bacterial leaf spot.
3. **Jaya:**- It is first dwarf variety of rice in India. It is high yielding variety. It gives more yield than TN-1 and IR-8 varieties. It is known as Indian merical rice. It is resistance of Blast.

4. **Jagannath & Sattari:-** It is developed by mutation.
5. **Lunshree, IR-8 and CSR-10**:- Tolerant to saline and alkaline soil.
6. **Sabarmati**:- It is resistance to blast.
7. **Bala and**:- It is good for drought area.
8. **Pankaj & Jagannath:-** Both are suitable for shallow water area.
9. **Padama:**-
10. **Jagannath**:- It is first mutant variety.
11. **Pusa Basmati:-** It is first best quality variety of basmati rice in world wide. It is developed from IARI, New Delhi.
12. **PRH**-1:- First hybrid variety of basmati rice.
13. **IR-**24:- Suitable for alkaline soil.
14. **Madhukar, Jalmagan and Chakaiya:-** All are suitable for deep water**.**
15. **Rajeshwari and Hema**:- They can grow Kharif and Rabi season both.
16. **Golden Rice**:- It has 37% carotein content. The grain is green in colour.
17. **Tarawati and Basmati**:- Both has highest swelling capacity during cooking.
18. **Rasi:-** Suitable for rain fed upland condition, medium bold, white, resistant to blast, yield: 56 q/ha.
19. **Prakash:-** Resistant to green leaf hopper stem borer, bacterial leaf blight.
20. **Mangala:-** High yielding, short duration variety, tolerant to cold.
21. **Shakthi:-** A dwarf variety with semi compact habit. Resistance to gall midge and is drought tolerant.

**Early variety of Rice:-** Early varieties are ready for harvesting in 100-105 days after planting. Eg.- Bala, Pusa-2-21, Kaveri, Govind, Nagina-22.

**Mid and late season varieties:-** These varieties ready in 120 days after planting. Eg.- Saket-4, Ratna, IR-

**Verities use in direct sowing:-** Govind, Bala, Kaveri, Pusa-2-21.

**Varieties developed from IARI:**- Bala, Kanchan, Kiran, Bhawani.

**Puddling:-** Puddling is achieved by cultivating the soil under saturated condition using animal drawn or tractor driven implements. Mechanical breaking and dispersing of soil aggregates destroys the soil structure and forms the puddled zone. Puddling softens the soil and assists manual transplantation of rice seedling, minimizes water use through reduced percolation losses and effective weed control.

**Manure and fertilizer: -**

- FYM: - 10-15t/ha.
- N: - 100kg/ha
- $P_2O_5$: - 60kg/ha
- $K_2O$: -50kg/ha
- Zinc Sulphate: 25 Kg/ha

The soil in the transplanted rice fields after puddling develops two zones in water logged conditions. The upper layer of soils (1 to 10 milli metre thick) generally receives Oxygen periodically from fresh supplies of irrigation water and turns in to brown colour called "Oxidised zone" and reacts like an unflooded upland soil. The remaining lower portion of puddled soil without oxygen is called "reduced zone". When ammonical nitrogen fertilizer is applied in such soils, it gets oxidised to nitrate ($NO_3$) form in the oxidised zone (upper surface layer of the soil). Afterwards nitrate nitrogen is leached down to the reduced zone and further gets denitrified to gaseous nitrogen. This gaseous nitrogen is lost. If ammonical nitrogen is incorporated in to the reduced zone of the soil, where it is held, the loss can be prevented. Fertilizers containing nitrogen in the nitrate form are more susceptible to loss of nitrogen through leaching and de-nitrification process. Therefore, ammonical form of nitrogen is found more beneficial for rice crop.

**Water management:-** The water requirement of rice crop is comparatively higher than any other crop of the similar duration. Assured and timely supply of irrigation water has a considerable influence on the yield of the crop. During the crop growth period, the water requirement is generally high at the initial seedling establishment stage. After the transplanting, water should be allowed to stand in the field at a depth of 5 centimeters till the seedlings are well established. The second, the most important critical stage is tillering to flowering and in this period the crop should not be subjected to soil moisture stress. The water supply should be ensured in required amount during panicle initiation to flowering stage. About five centimeters depth of water should be maintained in the field up to the dough stage of the crop. Before harvesting, water should be drained out from the field to allow quick and uniform maturity of grain.

**Weed Control:**- Rice field favours growth of aquatic and semi aquatic weds. A few common aquatic weds in rice are water hysinth, pistia, morning glory and algae. Terrestial including barnyard grass Ammonia baciflora (Jalmukhee) may be serious on ridges.

**Weed Control Practices:**

1. Flooding:- To prevent aquatic weeds, alternate and drainage is essential.
2. Row Cultivation:- In line sown rice fields hand rotary wear has proven a very effective weed control for floating aquatic weeds and perennial grasses. Hoeing and weeding give effective physical weed control of rice. In nurseries, hand puling is common methods.

**Herbicides Control:-**

Upland Rice:- A variety of grasses form primary weed flora in upland rice. For their control nitrogen @ 2.4 kg/ha is recommended as pre emergence control. Immediately after drilling. Butachlor can be used in upland rice.

**Propanil:-** 3 to 4 kg/ha. Malinate 2-4 kg/ha SWCP 4-6 kg/ha flurodifen 2-4 kg/ha, are effective selective post emergence herbicides against annual grasses.

**Harvesting, Yield and Storage:**- The right stage for harvesting as commonly understood by laymen is when panicles turn into golden yellow and the grains contain about 20 percent moisture. When the moisture in the paddy grains reaches 16-17 percent in the standing crop in the fields, the crop sustains a heavy loss owing to shattering and damage by birds and rodents. Generally 1 month after tillering crop is ready for harvesting.

**Yield of Early Varieties:**-40-50qt/ha

**Yield of Early Varieties:**-60-70qt/ha

**Seed and husk ratio:**- 1:2 (Hulling percent-65%)

For safe storage, grain should be cleaned and dried well in sun for a few days so that moisture content of grain comes down to 10percent.

**Major Insect of Rice**

- Brown Plant Hopper, *Nilaparvata lugens*
- Yellow Rice Stem Borer, *Scirpophaga incertulas*
- Rice Ear-head Bug, *Leptocorisa oratorius*
- Rice Hispa, *Dicladispa armigera*
- Rice Grasshopper, *Hieroglyphus banian*

**Major Diseases of Rice**

**Fungal Diseases**

1. **Blast** - ***Pyricularia oryzae***
2. **Brown Spot** - *Helminthosporium oryzae***:-** The disease was considered to be the major factor contributing to the "Great Bengal Famine" in 1942 resulting to yield losses of 50% to 90% and caused the death of 2 million people.

3. **Narrow brown leaf spot** - *Cercospora janseana*
4. **Sheath rot** - *Sarocladium oryzae*
5. **Sheath blight** - *Rhizoctonia solani*
6. **False smut** - *Ustilaginoidea virens*
7. **Udbatta disease** - *Ephelis oryzae*
8. **Stackburn disease** - *Trichoconis padwickii*
9. **Bunt or Kernel Smut or black smut** - *Tilletia barclayana*
10. **Stem rot –** *Sclerotium oryzae*
11. **Foot rot or Bakanae disease** - *Fusarium moniliforme*

**Bacterial Disesases**

1. **Bacterial leaf blight** - *Xanthomonas oryzae pv. Oryzae*
2. **Bacterial leaf streak** - *Xanthomonas oryzae pv. oryzicola*

**Viral Diseases**

1. **Rice Tungro Disease (RTD)** - *Rice tungro bacilliform virus* (RTBV) and *Rice tungro spherical virus* (RTSV)
2. **Rice Grassy stunt disease** - *Rice grassy stunt tenuivirus*

# Wheat

Botanical name:-

**1. Bread Wheat:** -*Triticum aestivum* (2n = 6x = 42): - It is grow at 95% of the total area in India, which is grow in Uttar Pradesh, Punjab, Haryana, Rajasthan, Bihar, West Bengal, Assam, Madhya Pradesh, Himachal Pradesh and Jammu & Kashmir

**2. Macaroni wheat:** -*T. durum* (2n = 4x = 28): - It is 4% of the total area in India, which is cultivated in Madhya Pradesh, Maharashtra and Gujarat

**3. Emmer Wheat:** -*T. dicoccum* (2n = 2x = 14): - It is 1% of total area in India, which is cultivated in Karnataka, Maharastra & Tamil Nadu

**Family:** - Poaceae.

**Origin:**- South-Western Asia

**Inflorescence:** - Spike

**Type of fruit:**- Caryopsis

**Leading states in India:**- Uttar Pradesh (34.534%), Punjab (18%), Haryana (13.387%).

**Percentage of carbohydrate:** - 62-71%.

**Percentage of protein:**- 8-15%.

- India is the second largest producer of wheat after China.
- India produces 12% of the world's wheat.
- Highest production of wheat in India is in Uttar Pradesh and productivity is of Punjab.
- Wheat is $C_3$ and LDP (Long Day Plant).
- Wheat is self-pollinated crops.
- Test weight wheat seed is 40 grams.
- The first single gene dwarf variety is Lerma Rosa and double gene dwarfvariety is Sonora-64 were prepared from Norin-10 genes.
- Wheat is the most eaten food in world and second after rice in India.
- Gluten proteins is found in the rice..
- It is believed that wheat is brought in India by the Aryans, and since then it is being grown in India.

**Climate: -** Wheat is grown in hot and sub-tropical climate and its cultivation is done in temperate climates from 47 ° South to 57 ° in the northern latitudes to the height of 3,300 meter sea level. It can tolerate cold and frost. The ideal temperature for germination of wheat seeds is 20-25 degrees Celsius. The suitable temperature for vegetative growth is 16- 22 ° C. 14-15 ° C is suitable during the maturity of wheat. When the temperature at maturity is above 25 degrees, the weight of the grains decreases

**Soil:-** Sandy loam and black soils are suitable for good wheat cultivation. The appropriate pH value for good crop growth is 5-7.5.

**Verities of Wheat**

| STATES | CULTURAL CONDITIONS | VARIETIES |
|---|---|---|
| Punjab, Haryana, Delhi, Western Uttar Pradesh, Rajasthan(Except Kota and Udaipur Divisions), foothills of Himachal Pradesh, Jammu& Kashmir and Uttarakhand | Irrigated Timely sown | PBW 343, HD 2687,WH 542, UP 2336,Raj 3077, CPAN 3004, PDW 215(d), PDW 233(d),WH 896(d) |
| | Irrigated Late Sown | PBW 373, UP 2338,PBW 226, Raj 3765, Raj 3077, UP 2425 |
| | Irrigated very late sown | HD 2285, Raj 3777, Raj 3765, HD 2402, |
| | Rainfed | PBW 175, PBW 299, PBW 65, PBW 396, WH 533,(in Haryana), C 306 |
| Bihar, eastern Uttar Pradesh, West Bengal, Orissa, Assam, Jharkhand and plains of north-eastern states | Irrigated timely sown | HD 2733, K 8804(K 88), HD 2402, HP 1731, HP 1761, K 9107(Deva), PBW 443, NW 1012, HUW 468, |
| | Irrigated late sown | HD 2643, HP 1633(Sonali), DL 784-3, HP 1209, HUW 234, HP 1744, NW 1014, |
| | Irrigated very late sown | HD 2285, Raj3777, Raj 3765, HD 2402, |
| | Rainfed timely sown | K 8027, C 306, |

| | | |
|---|---|---|
| | Rainfed late sown | HDR 77, K 8962(Indra), K 9465, |
| | Salt affected soils | KRL 1-4, Raj 3077, KRL 19, Job 666 |
| Madhya Pradesh, Gujrat, Kota and Udaipur divisions of Rajasthan, Jhansi division of Uttar Pradesh and Chattisgarh | Irrigated timely sown | DL 803-3, GW 190, HI 1077, HI 8498(d), GW 273, HD 2236, Raj 1555(d), HI 8381, (d) |
| | Irrigated late sown | GW 173, Swati, j 405, dl 788-2, |
| | Irrigated very late sown | HD 2285, Raj 3777, Raj 3765, HD 2402, |
| | Rainfed timely sown | C 306, Sujata, A 9-30-1(d), HW 2004, JSW 17, HD 4672(d) |
| | Salt affected soils | KRL 1-4, Raj 3037, KRL 19, Job 666 |
| Maharashtra, Karnataka, Andhra Pradesh | Irrigated timely sown | MACS 2496, DWR 162, DWR 1006(d), HD 2380, MACS 2846, AKW 1071(in Maharashtra) |
| | Irrigated late sown | HD 2501, DWR 195, HI 977, NIAW 34, |
| | Rainfed timely sown | NI 5439, N 59(d), MACS 1967(d), Bijaga yellow (d), NIDW 15(d) |
| | Salt affected soils | KRL 1-14, Raj 3077, KRL 19, Job 666, |
| | Dicoccum Wheat | NP 200, DDK 1001, DDK 1009 |
| Hills of Uttarkhand, Himachl Pradesh, J&K, Sikkim and far eastern states | Irrigated timely sown | HS 240, HD 2380, VL 738, |
| | Rainfed timely sown | HS 240, HD 2360, VL 738, DT 46(Triticale) |
| | Rainfed late sown | HS 207, HS 295, |
| | Rainfed early sown | VL 616, HS 277, |
| Tamil Nadu(Nilgiri and Palni hills) | All situations | HPW 42, HS 365, HW 971, HUW 318, HW 1085, HW 2044, |
| | Dicoccum Wheat | NP 200, DDK 1001, DDK 1009 |

- Kalyan Sona: - It is double gene dwarf variety. It can be cultivated in every type of climate. It is resistant to Pandemic disease.
- Raj-1482: -It is double gene dwarf variety. It is the resistant to Rust and Karnal Bunt disease.
- LOK-1: - It is double gene dwarf variety. It is suitable for late sowing.
- Raj-3077: - It is dwarf variety. It is resistant to Rust disease. It is suitable for late sowing.

**Tolerant varieties of saline and alkaline soil:** - Raj-3077, Sonalika, HD-2380, HD-2285, KRL-19, KRL-1-4, Job-666.

**Suitable for unarrigated areas:-** PBW-299, PBW-396, PBW-175, PBW-65, Pratap (HD-1981), Kundan, Mukta (HI-385), Meghdoot (HI-748), Sujata, PBW - 117, Kalyansona.

**Late Varieties:-** Swati, J-405, HD-2285, Raj-3777, Raj-3765, HD-2402, HD-2327, Sonalika, Lok-1, J1-104, Raj-4083, Raj-3077.

**Seed rate:-**

- For timely sowing: - 100 kg/ha.
- For late sowing, saline and alkaline soil and rain-fed areas:- 125 kg/ha.
- By Dibbler:- 25-30kg per hectare.

**Seed treatment:-**

- **For Loose smut:-** Treat the seed with Tebuconazole @ 1g/kg seed or Vitavax @ 2 g/kg or Bavistin @ 2.5 g/kg seed for the control of loose smut.
- **Flag smut:-** To control flag smut, treat the seed before sowing with Thiram @ 3 g/kg or Tebuconazole 1g/kg or Vitavax @ 2 g or Bavistin @ 2.5 g/kg seed.
- **Other diseases:-** Treat the seed with Captan or Thiram @ 3 g/kg seed for the control of root rot, foot rot, seedling blight, black tip and black spot of glumes.
- Treat the seed before sowing with *Trichoderma viride* @4 g/kg seed. It provides induced systemic resistance, thus reducing the severity of the yellow rust at later growth stages of the crop.
- In the termite prone areas, seed treatment with chlorpyriphos @ 0.9g a.i or Endosulfan @ 2.4g a.i/kg seed, be taken up for their management.
- **Ear cockle:** The infested seed lot should be floated in 2 percent brine solution for this purpose the galls will float on the surface. These should be separated and destroyed away from the field by burning. The seed should be thoroughly washed to remove the salt solution before sowing.
- For saline soils and salt water areas, seed should be treated with 3% sodium sulphate for 24 hours.

**Plant implantation:-** 22.5x10cm.

**Sowing time: -** From the first week of November to the last week of November.

**Manure and fertilizer: -**

- FYM: - 10-15t/ha.
- N: - 120kg/ha
- P2O5: - 60kg/ha
- K2O: -40kg/ha

**Irrigation: -** For good crops producation, 6 irrigation is required.

1. Crown Root Initiation (21 days after sowing)
2. Late Tillering (45-50 days after sowing)

3. Late Joinging (65-70 days after sowing)
4. Flowering (85-90 days after sowing)
5. Milk stage (100-105 days after sowing) and
6. Dough ripe (115-125 days after sowing)

**Weed control:-**

- *Phalaris minor* is the mimicry weed of wheat.
- *Convolvulus arvensis* (Hirankhuri/field bindweed) is major weed of wheat.
- Generally 25-30 and 40-50 days after sowing hand weeding should be practiced for manually weed control.
- As pre-emergence, only Stomp 30EC (Pendimethalin) is available which can be applied @ 3300 ml/ha (1000 g a.i/ha) at 0-3 days after sowing in 500 liters of water /ha. Care must be taken to have fine tilth for better performance of pendimethalin. It controls both grasses and broadleaved weeds.
- 2,4-D ethyl ester (Post-emergence) @ 0.4 kg/ha should be sprayed for broad leaf weed control after 35 days of sowing.
- To control *Phalaris minor* and monocot weed spray Tribunil or Isoproturon (Post-emergence) at the rate of 2kg per ha in 400-600 l of water 32-35 DAS.
- Grassy and Broad Leaved both type weed can be controlled by Sulfosulfuran(Post-emergence) @ 25.0g a.i./ha in 250-300 liters of water /ha.

**Harvesting and threshing:-** High yielding dwarf varieties of wheat should be harvested when the leaves and stems turn yellow and become fairly dry. To avoid loss in yield crop should be harvested before it is dead ripe. When harvest is not done in time, grain may be lost die to damage by rain, birds, and insects, shattering and lodging. Timely harvesting ensures optimum grain quality and consumer acceptance. The right stage for harvesting is when there is about 25-30% moisture in grains. Harvesting is normally done with serrate edge sickles by hand. Bullock driven reapers are also used occasionally. Combines are also available which can be harvesting, threshing and winnowing wheat crop in single operation. After harvesting the crop by hand, it is dried and three to four days on the threshing floor and then threshing is done by trampling bullocks or thresher attached to bullocks. Now-a-days power driven stationary threshers are becoming more popular because these are easy in operation and hasten the process.

**Yield:** When cultivation of high yielding dwarf varieties of wheat is done with improved scientific methods, they produce about 45-55qt of grain per hectare under irrigated conditions and 20-25 qt per hectare under rain fed conditions. For safe storage, grain should be cleaned and dried well in sun for a few days so that moisture content of grain comes down to 10-12 percent.

- Seed and husk ratio of tall variety:- 1:1.5
- Seed and husk ratio of dwarf variety:- 1:1.25

**Major Diseases**

1. **Foot Rot, Root Rot and Seedling Blight**

**Causal Organism:-** *Helminthosporium sativum* and *Fusarium spp* (Fungus).

**Description:-** These disease is caused by soil borne pathogens. The incidence of these diseases has been reported from Madhya Pradesh, Maharshtra, Karnataka, Uttar Pradesh and West Bengal although the causal

fungi differ from place to place. These disease can cause considerable yield losses depending on their intensity, which tends to be more severe under rainfed conditions than the irrigated areas.

**Symptoms:-** The first symptoms of wheat foot rot consist dark-brown patches appear on collar; plant turns yellow and dries up.

**Control Measure:-** The varieties like HD 2189 and NI 5439 recommended for the Peninsular Zone are relatively more tolerant. Seed-dressing with Agrosan GN or Ceresan @ 2 g/kg delay sowing till the 3rd week of October; apply heavy rainy (irrigation) to prepare the seedbed.

2. **Karnal bunt of wheat**

**Causal Organism:** *Neovossia indica*

**Description:-** It is also known as 'Partial Bunt'. Normally the disease appears sporadically but under epidemic conditions, it may cause substantial yield losses. The fungus affects the grain partially. The affected part of the grain is converted into a mass of black bunt spores while the remaining parts are normal. Freshly harvested grains emit foul smell due to the production of tri-methyl amine. Karnal bunt is both soil and air borne disease. Karnal bunt is a disease of quarantine importance because its occurrence is not known in most of the wheat growing countries of the world.

**Symptoms:-**

- Karnal bunt symptoms are evident when the grains have developed. After harvest, diseased grains can be easily detected by visual inspection.
- The grains are partially bunted. Black coloured spore mass replaces a portion of the grain and the pericarp may be intact or ruptured.
- Black powdery mass of spores can be seen in the groove of wheat grain.
- Diseased grains give off a foul fishy odour when crushed. It is due to the presence of trimethylamine in the diseased grains.

**Control measure**

- Sowing crops at night time.
- Seed should be treated with Vitavax at the rate of 2.5g/kg of seed
- Avoid excess irrigation at flowering time
- Spraying of Indofil M-45@2.5kg/ha in 1000 litres of water at the time of ear emergence stage.
- Spray of Propiconzole(Tilt 25EC@0.1%) should be given at the time of anthesis.Integration of one spray of bio agent fungus,*Trichoderma viride* (0.4% suspension) give almost cent percent disease control.

3. **Loose smut of wheat**

**Causal Organism:** *Ustilago nuda tritici*

**Description:-** The disease is internally seed bone in the form of dormant mycelium. Infection occurs during flowering through wind-borne spores. Its occurrence has been reported from all parts of the country but it incidence is higher in northern parts than the southern regions. The incidence of the diseases is the relatively more in the humid areas as compared to the dry parts. The fungus is capable of growing within a temperature range of 5-35$^0$C but most congenial temperature for diseases development is 23$^0$C. The disease

is capable of causing very high yield losses, which depends on the proportion of smutted heads in the field. The infected grains look similar to the healthy ones.

**Symptoms:-**

- The symptoms are visible only on the emergence of wheat ear-heads.
- The grains in a spike, except the rachis, are replaced by black masses of spores that are dried and blown away by the wind, leaving only the bare rachis.
- This black powdery mass, in the beginning in enclosed in a delicate silvery membrane, which reputes before the complete emergence of the ear from leaf sheath.

**Control measure:-** Seed treatment with fungicides like Carboxin (Vitavax) 75 WP @ 2.5 g/kg seed, carbendazim (Bavistin) 50 WP@2.5 g/kg seed. If disease infestation is low to moderate, treat the seed with a combination of *Trichoderma viride* @4 g/kg seed and half the recommended dose of carboxin @1.25 g/kg seed.

4. **Powdery mildew of wheat:-***Erysiphe graminis tritici* (Fungus):- Its incidence is mainly confined to northern and southern hills although its appear sporadically in plains and foot hill of the country. Its occurrence has been reported from most wheat growing state particularly after the wide spread cultivation of high yielding varieties and intensification of wheat production system. The severity of the attack depends on season, region and locality. The fungal conidia can germinate in temperature range of 0-35 $^0$C with optimum of 15-20$^0$C.

**Symptoms**

- The first visible symptoms are white to pale gray, fuzzy or powdery colonies of mycelia and conidia on the upper surfaces of leaves and leaf sheaths and sometimes on spikes.
- These patches later turn brownish studded with dot like black structure.
- The fungus usually develops on upper surface of the leaves, which get crinkled, twisted and deformed.

**Control Measure:-** Spray karathane 80WP at the rate of 1kg/ha or Bayleton at the rate of 500g/ha in 1000 litres of water at the appearance of first symptoms.

5. **Leaf rust (Brown rust):-***Puccinia triticina, Puccinia recondite var. tritici* and *Puccinia tritici-duri.*

6. **Ear Cockle Disease of Wheat / Tundu Disease: -**This disease is caused by *Anguina tritici* nemetod and *Corynebacterium tritici* bacterium.

**Important Insect :-**

1. Aphid (*Sitobion avenae, Rhopalosiphum padi*)
2. Brown Wheat Mite (*Petrobia lateens*)
3. Army Worm (*Mythimna separate*)
4. Termites (*Odontotermis obesus, Microtermis obesi*)
5. Soot fly

## Maize

**Botanical Name:-** *Zea mays*

- **Flint corn (*Zea mays indurata*):-** Entire outer portion of kernel is hard starch. Flint comes in many colours such as white, yellow, red-blue or their variable.

- **Dent corn (*Zea mays indentata*):-** About 95% of production in USA is dent corn. Hard starch is confined to kernel only. The amylose of soft starch in the core contracts when the grain is dried producing characteristic dent in the top of the kernel. May be yellow, white and red colour of kernel.
- **Sweet corn (*Zea mays saccharata*):-** Grown for food and harvested at 70% moisture content. It is good source of energy. About 20% of dry matter is sugar compared to 3% in dent corn. It is also a good source of vitamin C & A.
- **Flour corn (*Zea mays amylacea*):-** Kernel is largely composed of soft starch with little or no hard starch. Kernels are easy to grind. Primarily used by natives of Andean Highlands of South America.
- **Pop corn (*Zea mays everta*):-** It's kernel is small and extreme form of flint corn. When heated to 170°C, the grain swells and burst and turning inside out. At this temperature, the water held in the starch turns to steam and the pressure causes the explosion
- **Waxy corn (*Zea mays ceretina*):-** Due to waxy appearance of the kernel, it is called as waxy corn. The starch is entirely amylopectin whereas dent has 78% and 22% amylose. Hybrids of waxy are raw materials for wet milling starch industry for textile and paper sizing and corn oil.

**Family: -** Poaceae.

**Origin:-** Mexico

**Inflorescence: -** Spike (The corn silk growing out of the ear is the female part of a corn plant, and the tassel growing out the top of the corn stalk is the male part.)

**Type of fruit:-** Caryopsis

**Leading states in India:-** Andhra Pradesh, Karnataka.

**Percentage of carbohydrate: -** 66 %.

**Percentage of protein:-** 10-11%.

**Fat Content:-** 3.6-4%.

- USA is largest producer of Maize in word (37%).
- Maize is also known as "Back Bone of USA".
- India produces 2% of the world's maize.
- Highest production of maize in India is in Andhra Pradesh and productivity is of Karnataka.
- Maize is $C_4$ and Day Neutral Plant .
- Maize is cross-pollinated crops.
- Maize is also known as queen of cereal crops.
- Zein protein is found in Maize.
- Zeatin is natural cytokinin fond in maize.
- Maize is Monoicous in nature.
- Protandry (Dichogamy) found in maize.
- Maize introduce in India in 17 century by Portuguese.
- Removing of male part during hybridization is called detasseling.
- Lysine and tryptophan amino acid found in maize.
- Test weight of hybrid maize is 285gm.
- Test weight of composite maize is 200 gm.

**Climatic requirement**

Maize is warm season crop. Maximum rate of maize growth is at 24-30°C. Longer the grain filling period, higher the grain yield provided no freezing temperature. Higher the solar radiation, higher will be the photosynthesis in maize. Suitable temperature for germination is 21°C.

**Soil requirement**

Deep, fertile, rich in organic matter and well drained soils are the most preferred ones for the crop; however, maize can be grown on a variety of soil types. The soil should be medium textured with good water holding capacity. The crop is very sensitive to water logging and since it is mainly grown during rainy season, care should be taken to assure that water does not stagnate on the soil surface for more than 4-5 hours. Loamy or silty loam soil or silty clay loam soil having fairly permeable sub soil is ideal soil types. Thus, the ideal soil is neither clayey or sandy and has a pH between 6.5-7.5.

**Varieties:-** Under the auspices of the All India Co-ordinated Maize Improvement Scheme, eleven high yielding hybrids ('Ganga-1', Ganga-101', 'Ranjit', 'Deccan', 'Ganga-5', Ganga Safed-2', 'hi-Starch', 'Ganga-4', 'Himalayan 123', 'Ganga-3' and 'V.L. 54') and six composites ('Vijay', 'Amber', 'Sona', 'Kisan', Jawahar' and 'Vikram') have been released for cultivation in the various regions of the country.

| NAME OF HYBRID | GRAIN TYPE | SALIENT FEATURES |
|---|---|---|
| Ganga-1 | | It is first hybrid variety of maize in India developed in 1961. |
| Ganga-5 | Bold, yellow, semi-flint | A medium maturing (95-110 days), medium statured and widely adapted hybrid. Recommended for the northern Plains and Peninsular India. Resistant to leaf blight and brown strip, downy mildew, stem-border and drought |
| Ganga Safed-2 | Medium, white, semi-flint | A widely adapted medium maturing hybrid very popular in white maize growing regions of Uttar Pradesh, Bihar and Rajasthan. It is resistant to foliar diseases and most resistant to bacterial rot. |
| Deccan | Bold, yellow, semi-flint | A medium maturing maturing in 105-110 days, recommended for Peninsular India. Excellent husk cover. Highly resistant to leaf blight and downy mildew. This hybrid has widely adaptability. |
| Deccan-103 | | Drought resistant variety. |
| Himalayan | Bold, white, dent | A medium maturing widely hybrid. It has a high starch recovery and is preferred by the starch industry. It this very popular in Bihar and Uttar Pradesh, particularly during the Rabi. |
| Hi-Starch 123 | Bold, yellow, semi-flint | A medium maturing hybrid (105-115 days) recommended for high elevations up to 2000m. This hybrids is very popular for cultivation, at high elevations. Excellent husk cover. Highly resistant of downy mildew, leaf blight and rust. It is susceptible to stalk rots under water logged conditions. |
| Ganga-4 | Bold, white, flint | A full seasoned hybrid recommended for the white maize growing in the regions in the states of Madhya Pradesh, Bihar and Uttar Pradesh particularly in the Tarai tracts. More resistant to downy mildew and rust. It has been favored for Rabi cultivation in Bihar. |

| | | |
|---|---|---|
| Ganga-11 | | Resistant to downy mildew and blight diseases. |
| **NAME OF THE COMPOSITE** | **GRAIN TYPE** | **SALIENT FEATURES** |
| Vijay | Medium, yellow, flint to semi-flint | Medium maturing composite (100-110 days) which has shown wide adaptability to the Indian Sub-continent. Posses considerable resistance to foliar diseases |
| Kissan | Medium, yellow, semi-flint | Medium maturing composite (105-110 days) marked by resistant downy mildew and leaf blight. Well developed husk cover. It has shown superiority in the Tarai belt of Uttar Pradesh and in north Eastern Himalayan region. |
| Vikram | Medium, yellow, orange flint | Early maturing composites (90-95 days) recommended for the northern plains; shows considerable tolerance to drought and downy mildew. |
| Sona | Medium, orange, shiny flint | Medium maturing composite (100-110 days) recommended for northern plains, considerable resistance to foliar disease. |
| Jawahar | Medium, yellow, semi flint with caps | Recommended for northern plains and peninsular India matures in 100-110 days. Resistant to downy mildew and leaf blight. High resistant to stem border. |
| Amber | Yellow, bold, semi flint | A medium maturing composite (105-110 days) recommended for Peninsular India and the Himalayan belt up to an elevation of 1,700m. Resistant to leaf blight and downy mildew. |
| Mahi<br>Kanchan<br>Mahi Dhawal | Yellow, bold corn | Both are developed from Banswara, Rajasthan. Both are suitable for rabbi season. Both are resistance for downy mildew, blight and stem borer. |
| Bassi Selected | | Suitable for Rajasthan. |
| Tarun | | |
| Naveen | | |
| Navjot | | |
| Partap | | |
| Saweta | | |
| Kiran | | It is suitable for rain fed area. |
| Ageti-76 and D-765 | | Both are suitable for drought area. |

| Nutritionally superior opaque-2 composites (very superior in protein quality) | | |
|---|---|---|
| Shakti | Yellow to light yellow semi flint, with soft dull grains | A medium maturing Opaque-2 composite, recommended for cultivation in the states. |
| Rattan | Yellow to light yellow semi flint, with soft dull grains | A medium maturing Opaque-2 composite recommended for cultivation in the states of Punjab and Rajasthan. |
| Protina | Yellow to light yellow semi flint, with soft dull grains | A medium maturing Opaque-2 composite recommended for cultivation in Karnataka and the Tarai belt of Uttar Pradesh. |

**Rabi Season Varieties:-** Ganga-II, Deccan – 103, Deccan – 105, Trisholta, High starch (Hybrid Varieties) and Mangiri (Composite varieties).

**Zaid season varieties:-** Tarun, Naveen, Shweta, Navjat, Kanchan, D- 765, Azad Uttam, Kiran (J-660) and Hybrid No-9 (For green corn).

**Forage Maize:-** African Tall, J 1006

**Popcorn:-** Amber Popcorn, Pearl Popcorn

**Sweet Corn:-** Madhuri

**Very early maturity Varieties:-** Eg: Diana, Diana-3 and D-765.

**Seed Rate:-**

- **Hybrid varieties:-** 20-25kg/ha.
- **Composite varieties:-** 18-20kg/ha.
- **For Fodder:-** 40-50kg/ha.
- **By Dibbler:-** 4kg/ha.

**Seed treatment:-** Use pelleted seeds with insecticides (treat one kg of seeds with Chlorpyriphos 20EC or Monocrotophos 36 WSC or Phosalone 35 EC @ 4 ml + 0.5 gram gum in 20 ml of water) for the control of stem borer or seed treatment with Imidacloprid 70 WSC 10 g/kg of seeds.

Seed treatment with Metalaxyl or Thiram @ 2 g/kg of seed for the control of downy mildew and crazy top.

Seeds treated with fungicides may be treated with three packets (600 g/ha) of *Azospirillum* before sowing.

**Spacing:-** 60x25cm.

**Seed depth:-** 3-5cm

**Plant population:-** 66-70 thousand per hector.

**Manure and fertilizer: -**

- FYM: - 10-15t/ha.
- N: - 120kg/ha
- P2O5: - 60kg/ha
- K2O: -40kg/ha

**Water management:-** Maize crop is sensitive to both moisture stress and excessive moisture, hence regulate irrigation according to the requirement. Ensure optimum moisture availability during the most critical phase (45 to 65 days after sowing); otherwise yield will be reduced by a considerable extent. Regulate irrigation according to the following growth phase of the crop. Critical stages are, $6^{th}$ leaf, late knee high, tasselling, 50% silking and dough stages. Of which, tasseling and silking are most criticalstages and water stress during these stages reduces the maize yields considerably. About 500-800 mm water is needed.

**Weed control:-** It requires at least 2 hand weeding in maize crop, one is on 20 to 25 days and another is on 40 to 45 days after sowing. Should apply fertilizer as top dressing & do the earthling up operation after weeding is completed. Spray Atrazin 500 grams mixed in 1000 liters of water and life irrigation on 3rd or 4th day controls the weeds in maize field.

**Harvesting of Maize:-** Harvesting should be done when the crop outer cover of the cob turns from green to white colour. Harvesting can be done by hand. Machines are available to separate the seeds.

- Early varieties are harvest 70-80 days after sowing.
- Mid seasion varieties are harvest 80-90 days after sowing.
- Late varieties are harvest 90-120 days after sowing.

**Yield:-**

- Hybrid maize:- 40-60qt/ha
- Composite:- 30-40qt/ha
- Corn should be storage after drying in sun light for 3-4 days at 8-10% moisture.

**Insect Pests:**

1) Stem borer

2) Red Hairy Caterpillars

3) Aphids

4) Grass hoppers

**Diseases**

1. **Downy mildew:-** It is caused by *Peronosclerospora sorghi* and popularly known as sorghum downy mildew. Downy mildew appearing in the Rajasthan state is caused by a variant of *P. sorghi* and designated as Rajasthan downy mildew. Both forms of this diseases cause heavy yield loss. Seed treatment with Metalaxyl W.P. @ 4g/kg of seeds and foliar

spray of Mancozeb 2.5 g/l or Metalaxyl MZ at 2g/l provides excellent control over the disease.

2. **Turcicum leaf blight:** This is one of the most important diseases in Northern and North-eastern hills and peninsular India and is caused by *Exserohilum turcicum*. If not controlled at proper time, it has the potential to cause yield reduction up to 70%. Two to four applications of Maneb or Zineb @ 2.5-4.0 gm/litre of water at 7-10 days interval provide good control of the disease.
3. **Maydis leaf blight:** It is caused by Bipolaris maydis and generally appears in warm tropical and sub-tropical areas to wet temperate climate. It has the potential to cause as high as 70% yield loss. Application of 2-4 sprays of Diathane M-45 or Zineb @ 2.0-2.5 gm/litre of water at 7-10 days interval from the first appearance of disease controls the spread of pathogen.

**Rapeseed-Mustard**

**Scientific Name :***Brassica sp.*

**Family :** Cruciferae

**Brassicas grown in India**

| Taxonomic name | Common name | Hindi | Oil Content | Chromosome No. |
|---|---|---|---|---|
| *B. Campestris* | Turnip rape | Brown sarson | Kali sarson | 20 |
| *B. Campestris* var. *brown sarson* | Brown sarson | Kali sarson | 43% | 20 |
| *B. Campestris* var. *yellow sarson* | Yellow sarson | Peeli sarson | 45% | 20 |
| *B. Campestris* var. *toria* | Indian rape | Toria | 35% | 20 |
| *B. napus* | Swede, summer, winter rape | Gobhi sarson | 35% | 38 |
| *B. juncea* | Indian mustard, Mustard | Rai, Raya Laha | 35% | 36 |
| *B. juncea var. rugosa* | Hilly Mustard | | 36-38% | 36 |
| *B. toumefortii* | Wild mustard | Jungli rai | 18% | |
| *B. carinata* | | Ethiopian mustard, Karan rai | | 34 |
| *B. nigra* | | Black mustard, Banarsi rai | 29% | 16 |

| | | | | |
|---|---|---|---|---|
| *B.Oleratea* | | | | 18 |
| *Eruca sativa* | | Rocket, Taramira | 35% | 22 |
| *B.alba* | White mustard | Safed sarson | 27% | 22 |
| *Brassica hirta* | | | 27% | 22 |

| **Rapeseed vs. Mustard** | | |
|---|---|---|
| **Character** | **Rapeseed (Sarson/Toria/Lahi)** | **Mustard (Rai, Raya, Laha)** |
| Plant height (cm) | 45 – 150 | 90-200 |
| Leaves | Sessile, leaf lamina claps the stalk | Leaves stalked but do not clasp |
| Siliquae (pod) | Short or thicker | Long & slender |
| Pollination | Cross pollinated | Self pollinated |
| Seed coat | Smooth | Rough |
| **Brown sarson vs. Yellow sarson** | | |
| **Character** | **Brown sarson** | **Yellow sarson** |
| Leaves | Pale, thin | Dark green and fleshy |
| Branching | Erect, spreading | Erect |
| Siliquae (pod) | Thin, narrow | Thick and broad |
| Seed coat | Dark brown to reddish brown & Mucilaginous | Yellow & non mucilaginous |

**Origin**

- Rai – China
- Toria – East Afghanistan
- Brown sarson – E. Afghanistan & adjoining Indian sub-continent
- Yellow sarson – N.E. India

**Introduction**

- India is second largest producer of mustered after Canada in Word.
- India contribute maximum area of mustered in word.
- Rajasthan rank first in area and production of mustered in India.
- Eye irritation is due to isothiocyanate present in mustard oil.
- Pungent aroma in mustard oil is due to sinigrin alkaloids, it is poisonous compound.
- Yellow colour of mustered oil is due to carotenoids.
- Bitterness in mustard oil is due to glucosinolates.
- Erucic acid is found in mustard oil, it is beneficial for heart patient.

- Dropsy diseases is due to mixing of *Argemone mexicana* seed with mustard seed during oil extraction.
- *Argemone mexicana is* known as objectionable weed for mustard.
- Inflorescences type:- Catkin.
- Fruit type:- Silique.

**Climate**

- A crop of cool climate.
- It is cultivated in sub-tropics.
- Rabi season crop in India,
- Sep-Oct to Mar-Apr
- Temperature range 3 to 40°C
- Optimum 18-25°C with cool, dry clear weather
- High RF, high humidity, cloudy atmosphere at flowering undesirable
- Most susceptible to frost.

**Soil**

- Varying soil from sandy loam to clay.
- Thrives well in light soil
- Mustard on any soil but rapeseed in light
- Well drained soil is more suitable
- Waterlogging should not be
- Saline alkaline soils are unsuitable
- pH 6.5 to 7.5, neutral soil is ideal

**Improved Varieties**

**Toria Varieties**

| Variety | Duration (days) | Types of Cultivation | Yield (qt/ha) | Characters |
|---|---|---|---|---|
| T- 36 (Yellow) | 97-100 | Irrigated | 12-15 | Medium tall, yellow seed oil 44% |
| ITSA | 100-110 | Irrigated | 8-10 | Tall Profuse Branching Oil 44% |
| Sangam | 100-110 | Irrigated | 12-15 | High Oil contain 41% |
| TL 15 | 89-90 | Irrigated | 10 | Oil 44% |
| Bhavani | 80-85 | Irrigated | 12-13.5 | Oil 43% |
| T -36 | 95-100 | Irrigated | 10-12 | Oil 43% |
| PT 303 | 90-95 | Irrigated | 15-18 | Oil 42-44% |
| PT 30 | 90-95 | Irrigated | 14-16 | Oil 43.2% |
| Gaurani (B54) | 85-90 | Irrigated | 12-15 | Oil 42.4% |
| 18-2-9 | 85-90 | UnIrrigated | 12-15 | Dwarf Oil 44% |

| | | | | |
|---|---|---|---|---|
| PT 507 | | | | |
| D. K 1 | 80-85 | Unirrigated / irrigated | 9-10 | Early Variety Oil 44% |
| T 9 (Black) | 90-95 | Irrigated / Unirrigated | 12-15 | Dwarf Oil 44% |

**Yellow Mustard Varieties:-** Benoy (B-9), Type-42, M-3, K-88, T-151, K-88, 66-197-3, P.S-66

**Brown Mustard:-** Pusa Kalyani, Sufla, BSH-1, BS-70, KNS 3, KOS 1

**Rai Varieties/Indian Mustard**

| **Variety** | **Duration (days)** | **Types of Cultivation** | **Yield (qt/ha)** | **Characters** |
|---|---|---|---|---|
| T-59 (Varuna) | 125-130 | Irrigated | 20-25 | Bold Seed, Aphid resistant, Sensitive to rust, Oil 39.8% |
| Pusa Jai Kisan (Bio-902) | 115-125 | Irrigated | 25 | It has been developed through tissue culture technique, called somaclonal variation. A popular commercially released variety, Varuna (Type 59) was used as a donor parent for generating somaclonal variation. It is resistant to pod shattering. It is developed by Pro. V.L. Chopada in 1958. |
| RH-30 | | | | Late Variety |
| Vasundarra (RH-9302) | | | | It is resistant to pod shattering and logging. |
| NRCHB-506 | | | | It is first hybrid of mustard in word developed by DRMR, Bharatpur, Rajasthan. |
| NRCHB- 101 | | | | It is also hybrid varieties. |
| Kranti (PR-15) | 125-130 | Un Irrigated / Irrigated | 22-28 | Tolerant to frost, Powdery mildew & white rust resistant and Oil 40% |
| Krishna | 128-132 | Un Irrigated / Irrigated | 22-28 | Bold Seed, Frost Resistent |
| Rohini (KRB24) | 130-135 | Un Irrigated / | 22-28 | Bold Seed, Pest & Disease Resistent |

| | | | | |
|---|---|---|---|---|
| | | Irrigated | | |
| Vardan (Rk1468) | 125-130 | Irrigated | 22-28 | Suitable for Late & Mixed Crop |
| Narender Rai (8501) | 125 | Irrigated | 25-30 | Suitable for Alkaline & Saline soils |
| Vaibhav (PK1481) | 125-130 | Un Irrigated | 15-20 | White rust resistents |
| Durgamani | 135-140 | Irrigated | 10-12 | Insect Resistent |
| RLM 198 | 152-166 | Irrigatd | 10-12 | Excessive Minerals & aphids resistent |
| | 145-150 | Irrigated | 13-18 | |
| Pusa Bold | 135-140 | Irrigated | 18-26 | Bold Seed Pods, free shatter |
| Shekhar | 120-125 | Unirrigated / irrigated | 16-18 | Medium Size plant bold seed oil 40% |

**Other Varieties:-** Laha 101, RLM 514, Patan, Baagirathi, RW, Prakash, Seeta (B85), Laxmi (RH-8812), Arawali (RM-393), Krishna, Rajat, Sorabh, Aashirvad, Swarn Jyoti.

**Seed rate**

- Irrigated area:- 2.5kg/ha
- Rain fed area:- 4-6kg/ha.
- Mix Cropping:- 2-3kg/ha.
- Test weight:- 3-5 g depending upon crop and variety.

**Spacing:-** 30 x 10 to 30 x 15cm

**Plant population:-** 222000 to 333000/ha

**Depth of sowing**:- 3-4cm

**Sowing time:-** Mid-Sep to Oct end

**Manure and fertilizer for Irrigated area: -**

- FYM: - 10-15t/ha.
- N: - 80kg/ha
- P2O5: - 60-80kg/ha
- K2O: -40-50kg/ha

**Manure and fertilizer for Irrigated area: -**

- FYM: - 8-10/ha.
- N: - 40 kg/ha
- P2O5: - 30 kg/ha

- K2O: -20 kg/ha

**Irrigation**

- Total water requirement - 400mm
- Moisture at pre-flowering and pod filling stage is critical
- Two irrigations for mustard;One at rosette stage (20-30 DAS), Another at siliqua atage (50-60 DAS.
- In light soils three irrigations, the third at 90 DAS
- IW/CPE ratio of 0.6 is optimum

**Weed management**

- Dominant weeds:- *Chenpodium album, C. murale, Convolvulus arvensis,Melitotus alba*
- Intercultural operation 5-10days after 1st irrigation
- Hand hoeing is desirable, it aerates the soil
- Soil aeration is to conserve soil moisture
- Herbicides can also be used; Pendimethalin pre-emergence 0.5-1.5 kg/ha based on soil orFluchloralin 1.25kg pre-plant incorporation
- Post emergence Isoproturan 0.75 kg /ha for

**Harvesting maturity**

- Color of leaves, stem and silique turn green to pale yellow o Lower silique looks – dried appearance.
- Upper may be green.
- Seeds in the silique makes rattling sound.
- Silique with 2 carpels and a false septum.
- During over maturity the two carpels split and seeds shed.
- Premature harvest leads to shriveled grains.

**Yield:-**

| | |
|---|---|
| Irrigated rapeseed | 1.5 to 2.0 t |
| Rainfed rapeseed | 1.0 to 1.5t |
| Irrigated mustard | 2.0 to 2.5 t |
| Rainfed mustard | 1.5 to 2.0t |

**Cropping systems:-** Fallow / millets / pulses – mustard o Rice – rapeseed

**Intercropping**

- Mustard + chickpea
- Mustard + sugarcane
- Mustard + barley / wheat / chickpea
- Potato + mustard

**Diseases**

- **Alternaria Blight:-** The disease is caused by a fungus, *Alternaria brassicae*.
- **Downy Mildew:-** This disease is caused by a fungus, *Peronospora brassicae*.
- **White Blister/Rust:-** This disease is caused by the fungus, *Albugo candida*.

- **Club root:-** Clubroot is caused by the soilborne fungus *Plasmodiophora brassicae*.

**Insects Pests**

- Mustard Sawfly
- Mustard Aphid
- Cabbage Butterfly

## Sunflowers

**Botanical Name:-** *Helianthus annuus*
**Family: -** Asteraceae or Compositae.
**Origin:-**Mexico.
**Chromosome No.:-** 34
**Inflorescence: -**Capitulum
**Type of fruit:-** Achene
**Leading states in India:-** Karnataka.
**Percentage of protein:-** 40%.
**Oil content:-** 45-50%

- Sunflower is one of the most important oil seed crop grown in temperate countries. It is a major source of vegetable oil in the world.
- In India it has gained popularity due to the national priority of vegetable oil production.
- Russia is large producer of sunflower in word.
- Sun flower is $C_3$ and Day Neutral Plant.
- Red gram is cross-pollinated crops.
- Protandry found in Sunflower.
- Test weight of red gram is 60-62gm.
- Sunflower is a indicator plant of irrigation.
- Sunflower has allelopathic on other crops seed germination.
- Linoleic acid found in sunflower oil that are beneficial for heart patient.
- Sunflower seed was the third largest source of vegetable oil worldwide, following soybean and palm.

**Climate:-** The crop requires a cool climate during germination and seedling growth. Seedlings tolerate frosts moderately well until they reach the four to six leaf stage of development. It requires warm weather from the seedling stage up to flowering stage and warm and sunny days during flowering to maturity. 20-25ºC is suitable for luxuriance growth. High humidity accompanied with cloudy weather and rainfall at the time of flowering results in poor seed set.

The amount of linoleic acid decreases with high temperatures at maturity. Sunflower is a photo-insensitive crop, therefore, it can be grown successfully in any season viz., Kharif, Rabi and spring throughout India. It takes about 80-90 days in Kharif, 105-130 days in Rabi and 100-110 days in spring season.

**Soil:-** Sunflower can be grown on a wide range of soils and tolerates a moderate pH range and some salinity. It thrives best on deep loam soils with good drainage and irrigation facilities. The optimum range of soil pH for this crop is 6.5 to 8.5. It performs better than groundnut in heavy black cotton soils of Karnataka and Tamil Nadu.

**Varieties:-**

| Varieties | Details |
|---|---|
| BSH 1(Bangalore sunflower hybrid no.1) | It is a first commercial hybrid of sunflower and it has been produced in Karnataka in 1980. Plant: 155-160 cm in height. Matures in 85-90 days. It is suitable for cultivation in whole of India. |
| NSFH - 110 | It matures in 80-85 days. Plant: 135-150 cm in height with head of 17-19cm. Oil content: 43.5 percent. Yield: 2400-2700 Kg. Per hectare. |
| NSFH - 111 | It matures in 90-95 days. Plant: 180-200 cm in height with head of 18-20 cm. Oil content: 42-43 percent. Yield: 2800-3000 Kg. Per hectare. |
| NSFH - 592 | It matures in 85-90 days. Plant: 160-170 cm in height with head size of 18-24 cm. Oil content: 40-42 percent.Yield: 2500 -3000 kg per hectare. |
| APSH – 11 | Recommended variety for Andhra Pradesh. Resistant to rust. Yield: 1500 - 2000 kg per ha. |
| LDMRSH - 1 | Recommended variety for Maharashtra. Resistant to downy mildew. |
| LDMRSH - 3 | Recommended variety for Maharashtra. Resistant to downy mildew. Yield: 1595 Kg. Per hectare. |
| KBSH – 1 | Recommended variety for all India. High yield and high oil content with wide adaptability. |
| PSHF – 67 | Recommended variety for Punjab. |
| MSHF – 1 | Matures in 95 days. Plant height: 170-180 cms. Oil content: 40 percent. Yield: 2800 - 3000 Kg. Per hectare. Size of flower: 15-20 cm. Weight of 100 grains: 4-5 gms. |
| MSHF – 6 | Matures in 85 days. Plant height: 160-170 cms. Size of flower: 15-20 cms.Weight of 100 grains: 4-5 gms. Oil content: 40-45 percent. Yield: 2700-2900 kg. Per hectare. |
| MSFH – 8 | Matures in 92-94 days. Plant height: 190-200 cms. Size of flower: 18-22 cm. Weight of 100 grains: 4-5 gms. Oil content: 42-44 percent. Yield: 3200-3300 kg. Per hectare. |
| MSHF – 17 | Matures in 85-88 days. Plant height: 200-210 cms. Size of flower. 18-22 cms. Weight of 100 grains: 6-8 gms, Oil content: 40-41 percent, Yield: 2800-3000 kg. Per hectare. |
| MSFH – 30 | Matures in 88-90 days. Plant Height: 180-200cms. Size of flower: 15-20 cms. Weight of 100 grains: 4-5 gms. Oil content: 42-44 cms.Yield: 2800-3000 Kg. Per hectare. |
| MSFG-31 | Matures in 88-90 days. Plant height: 190-200 cms. Size of flower: 18-20 cms. Weight of 100 grains: 4-5 gms. Oil content: 42-44 percent. Yield: 2500-2800 kg. Per hectare. |

**Often-cross pollinated crop:-** Surya, Modern, BSH-1

**Powdery mildew resistant varieties:-** MSFH-8

**Other Varieties:-** Sunrise Varun, Morden Dwarf, Ramson Record, Kota improved.

**Seed Rate:-**

- Hybrid Varieties:- 7-8kg/ha
- Local Varieties:- 10-15kg/ha

| Season | Sowing Time | Planting Distance |
|---|---|---|
| Rabbi | Mid Oct-Mid Nov | 45x20cm |
| Kharif | June-July | 60x20cm |
| Zaid | January-March | 45x20cm |

- It is mostly grown in rabbi season.

**Plant Population:-** 60000-65000 plants

**Manure and fertilizer: -**

- FYM: - 10-15t / ha.
- N: -60-80kg / ha
- P2O5: -40kg / ha
- K2O:- 40kg/ha

**Weed Control:-** In sunflower farming, Inter cultural operations are essential to minimize the competition of sunflower plant with the weeds. Weed-free conditions up to 60 days after sowing results in better yield performance. When the plant attains a knee high stage earthing should be done along the rows. This provides safe-guard against lodging which is likely to occur at heading stage if winds of high velocity blow. Use of Sirmate at the rate of 4 kg per hectare applied as pre-emergence has been found effective in controlling weeds in sunflower crop. If Sirmate is not available use Basalin at the rate of 1 kg a.i. per hectare dissolved in 800-1000 litres of water as pre-planting spray.

**Water management:–** In sunflower farming, normally no irrigation is needed for kharif crop. However, one irrigation may be given in case of uneven distribution of rainfall. Rabi crop may be irrigated thrice after 40, 75 and 110 days of sowing. Sunflower crop is highly sensitive to water stress between flowering and grain filling stages. Therefore, one irrigation may be provided in case of moisture deficiency during this stage. Irrigation requirement of crop during summer is relatively higher. Irrigation at grain-filling stage should be light and given on calm and windless evening to avoid lodging. Among the various stages, bud initiation, flowering period and seed development stages are critical stages in terms of irrigation.

**Harvesting:-** The sunflower crop is ready for harvest when moisture in seed is 20 per cent. Phenotypic ally the heads are ripe when back of the head turns yellowish-brown. All heads may not be ready for harvesting at one time. Harvesting may, therefore, by done in two or three instalments to avoid shattering. The harvested heads should be dried well in sun and then only threshes by beating the centre of the head with a small stick. The commercial crop may be threshed with available threshers by reducing their speed. Further, sun-drying of the seed is desirable before storage or oil. Storage should be at 9-10% moisture content.

**Yield:-** 3-10qt/ha.

**Diseases**

- **Rust** (fungus - *Puccinia helianthi*)
- **Powdery Mildew** (fungus - *Erysiphe cichoracearum*)
- **Downy Mildew** (fungus - *Plasmopara halstedii*)
- **Mosaic** (virus)
- **Charcoal Rot** (fungus - *Macrophomina phaseolina*)
- **Southern Blight** (fungus - *Sclerotium rolfsii*)
- **Sclerotinia Wilt** (fungus - *Sclerotinia sclerotiorum*)
- **Rhizopus Head Rot** (fungi - *Rhizopus* spp)

**Insect:-**

- Sunflower Beetles
- Cutworms
- Sunflower Borers
- Sunflower Moths
- Grasshoppers

## Soyabean

**Botanical Name:-** *Glycine max*

**Family: -**Leguminosae.

**Origin:-**China.

**Chromosome No.:-** 40

**Inflorescence: -**Racemes

**Type of fruit:-** Pod

**Leading states in India:-** MP.

**Percentage of protein:-** 40-45%.

**Oil content:-** 20%

- Soybean is cultivating in United state is major part, In their 30 to 35% production in all over the world. It is also known as "GOLD of AMERICA"
- Argentina is also main production country; it is 16 to 20% production in all over the world.
- India is also a main cultivation and production country in all over the world. In India soybean is 3 to 5% production in all over the world.
- In India is cultivated in Madhya Pradesh (M. P.), Himachal Pradesh (H.P.), Utter Pradesh (U.P.), Punjab and Delhi.
- Madhya Pradesh is leading state in soybean production. MP is known as fort of soybean.
- Soybean is known as the "GOLDEN BEAN", "WONADER CROP", "POOR MAN MEAT" and "VEGETABLE MEAT".
- Soybean is a $C_3$ and Short Day Plant.
- Soybean is major oil seed crop (first in edible oil conception among other edible oil) in word. It is contribute 50% oil production of total edible oil production of word.
- Soy milk is prepared by soybean, it is rich source of protein.
- Soybean is a pulses and oilseed crop but mostly grown for oil purpose.
- Black colour of soybean is due to anthocyanin.
- Linoleic acid found is soybean that are good for heart patient.
- It has low concentration of carbohydrates so it is good for sugar patient.
- Soybean oil also use in vegetative ghee making.
- Soybean contains essential heart friendly omega-3 fats.

**Climate-** Soybean needs about 15 to 320C temperature for germination but for growth 25-30$^{o}$C temperature is good. The crop requires about 60-65 cm annual rainfall drought at flowering or just before flowering results in flower and pod drops, while rains during maturity impairs the grain quality of soybean.

**Soil:-**Soybean requires well drained and fertile loamy soils with a pH range between 6.0 and 7.5 are most favorable for its cultivation. Saline soils and sodic inhibit germination of Soybean seeds. Water logging damages the crop, so it is mandatory to have good soil drainage in rainy season.

**Verities:-**VL Soya 21, Ahilya 2 (NRC 12), MACS 124, JS 75-46, Pusa 16, JS 80-21, Ahilya 1 (NRC 2), Ahilya 3 (NRC 7), Pant Soybean 1029, Pusa 9712, TAMS 38, Phule Kalyani, Phule Kalyani, VL Soya 47, Ahilya 4 (NRC 37), PK 1092, Pratishta (MAUS 61-2), JS 71-05, JS 93-05, MACS 450, Indira Soya 9, Hara Soya, Parbhani Sona (MAUS 47), Samrudhi (MAUS 71), Pusa 9814, Pratap Soya 2, TAMS 38.
**Introduce from USA:-** Bragg, Clark-63, Black Hart, Scott Lee (it is good for hilly area), Clark-69.
**Indian other Varieties:-** Ankur, Alankar, Gorav, T-49, Punjab-1.
**Silajeet:-** It is resistant to Yellow Vine Mosaic various.

| | Rainy Season Crops | Summer season Crops |
|---|---|---|
| **Seed Rate** | 70-80kg/ha | 100-120kg/ha |
| **Sowing Time** | 25 June-15July | Feb-March |
| **Planting Distance** | 45-60 x 15-20cm. | 30-45x15-20cm |

- Soybean is mainly rainy season crop.

**Manure and fertilizer: -**

- FYM: - 10-15t / ha.
- N: -20-30kg / ha
- P2O5: -60-80kg / ha
- K2O:- 40-60kg/ha

**Weed Control:-** Keep plot weed free upto 40 days by one or two hoeings, two weedings upto 40 days. Herbicides such as Toke 25, 1.5 to 2 Kg/ha pre-emergence before sowing controls the weeds.

**Irrigation:-**In case of Kharif crop irrigation is not needed and it is grown rainfed. However during summer the crop can be grown only under assured irrigation and it needs about 5-6 irrigations. The crop should be irrigated at the following critical growth stages to minimize water.

1. Sprouting stage

2. Flowering pod initiation and bean filling stages are important from yield point of view.

**Harvesting:-** Crop harvested at proper stage by usual method, threshing machine.Signs of maturity- Dropping of leaves, leaves turn yellow, moisture content of seed 15%.

Yield:-

**Irrigated:-** 25-30qt/ha.

**Rain fed:-** 10-15qt/ha.

**Insect Pest:-**

- Griddle Beetle.
- Bean Leaf Beetle.
- Brown Marmorated Stink Bug.
- Brown Stem Rot.

**Diseases:**

- Dry root rot - *Macrophomina phaseolina*
- Wilt - *Fusarium oxysporum f. sp. tracheiphilum*
- Leaf spot - *Cercospora sojana*
- Mosai - Soybean mosaic virus (SMV):- It is transmitted by Aphid.

## Ground Nut

**Botanical Name:-** *Arachis hypogaea L.*
**Family: -** Leguminous.
**Origin:-** Brazil.
**Chromosome No.:-** 2n=4x=40
**Inflorescence: -** Racemes
**Type of fruit:-** Pod/Lomentum.
**Leading states in India:-** Gujarat.
**Oil Percentage:-** 46%
**Percentage of protein:-** 25%.
**Carbohydrate content:-** 6.0- 24.09%

- The botanical name for groundnut, *Arachis hypogaea* Linn., is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground, referring to the formation of pods in the soil.
- Groundnut is known as "King of edible oil seed".
- It has the 13th most important food crop and 4th most important oilseed crop of the world.
- Groundnut seeds are a nutritional source of vitamin E, niacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium.
- Groundnut kernels are consumed directly as raw, roasted or boiled kernels or oil extracted from the kernel is used as culinary oil.
- It is also used as animal feed (oil pressings, seeds, green material and straw) and industrial raw material (oil cakes and fertilizer).
- Cultivated groundnut originates from South America.
- It is one of the most popular and universal crops cultivated in more than 100 countries in six continents.
- Major groundnut growing countries are India (26%), China (19%) and Nigeria (11%).
- Its cultivation is mostly confined to the tropical countries ranging from 40º N to 40º S.
- Major groundnut producing countries are: China (40.1%), India (16.4%), Nigeria (8.2%), U.S.A (5.9%) and Indonesia (4.1%).
- Among oilseeds crops in India, groundnut accounts for about 50% of area and 45% of oil production. It is major oilseed crop in India.
- In India, about 75% of the groundnut area lies in a low to moderate rainfall zone (parts of peninsular region and western and central regions) with a short period of distribution (90-120 days).

- Based on rainfall pattern, soil factors, diseases and pest situations, groundnut-growing area in India has been divided into five zones.
- In India, most of the groundnut production is concentrated in five states viz. Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra.
- These five states account for about 86% of the total area under peanut cultivation.
- The remaining peanut producing area is scattered in the states of Madhya Pradesh, Uttar Pradesh, Rajasthan, Punjab, and Orissa.
- Although the crop can be grown in all the seasons, it is grown mainly in rainy season (*Kharif;* June-September).
- The *kharif* season accounts for about 80% of the total groundnutproduction.
- In the Southern and Southeastern regions, groundnut is grown in rice fallows during post-rainy season (*Rabi; October to March).*
- If irrigation facilities are available, groundnut can be grown during January to May as a spring or summer crop.
- Monsoon variations cause major fluctuations in groundnut production in India.
- Groundnut is self-pollinated crop.
- Flowering in groundnut begins 20 to 30 days after emergence, depending on genotype and environment, especially temperature. After pollination, meristematic region grows at the base of the ovary and become a stalk like structure (gynophore) referred to as Peg. Which bend downward and forces the ovary into the soil. The peg carrying the ovary pushes itself into the soil. Hypogeal burying itself to ripen underground. Fruit is an indehiscent pod containing one to five seeds. Each seed consists of two cotyledons. Seed coat known as testa is papery and thin. Cotyledons contain oil and other food materials.

**Climate**

Groundnut is essentially a tropical plant. It requires a long and warm growing season. The most favourable climatic conditions for groundnuts are a well-distributed rainfall of at least 50 centimetres during growing season, abundance of sunshine and relatively warm temperature. It seems the plant will grow best when the mean temperature is 21°C to 26.5°C. Lower temperatures are not suitable for its proper development. During the ripening period, it requires about a month of warm, dry weather.

**Soil**

Groundnut is grown on a variety of soil types. However, the crop does best on sandy loam and loamy soil and in black soils with good drainage. Heavy and stiff clays are unsuitable for groundnut cultivation as the pod development is hampered in these soils. 6.5-7.5 pH good for cultivation.

**Varieties:-**

Classification based on growth habit

a) **Spreading:-** Branches are spreading, main shoot may erect or bent.

b) **Semi-spreading:**Main shoot always erect.

c) **Bunch:-**Branches makes acute angle with the erect main shoot.

**Bunch type:-** Junagadh-11, TMV-2, Pol-2, AK 12-24, Kopergaon-3, KG-61-240 (Jyoti), Malika, RG-131, ZN-24.
**Semi-spreading type:-** TMV-6, TMV-8, Kopergaon-1, C-501.
**Spreading type:-** Punjab-1, GAUG-10, Kadiri-711, TMV-1, TMV-3, S-230, Karad4-11, RS-1, M-13, Chandra, SB-11.

| Types of Varieties | Seed rate/ha | Spacing |
|---|---|---|
| **Spreading type & Semi-spreading type** | 60-80kg | 45x10cm |
| **Bunch type** | 80-100kg | 30x10cm |

**Manure and fertilizer: -**

- FYM: - 10-15t / ha.
- N: -20-40kg / ha
- $P_2O_5$: -50-90kg / ha
- $K_2O$:- 20-40kg/ha

**Irrigation**

The kharif crop is caught in a long spell of drought, especially at the pod-formation stage, supplemental irrigation is given. For the irrigated groundnut, the frequency of irrigation depends on the soil texture, and the interval between irrigation ranges from 8-12 days. The peg-formation stage is critical.

**Weed control**

For controlling weeds, and also to keep the soil in a friable condition, the crop should generally receive a hand-weeding and one or two hoeings, with bullock-drawn implements, the first about three weeks after sowing and the second and the third about a fortnight and a month later. No interculture would be done after the pegs (about 55days) have commenced going underground. Earthing up can be done in the case of bunch and semi-spreading types for facilitate the maximum penetration of the pegs into the soil. Weeds can also be controlled effectively with Lasso or Tok-E-25 weedicide at the rate of 5 litres in 500 litres of water per hectare as a pre-emergence soil spray within two days of sowing groundnut.

**Harvesting**

Groundnuts mature from 90-130 days depending on the varieties. Mature nuts should be firm and dry and brown on the outside. The inside of the pods should be grey and produce a rattling sound when shaken. To harvest, dig up nuts with great care to avoid them breaking off and remaining in the ground. Dry for 2-3 days, after which you can remove the nuts from the plants and dry them on mats for 7-10 days, to a moisture content of 10%. Shelling should be done by hand followed by sorting to remove the broken, dirty, damaged nuts which lower the quality and consequent selling price.

**Yield:-** 20-30qt/ha

**Shelling Percent:-** 70-75%

**Insect-Pest**

- Groundnut leaf miner (*Stomopteryx subscecivella*)
- Groundnut bud borer (*Anarsia ephippias*)
- Red Hairy caterpillars (*Amsacta albistriga*)
- Aphids (*Aphis craccivora*)
- Thrips (*Scirtothrips dorsalis, Thrips palmi*)

**Diseases**

1. **Tikka leaf spots**

- **Early leaf spot:** *Cercopora arachidicola*
- **Late leaf spot:** *Phaeoisariopsis personata* (Syn : *Cercospora personata*)

- Moderately resistant varieties like ALR 1.

***2.*** **Rust** - ***Puccinia arachidis***

- Moderately resistant varieties like ALR 1.

3. **Collar rot or seedling blight or crown rot** - *Aspergillus nigerand A. pulverulentum*
4. **Root rot** - *Macrophomina phaseolina*
5. **Rossette** - *Groundnut rosette assistor virus* (GRAV), *Groundnut rosette virus* and *Groundnut rosette satellites*
6. **Groundnut bud necrosis disease:-** *Groundnut bud necrosis virus* (GBNV- Tospo virus)
7. **Aflatoxins:-**Infection of groundnut seed by molds mainly *Aspergillus flavus* Link ex Fries and *Aspergillus parasiticus* Speare can result in the contamination of the seed with aflatoxins, which are toxic fungal metabolites (mycotoxins). Aflatoxin contamination of groundnut could occur before harvest while the crop is maturing in the field particularly favored by drought stress and high soil temperature, in storage and during marketing.

## Black Gram

**Botanical Name:-** *Vigna mungo*
**Family: -** Leguminous.
**Origin:-** India.
**Chromosome No.:-** 22
**Inflorescence: -** Racemes
**Type of fruit:-** Pod
**Leading states in India:-** Maharashtra (18.5%), Andhra Pradesh (16.23%).
**Percentage of protein:-** 24%.

- Black gram is popularly known as "Urad", is one of the most important pulses crop, grown across India.
- The Urad crop is resistant to adverse climatic conditions and improve the soil fertility by fixing atmospheric nitrogen in the soil.
- This crop is grown primarily for its protein rich seeds and used as daal and as main ingredient in breakfast snacks like dosa,idli, vada & papad.
- Urad is used as a fodder for animals.
- Apart from proteins in urad, the dominance of riboflavin, phosphorus, ascorbic acid and thiamine is found.

**Climate:-** Urad can be cultivated in a wide range climate. Specially it is hot and humid climate crop. 25-30$^{o}$C temperature is good for growth. It give good yield in 60-70cm annual rainfall area.
**Soil:-** Loam and clay loam soil are best suited for its cultivation.
**Varieties:-** Krishna, Naveen, Azad-1, Barkha (RBU-38), T-9, Pant-U-19, Pant-U-35, Pant-U-30, IPU-2000, BDU-1, TAU- 1, TAU-2, TAU-4.

| Season | Seed rate | Spacing | Sowing Time |
|---|---|---|---|
| Kharif | 12 to 15 kg / ha | 30 X 10 cm | Mid-February- Mid-March, |
| Zaid | 20 to 25 kg / ha | 20-25 X 10 cm | June-July |

**Seed treatment:-** Seed should be treated with thiram and Captan 75 WS @ 2.5 g / kg seed. It should be treated with rhizobium culture for atmospheric N fixation.
**Manure and Fertilizer**

- FYM:- 10-15t/ha.
- N:-20 kg/ha.

- $P_2O_5$:-40kg/ha
- $K_2O$:- 20Kg/ha
- Gypsum:- 125Kg/ha

**Irrigation management:-** Irrigation is not needed in rainy season, but in summer season irrigation should be given as per critical stages and availability of irrigation water. Number and frequency of irrigation depend upon the soil type and weather. The crop should get irrigation at an interval of 10-15 days. From flowering to pod development stage, there is need of sufficient moisture in the field.

**Weed management:-** One or two hand weeding should be done up to 40 days of sowing depending upon the weed intensity. Weeds can be controlled by the use of herbicides i.e. Fluchloralin (Basalin)
1kg a.i. / ha in 800-1000 litres of water as pre-planting application.

**Harvesting stage:** - Urad is ready for harvesting in 80-100 days.

**Yield:-** 6-10 qt/ha.

**Importand Diseases:-**

1.Powdery mildew (*Podosphaera fusca*)
2. Cercospora leaf spot (*Cercospora spp.*)
3. Yellow mosaic:- It is caused by virus, It is transmitted by white fly.

**Important Insect:-**

1. Cut worm
2. Leaf Hopper
3. White Fly

## Red Gram/Pigeon Pea

**Botanical Name:-** *Cajanus cajan*

- ***Cajanus Cajan* var *bicolor:-*** It is most popular in India.
- ***Cajanus cajan* var. *flavus:-*** It is most popular in south India and it is annual in nature.

**Family: -** Leguminous.

**Origin:-** Africa.

**Chromosome No.:-** 22

**Inflorescence: -** Racemes

**Type of fruit:-** Pod

**Leading states in India:-** UP.

**Percentage of protein:-** 21-26%.

- Red gram is second important pulses crop after green gram in India.
- Red gram is important pulses crop of Kharif season.
- India is large producer of red gram in word-wide.
- India is largest producer of red gram in word.
- Red gram is $C_3$ and Short Day Plant.
- Red gram is often cross-pollinated crops.
- Male sterility found in Red gram
- Test weight of red gram is 70gm.
- It is also known as Tour dal and Arhar.
- In regions where it grows, fresh young pods are eaten as a vegetable. The split dried seeds are used as a lentil, in dishes such as sambar (lentil soup).
- Pod shattering problem is not found in red gram.
- Red gram is use as guard crop.
- Red gram share 27% production of total pulses production.
- Harvesting Index of red gram is 19% (Minimum among all cros)

**Climate:-** Toor Dal ( Arhar) needs a moist and warm weather; 30 – 35 °C during germination and slightly lower temperature (20 -25°C) during active vegetative growth. During flowering and pod setting it requires 15-18°C temperature and at maturity it needs higher temperature of around 35 – 40°C. Water logging, heavy rains, frost are very harmful to the crop.

**Soil:-** This crop grows well on all types of soils but loam to sandy loam soil is suitable. This crop also does well in slopy lands in the mid-hills.It can be grown successfully on neutral soils having a pH range of 6.5 to 7.5.

**Varieties:**
**Extra-short-duration varieties of pigeonpea released in India:-** UPAS-120 (Shorter duration than other), Pant A3, Prabhat, ICPL 87 (Pragati), ICPL 151 (Jagriti).
**Short-duration varieties of pigeonpea ralaasad in India:-** Pusa Ageti, T21, HY2, Pusa 84, C01.
**Medium-duration varieties of pigeonpea developed in India:-** HY 1, HY 3A, HY 5, AS 71-37, BDN 1, S20.
**Late-duration varieties of pigaonpaa ralaaaad in India:-** C11, Bahar, Laxmi, Gwalior 3.
**Late Varieties:-** Bahar-1228, Pusa-9 and Basant, N-1234.
**Other Varieties:-** Pusa-33, November-141, Pusa-855 and Sharda.
**Seed rate:-** 12-15kg/ha for single and 6-8kg/ha for mix cropping
**Spacing:**-60-75 x 15-20 cm.
**Seed Depth:-** 5cm.
**Plant Population:-** 100000 plants.
**Sowing Time:-** June-July.
**Seed treatment:**

- Seed should be treated with thiram @ 1.5 to 2 g / kg seed or treatment with 3 g thiram/kg + 3 g carbendazim/kg seed.
- After that should be treated with rhizobium culture for atmospheric N fixation..

**Manure and fertilizer: -**

- FYM: - 10-15t / ha.
- N: -20-30kg / ha
- $P_2O_5$: -80-100kg / ha
- $K_2O$:- 40-50kg/ha
- ZnSo4:- 20-25kg/ha

**Irrigation management: -**Red Gram requires 350-400 mm water, during its entire growth period. Optimum moisture is necessary during (a) budding (b) flowering and (c) pod formation stages.

As red gram is a rainfed crop grown in assured rainfall areas, usually it does not require any irrigation. If there is water stress, protective irrigation may be given in alternate rows at these 3 stages.

**Weed Control: -** Pigeon pea grows very slowly during their early growth period of 45 – 50 days. This makes pigeon pea less competitive with weeds. If weeds are not controlled in time, it can cause up to 90% reductions in seed yield. Therefore it is advisable to keep the field free from weeds.

Weed free condition may be achieved by giving two hand weedings once about 25-30 days and another about 45-50 days after sowing the crop.

For chemical control pre emergence herbicides effective for pigeonpe a are pendimethalin (Stomp® a.i. 1.0-1.5 kg ha- 1) or metachlore (Dual® a.i. 1 kg ha-1)

**Maturity, harvesting & threshing: -** Pods and plant dried, grains become hard, and moisture percent in grain at harvesting should be 20-22 %. Pod shattering is common problem in pulse. Harvest the whole

plants with sickle when 80% of the pods mature. The pods or whole crop after complete drying should be threshed manually or by machine.

**Yield: -** 20-25qt/ha.

**Storage: -** Red gram should be storage at 10-12% moisture content.

**Insect-pest**

- **Gram pod borer:-** *Helicoverpa armigera*
- **Blue butterfly:-** *Lampides boeticus*
- **Grass blue butterfly:-** *Euchrysops cnejus*
- **Plume moth:-** *Exelastis atomosa*
- **Spotted pod borer**
- **Bean Aphids:-** *Aphis craccivora*
- **Whitefly:-** *Bemisia tabaci*

**Diseases:-**

1. **Fusarium Wilt:-***Fusarium udum*
2. **Sterility Mosaic Disease (SMD):-** It is viral diseases.
3. **Alternaria Leaf Spot:-** *Alternaria alternate*
4. **Powdery mildew:-** *Oidiopsis taurica*

## Pea

**Botanical Name:-** *Pisum sativum var. Hortense* (Garden Pea)
*Pisum sativum var. arvense* (Field Pea)
**Family: -** Leguminous.
**Origin:-** Ethiopia.
**Chromosome No.:-** 2n=14.
**Inflorescence: -** Racemes
**Type of fruit:-** Pod
**Leading states in India:-** UP.
**Percentage of protein:-** 7.2% (Green Pod) & 23-25% (Pulses).
**Introduction:-**

- Pea (*Pisum sativum* L.), the famous plant in which G.H. Mendel worked out Mendel Laws and Genetic Principles, is a noble and aristocratic vegetable.
- The crop is cultivated for its tender and immature pods for use as vegetable and mature dry pods for use as a pulse. In both cases, seeds are separated and used as vegetable or pulse. Peas are highly nutritive and contain high content of digestible protein (7.2 g / 100g at tender stage & 23-25% at dry stage), Carbohydrate (15.8 g), Vitamin-C (9 mg), phosphorus (139 mg) and minerals.
- Tender seeds are also used in soups.
- Canned, frozen and dehydrated peas are very common for use during off-season.
- Like any legume crop, pea is an integral component of sustainable agriculture due to its soil enriching and conditioning properties.

**Varieties**

Pea cultivars grown in different parts of the world exhibit wide variation in height of stem, branching, pod size, seeds per pod, shelling percentage, smoothness of seeds (smooth / wrinkled) etc.

**The cultivars / varieties are grouped based on various characters as given below:**

**Basal on maturity period**

- **Early types:-** green pods will be ready for harvest by 65 days after sowing.
- **Mid-season types:-** pods will be ready for harvest by 85-90 days after sowing.
- **Late main season types:-** Pods will be ready for harvest by 110 days after sowing

**Based on height of plant**

- Bush or dwarf types
- Medium tall
- Tall
- ✓ Usually dwarf types are early and mid-season types are medium tall. Late types are tall and require support.

| Developing institution | Variety | Special features |
|---|---|---|
| IIHR, Bangalore. | Arka Ajit | Resistant to powdery mildew and rust. Yield 10t/ha in 90 days. |
| | UN 53-6 | A snap pea where the whole pod is edible. Yield 8-9 t/ha in 90 days. |
| IARI, New Delhi. | Arkel | Early season variety introduced from England. Dwarf plants bearing double pods at lower nodes and single at upper nodes. Pods 8.8 cm long and sickle shaped. Suitable for fresh market and dehydration. Susceptible to collar rot at high temperature. Yield 7.5 t/ha in 50-55 days. |
| | Bonneville | Mid-season variety introduced from USA. Medium tall plants bearing double pods. Pods more than 9 cm long. Yield 8.5 t/ha. Seeds green and wrinkled. |
| | Sylvia | Introduced edible podded variety suitable for kitchen garden. Pods curved, yellowish green without parchment. |
| IARI, Regional Station, Katrain | Lincoln | Early season variety introduced from France. Medium tall plants bearing double pods of 8-9 cm length and sickle shaped. Mature seeds wrinkled. First picking 85-90 days after sowing (DAS). Yield 68-10 t/ha. |
| IIVAR, Varanasi. | VRP 2 | Plants 50 cm tall. Pods straight and medium sized. First harvest 55-58 DAS. Yield 10 t/ha. |
| | Kashi Nandini | Early maturing variety developed through pedigree selection. Plants erect and dwarf. Pods long. Tolerant to leaf miner and |

| | | |
|---|---|---|
| | (VRP 3) | pod borer. Yield 6.5 t/ha with 80 % shelling percentage. |
| | Kashi Shakthi<br>(VRP 7) | Mid-season variety. Plants 80 cm tall with attractive pods. Yield 7.5 t/ha. |
| Tamil Nadu Agricultural University. | Ooty 1 | A dwarf variety with a yield of 11.9 t/ha in 90 days. Resistant to white fly. |
| NDAU&T,<br>Faizabad, UP. | NDVP 8 | Mid-season variety with 10 t/ha. |
| | NDVP 10 | Mid-season variety with 10 t/ha. |
| Punjab Agricultural University, Ludhiana | Punjab 88 | Early season variety developed through selection from cross between Pusa 2 x Morrasis 55. Podsdark green, long (8-10 cm) and slightly curved.Days to first harvest – 100. Yield 15 t/ha with 47% shelling percentage. |
| | Matar Ageta 6 | Early season dwarf variety. Tolerant to high temperature. Yield 6 t/ha with 44.67% shelling percentage. Seeds smooth and green. |
| CSAUA&T,<br>Kanpur. | Azad P.2<br>(PRS4) | Resistant to powdery. Plants tall (130-150 cm). Straight and smooth pods. Yield 12 t/ha in 90-95 days. |
| | Azad P-3<br>(PRS 4) | Early maturing variety. Pods straight, medium size. Yield 8 t/ha. |
| JNKV, Jabalpur. | Jawahar Matar 1<br>(JM 1, GL 141) | Mid-season dwarf variety with big, attractive green, 8-9 cm long pods containing 8-10 sweet green ovules. |
| | Jawahar Matar 2 | Pods dark green, big, curved with 8-10 sweet ovules, wrinkle seeded, susceptible to powdery mildew. |
| | Jawahar Matar-3<br>(Early December) | Early season variety developed through selection from cross between T 19 x Early Badger. First picking in 50 DAS, Pods 7 cm long, light green and round oval /ovules. |
| | Jawahar Matar-4 (JM 4, GL195) | Mid-season variety derived from T 19 x Little Marvel. Plants 50-60 cm tall. Pods 7 cm long, green. Mature seeds green and wrinkled. |
| | Jawahar<br>Matar 15 | Resistant to powdery mildew and Fusarium wilt.<br>Plants dwarf. Yild 13 t/ha. |
| | Jawahar<br>Matar 54 | Powdery mildew resistant variety with big incurved pods enclosing 8-9 big wrinkled seeds. Yield 7 t/ha. |
| | Jawahar | Mid-season powdery mildew resistant variety developed through double cross (Arkel x JP 829) x (46 C x JP 501). |

| | | |
|---|---|---|
| | Peas 83 | Plants dwarf. Pods big and curved with 8 green and sweet ovules. Yield 12-13 t/ha. |
| | Harbhajan | Early variety resembling to field pea. Susceptible to powdery mildew. Av. Yield 3 t/ha. |
| GBPUA&T Pantnagar | PM 2 | Early variety developed through pedigree selection from cross between. Early Badger x Pant Uphar. Pods smaller than Arkel. Yield 10t/ha. |
| | Pant Uphar (IP3) | Medium maturity, ready for harvest by 70-80 DAS. Flowers white, Pods round. Seeds wrinkled, Susceptible to powdery mildew. Resistant to stem fly. Yield 10 t/ha. |
| | Pant Sabji Matar 3 | Early season variety with long curved pods with 8-9 ovules. Picking starts 60-75 DAS. Yield 9t/ha. |
| HAU, Hisar. | Hisar Harit (PH 1) | Developed through selection from cross between. Bonneville x P 23. Pods large, sickle shaped and single or double. Yield 9 t/ha. |
| VPKAS, Almora | VL Matar 3 | Plants determinate. White flowers, straight and double podded. Length – 6.8 cm. First picking is 100 DAS. Yield 10 t/ha. |
| | VL Agethi Matar 7 (VL 7) | Early season dwarf variety. First picking in 120- 125 DAS. Pods 8 cm long, light green, slightly curved. Seeds wrinkled. Yield 23-25 t/ha. With 42% shelling. |
| | VL 8 | Mid-season variety with 10 t/ha. |
| | Vivek (VL Matar 6) | Medium mature variety with straight, 6-7 cm long pods. Seeds semi wrinkled. Moderately tolerant to cold and moisture stress. Yield 11 t/ha. |

In addition to the above improved varieties, cultivars like Asauji, Alaska, Meteor, Early Badger etc. are also very popular among farmers.

**Climate:-** Pea is typically a cool season crop and thrives well in cool weather. Optimum temperature for seed germination is 22$^{o}$C. Even though seeds germinate at 5$^{o}$C, speed of germination is less. At higher temperature, decay of seedlings is more. Early stage of crop is tolerant to frost. But flowering and fruit development are adversely affected by frost. Optimum monthly mean temperature for growth of plants is 10-18.3$^{o}$C. As temperature increases the maturity is hastened and yield is reduced. Quality of pods produced is also low at high temperature due to conversion of sugars to hemicellulose and starch.

**Soil:-** Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 6.0-7.5 and it grows under alkaline soil. If soil is acidic, liming is recommended.

**Seed rate:-** Seeds are sown in flat or raised beds by broadcasting or by dibbling at 2.5-5.0 cm depth. Early varieties are sown at a closer spacing of 30 x 5-10 cm and the seed rates is 100-120 kg/ha. Mid-season and late varieties are sown at wider spacing of 45 x 10 cm. Late varieties are sown on either edge of raised beds which are 120-150 cm wide with furrows in between. Seed rate for late varieties is 80-90 kg/ha. Overnight soaking of seeds in water or $GA_3$ (10 ppm) improves germination.

**Sowing time:-** October to middle of November

**Manure and fertilizer: -**

- FYM: - 20-25t / ha.
- N: -20-30kg / ha
- $P_2O_5$: -60-80kg / ha
- $K_2O$:- 50-60kg/ha

**Irrigation:-** Pea, like any legume vegetable, is sensitive to drought and excessive irrigation. Excessive irrigation immediately after sowing results in poor germination due to hard crust formation. Excessive irrigation in earlier stags increases vegetative growth. Light irrigations t 10-15 days intervals is given for pea. Flowering, fruit set and grain filling periods are critical stages and care should be taken to irrigate crop at these stags. Four irrigations at pre-bloom, pod set and fruit picking stages are recommended for variety Bonneville under Bangalore conditions.

**Weed control:-** Care should be taken to remove weeds in early stags of crop. Lasso (alachlor) @ 0.75 kg a.i. or tribunal @ 1.5 kg a.i./ha or pendemethalin 0.5 kg a.i. / ha as pre emergence spray along with one hand weeding at 25-45 days after sowing is very effective for weed control.

**Harvesting:-** Since tender peas with high sugar content fetch premium price in market, care should be taken to harvest pods at correct maturity. During maturity, sugar content decreases and polysaccharides and insoluble nitrogen compounds like protein increases. Calcium migrates to seed coat and becomes tougher during ripening. Toughness of seeds is determined using Tendrometer, especially for processing purposes. Peas with low tendrometer reading is offered high price.

Many workers calculated heat units to ascertain maturity and harvesting of peas. Number of degree hours above 4.4$^{o}$C required to bring a variety to maturity is calculated and it varies from variety to variety.

Usually 3-4 harvests at 10 days intervals are possible.

**Yield:-**

- Early Varieties:- 2.5-4.0 t/ha.
- Mid varieties:- 6.0-7.5 t/ha.
- Late Varieties:- 8.0-10.0 t/ha.
- Shelling percentage ranges from 35-50%.
- Seed yield varies from 2.0 to 2.5 t/ha.

**Insect-Pest:-**

- Stem fly
- Pea aphid
- Leaf miner
- Pod borer

**Diseases**

- Pea wilt (*Fusarium oxysporum*)
- Downy mildew (*Peronospora viciae*)

- Leaf and pod spots (*Ascochyta pisi, Mycosphaerella pinodes and Phoma medicaginis*)
- Botrytis, or grey mould (*Botrytis cinerea*)
- Powdery mildew (*Erysiphe pisi*)
- Foot and root rots (*Fusarium solani*).

**Jute**

**Botanical Name:-** *Corchorus sp*

- **White Jute:-** *Corchorus capsularis*
- **Tossa Jute:-***Corchorus olitorius*

**Family: -** Tilaceae.

**Origin:-** Indo-Burma.

**Chromosome No.:-** 14.

**Inflorescence: -** Cymose

**Leading states in India:-** West Bengal.

- India is largest producer of jute in word.
- Highest production of jute in India is West Bengal.
- Jute is natural fiber known as "Golden fiber".
- Jute is the cheapest and most important of all textile fibers next to Cotton (*Gossypium sp*) and used extensively in the manufacture of different types of packing materials for various agricultural and industrial products.
- Jute is the bast fiber obtained from the secondary phloem of two species of the genus 'Corchorus'.
- Jute ranks second in importance next to Cotton (*Gossypium sp*) as natural fiber and occupies importance place.
- In Indian economy, Jute is the cheapest and most of all textile fiber next to Cotton (*Gossypium sp*).
- Jute is, however, our potential foreign exchange earner and must finds its place in our economy.
- Gunny bag, carpet, rope etc are the important products of Jute fiber. Stalks, stripped of fibers, are used as fuel and for making gun powder charcoal.
- The green leaves of *C. olitorius* L are used as vegetables.
- The leaves of *C. capsularis* L are tastes bitter, hence it is known "**Tita (Bitter) pat**", whereas *C. olitorius* L is "**Mitta (Sweet) pat**".
- The Jute fiber is extracted from phloem tissue (bast or bark fiber) in the stem of the both of *Capsularis* species of Jute.
- The fiber of *Olitorius* is finer, stronger and more lustrous than that.
- The fiber of *Capsularis* is whitish and of *Olitorius* is yellowish and accordingly they are called white jute and Tossa jute respectively.
- Juite is $C_3$ and Day Nutral Plant.
- Juite is self-pollinated crops.
- It is also known as Mesta.

**Climate:-** Jute crop grows well in rainfed, moderate, warm humid atmosphere and sunshine conditions. 25°C to 30°C is ideal for jute cultivation. Jute cultivation requires about 160 cm to 200 cm rainfall. Humid weather will result in good yield.

**Soil:-** River basins or alluvial or loamy soils are best for jute cultivation. Jute cultivation in red soils may require high dose of manure and pH range between 4.8 and 5.8 is best for its cultivation.

**Varieties:-**

**White jute:-** JRC-321, JRC-212, JRC-7447, JRC-4444, UPC-94, Padma, KTC-1, JRC-698, Bidhan Pat 1,Bidhan Pat 2, Bidhan Pat 3, JRC-80.

**Tossa Jute:-** JRO-632, JRO-878, JRO-7835, JRO-524, TJ-40, JRO-3690, KOM-62, JRO-66, JRO-8432, JRO-128, S-19 (Subala), Bidhan Rupali tossa, JRO-204 (Suren).

**JRO-204:-** It is recommended for sowing as early season crop.

**Seed Rate, Spacing, Sowing Method, Plant Population**

There are two ways of sowing methods in jute cultivation.1) Line Sowing method 2) Broadcasting method. Seed rate is given below.

| Jute type/Variety | Seed Rate (kg/ha. | | Spacing (cm) of plants. | No.Of Plants/Sq.Mt |
|---|---|---|---|---|
| | Line Sowing | Broad Casting | | |
| Olitorius | 5 | 7 | 25 x 5 | 85 |
| Capsularis | 7 | 10 | 30 x 5 | 70 |

**Sowing Time:-** Feb month of the year.

**Jute Crop Duration:-** 4 months to 5 months.

**Manure and fertilizer: -**

- FYM: - 8-10t / ha.
- N: -20kg / ha
- $P_2O_5$: -20kg / ha
- $K_2O$:- 20kg/ha

**Weed Control:-** Hand weeding has to be carried out twice in 3 weeks to 4 weeks after sowing and 5 weeks to 6 weeks after sowing. Herbicides like Fluchloralin should be sprayed 3 to 4 days after sowing the rate of 1.5 kg/ha and is followed by watering. One hand weeding can also be taken up 4 weeks to 5 weeks after sowing.

**Harvesting Time:-** The value of jute lies in its fibre. The quality and quantity of fibre are dependent upon the maturity of plants. Therefore selection of proper harvesting time is very important. Jute is harvested any time between 120 days to 150 days when the flowers have been shed, early harvesting gives good healthy fibres. The plant from 8 to 12 feet high are cut with stickles at or close the ground level. In flooded land, plants are up rooted. The harvested plants are left in field for 3 days for the leaves to shed.

**The fibre Extraction:-** The jute plant's fibres lie beneath the bark and surrounded the woody central part of the stem. To extract the fibres from the stem, the process is carried out in the following stages:

**Retting of Jute:** Retting is the process by which the fibre is removed from the stalk. Then the fibres are washed in clear water. Jute is a natural fibre. The plant is easy to cultivate and harvest. The fibre is obtained by retting. Retting is process in which the fibres in the bark are loosened and separated from the woody stalk due to the removed of pectins; gums etc. Tish is done by the combined action of water and microorganisms. During retting, disintegration of the tissues starts from the interior of the stem and extends of the outside, liberating the fibre boundless from the wood. The presence of periderm on the stem surface hampers retting and lowers the fiber quality. At lower temperature and running water retting process may take about one month.

**Cutting of Jute:** Cutting of jute is usually done by hand with 'dao'.The cut stemps are tied into bundles of about 9 to 142 inches in diameter. The bundles are then laid on the ground for a period to allow the stem to soften fall off. The bundles are then taken to aonvenient location of water. These are then arranged in layers in ponds.

**Stripping of jute fibre:** Stripping is the process of removing the fibres from the stalk after the completion of retting. To judge the right time for striping the fibres from the retted plants of the ponds or cannels where the plants have been kept for retting. When is found that fibres can be separated from the stem each stripping. Washing and drying of the fibres should be done as quickly as possible. There are two methods of stripping. They are,

**Stripping by hand:** The bundles of stems are removed from water, allowed to drain off and then each stem stripped separately. Fibres are made up into handful and then washed.

**Bunch stripping:** The worker stands in water. He takes some stems in his left hand and beats the roads of the steams cloth a wooden mallet. When the roots ends are sufficiently crushed, they are broken off. Loose fibres are then drawn to permit easy separation from the rest of the stems. The stripped of fibres are then washed.

**Washing and drying:** Extracted fibres are washed in clean water. The dark colour of fibres can be removed by dipping them in tamarind water for 15 to 20 min and again washed in clean water. After squeezing excess water the fibres are hang on bamboo railing for sun drying for 2-3 days. The fibre is graded into tops, middles, B, C and X-bottom. Packing into kutcha bales about 250 pounds for use in the home trade. They are transport to market or direct in jute mills.

**Bailing and Packing:-** After grading the jute they packed in bales about 250 pounds for use in the home trade. They are transported to jute market or direct to jute mills.

**Yield:-** With good farm management practices, green plant yield can be expected up to 40 to 50 tonnes/ha and fibre yield up to 2.0 to 2.75 tonnes/ha.

**Insect Pest:-**

- **Jute Mealybug**: *Phenacoccus hirsutus*
- **Jute Semi-looper:** *Anomis sabulifera*
- **Beet Armyworm:** *Spodoptera exigua*
- **Jute Stem-girdler:** *Nupserha bicolor*
- **Jute Stem Weevil:** *Apion corchori*

**Diseases**

- **Stem gall:-** *Physoderma corchori*
- **Soft rot:-** *Corticum rolfsii*
- **Stem rot :-** *Collecotrichum cochorum*
- **Leaf Sport Disease:** It is a bacterial disease caused by *Xanthomonas sp.*

**Sugarcane**

**Botanical Name: -***Saccharum officinarum*
**Family: -**Poacea.
**Origion:-**South and Southeast Asia.
**Types of Inflorescences:-** Panicle
**Type of fruits:-** Caryopsis
**Chromosome No:-** 2n=80
**Leading State: -** UP, Maharashtra
**Sugar content content: -** 21-22%.

- The subtribe is *Sacharae* and the genus, of course, *Saccharum*, derived from the Sanskrit "sarkara = white sugar", a reminder that the plant reached the Mediterranean region from India.
- Brazil has the highest area (5.343 million ha), while Australia has the highest productivity (85.1 tons/ha) and India rank second in area (4.608 million ha) and production (289.6million tons) in both.
- Sugarcane is a most important cash crop of India.
- It is estimated that about 50 million farmers and their dependents are engaged in the cultivation of sugarcane and about 0.5 million skilled and unskilled workers are engaged in sugar factories and its allied industries.
- Sugarcane is a renewable, natural agricultural resource because it provides sugar, besides biofuel, fibre, fertilizer and myriad of by products/co-products with ecological sustainability.
- Sugarcane juice is used for making white sugar, brown sugar (Khandsari), Jaggery (Gur) and ethanol. The main byproducts of sugar industry are bagasse and molasses.
- Molasses, the chief by-product, is the main raw material for alcohol and thus for alcohol-based industries. Excess bagasse is now being used as raw material in the paper industry. Besides, co-generation of power using bagasse as fuel is considered feasible in most sugar mills.
- Sugar cane is Mid Day Plant.
- Sugarcane is cross pollinated crop.
- Sucrose is measured in sugarcane by Refractometer.
- Broadly there are two distinct agro-climatic regions of sugarcane cultivation in India, viz., tropical and subtropical. Tropical region shared about 45% and 55% of the total sugarcane area and production in the country, respectively. Sub-tropical region accounted for about 55% and 45% of total area and production of sugarcane, respectively.

**Climate:-** It requires rainfall of 150 cm and temperatures between 20° to 26°C. For or snowfall damages the plant. Sugarcane requires about 25-32°C for good germination.
**Soil:-** Heavy soils with good drainage are preferred for sugarcane cultivation, though it grows well on medium & light-textured soils also with assured irrigation. Soils with 0.5- 0.6 % carbon content & pH 6.5 to 7.5 are most suitable for sugarcane growth. In northern India, it is cultivated largely on the loams & clay loams of Gangetic & other alluviums, and in peninsular India, it is grown on brown or reddish loams, laterites and black cotton soils.

**Varieties**
**Early maturing-** Co Pant 94211, Co S8436, Co S 88230,CoS 98014, Co S 96268, Co J-85, Co S 95255, Co S 96258, Co S 96268, Co S 98247, Co 7219 (Sanjeevani),
**Mid & late-** Co S 767, Co S 8432, Co S 96275, Co Pant 84212, Co Pant 90223, Co Pant 97222, Co Pant 96219, Co Pant 99214, Co Pant 93227, Co S 94257, Co S 97264, Co Se 93232, Co S 92423, Co S 96436.
**Water logged Variety-** UP 9529, UP 9530, Co S 94636, Co Pant 90223.

**Saline and Alkaline Variety-** CoS-767, CoS 95225, Co S-95222, Co S-93278, Co S-95257, Co S-95222, Co S-93278, Co S-94257, UP-9530.
**For foggy areas -** Co S 767, Co S 88230, Co S 64, Co S-88216.
**Planting Time:-** Sugarcane take generally one year to mature in sub tropical states (U.P., Punjab, Haryana, Rajasthan, Bihar etc.) called "Eksali" however in some tropical states it matures in 18 months (Andhra Pradesh, Karnataka, Maharashtra etc.) called "Adsali".

- Spring cane is planted in February-March. March is the best time for cane planting in Punjab, Rajasthan and Haryana, February-March in Uttar Pradesh and January-February in Bihar.
- The planting time is advanced as we move towards east. In Tamil Nadu, Andhra Pradesh, Maharashtra and Karnataka cane planting is done in December-February.
- Sugarcane can be planted as per the recommendation for the region i.e. Autumn planting (15 Sept. to Oct.) and Spring planting (Feb. to March). Improved method of planting should be adopted like, deep furrow, trench methods, ring pit method and paired row method instead of furrow system.

**Seed rate:-** Seed rate in sugarcane varies from region to region. Seed rate generally varies from 35,000 to 45,000 three budded setts per hectares.

**Seed Treatment:-** Treat the setts soon after cutting in 0.1% (at 1g/liter) Carbendazim solution for 15 minutes. Three important diseases viz., grassy shoot disease, smut and ratoon stunting disease are carried forward through seed cane material. These diseases lead to progressive decline in yields and degenerate sugarcane varieties. For control of these diseases treat the seed material (setts) with moist hot air at 52°c for 30 minutes. To control termites early shoot borer and scale insects treat the setts in a systematic insecticide viz. Malathion 50EC (at 2 ml/liter) or Dimethoate 30EC (at 3 ml/liter) for 15 minutes.

**Spacing:-** 60-100cm row to row.

## Manure and fertilizer: -

- FYM: - 20-25t/ha.
- N: - 150kg/ha
- $P_2O_5$: - 125kg/ha
- $K_2O$: -100kg/ha

**Weed Management:-**

i. Spray Atrazine 2 kg or Oxyflurofen 750 ml/ha mixed in 500 ltr. of water as pre emergence herbicide on the 3rd day of planting, using deflector or fan type nozzle.

ii. If pre-emergence spray is not carried out, go in for post-emergence spray of Grammaxone 2.5 litre + 2,4-D sodium salt 2.5 kg/ha in 500 litre of water on 21st day of planting.

iii. If the parasitic weed striga is a problem, post-emergence application of 2,4-D sodium salt @ 1.25 kg/ha in 500 litre of water/ha may be done. 2, 4-D spraying should be avoided when neighbouring crop is cotton or bhendi.

iv. Apply 20% urea also for the control of striga as direct spray.

v. Pre- plant application of glyphosate at 2.0 kg/ha along with 2% ammonium sulphate at 21 days before planting of sugarcane followed by post emergence direct spraying of glyphosate at 2.0 kg/ha along with 2% ammonium sulphate with a special hood on 30DAP suppressed the nut sedges (Cyperus rotundas) and provided weed free environment.

vi. If herbicide is not applied work the junior-hoe along the ridges on 25, 55 and 85 days after planting for removal of weeds and proper stirring.

vii. Remove the weeds along the furrows with hand hoe. Otherwise operate power tiller fitted with tynes for intercultivation.

**Water management:-** In sugarcane, maintenance of optimum soil moisture during all stages of crop growth is one of the essential requisites for obtaining high yield. The crop should, therefore, be grown in areas of well-distributed rainfall or under assured and adequate irrigation. In tropical India, total water requirement of the crop for optimum growth varies from 2000 to 3000 mm inclusive of rainfall. The requirement of an adsali crop is proportionately higher (3200 to 3500 mm). In sub-tropical India, the water requirement is 1400-1800 mm. In tropical area, irrigations are to be given once in 7 days during germination phase (1 –35 days after planting), once in 10 days during tillering phase (36 – 100 days after planting), again once in 7 days during grand growth phase (101 – 270 days after planting) and once in 15 days during maturity phase (271 days after planting up to harvest) adjusting it to the rain fall pattern of the area. About 30 to 40 irrigations are needed.

About 250 tonnes of water is needed to produce one tonne of sugarcane. Methods like alternate furrow irrigation, drip irrigation and trash mulching could be of use to economize irrigation water during water scarcity periods. Foliar spraying of a solution containing 2.5% urea and 2.5% muriate of potash 3 or 4 times at fortnightly intervals during drought periods would help to reduce the impact of drought on the crop. Critical stages are those during which sugarcane is affected severely due to water stress and the loss cannot be restituted by adequate water supply at later stages. These stages are: sprouting (germination), formative stage or tillering, ripening and initiation of sprouting in ratoons. In case of limited water availability, one may sustain sugarcane productivity by irrigating at critical stages of growth. Water requirement is 1500-2500mm.

**Earthing-up:-** Earthing-up operation is also known as "hilling-up". This operation is carried out in two or three stages.The first earthing-up operation is known partial earthing-up and the second/third operation is known as "full earthing-up".

The partial earthing-up is done at 45 days after planting. In partial earthing-up, little amount of soil from either side of the furrow is taken and placed around the base of the shoots. While doing partial earthing-up, the furrow in which the cane row is present gets partially filled-up.

Full earthing-up is done after 120 days after planting coinciding with the peak tiller population stage. During full earthing-up the soil from the ridge in between is fully removed and placed near the cane on either side. This operation converts the furrows into ridges and ridges into furrows.This operation could be done either manually or by using a bullock-drawn/tractor drawn furrower depending upon the spacing adopted.

**Detrashing:-** Detrashing refers to removal of unwanted bottom dry and green leaves at regular intervals. Sugarcane stalk bears large number of leaves (30-35) equal to the number of inter-nodes under good management systems.

**Propping:-** The operation of tying the leaves together using the bottom dry and green leaves is known as propping. It is primarily done to check lodging of cane.

**Removal of Water Shoots:-** Water shoots are the late-formed tillers or side shoots, which are robust and fast growing. They originate mainly due to plentiful supply of water, inadequate earthing-up and late fertigation. These water shoots, as the name indicates, contain lot of water and less sucrose and more of reducing sugars.

Water shoots affects the growth of adjacent stalks. They harbour insect-pests and when they are harvested and sent to mill for crushing, lead to reduced juice quality and affect sugar recoveries. Therefore it is advisable to remove water shoots as and when they arise. The water shoots can be used as cattle feed.

**Harvesting Stage:-**

- **Crop Age:-** Harvesting is done based on maturity (age) group. Farmers who grow a particular variety are usually conversant with the harvesting time. Even most sugar factories give cutting orders to farmers based on crop age. This is not a scientific method since, planting time, crop management practices and weather conditions etc influences maturity.

- **Visual Symptoms:-** Yellowing and drying of leaves, metallic sound of mature canes when tapped, appearance of sugar crystal glistening when a mature cane is cut in a slanting way and held against the sun are some of the visual indices of assessing maturity of cane.
- A cane crop is considered fit for harvesting if it has attained a minimum of 16% sucrose and 85% purity.

**Yield:-** 60-80t/ha

**Major Insect Pests of Sugarcane**

| Name of the pest | Scientific Name | Plant parts infested | Peak period of activity |
|---|---|---|---|
| Termites | *Odentotermes obesus* Ramb. | Cane setts, shoots and canes. | Active in all seasons severe under drought conditions. |
| Shoot borer | *Chilo infuscatellus* Snellen. | Young Shoots and during drough the internodes. | March-June |
| Top borer | *Scirpophaga excerptalis* Wlk. | Shoot and grown up canes | June – December |
| Root borer | *Emmalocera depressella* Swinhoe | Young plants | April – June |
| Leaf hopper | *Pyrilla perpusilla* Wlk. | Leaf and leaf sheath | Summers with moderate to high humidity low rainfall or March-October |
| Lygaeid bug or black bug | *Cavelerius excavatus* Dist. | Leaf whorl mostly ratoons | Pre mansoon period |
| Scale insect | *Melanaspis glomerata* (Green) | Internodes | May – December |
| Mealy bug | *Saccharioccus sacchari* Cockerell. | Nodal region | Throughout the year but severe under drought |
| White fly | *Saccharioccus sacchari* Cockerell. | Leaf | Well-manured and heavy crops or August-October |
| White grub | *Hilotrichia consanguinea* Blanch. | Roots, lower portion of stem covered by the soil | March to October (Mass emergence immediately after first heavy rain) |

**Diseases:-**

**1. Whip Smut:-** Whip smut of sugar cane is a fungal disease caused by *Ustilago sacchari*. Disease resistant varieties like – CO – 7219, COM – 7125 etc.

**2. Red-rot:-** It is a fungal disease caused by *Colletotricum falcatum.*

**3. Rust:-**

**4. Grassy Shoot:-** This is mycoplasma disease of sugarcane ad spread by aphids.

**5. Twisted Top and Mosaic**

**Sorghum**

**Botanical Name: -***Sorghum bicolour*
**Family: -**Poacea.
**Origion:-**Africa
**Types of Inflorescences:-** Panicle
**Type of fruits:-** Caryopsis
**Chromosome No:-** 2n=20
**Leading State: -** Maharashtra
**Carbohydrate content: -** 72.6%.
**Protean content: -** 10.4%.
**Fat content:-** 1.9%.

- The sorghum is called the king of coarse grains.

- Sorghum is $C_4$ and often cross-pollinated plant.
- Jowar, is the most important food and fodder crop of dryland agriculture.
- Sorghum is a short day plant.
- *Guinea* and *dura* species is most popular in sorghum.
- Jowar is mainly concentrated in the peninsular and central India. Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh (the Bundelkhand region) and Tamil Nadu are the major jowar growing states.
- The sorghum grain is used primarily as human food in various forms, such as *roti* or *bhakri* (unleavened bread), or is cooked like rice.
- Sorghums are also malted, popped and several local preparations are made.
- Green and dried fodder is the most important roughage for feeding cattle throughout the country. The utilization of grain sorghum as a cattle feed, poultry ration and other industrial uses is at present not very significant, although considerable scope exists.

**Climate:-** Sorghum plants are very hardy and can withstand high temperature and drought, however, it is grown in arid regions of U.P, Rajasthan and humid regions of Bengal and Bihar. It may be successfully grown under atmospheric temperature ranging between $15^0$C to $40^0$C and annual rainfall ranging from 400 to 1000 mm. 20$^o$C temperature is good for germination and 26-30$^o$C is good for luxuriant growth. Below the temperature of 15$^o$C, the growth of sorghum is stopped.

Due to the excessive moisture loss, the growth of the plant stops and whenever the water is received, the growth will start again. That's why it is called a "*Camel Crop*".

**Soil:-** Sorghum is grown on a variety of soil types but the clayey loam soil rich in humus is found to be the most ideal soil. It may tolerate mild acidity to mild salinity under pH 5.5 to 8.0. A good sorghum soil must have an efficient drainage facilities though, it may withstand water logging more than maize.

**Varieties:-**

**A. Suitable for grain: -**

- CSH-1:- It is the first hybrid variety of sorghum which was developed in 1964.
- CSH-9: - This type is a resistant variety to head mold and mites.
- CSV-17: - It is tolerant to stem fly, stem borer and resistant to, leaf blight, brown leaf spot and blight disease.
- SPV-245: - It is tolerant to anthracnose.
- **Other Varieties:-** CSH-5, CSH-6, CSH-148 (SPH-468), CSH-13, SPV-96, SPV-346 (CSV-10), CSV-13 (SPV-475), CSV -15, Pratap Jawar-1430.
- **Sweet Varieties:-** SSV-53, SSV-84, SSV-96 and CSH-22.
- **Hybrid Varieties: -** CSH-1,2,3,4,5,6,9,10

**B. Suitable for green fodder: -**

- Rajasthan Chari-1: - It is suitable for high rainfall area.
- Rajasthan Chary -2: - It is suitable for low rainfall area.
- **Other varieties:-** SSG 59-3 (sweet Sudan), Harasona-855, White Pearl (FSH-92079), Pusa Chari Hybrid-109 (PCH-109), Pusa Chari-615, CSH-20-MF (UPMCH-1101)
- **Single harvesting fodder crops:-** PC-6,9,23, HC-171, 260, 136, UP Chari-1, 2, Raj Chari-1, Raj Chari-2.
- **Double harvesting fodder crops:-** CO-27, AS-16.
- **More than two harvesting fodder varieties: -** SSG-988, 898, 855.

**Seed Rate:-** 10-12kg/ha for seed and 30-40kg/ha for fodder crops.

**Spacing:-** 45x12-15cm

**Seed Depth**:- 3-5cm.

**Plant Population:-** 150000-175000 plants.

**Water Management:-** Water requirement is 450-650mm. If the crop is sown in monsoon time (July). it may require l to 3 irrigations depending upon rains. For summer crops, 6 to 7 irrigations may be carried out due to high temperature. In South India, Rabi season crops need about 4 to 5 irrigations. Critical stage of irrigation are Booting, Blooming and Milky Dough Stage.

**Weed Control:-** To control the weeds in sorghum crop, weeder cum mulcher should be used to give 1hoeing @ 3 weeks crop stage. Should use pre-emergence application of atrazine @ 0.50 kg/ha in 650 liters of water to control the weeds effectively.

**Manure and fertilizer: -**

- FYM: - 10-15t/ha.
- N: - 80kg/ha
- $P_2O_5$: - 40 kg/ha
- $K_2O$: - 40 kg/ha

**Harvest:-** Harvest the crop when the grains turn yellow. For fodder the crop will be ready in single cut varieties for harvesting 65 to 75 days after sowing (50%, flowering stage). In multi cut varieties, first cut should be done 45-50 days and subsequent cuts should be carried at 1 month intervals.

**Yield:-**Hybrid Varities:- 30-35qt/ha and Local Varieties:- 10-15qt/ha.

**Fodder Yield:-** 300-400qt/ha. (For fodder purpose crop shold be harvest 55 days after sowing because HCN syntesises before 35-40 days and its effect slow down at 45 days).

**Kadvi Yield:-**Hybrid Varities:- 80-100qt/ha and Local Varieties:- 100-150qt/ha.

**Storage:-** Grane should be storage at 10-12% moisture.

**Insect Pest**

1. Sorghum Shoot fly: *Atherigona soccata*
2. Stem borer: *Chilo partyellus Swinehoe*
3. Aphids*: Rhopalosiphum maidis*
4. Grain/Earhead Midge*:* Contarinia sorghicola
5. Semi looper: *Eublemma silicula*

**Diseases**

1. Downy Mildew - *Peronosclerospora sorghi*
2. Leaf blight - *Exerohilum turcicum* (Syn: *Helminthosporium turcicum*)
3. Rectangular Leaf spot -*Cercospora sorghi*
4. Anthracnose and red rot -*Colletotrichum graminicolum*
5. Rust -*Puccinia purpurea*
6. Grain smut/Kernel smut / Covered smut / Short smut - *Sphacelotheca sorghi*
7. Long smut - *Tolyposporium ehrenbergii*
8. Head smut - *Sphacelotheca reiliana*
9. Ergot or Sugary disease - *Sphacelia sorghi* Symptoms

## PEARL MILLET

**Botanical Name:-** *Pennisetum glaucum*
**Family: -** Poaceae.
**Origin:-** Africa.
**Inflorescence: -** Spike
**Type of fruit:-** Caryopsis
**Leading states in India:-** Rajasthan.
**Percentage of carbohydrate: -** 67 %.
**Percentage of protein:-** 11-12%.
**Fat Content:-** 5%.

- India is largest producer of pearl millet in word.
- Highest production of millet in India is in Rajasthan and productivity is of Gujarat.
- Millet is $C_4$ and Short Day Plant .
- Millet is cross-pollinated crops (Anemophilous).
- Protogyny (Dichogamy) found in millet.
- Test weight of hybrid millet is 5-7gm.
- Millet content maximum fat among cereal.
- Millet has maximum drought resistant capacity among cereal crops.
- Dwarfing gene of millet is Tift 23A.

**Climate:-** Bajra grows well in dry and warm climatic conditions and it's drought tolerant crop which requires low annual rainfall ranging between 40 cm to 60 cm. Ideal temperature for bajra cultivation is between 20°C to 32°C but 28-32°C is best. Moist weather is advantageous during its vegetative growth. In North India, bajra is grown as kharif crop and in some southern parts is grown as summer crop providing irrigation.

**Soil:-** Bajra can be grown in wide range of soils. It thrives best in loamy, sandy loam soils having well drainage. This crop does not prefer acidic and water logging soils. Avoid saturated soils for its cultivation. It grows successfully with 7.5-8.0 pH.

**Varieties**

**HB-1:-** It is first hybrid of millet developed from PAU, Ludhiana.

**HHB-67:-** Extra early single-cross hybrid, bold grain, short panicles, the ability to produce basal tillers regularly, short plant height.

**ICMH-90852:-**Medium to late maturity, high tillering potential, thin intermediate panicles and medium grain size.

**CZ-IC-922:-** Medium maturing, open-pollinated variety, low tillering potential, medium to large panicles, medium thick stems, medium-tall plant height and medium grain size.

**RCB-IC-911:-** Medium maturity, open-pollinated variety, very large grain size, thick compact panicles, and low tillering potential.

**MH-179:-** Late maturing single-cross hybrid, long panicles, low tillering potential, thick stems, medium grain size, bristles, and medium-tall plant height.

**CZP-IC-923:-** Late maturing, open-pollinated variety, long, thick panicles, low tillering potential, tall plant height, large grain size, and thick stems.

**ICMP-94881:-** Late maturing, open-pollinated variety, with intermediate tillering potential, and less compact panicles.

**CZH-IC-313:-** Early maturing, top cross hybrid, medium-high tillering potential, large grain size, and medium-longpanicles.

**CZP-IC-315:-** Medium-late maturing-open-pollinated variety, with high tillering potential medium-long, think, compact panicles, with small-medium grain size, and medium plant height.

**RCB-2:-** It is developed from ARS, Durgapura, Jaipur. It is resistant to downy mildew, smut and rust diseases.

**RHB-58:-** It is downy mildew resistant variety.

**CM-46:-** It is downy mildew resistant variety.

**Pusa-605:-** It is hybrid develop from IARI, New Delhi. It is suitable for rain fed area.

**Varieties suitable for drought area**:- WCC-75, RHB-30, RHB-90, NHB-67, MH-179.

**Hybrid Varieties:-** HB-2, HB-3, HB-4, HB-5, RCB-2, RHB-90, Pusa-323.

**Varieties Developed from ARS, Durgapura, Jaipur:-** RCB-2, RHB-30 and RHB-90.

**Local Varieties:-** WCC-75, NHB-3, NHB-4.

**Varieties for fodder:-** Composite-6.

**Seed Rate:-**

- 4-5kg by direct sowing.
- 2-2.5kg by planting method(500 $m^2$ area required for one hector planting).

**Planting Distance:-** 40-45x10-15cm.
**Plant Population:-** 175000-200000 plant per hector.
**Sowing Time:-** Mid June- Mid July.
**Manure and fertilizer for Irrigated area: -**

- FYM: - 10-15t/ha.
- N: - 80-100kg/ha
- P2O5: - 60-80kg/ha
- K2O: -40-50kg/ha

**Manure and fertilizer for Irrigated area: -**

- FYM: - 8-10/ha.
- N: - 40-50kg/ha
- P2O5: - 30-400kg/ha
- K2O: -20-30kg/ha

**Water Management:-** Three irrigation require for good production. Germination, flowering and grain filling stage are critical stage of irrigation.

**Weed control:-** Gap filling or thinning is followed, Applying Atrazine @ 0.5 kg/ha works well to control weeds.

**Harvesting and Threshing:-** The crop is ready for harvesting when the grain become hardy & contain moisture. Two methods can be followed in harvesting bajra crop: Cutting earhead or cutting of entire plants by sticks. stalk the cut plants for 4 to 5 days in sun for drying grains. Grains can be separated by beating the earheads.

**Yield:-**

- Average:- 15-20qt/ha.
- Unirrigated:- 12-15t/ha.
- Irrigated:- 30-35t/ha.
- Fodder:- 300-400qt/ha.
- Grain should be storage at 12-14% moisture level.

**Insect pests**

- Shoot fly: *Atherigona soccata*
- Grasshopper: *Hieroglyphu sp*
- White ant: *Chrotogonu sp*
- Grey weevil: *Mylloceru sp*
- Stem borer: *Chilo partellus*
- Earhead bug: *Calocoris angustatus*
- Hairy caterpillar: *Spilosoma oblique*
- Earhead worm: *Cryptoblabes gnidiella*
- Blister beetle: *Mylabris pustulata*
- Chaffer beetle: *Rhizotrogus majalis*

**Diseases**

- Ergot: *Claviceps fusiformis*
- Smut: *Moesziomyces parepenicillariae*
- Rust: *Puccinia substriata*
- Blast: *Pyricularia grisea*

## C. (1) Introduction, distribution and economic, importance of fruit – Mango, Banana, Guava, Lime, Grape, Apple, Pomegranate.

# Mango

**(National fruit of India, King of fruit, Bathroom Fruit)**

**Botanical name:-***Mangifera indica*
**Family:-** Anacardiaceae
**Origin:-** Indo-Burma
**Chromosome number:-** 2n=4x=40 (Allopolyploid)
**Type of fruits:-** Drup
**Type of inflorescence:-** Panicle
**Edible part:-** Mesocarp

- India is leading country in mango production (about 54.7)
- Uttar Pradesh is leading stay in mango products and mango area in India.
- Mango is a rich source of vitamin-A.
- Yellow colour in mango due to beta-carotene.
- Vitamin-C present in unripe mango.
- Mango used as a fresh fruit, Amchur, pickle and Canning.
- In Fruit processing, mango is contribute maximum part of export from India.
- Mango is contribute maximum area in total fruit area and second in production after banana in India.

- Akbar planting 100000 plants of mango in Bihar so that area is called as *Luckhi Bagh.*
- Mango contribute 20.7% production from total fruit production of India.
- Mango contribute maximum area from total fruit area of India (about 34.8%)
- TSS content of mango:- 20$^{o}$Brix.
- Gynodioecious flowering behaviour found in mango (Gynodioecious:- Hermaphrodite and female flowers in same tree at different location)
- Maximum Hermaphrodite flower found in Langra mango.
- Bappakai, Chandrakaran, Kensington, Kitchner, Kurukkan, Muvandan, Mylepelian, Nekkare, Olour, Peach, Prior and Starch are polyembryonic while mango varieties of commercial importance are monoembryonic.

**Climate:-** Mango is belong to tropical climate but it also cultivated in subtropical area.

- Rainfall is harmful during flowering.
- Best temperature of growth:- 24 to 28$^{o}$C

**Soil:-** Sandy loam.

- Suitable Ph value 6.5 to 7.5

**Propagation:-**

1. **Veneer grafting:-** It is commercial propagation method of mango. Suitable time for veneer grafting is August.
2. **Stone Grafting:-** Best time of stone grafting is September. It is practices in Konkan region of Maharashtra.
3. **Inarching:-** This method is adopted by East Indian farmers. Best time for Inarching is July.

**Root stock:-**

- Vellaicollumban is allo-octaploid (2n=2x=80) and it is a dwarf root stock.
- Other dwarfing root stock:- Kurkan, Olour, Nileswara Dwarf and Totapuri Red Small.
- Alkali soil tolerance rootstock:- Kurkan, Nickerie and Olour.

**Time of Planting:-** June-July
**Size of pit:-** 1x1x1m
**Planting Distance:-** 10x10m
**Time of pruning:-** Aug-Sept
**Method of Training:-** Modified leader system
**Flowering time:-** Feb-March
**Fruiting Time:-** May-July
**Harvesting Index:-**

- 90-110 days after flowering fruit is ready for harvesting.
- Natural wax develop on fruit during maturity.
- Solder swell during maturity.
- Specific Gravity
- Yellow or golden colour start appearing.

**Yield:-** 90-120kg/tree or 15-20t/ha

**Varieties:-**

1. **Alphonso:-** One of the most popular of India, it is mainly grown in Ratnagiri area of Maharashtra and to a small extent parts of south Gujarat and Karnataka. It is susceptible to spongy tissue.
2. **Banganapalli:-** It is a widely cultivated, early maturing mango of south India. It is the main commercial variety of Andhra Pradesh.
3. **Bombay Green:-** It is one of the earliest varieties of north India. Its fruits are highest content of Vit-C. Highly suitable to Mango-malformation.
4. **Chausa:-**Late- maturing variety of south India, it matures during July or beginning of August. It is sweetest variety of mango.
5. **Dashehari:-** One of the most popular variety of north India and Rajasthan
6. **Fazli:-** Late- maturing variety.
7. **Kesar:-** Popular in Saurashtra region of Gujarat, Kesar is an irregular bearing mango. Fruits ripen to attractive apricot yellow color with red blush. It has good processing quality.
8. **Langra:-** An important commercial mango variety of north India, it is biennial- bearer and a mid-season variety. It is highly prune by fruit dropping.
9. **Neelum:- I**t has regular bearing habit.
10. **Madhulika:-** It is a off season cultivar.
11. **Niranjan:-** It is a off season cultivar.
12. **MOCH-1:-** It is a off season cultivar.
13. **Lal Sinduri:-** Powdery mildew resistant variety.
14. **Rosica:-** Mutant variety.
15. **Rumani:-** Apple Shape variety.
16. **Pusa Surya**
17. Paiyur-1
18. Pairi
19. Mankurad
20. Haden
21. Ice cream
22. Vanilla

**Hybrid Verities:-**

| Hybrid | Place of research | Parentage | Importance characters |
|---|---|---|---|
| Mallika | IARI, New Delhi | Neelum x Dashehari | Highest Vit-A content |
| Amrapali | IARI, New Delhi | Dashehare x Neelum | Dwarf variety of mango.<br>Planting Distance:-2.5x2.5m<br>1600 plant planted in 1 hector. |
| Ratna | FRS, Vengurla | Neelum x Alphonso | Free from spongy tissue |
| Sindhu | FRS, Vengurla | Ratna x Alphonso | Regular- bearer, stone thin |
| Arka Puneet | IIHR, Banalore | Alphonso x Banganapalli | Free from spongy |
| Arka Aruna | IIHR, Banalore | Baganpalli x Alphonso | Free from spongy |

| | | | |
|---|---|---|---|
| Arka Anmol | IIHR, Banalore | Alphonso x Janardhan Pasand | Free from spongy |
| Arka Neelkiran | IIHR, Banalore | Alphonso x Neelum | Free from spongy |
| Au Rumani | | Rumani x Mulgoa | |
| Manjeera | | Rumani x Neelum | |
| Ambika/CISH-1 | CISH, Lucknow | Amrapali x Janardhan Pasand | |
| Pusa Arunima | | Amrapali x Sensation | |
| Pusa Lalima | | Amrapali x Sensation | |
| Pusa Pratibha | | Amrapali x Sensation | |
| Pusa Shreshtha | | Amrapali x Sensation | |
| Sai Sugandha | | Totapuri x Keser | |
| Prabha Sankar | | Bombay x Kalapady | |
| Sunder Langra | | Langra x Sunder Prasad | |
| Neeleshan | | Neelum x Baneshan | |
| Swarna Jehangir | | Chinnaswarnarekha x Jehangir | |
| PKM-2 | | Neelum x Mulgoa | |
| PKM-1 | | Chinnaswarnarekha x Neelum | |
| Neelgoa | | Neelum x Yerra Mulgoa | |
| Neeludin | | Neelum x Himayuddin | |

**Physiological disorders of Mango**

1. **Spongy Tissue:** It is a major problem in Alphonso, It is a physiological disorder in which fruit pulp remains unripe because of unhydrolyzed starch due to physiological and biochemical disturbances because of high temperature, convective heat and post harvest exposure to sunlight.

   **Management:-** Use of mulching and post harvest exposure to low temperatures between 10-15$^{o}$C for 10-18 hours has been useful in reducing the malady.
2. **Biennial Bearing/ Alternate Bearing:-** Mango tree heavily bear fruits in one year (on year) and a much reduced crop in the following year (off year).
   - Draining out of CHO and N reserves during "On Year" is known to lead to a lean crop in the "Off Year" as they are important for fruit bud initiation e.i high C/N ratio helps for fruit bud initiation.
   - Varieties with axillary fruit bearing habit posses less than terminal bearing.
   - Many commercial varieties are irregular bearers.
   - Totapuri, Neelum, and hybrids in which Neelum is involved as one of the parents are regular bearers.

**Measures to control alternate or biennial bearing**

- Proper up keeping and maintenance of orchard.
- Smuding.
- Soil drenching with paclobutrazol (5-10g tree) or Cultar @ 4 g/tree results in minimum outbreak of September to October flushes, which results in early and profuse flowering.
- Ringing of branches is recommended as means of inducing flowering in the 'Off' year. Ringing should be done in August or early September, well before the time of fruit-bud differentiation.It involves removal of 1 cm wide ring of bark on a branch of about 15 cm thickness. Ringing stops vegetative growth and results in accumulation of carbohydrates and other metabolites in the portion of the branch above the ring, thereby creating physiological condition for flowering.

3. **Fruit Drop:-** In mango, there is a heavy drop of hermaphrodite flowers and young fruits amounting to 99% or more. The commercially grown varieties, Langra and Dasheri are more susceptible to drop in the month first three weeks of April. The fruit drop is more or less a continuous process and can be classified into three phases, viz. (i) Pinhead drop, (ii) post-setting drop and (iii) May-month drop. The fruit drop in first two phases are insignificant compared to the third phase which affects the final yield significantly and needs more attention.

   **Management:** Regular irrigation during fruit setting and development period can reduce this problem. Application of plant bio-regulators like NAA 25 ppm and 2,4 D 10-15 ppm at 6 week after fruit set, reduce fruit drop considerably. Single spray of NAA or 2,4-D each at 20ppm or Alar 100ppm at pea stage of fruit gives promising results.

4. **Black Tip :-**Black tip is a serious disorder, particularly in the cultivar Dasheri. The distal end of the fruit first exhibits etiolated patches, later running black followed by discolorations and necrosis of the mesocrap.

   **Symptoms:-**
   - Gases like $SO_2$, Ethylene and CO affect the fruits.
   - The distal end of the fruit turns black and get hardened.
   - Affected fruits become ripe pre maturely and unmarketable.
   - Exuding a brown gummy substance

   **Remedies:-**
   - Planting of mango orchards in North-South direction and 5-6 km away from the brick kilns may reduce incidence of black tip to a greater extent.
   - Chimney height should be increased to at least 18 to 20 m.
   - The incidence of black tip can also be minimized by spraying Borax (1%) or other alkaline solutions like 2% sodium carbonate.
     (a) Before flowering.
     (b) During flowering
     I At fruit-set stage
   - The first spray of Borax should be done positively at pea stage followed by two more sprays at 15 days interval.

5. **Mango Malformation:-** It is first reported in Darbhanga, Bihar in 1891. Malformation is widely prevalent in northern India, particularly in the states of Punjab, Delhi and western U.P. where more than 50% of the trees suffer from this malady. Mango malformation is of two types viz. vegetative and floral. The vegetative malformation generally affects seedlings of young plants in which there is a swelling of buds and formation of small shoots with short inter nodes at the apical portion and given an appearance of witches broom like structure. In floral malformation, panicles become deformed, axis become short and rachis thick, due to this inflorescence look like a cluster. Malformed panicles have bigger flowers than the normal flowers and are mostly male.

   **Management:** Spraying of Planofix (200 ppm) during the first week of October followed by deblossoming at bud burst stage is recommended as a remedial measure against malformation. Cutting of the malformed twing alongwith the approximate 15cm healthy portion after complete fruit set in may.

6. **Clustering in Mango ('Jhumka') :-** A fruiting disorder, locally known as 'Jhumka', is 115socrates115al115 by the development of fruitlets in clusters at the tip of panicles. Such fruits cease to grow beyond pea or marble stage and drop down after a month of fruit set. Absence of sufficient population of pollinators in the orchards is the major reason. The other reasons causing the disorder are old and overcrowding of trees, indiscriminate spraying against pests and diseases, use of synthetic pyrethroids, monoculture of Dashehari and bad weather during flowering.

**Management:-** Introduction of beehives in the orchards during flowering season for increasing the number of pollinators and restrict insecticidal sprays at full bloom to avoid killing of pollinators. Pests and diseases should be controlled in time by spraying the recommended pesticides and concentrations. Spraying of NAA (300 ppm) during October-November is recommended. The practice of monoculture of a particular variety may be avoided. Particularly in case of Dashehari, 5- 6% of other varieties should be planted in new plantations.

**Diseases:-**

1. **Powdery mildew (*Oidium mangiferae* Berthet) :** Powdery mildew is one of the most serious diseases of mango affecting almost all the varieties,

   The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalks of panicles, flowers and young fruits. The affected flowers and fruits drop pre-maturely reducing the crop load considerably or might even preven the fruit set. Rains or mists accompanied by cooler nights during flowering are congenial for the disease spread.

   **Control :-** Wettable sulphur 0.2 per cent (2 g Sulfex / lit. water) or Tridemorph 0.1 per cent ( 1 ml Calixin / lit. water) or Dinocap 0.1 per cent (1 ml / g Karathane / lit. water).
2. **Anthracnose (*Colletotrichum spp*) :-**

**Insect-Pests:-**

**1. Mealy bug :** It is major pest of mango in India.

**Control:**- Polythene (400 gauge) bands of 25 cm width fastened around the tree trunk have been found effective barrier to stop the ascent of nymphs to the trees. The band should be fastened well in advance before the hatching of eggs, i.e., around November – December.

2. **Hopper (*Amritodus atkinsoni* ):** Of all the mango pests, hopper is considered as the most serious and widespread pest throughout the country.

3**. Stone weevil (*Sternochetus mangiferae*) :**

4. **Mango fruit fly** (***Ceratitis cosyra***):- It is major problem for exporte. Gama radiation treatment given for fruit fly control.

## Banana

### (Tree of Paradise, Fruit of Paradise, Kalpataru/ A plant of virtues)

**Botanical name:-***Musa 116socrates116al*

**Family:-** Musaceae

**Origin:-** South-East Asia (Assam, Burma etc.)

**Chromosome number:-**2n=22 and 2n=3x= 33.

**Type of fruits:-** Berry

**Type of inflorescence:-** Spadix

**Edible part:-** Mesocarp & endocarp.

**Carbohydrate content:-** 36.4%.

**Introduction**

- India is leading banana producer in word, contribute 21% production of world.
- Banana rank first in production of total fruit production in India (33.4%) and second in area after mango.
- Banana rank also second in productivity after Papaya (about 35t/ha).
- One of the oldest fruits in India.
- India has the second largest diversity of indigenous bananas in the world more than **600 types of *Musa***germplasm comprising wild forms and cultivated species are reported the world over. India has more than **300 types of germplasm** although there are numerous synonyms of each cultivar.
- *Musa 116socrates* is the source of today's edible banana.
- Banana is herbaceous, monocotyledonus and monocarpic fruit crop.
- It is moisture loving plant
- In India, mostly triploid cultivar cultivated in commercial scale.
- Banana improvement work was started in 1949 in Tamil Nadu.
- Tamil Nadu is leading state of banana production in India.

- Banana is staple food of South Africa.
- Banana is a rich source of carbohydrate and is rich in vitamin B. It is also a good source of potassium, phosphorus, calcium & magnesium.
- It helps in reducing risk of heart diseases, arthritis, ulcer, gastroenteritis and kidney disorders.
- Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit.
- Plantains or cooking bananas are rich in starch and have a chemical composition similar to that of potato.
- National Research Centre for Banana, Podavur, Tamil Nadu.
- Genetic classification of banana given by Simmond and Shephard in 1955.

**Climate**

Banana is well adapted to tropical climate in the warm and humid parts in Asia. Among the climatic variables, temperature, frost occurrence, light/solar radiation and rainfall distribution, relative humidity and wind velocity largely influence the growth, morphology and productivity of banana. It can grow in temperature range 10-40°C (26.5$^{o}$C) and frost sensitive. Wind breaks necessary. Tamperature above 36-38$^{o}$C causes scorching effect with increased transpiration. Strong wind are harmful for banana cultivation.

**Soil**

Banana can be grown in almost all types of soil provided adequate soil moisture is available. Deep, well drained, fertile, loamy soil with adequate organic matter with 6-7.5 Ph is ideal for its cultivation. Shallow rooted crop, so depth & drainage are essential. It can be grow in slight alkaline but not in saline soils.

**Varieties**

**Dwarf Cavendish (AAA):** It is a popular commercial cultivar grown extensively for table and processing purpose in the states Maharashtra, Gujarat, Bihar and West Bengal. It is also popular in Tamil Nadu, Karnataka and Andhra Pradesh. It is contribute 58% production of total production of banana.

- **'Basrai**' is the leading commercial variety of Cavendish group and is a leading commercial variety of Maharashtra. The plant stature is Dwarf making it less prone to wind damage.
- **Gandevi selection** known as 'Hanuman' or 'Padarre' is gaining importance inspite of its longer crop duration.
- It is highly susceptible to Sigatoka leaf spot disease in humid tropics restricting its commercial cultivation.

**Robusta (AAA):** It is a semi-tall variety, grown mostly in Tamil Nadu and some parts of Karnataka for table purpose. Robusta is highly susceptible to Sigatoka leaf spot disease in humid tropics.

**Rasthali (Silk AAB):** It is a medium tall variety commercially grown in Tamil Nadu, Andhra Pradesh, Kerala, Karnataka and Bihar. Its unique fruit quality has made Rasthali popular and a highly prized cultivar for table purpose. Longer crop duration, severe susceptibility to *Fusarium* wilt, requirement of bunch cover to protect fruits from sun cracking and formation of hard lumps in fruits make crop production more expensive.

**Poovan (Mysore AAB):** Medium sized bunch, closely packed fruits, good keeping quality and resistant to fruit cracking is its plus points. But it is highly susceptible to Banana Bract Mosaic Viral (BBMV) disease and Banana Streak Virus, (BSV), which cause considerable reduction in yield.

**Nendran (AAB):** It is a popular variety in Kerala where it is relished as a fruit as well as used for processing. Nendran is highly susceptible to Banana Bract Mosaic Virus (BBMV), nematodes and borers.

**Red Banana (AAA):** Red banana is the most relished and highly prized variety of Kerala and Tamil Nadu. It is highly susceptible to bunchy top, fusarium wilt and nematodes.

**Ney Poovan (AB):** Ney Poovan is the choicest diploid cultivar, which is under commercial mono cultivation on a large scale especially in Karnataka and Tamil Nadu. Fruit is highly fragrant, tasty, powdery and firm. Ney Poovan is tolerant to leaf spot but susceptible to *Fusarium* wilt and banana bract mosaic virus.

**Virupakashi (AAB):** It is an elite variety in South India especially grown for table purpose in Palani and Shevroy hills of Tamil Nadu under perennial cultivation. It has many ecotypes like 'Sirumalai' (grown on hills), 'Vannan', 'Kali' etc. well suited for cultivation in plains. Perennial system of cultivation aggravates Banana Bunchy Top Virus (BBTV).

**Pachanadan (AAB):** It is a popular variety in Tamil Nadu grown especially for its cooling effects in hot tracts in summer. Pachanadan could be used in the Nendran plantations for gap filling as it comes up for harvest along with

Nendran. This variety is tolerant to leaf spot and Banana Bunchy Top Virus (BBTV) diseases, but susceptible to wilt disease.

**Monthan (ABB):** It is a widely cultivated variety for processing. The new prolific 'Monthan' type clones of economic value namely 'Kanchi Vazhai' and 'Chakkia' are recently becoming popular in Tamil Nadu. It has many desirable qualities like immunity to Banana Bunchy Top Virus (BBTV) diseases, salt tolerance and normal bunch mass even under marginal condition, but it is highly susceptible to *Fusarium* wilt disease.

**Karpuravalli (ABB):** It is a popular variety grown for table purpose in medium rich soils. Karpuravalli is highly susceptible to wilt disease, tolerant to leaf spot disease and well suited for drought, salt affected areas and for low input conditions.

**Safed Velchi Musa (A B Group):**This is considered a good quality fruit for table purpose and is cultivated in the Thane, Nasik districts of Maharashtra. It is grown under the shade of arecanut gardens in the South Kanara districts of Karanataka.

**Gross Michel (AAA):-** It is susceptible to Panma wilt.

**Moongli:-** It is mutant of Nendran.

**Rajpuri:-** Resistant to cold.

**FHIA-01** (AAA):- This hybrid is hardy, semi-dwarf, apple-flavored dessert banana which is resistant to Panama disease, tolerant to Sigatoka leaf spots, and resistant to nematodes.

**FHIA-03(Hybrid):-** It is hardy, semi-dwarf, cooking banana which is resistant to black Sigatoka, Panama disease, and Moko disease, and is tolerant to nematodes.

**Bodles Altafort (AAA):-** Syntetic hybrid doveloped by cross between Gross Michal (AAA) x Pisanglin.

**Klue Teparoid (AABB):-** It is natural tetraploid.

**CO-1:-** It is developed by three way cross of Kellar Laden x Musa Balbasiana x Kadali.

- AAB, AAA clones are grown under irrigation condition.
- ABB clone are grown under rain fed condition like Monthan, Kanthali, Kunnan etc.
- AAA clone are susceptible to sigatoka leaf spot.

**Propagation:-** Banana is propagated by suckers and rhizome.

- **Sword suckers:-** Leaves are pointed, narrow & upright. Rhizome is conical with sound heart. Growth is vigorous & fast. Bearing is early (11 months.). Sword suckers are best for propagation.Suckers weight should be 750g for propagation.
- **Water suckers:-** Leaves are broader, spreading with roundish tip. Rhzome flat with non-sound heart. Growth slow. Bearing late (15 months.).
- **Tissue Culture:-** It is most popular method of propagation now a days.

**Planting of suckers:-** Sword suckers of 3-4 months old separated from mother rhizome & planted.

**Planting of Rhizome:-** Pseudo stem of sucker is completely removed from rhizome. Such rhizomes are stored under shade in cool & dry place for 2 months. The conical rhizomes with sound heart & few side buds are used for planting.

**Distance of Planting:**

- Tall varieties – 2.5 x 2.5 m
- Dwarf varieties – 1.8 x 1.8 or 1.2 x 1.2 m
- 31.6 tons of rhizomes i.e. 3000 numbers required per ha.

**Planting Season: -** 15 June to 15 July. If early planting, bunch will emerge during severe winter, which reduce the yield.

**Pit Size:-** 45x45x45cm

**Irrigation:-** Water requirement of banana varies according to topography, soil, climate, cultivar and type of culture. If there is no rain, the plants should be irrigated immediately after planting. Banana requires high amount of water ranging from 1800-2500 mm annually. The requirement is met either through well distributed rainfall or

through irrigation. Therefore, rainfall is an important aspect to be considered before growing bananas. Banana need plenty of water throughout the life.

- Summer 7-8 days interval
- Winter 10-12 days interval
- Totally 40-50 irrigations/year.

**Manures & fertilizers:-**

- Nutritional requirement is very high.
- **FYM** 10-15 kg/Plantat the time of filling the pits

| Time | **AS(N) (g)** | **SSP(P2O5)(g)** | **MP(K2O) (g)** |
|---|---|---|---|
| 3rd month | 350 (70) | 218 (35) | 140 (70) |
| 4rth month | 350 (70) | 218 (35) | 140 (70) |
| 5th month | 300 (60) | 189 (30) | 120 (60) |
| **Total** | **1000 (200)** | **625 (100)** | **400 (200)** |

- For more improvement 2 % urea can be sprayed.
- Two spray of $KH_2PO_4$ at fruit development stage increase the bunch weight.

**Weeding: -** Weed free condition is necessary to control pest and diseases.

**Desuckering:-** Suckers are produced from the rhizome of banana. The number of suckers produced per clump varies depending on cultivar, soil fertility, environment,etc. Removal of unwanted suckers is one of the most critical operations in banana cultivation and is known as desuckering. It is done either by cutting off the sucker or/and by use of 2-4, D on cut surface of suckers (2-3 drops of 10 ppm). Desuckering once in 45 days.

**Earthing up:-** During rainy season to give the support and to avoid water-logged condition.

**Propping:-** The lodging of banana plants particularly at mature stages results in heavy loss. The falling of the pseudostem may occur due to strong winds, rhizome rot, burrowing nematode or tall cultivar. There is no doubt that strong wind is one of the important limiting factors in banana production. Supporting with bamboo at bunch emergence period.

**Wrapping:-** Covering of bunches with plastic or dry leaves to protect from sunburn, hot wind, dust etc which improves colour of fruit.

**Removal of dried & decayed leaves:-** Pruning of surplus leaves is a common operation in banana production. Leaf removal helps to reduce the disease spreading through old and senescence leaves. The micro climate is changed by leaf pruning, especially light and temperature.

- For getting maximum yield a minimum of 10-12 leaves are required to be retain on the mother plant.

**Denavelling:-** Removal of male buds helps fruit development and increases bunch weight. Male buds are removed from the last 1-2 small hands with a clean cut keeping a single finger in the last hand.

**Mattocking:-** Mattocking is the operation of gradually removing the psuedostem of a parent plant of banana after the harvest of bunches during subsequent cultural operations; operation named after mattock, a combination of an axe and a hoe.

**Flowering & Fruit Development:-** Flowering starts after 6-8 months of planting. Inflorescence has hermaphrodite flowers. Edible banana are parthenocarpic, whereas wild are having seeds. Banana plant is monocarpic (having only one flower bud). Therefore, plant produce only onece in its life.

**Harvesting & Yield:-** The fruit is harvested when maturity sign was observed.

**Maturity Index:**

- Drying of leaves.
- Change of colour of fruit skin from deep green to light green.
- Ridges of the fruit turn round from angular.
- The dwarf varieties of bananas are ready for harvest within 11 to 14 months after planting. Tall varieties ready to harvest after 14-16 months.
- Main harvesting season is September to April.

**Yield:-** 35-60t/ha.

**Storage:-** Banana can be stored at a temperature slightly above 55°F (13°C) and with a relative humidity of 85 to 95 per cent for about three weeks.

**Ripening:-** Climacteric fruit. Must be ripened in store room.

(1) Smoke treatment

(2) Chemical treatment- 1000 ppm ethrel solution for five minutes and then keep it with ice (15 kg ice for 100 kg banana) for 48 hrs in airtight chamber for uniform ripening with better quality fruits.

**Insect-Pest**

- Rhizome weevil: *Cosmopolites sordidus*
- Hard scale: *Aspidiotus destructor*
- Pseudostem borer: *Odoiporus longicollis*
- Banana aphid: *Pentalonia nigronervosa f. typica*
- Tingid or Lace wing bug: *Stephanitis typicus*
- Fruit rust thrips: *Chaetanaphothrips signipennis*
- Castor hairy caterpillar: *Pericallia ricini*
- Cut worm: *Spodoptera litura*

**Diseases**

1. **Sigatoka Disease:-** It is a fungal disease caused by *Mycosphaerella musicola*. It is due to High Density Planting.

- Yellow Sigatoka: Worldwide in distribution
- First observed in Java in 1902
- Epidemic in 1913 in *Sigatoka* valley in Fiji
- In India, yellow sigatoka is a serious threat to banana production in the states of Assam, T.N, Karnataka and A.P.
- Black sigatoka is not prevalent in India.
- Susceptible cultivars like Grand Naine, Dwarf Cavendish and Giant Cavendish
- Moderately resistant cultivars like Karpura Chakkerakeli
- Planting at recommended density (1000 plants/acre)

2. **Panama disease or *Fusarium* wilt:-** It is a fungal disease caused by *Fusarium oxysporum f. sp. Cubense* .

- First reported from Australia in 1874
- Cultivars Rasthali (Amrutapani), Gros Michel, Karpooravalli cultivars are susceptible
- Resistant Cavendish varieties, *viz*., Basrai (Vamanakeli or Dwarf 120socrates), Poovan (Karpura chakkarakeli) etc.

3. **Moko disease or Bacterial wilt:-**It is caused by a bacterium, *Ralstonia (Pseudomonas) solanacearum* race 2.

- First recorded in Guyana in 1840 in *Moko* plantain.
- Resistant varieties :-Poovan and monthan

4. **Erwinia rhizome rot or Soft rot or Tip-over disease:-** It is fungal diseases causes by *Erwinia caratovora* sub.sp. *caratovora.*

- First recorded in Honduras on Gros Michel in 1949
- The disease has been reported on Nendran and Dwarf Cavendish banana in Kerala, Tamil Nadu, Karnataka and Gujarat.
- Growing susceptible cultivars like Cavendish and Tella chekkarakeli

5. **Bunchy top / Curly top / cabbage top /strangles disease:-** Bunchy top is a viral disease caused by the Banana bunchy top virus (BBTV).

- First reported from Fiji in 1889 in Cavendish varieties
- Around 1940, introduced into India from Srilanka through cyclone.
- Tetrazolium test for Bunchy top virus detection.

6. **Banana Mosaic / Infectious chlorosis / Heart rot**

7. **Banana bract mosaic:-** Bract mosaic is a viral disease caused by the Banana bract mosaic virus (BBrMV) and transmitted by aphids.

**Physiological disorder**

**Choke throat:-** It is due to low temperature affecting active growth of the plant.

**Chilling injury:-** Chilling occurs when pre-harvest or post-harvest temperatures fall below 14°C for various time periods.

**Kottaivazhai:-** It is a serious malady in Poovan variety of banana, reducing the production by 10-25%. It is due to imbalance of PGR. Application of 2,4- D 25ppm and GA 100ppm after the opening of last hand favours development of parthenocarpic fruit.

**Chlorosis:-** The most characteristic of the K deficiency symptoms is the yellowing of older leaf tips followed by inward leaf curling and death.

**Stunted growth:-** Usually, a K deficient banana plant will grow slowly and have a sturdy appearance due to the shortening of internodes.

**Bunch deformation:-** The banana bunches in K deficient plants are short, slim and deformed as a consequence of poor fruit filling caused by reduced photosynthesis and sugar transportation.

**Finger Tip:-** It is due to High Density Planting.

# Guava

**(Apple of Tropics, King of Tropical Fruits))**

**Botanical name:-***Psidium guajava*

**Family:-**Myrtaceae

**Origin:-** Mexico/Tropical America.

**Chromosome number:-** 2n=22.

**Type of fruits:-** Berry

**Type of inflorescence:-** Solitary

**Edible part:-** Thalamus and pericarp.

- It is self-pollinated crop.
- *Psidium cattleianum* (cattely or Chinese or strawberry Guava) which was the native product of Brazil. It‟s flesh was soft and white towards the centre and contained numerous hard seeds.
- *Psidium guineense* was a shrub or a small tree. The fruit was round and of greenish yellow in its colour.
- *Psidium friedrichsthalianum* (Coosta Rican Guava) was a tall tree. It is a wilt resistant species, and was used as a wilt resistant rootstock in the different parts of the world.
- *Psidium montanum*, was found on the mountains in Jamaica.
- Guava contribute 4.61% of total fruit production of India ($5^{th}$ in area and $4^{th}$ in production).
- India is leading country in guava production in world.
- Utter Pradesh is leading state in guava production in India.
- India, the Guava had been introduced by the Portugues in the early Seventeenth century.
- It was one of the most common and major fruits of India and was considered as the fifth most important fruit in respect of its area and production after banana, mango, citrus, and apple.
- Guava also known as “poor man’s fruit” or “apple of the tropics”.

- Guava and apple were found to be rich in anti-oxidants, which were intimately involved in the prevention of cellular damage which was the common reason for cancer, ageing and for a variety of degenerative diseases.
- A semi-dwarfing rootstock for guava is Aneuploid 82.
- Guava is good source of Vit-C (299mg/100g)
- Guava is also good source of pectin; which is useful in jelly making.
- Tree bending is practice in Maharashtra.
- Wintering is practice in East-India for Bahar treatment.
- South Indian farmer take Ambe bahar crop while North Indian farmer take Mrigh bahar crop.
- Spraying of 200ppm NAA for fruit thinning of guava.
- Take 10% for Allahabad Safeda and 20% for L-49 solution of urea for bahar treatment by foliar spray.

**Climate:-** Owing to its hardy nature, guava is grown successfully in tropical and subtropical regions up to 1, 500 m above mean sea-level. Best quality guavas are obtained where low night temperatures (10`C) prevail during winter season. 23-25$^{o}$C temperature is good for growth and handsome production. It tolerates high temperatures and drought conditions in North India during summers but it is susceptible to severe frost as it can kill the young plants. An annual rainfall of about 100 cm is sufficient during the rainy season (July- September). The rains during harvesting period, however, deteriorate the quality of fruits.

**Soil:-** Guava is cultivated on varied types of soils-heavy clay to very light sandy soils. Nevertheless, very good quality guavas are produced in river-basins. It tolerates a soil Ph of 4.5-8.2. Maximum concentration of its feeding roots is available up to 25cm soil depth. Thus the top soil should be quite rich to provide enough nutrients for accelerating new growth which bears fruits.

**Varieties**

- **Lucknow 49/L-49:-** Also known as Sardar. It is bronzing resistant variety.
- **A1lahabad Safeda:-** It can withstand drought condition. It is guava wilt resistant variety.
- **Chittldar:-** This variety is very popular in we stem Uttar Pradesh.
- **Harijha:-** Harijha is more popular in Bihar because of profuse bearing.
- **Hafshi:-** It is red fleshed guava having good taste.
- **Apple Colour:-** Its fruits are medium sized and pink coloured.
- **Saharanpur Seedless**
- **Nagpur Seedless**
- **Pusa Srijan:-** It is good for high density planting.
- **Arka Mridula:-** This is a seedling selection of variety Allahabad Safeda. It is seed less and dwarf variety.
- **Allahabad Surkha:-** Allahabad Surkha is an outstanding variety of large, uniform pink fruits with deep pink flesh.
- **Lalit:-** It isa new variety of Guava had been released by the CISH, Lucknow, for commercial cultivation. It is also good for Rajasthan climate.
- **Pant Prabhat** had been selected by the Department of Horticulture,GBPU&T, Pantnagar (Uttranchal).
- **Behat coconut:-** It is seedless variety.
- **Allahabad Round:-** Parthenocarpic variety.
- **Arka Amulya:-** It is hybrid variety cross between Arka Safeda x Seedless.
- **Hissar Surekha:-**
- **Shweta:-**
- **Baptla:-**

- **Arka Rashmi:-** It is pink flesh variety. It is from the cross Kamsari x Purple Local.
- **Arka Kiran :** It is from the cross Kamsari x Purple Local. The pulp is firm and deep pink in colour.
- **Kohir Safeda:-** Kohir x Allahabad Safeda.
- **Safed Jam:-** Allahabad Safeda x Kohir.
- **Hybrid-45:-** It is developed by cross between Allahabad Safeda x L-49

**Propagation:-** It is commercial propagated by Stooling. Air Layering also practices at commercial scale.

**Propagation Time:-** June-July.

**Planting Distance:-** 6-8 x 6-8 m (6x6m)

**Pit Size:-** 1x1x1m

**Method of Training:-** Modified leader system.

**Time of pruning:-** Feb-March.

**Manure and Fertilizer:-**

| Age of Tree (Years) | Farmyard manure (Kg/Plant) | Urea (gm/plant) | Superphosphate (Kg/plant) | Muriate of Potash (gm/plant) |
|---|---|---|---|---|
| 1–3 | 10–20 | 150–200 | 0.5–1.5 | 100–400 |
| 4–6 | 25–40 | 300–600 | 1.5–2.0 | 600–1000 |
| 7–10 | 40–50 | 750–1000 | 2.0–2.5 | 1100–1500 |
| 10 and above | 50 | 1000 | 2.5 | 1500 |

**Irrigation:-** The young guava plants required irrigation at weekly intervals during the summer months and 2 to 3 irrigations during the winter months.

**Harvesting:-** Guava is ready for harvest as soon as the deep green colour turns light and a yellowish green patch appears.

**Yield:-** 40-50kg/tree, 400-500 fruits/tree and 25-30t/ha.

**Storage:-** It can be storage at 9-10$^{o}$C temperature and 85% relative humidity for 3 weeks.

**Insect pests:**

- **Fruit fly:-** *Bactrocera correcta*
- **Fruit borer:-***Rapala varuna*
- **Bark eating caterpillar:-***Indarbela tetraonis*

**Diseases**

- **Guava wilt:-***Fusarium oxysporum f.sp. psidii*:- It is major diseases of guava.
- **Fruit rot:-***Phytophthora nicotianae*
- **Stem canker and dry fruit rot:-***Physalopara psidii*
- **Dieback and fruit rot:-***Colletotrichum psidii*

**Physiological disorder of Guava**

**Bronzing:-** It is due to Zn deficiency.

**Lime**

**BN:-***C. aurantifolium*
**Family:-** Rutaceae
**Origin:-** 18.
**Chromosome no**.:- 2n=18
**Type of fruit:-** Hesperidium
**Edible part** :- Juicy placenta heirs
**Type of pollination:-** Self-pollination (Homogemy)
**Rate of Respiration:-** Non climacteric
**Type of bearing habit:-** Mix bearing

**Climate:-** Lime and lemon trees are evergreen, grown in truly subtropical climates but it is also grow in tropical region. Best temperature for growth is 16-32$^{o}$C.

**Soil:-** Loamy soil with 6.5 to 7.5 Ph is good for luxuriance growth.

**Varieties:-**

- Pramalini : Canker tolerant, Cluster bearing.
- Vikram:-
- Chakradhar: Seedless variety of acid lime.
- PKM-1
- Sai sarbati :- Tolerant to tristiza and canker
- Jai devi :- Pleasant Aroma.
- Kagzi Nimbu:- It has thin peel. It is indicator plant of tristiza.
- Patti Nimbu
- Banarsi Nimbu
- Indore Seedless

**Propagation:-**

- **Acid and Sweet Lime:-** Both are commercially propagated by seed (Polyembryony).

**Time of propagation:-** June-July.

**Planting Time:-** June-July.

**Planting Distance:-** 6x6m.

**Pit Size:-** 75x75x75cm.

**Irrigation:-** In summer 15 days interval and 25 days interval in winter. During flowering season should not supply much irrigation.

**Harvesting Stage:-** The fruits mature in six months after flowering. In South India, about 60 per cent of the total crop is harvested during July to September, 30 percent from October to January and 10 percent from February to May.

In north India, the main harvesting seasons in the months of August-September.

**Yield:-** 1000-1200 fruits/tree or 50-75kg/tree.

- Acid lime is sensitive to citrus canker.
- Sweet lime is resistant to greening diseases.
- Gajnima is rootstock of lime.

**Storage:-** Limes and lemon can be stored for 6-8 weeks at 9-10$^{o}$C storage temperature with 80-90% RH. Limes are subjected to pitting after storage at temperature below 7°C. Waxing treatment further reduces moisture loss extends shelf life in all citrus fruits.

**Physiological disorder:-**

1. **Fruit Splitting:** It is due to moisture imbalance.
2. **Little leaf:-** it is due to Cu deficiency in citrus fruit and Zn deficiency in other fruits.
3. **Hard fruit:-** It is due to B deficiency.
4. **Leaf Mottling/Frenching:-** Due to Zn deficiency.
5. **Yellow leaf:-** Due to Zn deficiency.
6. **Granulation:-** Due to high humidity and high temperature.

**Diseases:-**

1. **Citrus Gummosis –(***Phytophthora spp.*) The symptoms appear as yellowing of leaves, followed by cracking of bark and profuse gumming on the surface.
2. **Citrus canker-** (Xanthomonas citri):- Three sprays of Streptocycline 100 ppm.
3. **Citrus Greening:-** It is transmitted by Citrus psylla
4. **Tristeza Virous:-**
5. **Greening of citrus:** This disease is spread through grafting and citrus psylla (Diaphorina citri)
6. **Die Back/ Xenthima/ Amonination:-** It is due to*Colletotrichum spp* fungus and Cu deficiency.

**Insect-Pest:-**

1. **Citrus thrips**
2. **Cirrus butterfly:-***Papilio demolious*
3. **Citrus aphids**
4. **Citrus leaf miner:**
5. **Citrus psylla** (*Diaphorina citri*):-Both nymphs and adults suck sap from the plants and injection of toxic saliva. It is transmits the "Greening" virus. Symptoms of damage
6. **Fruit sucking moth**: Both nymphs and adults suck the sap from the cells of tender branches and fruits.

# Grapes/Fruit of the vine

**Botanical name:-***Vitis vinifera* (It si natural cross of *V. 125socrat & V. labrusca)*
**Family:-** Vitaceae.
**Origin:-** Black to Caspian sea.
**Chromosome number:-** 2n=38.
**Type of fruits:-** Berry
**Type of inflorescence:-** Panicle
**Edible part:-** Placenta

- It is a deciduous crop. Its natural habitat is temperate climate.
- It was introduced into north India from Iran and Afghanistan in 1300 AD by the Muslim invaders; and into south India in 1832 by the Christian missionaries from France.

- However, grape was known in ancient India though it was not commercially cultivated until the 14th century.
- Wild grapes grown in Himachal Pradesh were used to prepare local wine.
- China is leading country in grapes area and production.
- India rank 8th in word for grapes production.
- Presently grape cultivation is concentrated in the peninsular India (surrounded Arabian Sea, Bay of Bangal & Indian Ocean), accounting for 90% of the total area.
- Major grape-growing states are Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and the north-western region covering Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan and Madhya Pradesh.
- Maharashtra is a leading state in production of grapes in the whole country.
- Vitis is a genus 126socrates, rarely evergreen, shrubby climber.
- Aroma (Muscat 126socra) in grapes is due to methyl anthranilate.
- Tartaric acid is commercially extracted from grapes.
- HD Olmo is a grape breeder (Delight and Perlette are developed by Olmo).
- TSS- 20-24$^{o}$Brix.
- Vitis contains about 60 species. Among these some popular species are:-
    - ✓ Fox grape (*Vitis valpinia*)
    - ✓ Frost grape (*Vitis labrusca*)
    - ✓ River bank grape (*Vitis riparia*)
    - ✓ Bird grape (*Vitis munsoniana*)
    - ✓ Bullace grape (*Vitis rotundifolia***)**
- Mostly it grown for making wines and preparation of raisin and then as a table fresh fruit. While in India, it is mainly grown for table use.
- **Viticulture/Viniculture:-** It is drive from two Latin word "Viti/Vini" means wine and "Cultura" means cultivation. It is branch of horticulture science in which deal study of cultivation and processing of horticulture crops.
- Oenology is the science and study of wine and winemaking; distinct from viticulture, the agricultural endeavours of vine-growing and of grape-harvesting. The English word oenology derives from the word oinos, "wine" and the suffix –logia "study of" from the Ancient Greek language.

**Climate:-** It is naturaly temperate reason crop. In its natural habitat, the vines grow and produce during the hot and dry period. Under South Indian conditions – vines produce vegetative growth during the period from April to September and then fruiting period from October to March. Temperatures above $10^{0}$C to $40^{0}$C (best temperature 28-32$^{o}$C) influence the yield and quality. High humidity and cloudy weather invite many fungal diseases, besides lowering the T.S.S. : Acid ratio.

**Soil:-** The grape is widely adopted to various soil conditions, but the yield and quality reach to the highest on good fertile soils have Ph 6.5 to 8.5, organic carbon above 1.0%, free of lime and having a medium water holding capacity. Early but medium yields with high T.S.S. are harvested on medium type of soils.

**Varieties:-**

- **Coloured Seeded:-** Bangalore Blue, Gulabi, Kishmish Chorni.
- **Coloured Seedless:-** Beauty Seedless, Sharad Seedless.
- **Green Seeded:-** Anab-A-Shahi, Dilkhush.
- **White Seedless:-** Perlette, Pusa Seedless, Tas-A-Ganesh, Sonnaka, Manik Chaman.

Suitable varieties for different grape growing regions

| Region | Varieties |
|---|---|
| Maharashtra, Northern Karnataka and Hyderabad | Thompson Seedless, Tas-A-Ganesh, Sonaka and Manik Chaman, A 17/3, Fantasy Seedless, Sharad Seedless, Crimson Seedless, Red Globe. |

| | |
|---|---|
| South Interior Karnataka | Thompson Seedless, Sonaka, Flame Seedless, Sharad Seedless, Crimson Seedless and Red Globe. |
| Tamil Nadu | Thompson Seedless, Gulabi, Bangalore Blue. |
| North India | Flame Seedless, Perlette and Beauty Seedless |

**Varieties Presently in Export:-**

- **Green Seedless:** Thompson Seedless, Tas-A-Ganesh, Sonaka, A 17/3
- **Coloured Seedless:** Flame Seedless, Sharad Seedless, Fantasy Seedless
- **Green Seeded:**- Italia
- **Coloured Seeded:**- Red Globe

**Raisin Making:-** Thompson Seedless, Sonaka, Tas-A-Ganesh. Manik Chaman, Arkavati, A 17-3, E 12/3, Mint Seedless, Superior Seedless, KR White, Manik Chaman, A 18-3, Cardinal, Sultan.

**Wine Processing:-**

- **White Wine Varieties:-** Sauvignon Blanc, Chenin Blanc, Ugni Blanc, Chardony, Clairette found promising and being utilized by commercial wineries in the country.
- **Red Wine Varieties:-** Cabernet Sauvignon , Shiraz, Merlot, Zinfendel, Pinot Noir.
- **Other Wine Varieties:-** Grenache, Convent Large Black, Carignane, Prince, Saperavi.
- Thompson Seedless variety with its clone occupies 55% area under grape cultivation.

**Propagation:-** Hard wood cutting is commercial propagation method. Chip budding also use at small scale as commercial level propagation. For hardwood cuttings, IBA, 1000 ppm treatment is useful for early, better and uniform rooting of cutting.

**Propagation Time:-** Usually planting is done from October onwards till January. Rarely planting is also done during June-July where the monsoon is late. Monsoon planting is avoided mainly for avoiding diseases on young growth.

**Rootstock:-**

- Dogridge- Resistant to nematode, salt, Phylloxera diseases.
- 1613:- Resistant to nematode and Phylloxera diseases.
- Salt Creek:- Resistant to nematode and salt.
- Temple:- Resistant to Pierce's diseases.
- Other:- Ramsey, 1616, 1103P, So4 etc.

**Planting Distance:-** 3x3m.

**Pit Size:-** 45x45x45cm.

**Planting Time:-** North India- Jan-Feb, South India:- Oct-January.

**Irrigation:-** Grape is strictly irrigated perennial crop and regularly irrigated. For flood irrigation, 5-7 days during summer 8-10 days during winter and 15-20 days during rainy season.

**Method of Training**

1. **Bower System:-** Owing to the high productive potential, bower was a very popular system of training in the past. It is highly suited for vigorous varieties like Anab-e-Shahi, Bangalore Blue and Gulabi. But in varieties like Thompson Seedless and Tas-A-Ganesh where vine vigour and excessive foliage density affects the productivity adversely, this system is not popular.
2. **Cordon/trellis:-** It is most common method in North India.
3. **Telephone System:-** T-trellis is used in this system of training. With three top wires and 'T' shaped supports, the trellis looks like a telephone pole and wires and hence the name. This system is followed for

moderately vigorous varieties like Thompson Seedless, Perlette and other seedless cultivars in about 25-30 percent of the vineyard area in Maharashtra. Yields in this system are less than the bower. In very hot and dry places, sunburn of the berries and of the arms are experienced in summer.

4. **Tatura trellis:-** A trellis system is described on which grapevines were planted at densities of 2222 and 4444 per hectare and trained in a 60° V shape with the permanent framework specially arranged for the vines to occupy their spaces quickly on a multiple wire trellis. The design, called the Tatura Trellis, has a canopy with a high population of shoots maintained with regular boundaries and affords good leaf exposure to solar radiation. It is costly method but production is higher than other.

**Time of pruning:-** January.

**Girdling:-** Vines are trunk girdled at bloom period to increase the fruit set, to increase the weight and T.S.S. and also to enhance maturity.

**Harvesting and yields:-** Normal grape harvest season starts in February and continuous up to end of April. Well matured bunches having at least 180 Brix are harvested

- Average yields – For seedless varieties – 20 to 30 t/ha/y
- For seeded varieties – 40 to 50 t/ha/y
- In North India take one crop in a year and in South India take two crop in a year.
- Harvested grapes are packed in 2 to 4 kg-corrugated boxes. Grape guards (use KMS in grape guards), pouches are kept inside the boxes for distant markets.
- Grapes are storage 6-8 weeks at 0-2$^{o}$C and 80-85% RH.

**Diseases**

- Powdery Mildew:- It is a fungal disease caused by *Palsamapora viticola*.
- Downey mildew:- It is fungal diseases causes by *Plasmopara viticola*.
- Anthracnose:- It is fungal diseases causes by *Elsinoe ampelina*.

**Insect-Pest:-**

- Stem girdler: *Sthenias grisator*
- Flea beetle: *Scelodonta strigicollis*
- Thrips: *Rhipiphorothrips cruentatus*
- Mealy bug: *Ferrisia virgata*
- Berry plume moth: *Oxyptilus regulus*

Physiological Disorder:-

1. **Water Berries:-** Water berry is associated with fruit ripening and most often begins to develop shortly after berry softening. The affected berries become watery, soft, and flabby when ripe. They shrivel and dry by the time of harvest. Such berries mostly confine to the tip of the main rachis or its branches.

   **Management:** Excessive irrigation and nitrogenous fertilizers should be avoided during berry development to reduce the water-berry formation.

2. **Shot Berries and Coloured Berry:-** They are formed due to delay in pollination and fertilization of a few flowers or due to inadequate flow of carbohydrates into the set berries. Boron deficiency, incorrect stages of GA application and girdling are the known reasons for shot-berry formation.
   **Management:-** Similarly application of GA at proper stage should be ensured. Boron deficiencies should be corrected.
3. **Pink Berry Formation:-** It is due to high temperature. It is a common disorder in Thompson Seedless and its clone Tas-A-Ganesh in Maharashtra.
4. **Uneven Ripening:-** Presence of green berries in a ripe bunch of coloured grapes is called uneven ripening. It is a varietal character and a problem in Bangalore Blue, Bangalore Purple, Beauty Seedless and Gulabi

grapes. Within a variety this problem varies from bunch-to-bunch. Generally inadequate leaf area, and non-availability of reserves to a developing bunch is the reason. Cultural practices like cluster thinning, girdling and use of growth regulators can reduce uneven ripening. Application of Ethephon (250ppm) at colourbreak stage is recommended to reduce the problem.

5. **Post harvest berry drop:-** This is due to weak pedicel attachment to the berries. This is common in Anab-e-Shahi, Cheema Sahebi and Beauty Seedless. Spraying of NAA (50ppm), a week prior to harvesting can minimize the post-harvest berry drop.
6. **Hen and Chicken Disorder:-** It is due to Boron deficiency.
7. **Millerandage:-** It is due to Boron deficiency.
8. **Calyx end rot:**- It is due to Ca deficiency.
9. **Berry or Blossom Drop:**- Improper pollination & fertilization.

# Apple

**Botanical name: -***Malus domestica*
**Family: -** Rosaceae
**Centre of Origin: -** South-Western Asia.
**Chromosome Number: -** 2n = 34
**Inflorescences Type: -** Cyme.
**Type of fruit: -** Pome.
**Edible portion: -** Fleshy thalamus (mid-fruit fever).
**Leading in India: -** Jammu and Kashmir, Himachal Pradesh
**Local name: -** King of temperate fruit, Symbol of health, Premier fruit of the world

- It is cross pollinated. Pollination is done by bee.
- China is leading country in apple production.
- Himachal Pradesh is known as bowl of apple in India.
- Jammu & Kashmir is leading state in apple production. Himachal Pradesh rank second in apple production.
- Apple is predominantly grown in Jammu and Kashmir, Himachal Pradesh and hills of Uttarakhand, accounting for about 90% of the total production. Its cultivation has also been extended to Arunachal Pradesh, Sikkim, Nagaland, and Meghalaya in north-eastern region and Nilgiri hills in Tamil Nadu. The agro-climatic conditions in these states are not as conducive as in north-western Himalayan region.
- The sub-family of apples is Pomoideae.
- Apple rank first in among temperate fruit production.
- India's 4$^{th}$ position in apple production in the world.
- Crab Apple has beautiful flower so it is utilized for beauty purpose, It is also good source of diseases resistance breeding and pollination agent.

**CLIMATE:-** Most of the apple varieties require 1000-1500 hours of chilling below 7$^0$C during winter to break the rest period. These conditions are available at an elevation of 1,500-2,700m above mean sea-level in the Himalayan ranges. By and large, the average summer temperature should be around 21°-24°C during active growth period. The areas with frost-free spring and adequate sunshine during summer without wide fluctuations in temperature are most suitable for apple cultivation. Low temperature, rains and cloudy weather, during flowering period hamper the bee activity, affecting cross pollination adversely. Areas exposed to high winds particularly the hill tops are also not suitable for its cultivation. Dry winds during summer desiccate flowers and hamper bee activity, resulting in poor fruit set inclement weather, particularly low temperature below 15°C during bloom restricts the bee activity which is completely inhibited below 4.4°C, affecting fruit set. Fully opened blossoms may be killed at temperatures below -2.2°C. The optimal temperature for pollen germination and fruit setting is 21.1-26.7°C.

Well-distributed rainfall of 100-125cm throughout the growing season is most favourable for its optimal growth and fruitfulness.

**Soil:-** Soil depth, drainage and Ph determine the suitability of soil type. Loamy soils, rich in organic matter having a Ph of 5.5-6.5 with gentle to moderate slope, proper drainage and good aeration are most suitable. The soil should

be free from hard substrata and waterlogged conditions. Where cultivation is done on flat soils, proper drainage channels need to be developed to restrict the incidence of collar- rot, root-rot and other soil-borne diseases.

**Varieties:-** Delicious apples have replaced the English ones. As a result of this phenomenal change, Delicious group occupies more than 83% of the total areas under apple in Himachal Pradesh, 15% in Jammu and Kashmir and 30% in Uttarakhand. In Jammu and Kashmir, the area under Ambri has decreased 1ess than 1% due to late-bearing of this variety, though the fruits are highly attractive with a long shelf-life.

**Recommended apple varieties in different states**

| | **Seasons** | **Himachal Pradesh** | **Jammu & Kashmir** | **Uttarakhand** |
|---|---|---|---|---|
| **1.** | Early Season | Tydeman's Early, Michael, Molies Delicious, Schlomit Starkrimson | Irish Peach, Benoni | Early Shanburry, Fenny, Benoni, Chaubattia Princess |
| **2.** | Mid Season | Starking Delicious, Red Delicious, Richared, Vance Delicious, Top Red Golden, Lord Lambourne, Red Chief, Oregon Spur, Redspur, Red Gold, | American Mother, Razakwar, Jpnathan, Cox's Orange Pippin, Red Gold, Queen's Apple, Rome Beauty, Scarlet Siberian, | Rea Delicious, Starking Delicious, McIntosh, Cortland Delicious |
| **3.** | Late Season | Golden Delicious, Yellow Newton, Winter Banana, Granny Smith, | King Pippin, American Apirouge, Kerry Pippin, Lal Ambri, Sunhari Chamure, Golden Delicious, Red Delicious, Ambri Baldwin, | Rymer, Buckingham (P) |

| | | | | |
|---|---|---|---|---|
| | | | Yellow Newton,<br><br>White Dotted Red | |

- **Propagation Method: -** Tongue grafting
- **Time of propagation: -** February-March
- **Planting Distance: -** 6x6m
- **Planting time: -** February-March.
- **Size of the pit: -** 1x1x1 m

**Root Stock:-** Generally rootstock is prepared by seed or clone.

(**Stratification:-** Apple seeds need stratification in moist sand at 4-7 ºC for 60-90 days. The water soaked seeds are placed between 2 and3 cm thick layers of moist sand in wooden boxes or polythene bags during December. The stratification boxes of bags are placed in cool place where the required chilling temperature of less than 7°C for l,000-l,500 hr is met in 60-90 days. The sand is kept moist during stratification. The stratification can be accomplished in the lower chamber of the refrigerator also. The stratification requirement is also met with in areas having very cool winters by direct sowing of seeds in nursery beds during November-December. The pre stratified seeds, as indicated by whitish tip at the micropylar end, are sown during February-March in well-developed, raised beds.)

| **Root Stock** | **Characteristic** | **Planting Distance** |
|---|---|---|
| M27 (Malling) (Similar to: P9) | Ultra dwarf | 1.2m (48") |
| M9 (Similar to: Pajam 2, Pajam 9, P2) | Dwarfing | 1.8-2.4m (6-8ft) |
| M26 | Dwarfing | 2.4-3m (8-10ft) |
| M6 | Semi Dwarfing | 3m (10ft) |
| MM106 (MaIling Merton) | Semi Dwarfing | 3-4m (10-13ft) |

**High Density Planting:-** There are 4 categories of high-density planting-low (less than 250 plants/hac), moderate (250-500 plants/ha), high (500-1,250 plants/ha) and ultra high density (more than 1,250 plants/ha). With the increase in planting density, the yield may increase, but beyond a threshold density, quality is deteriorated and may not be profitable in terms of economical returns, Super high-density plantings or meadow orcharding with a density of 20,000-70,000 plants/ha in some European countries have been raised but not commercialized so far.

**Manure and Fertilizer:-** In an orchard of optimal fertility, N, P and K may be applied in the ratio of 70:35:70g/year age of the tree. The dose should be stabilized (700:350:700g N:P:K/ tree) after 10 years of age. These applications may be supplemented with farmyard manure @10kg/year age of the tree with the maximum of 100 kg.

**Fruit drop:-** Most of commercial varieties experience 3 phases of fruit drop early drop. June drop and pre-harvest drop, the early drop considered natural, occurs due to lack of pollination and fruit competition. The June drop is

caused by moisture stress and environmental conditions which can be checked by maintaining soil moisture through irrigation or mulching. The pre-harvest drop causes serious economic losses, as the mature marketable fruits abscise before, harvesting due to reduction in levels of auxins or increase in ethylene levels in fruit. Early-ripening varieties like tydeman's Early, Red Gold and Pippins experience 40-60% drop, whereas in Delicious group loss occurs to the extent of 15-20% of crop load. Application of NAA (10ppm) before the expected fruit drop or 20-25 days before harvesting checks the pre-harvest fruit drop effectively.

**Irrigation: -** The time of April to August is most important for irrigation.

**Flowering time: -** Central April-mid May.

**Training Method:-** Modified leader system.

**Pruning time: -** February.

**Time of fruiting: -** After 100 -200 days of flowering, the fruits are ready to tumble. Apple is a climatic fruit.

**Yield: -** 8-13t / ha

**Storage: -** Apples stored for -1-8Oc temperature and 90-95% expected humidity for 4-8 months.

**Diseases**

| | |
|---|---|
| Apple scab | *Venturia inaequalis*<br>*Spilocaea pomi* [anamorph] |
| Blue mold | *Penicillium* spp. |
| Calyx-end rot | *Sclerotinia sclerotiorum* |
| Phytophthora fruit rot | *Phytophthora spp.* |
| Powdery mildew | *Podosphaera leucotricha* |
| Blister spot | *Pseudomonas syringae pv. Papulans* |
| Crown gall (Bacteria) | *Agrobacterium tumefaciens* |
| Fire blight (Bacteria) | *Erwinia amylovora* |
| Hairy root (Bacteria) | *Agrobacterium rhizogenes* |

**Insects**

- San Jose Scale
- Apple Maggot
- Apple Pandemis
- Codling Moth
- Cribrate Weevil
- Woody Apple Aphid
- Green Apple Aphid

**Physiological Disorder:-**

- Water Core:- It is due to B deficiency.
- Bitter Pit+Cracking:- It is due to Ca deficiency.
- Wither Tip:- It is due to Cu deficiency.
- Rossette leaves:- It is due to Zn deficiency
- .Interveinal chlorosis:- It is due to Mg deficiency.
- Scald:- Due to high temperature during storage.

# Pomegranate

**Botanical name:-***Punica granatum*
**Family:-** Punicaceae
**Origin:-** Iran
**Chromosome number:-** 2n=18
**Type of fruits:-** Balusta.
**Type of inflorescence:-** Hypanthodium
**Edible part:-** Juicy Seed Coat.
**Introduction**

- India has occupied first position in the world with respect to pomegranate area and production.
- Maharashtra is leading state in pomegranate production in India.
- Fruit cracking is common in Mrigh Bahar and such bahar fruits are also more prone by insect-pest and diseases.
- South Indian farmer take production from Ambe Bahar.
- Rajasthan farmer take production from Mrigh Bahar because low rainfall and water stress.
- Hast Bahar fruits demand is higher than other so Jodhpur farmer take production from Hast Bahar and quality of Hast bahar fruit are also better.
- National Research Centre on Pomegranate, Solapur, Maharashtra.
- Pomegranate is considered to be highly drought tolerant.
- Juice of pomegranate is useful for patient suffering from leprosy.
- Bark and rind of fruit are commonly used in the therapeutics in dysentery and 133socrate.
- Heterostyly- hermaphrodite (pin) and male flowers (thrumb)
- Punica granatum has been classified in to two sub species, namely *chlorocarpa* and *porphyrocarpa*. *Chlorocarpa* is found in Transcaucacus region and *porphyrocarpa* in central Asia.
- Pomegranate contains calcium, phosphorous, iron and other mineral as well as 'B' and 'C' vitamins.
- Edible portion:- 68%.

**Climate:-** Pomegranate plant has a versatile adaptability to wide range of climatic conditions. It grows best in semi-arid climate, where cool winter, hot and dry summer prevail. In areas of low temperature, the tree is deciduous but in tropical and sub-tropical conditions it is evergreen or partially deciduous. (Sham Singh, et.al 1967). Pomegranate tree requires hot and dry climate having the range of temperature of 38°C during the period of fruit development and ripening. It cannot produce sweet fruits, unless the temperature is high for long period. The quality of fruit is adversely affected in humid climate. It flowers well in clear, dry weather, bright sunshine. Availability of these ideal climatic conditions promote shining, attractive red colour of rind as well as to seeds (aril), fair size of fruit, sweet test and overall best quality.

Pomegranate is winter-hardy, and drought tolerant plant and can thrive under desert conditions but bears well only under irrigation,

**Soil:-** The pomegranate is not very particular about its soil requirement and can be grown on diverse types of soil. The tree gives very good yield in deep loamy soil or alluvial soil with 6.5 to 9.0 Ph, it can tolerate soils which are limy and slightly alkaline. It can also be grown in medium or light black soils of at least 60cm deep.

**Verities:-**

**Ganesh:-** This variety is developed by selection method (selction from Alandi). It is the commercial cultivar of Maharashtra. Developed by Dr. Cheema at Pune.

**Alandi or Vadki:-** The fruit size is medium, blood red or deep pink with sweet acidic taste with hard seeds. It is the commercial cultivar of Maharashtra.

**Dholka:-** Fruits large, rind yellowish red with pinkish white aril. It is a popular cultivar of Gujarat.

**Jodhpuri Red:-** It's give more yield in water stress condition.

**Jalore Seedless:-** It is tolerate to saline and alkaline soil.

**Mridula:-** It is soft seeded variety. It is developed by cross between Ganesh x Gul-a-Shah Red.

**Arakta:-** The fruits are smaller than Ganesh variety having dark red coloured arils with soft seeds.

**Phule Arakta:-** Released from by MPKV, Rahuri.
**Bhagwa:-** Also known as Shendria or Sinduri, Astagandha and Kesar. This is a selection from $F_2$ population of the cross Ganesh x Gulesha Red. It is soft seeded variety. It is the commercial cultivar of Maharashtra. It is grow in Barmer district of Rajasthan.
**Paper Shelled:-** The fruit size is medium with pink aril of good quality, thin peel, seeds are soft.
**Ruby:-** This variety is developed at IIHR, Bangalore. It is developed by tree way cross among Ganesh x Kabul x Yercaud.
**Co 1:-** Soft seeded variety.
**Amalidana:-** It is cross between Ganesh x Nanha.
**IIHR selection:-** It is a selection from the open pollinated seedlings.
**Jyoti:-** It is developed by cross between Bassein Seedless x Dholka.
**P23:-** Seedling selection from a traditional Muskat seedling.
**P26:-** A seedling selection of Muskat.
**Other Varieties:-** Ankali, Bedana, Bassein seed, Country Large Red, Chowla, G-137, G-133, Jodhpuri White, Jodhpuri Seedless, Ko-1, Kolhari, Muskat Red, Madhuriji, Muskat, Nabha, Parkumel, P-16, P-13, P-23, Vet lodue, Vadki. Spanish Ruby, Yercaud 1, Kabul, Kandhari, Rudra.

**Propagation:-** Hard Wood Cutting

**Propagation Time:-** July-August

**Planting Distance:-** 5-6x5-6m (5x5m)

**Pit Size:-** 50x50x50cm.

**Planting Time:-** Monsoon.

**Training Method:-** Multiple stem training.

**Pruning Time:-** February

**Irrigation:-**

- In summer season:- 7-10days interval.
- In winter season:- 15-20days interval..
- Imbalance of irrigation lead to fruit cracking.

**Mauring and fertilizers:-** Well rotten FYM is applied to pomegranate plants at the rate of about 20kg per tree while planting. After this, about 20kg of FYM is given to each plant every year at the break of Monsoon. Application of small quantity of ammonium sulphate is also recommended.

Bearing orchards should be given 500gm N, 250gm $P_2O_5$ and 250gm $K_2O$/per plant,as it has been found adequate for 4-6 years old bearing trees for economic yield.

**Harvesting:-** The fruits are ready for harvest after 5-7 months after blossom. When skin turns slightly yellow, fruits gives a metallic sound when tapped, the fruits are harvested. Each tree bears about 100 fruits and continues to give economical crop upto 25-30 years.

**Yield:-** 60-120kg/ha or 40-60kg/tree or 20-25t/ha.

**Storage:-** It can be storage 6-7 weeks at 4.5$^{o}$C temperature and 80-85% RH.

**Insect pests:**

- Fruit borer or pomegranate butter fly (*Virochola 135socrates*):
- Bark eating catter pillar (*Inderbela tetraonis*):
- Stem borer(*Aleurodes sp*):
- Mealy bugs (*Drosicha mangiferae*)
- Scale insects (*Saissetia nigra*)
- Aphids (Aphis punicae)

**Diseases:-**

- Leaf Spot: [*Xanthomonas punicae* (Bacteria), *Colletotrichum gloeosporioides* (Fungus)]:- The disease is caused by both bacteria and fungus.
- Fruit Rot (Phomopsis sp):
- Wilt (*Fusarium, Rhizoctonia,* Nematodes): Wilt in pomegranate is caused due to fungi and nematode.

## (2) Introduction, distribution and economic importance of Vegetables – Potato, Tomato, Cauliflower, Cabbage, Spinach, Brinjal, Bottle gourd, Pumpkin, Cucumber.

# Potato

**(Poor man's Vegetable, Poor man's friend)**

**Botanical name:-***Solanum tuberosum.* **Family:-** Solanaceae.

**Origin:-** Peru (South America/Tropical America).

**Chromosome number:-** 2n=4x=48 (autotetraploid).

**Usable Part:-** Tuber (Modified Stem). **Inflorescences type:-** Cymose.

**Type of fruit:-** Berry. **Carbohydrate:-** 22.6%.

**Protein:-** 2.5%. **Fibbers:-** 2.2%.

**Fat:-** 1.14% **Vit-C:-** 17mg/100gm.

**Potassium:-** 568mg/100g.

**Introduction**

- Potato is a native of South America. In India, potato has been cultivated since its introduction in early part of 17 $^{th}$ century by Portuguese.
- Potato popularly known as 'The king of vegetables', has emerged as fourth most important food crop in India after rice, wheat and maize.
- India is the third largest producer of Potato (first China).
- Uttar Pradesh is leading state of potato production in India.
- Dholpur is leading district of potato production in Rajasthan.
- Potato is grown in more than 100 countries
- In India potato is grown in all state except Kerala.
- Potato is self-pollinated crop.

- Stem of potato is known as Hulm.
- Central Potato Research Institute is situated in Kufri, Solan, Himachal Pradesh.
- International Potato Center, Lima, Peru was established in 1971.
- It is a cash crop.
- It is a $C_3$ and Short Day Plant.
- Lysine amino acid is found in potato tuber.
- Potato is biannual in nature.
- Aroma in potato is due to di-methyl pyrazine.
- Thiourea is used for breaking dormancy of potato.
- If tuber expose to sunlight when tuber turn in green colour due to solanin synthesis. 5mg/100g solanin is normal if it is greater than 20 mg/100g it is unfit for consumption.

**Climate:-** Potato is basically a cool season crop. It is grown in winter in plains of India. However, in northern hills, it is grown as summer season crop. About 20°C temperature is good for tuber formation and it reduces as the temperature increases. Tuberization is badly affected at about 30°C temperature. It grows best under long day conditions sunshine along with cooler nights are essential for reducing the spread of diseases.

**Soil:-** Potato can be produced on a wide range of soils, ranging from sandy loam, silt loam, loam and clay soil. Well- drained sandy loam and medium loam soils are most suitable for potato cultivation. Light soil is preferred, because they tend to promote more uniform soil temperatures and make harvesting of the crop easier. Alkaline or saline soil is not suitable for potato cultivation. They are well suited to acidic soils (pH 5.0 to 6.5) as acidic conditions tend to limit scab disease.

## Varieties

| **Varieties** | **Resistant** |
|---|---|
| **Early-maturing (**Early varieties are ready for harvesting in 75-100 days after planting**)** | |
| Kufri Chandramukhi | It is a derivative of the cross S.4485 × Kufri Kuber and released in 1967. Moderately Resistant to late & early blight |
| Kufri Ashoka | EM/C-l 020 × Allerfi'uii lleste Gelbe |
| Kufri Alankar | It is a derivatives of the cross (Kennebee × O.N .2090) × (Majestic × Ekishiraju), released in 1968. |
| Kufri Kuber | Resistant to black scurf. |
| Kufri Navjot | |
| Kufri Luvkar | It is a derivative of cross Serkoy × Adina released in 1973.Warmer climate variety |
| **Medium-Maturing (**Mid-varieties are ready for harvesting in 100-105 days after planting**)** | |
| Kufri Chipsona-2 | It is a derivative of F-6 x QB/B-92-4 and released from CPRI, Shimla in 1998. Late blight & excellent for chip making. Frost tolerant. |
| Kufri Badshah | It is a cross of Kufri Jyoti and Kufri Alankar and released in 1980. Cyst nematode, Virus, Late and early blight resistant |
| Kufri Pukhraj | It is a wider adaptable variety and a cross of Craig's Defiance × JEX/B-687, which released in 1998 from CPRI, Shimla. Resistant to Early blight and moderately resistant late blight. |
| Kufri Jyoti | It is a derivative of the cross 3069d (4) × 2814 Q (1) and released in 1968. Resistant to Late and early blights & tolerant to viruses |
| Kufri Kundan | Resistant to Late blight |

| | |
|---|---|
| Kufri Sheetman | It is a derivative of the cross Craig Defiance x Phulwa, released in 1968. Resistant to frost. |
| Kufri Jawahar | It is a derivative of Kufri Neelamani x Kufri Jyoti and released in 1996. Late blight and ideal for intercropping |
| Kufri Bahar | It is a derivative of the cross Kufri Red x Ginek and released in 1980. |
| Kufri Lalima | It is a fast bulking variety and a derivative of the cross Kufri Red x CP 1362, which released in 1982. |
| Kufri Swarna | It is a cross of Kufri Jyoti x (VIn) 2 (62.33.3) and released in tile year of 1985 from CPRI, Shimla. Cyst nematode, and Late blight resistant |
| Kufri Sutlej | It is a derivative of Kufri Bahar × Kufri Alankar and released in 1996 from CPRI, Shimla. |
| Kufri Giriraj | It is north and south India adaptable variety. It is a cross of SLB/1-132 x EX/A 680-16 and released from CPRI, Shimla in 1998. |
| Kufri Pukhraj | Resistant to early blight. |
| Kufri Chipsona | It is a cross of MEX.750826 × MS/78- 79 and released from CPRI, Shimla in 1998. Excellent for chip making. |
| Kufri Muthu | It is a derivative of the cross 3046(1) × M-l09-C and released in 1971. |
| **Late-Maturing (**Late varieties are ready for harvesting in 120-130 days after planting**)** | |
| Kufri Kumar | Resistant to Late blight |
| Kufri Chamatkar | A derivative of the cross Ekishiraju × Phulwa and released in 1967. Resistant to Early blight |
| Kufri Sindhuri | It is derivative of the cross Kufri Kundan × Kufri Red and in 1966. Resistant to Early blight. |
| Kufri Dewa | It is a derivative of the cross Craigs Defiance × Phulwa and released in-1973. Resistant to frost |
| Kufri Jeevan | It is a derivative of the cross M-I09-3 × D 698 and adopted for northwest hills. |
| Kufri Megha | |

## Introduced Varieties:-

- **Up to Date:-** Import from Ireland

**Clonal Selection Varieties:-** Kufri Red, Red Round, Kufri Safed.

**Propagation Method:-**By Tuber.

**Seed Rate:-** 25-30qt/ha (Each tuber weight should be 40g and diameter should be 2.5-3.5 cm).

**Planting Distance:-** 60x25 or 50x20cm.

**Planting Time:-**

- **In Plains**
  - ✓ **Early Crop:** Third week of September to first week of October.
  - ✓ **Main Crop:** First week of October to third week of October.
  - ✓ **Late Crop:** Third week of October to first week of November
- **In Hills:-** Potato is planted in hills from the third week of February to second week of April.

**Potato is planted mainly by two methods:**

1. Ridge and Furrow Method,
2. Flat Bed Method.

**Manuring & Fertilizers:-**

- FYM:- 20-25 t/ha.
- N:- 150kg/ha.
- $P_2O_5$:- 60-80kg/ha.
- $K_2O$:- 80-120kg/ha.

**Irrigation:-** Potato needs irrigation at frequent intervals, depending upon the soil and climatic conditions. Usually 6 irrigation is sufficient. Pre-sowing irrigation followed by 5-6 light irrigations. Water Requirement is 350-550mm.

**Weed Control:-** The weed control in potato crop is normally done by manual labour. Weeds can be controlled indirectly by crop rotation and stubble cleaning. Earthing up also helps in weed control. Alachlor (Lasso) may also be used as pre-emergence herbicide.

**Earthing Up:-** Earthing should be done when the plants are 15 to 22 cm in height. Generally earthing is done at the time of top dressing of nitrogenous fertilizers. The ridges should be high enough to cover up tubers. If necessary, a second earthing may be done after two -week of the first one. A mould board plough or a ridger may be used for earthing up in large area. Earthing up control to greening of potato.

**Harvesting:-** Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out. Harvesting is done by potato digger.

**Curing:-** After harvesting tuber should be exposed in sun light for 2-3 days for development of protective layer.

**Yield:-**

- Early Varieties:- 200-250qt/ha.
- Mid or Late varieties: - 300-400qt/ha.

**Storage:-** Potato are stored at 2.2 to 3.3 degree Celsius and 75-80% RH for 34 weeks.

**Insect-Pest:-**

1. **Colorado potato beetle** (*Leptinotarsa decemlineata*):- It is a serious pest with strong resistance to insecticides.
2. **Potato tuber moth**:- It is a most common pest*Phthorimaea operculella*, and is the most damaging pest of planted and stored potatoes in warm, dry areas.
3. **Leafminer fly** (*Liriomyza huidobrensis*):- A South American native common in areas where insecticides are used intensively.
4. **Cyst nematodes** (*Globodera pallida* and *G. rostochiensis*): It is a serious soil pests in temperate regions, the Andes and other highland areas

**Diseases:-**

- **Late blight:-** *Phytophthora infestans:-* Irish famine (1845-46) is due to such disease.
- **Black Leg -***Erwinia carotovora* (Bacteria)
- **Dry rot -***Fusarium coeruleum*
- **Brown rot -***Ralstonia solanacearum*
- **Potato wart -***Synchytrium endobioticum*
- **Scab -***Streptomyces Scabies*
- **Sclerotium rot -***Sclerotium rolfsii*
- **Silver scurf -***Spondyocladium atrovirens*
- **Charcoal rot -***Macrophomina phaseolina*

**Physiological Disorder**

- **Internal Brown Spot:-** Appears particularly in light sandy soil which are not irrigated regularly. Craig's variety more prone to such disorder.

- **Black Heart:-** It is storage disorder due to lack of $O_2$ and high temperature at storage condition.
- **Hollow Heart:-** It is due to excess of $N_2$.
- **Chilling Injury:-** It is due to low temperature.
- **Greening:-** It is due to expose of tuber to sunlight.

**True Potato Seed (TPS):-**

True Potato Seed (TPS) is the actual botanical seed produced by the potato plant (*Solanum tuberosum*). This technique is developed by Dr. S. Ramanujan, the founder director of CPRI. About 100-120g TPS is enough to raise a seedling crop or if the commercial crop is to be produced using seedling crop or if the commercial crop is to be produce of 40-45g True Potato Seed is enough to plant one hectare crop.

**Seed Plot Technique:-** It is a technique in which prepared virus free plant. This technique is developed by Dr. Pushkar Nath. In this technique potato seed harvest before population of aphid reaches 20 Aphid/plant.

# Tomato

## (No. one processing vegetable, Wolf Apple, Vilayati Brinjal)

**Botanical name:-** *Lycopersicon esculentum.* **Family:-** Solanaceae.

**Origin:-** Peru (South America/Tropical America). **Chromosome number:-** 2n=24.

**Type of fruit:-** Berry. **Type of inflorescence:-** Truss.

- India ranks 2rd in tomato production (First-China).
- Bangalore region of Karnataka and Pune region of Maharashtra are famous for quality tomato production.
- Jalore is a leading district in tomato production in Rajasthan.
- Highest processing is done in tomato from all vegetables.
- Tomato is a Day Neutral Plant and $C_3$ plant.
- Clastogamy is found in tomato.
- Tomato is a good source of Vit-C and Vit-D.
- Tomato is used as a fresh fruit, Salad, Vegetable, Ketchup, Sauce, Puree, Peat and Soup making.
- Tomato is Zn loving plant.
- First hybrid variety of tomato is Karnataka.

**Classification of tomato:-**

1. **Determinate tomatoes:-** Determinate tomatoes, or "bush" tomatoes, are varieties that grow to a compact height (generally 3 - 4'). Determinates stop growing when fruit sets on the top bud. All the tomatoes from the plant ripen at approximately the same time (usually over period of 1- 2 weeks). They require a limited amount of staking for support and are perfectly suited for container planting. It is mostly cultivated in open field cultivation. E.g.-

| Variety | Characteristics |
|---|---|
| ARTH 3 | Suitable for table purpose. |
| Avinash 2 | Suitable for processing; tolerant to TLCV. |
| Co 3 | A mutant of Co 1 |
| HS 101 | Suitable for winter season for northern India; tolerant to tomato leaf-curl virus. |
| HS 102 | |
| HS 110 | |
| Hisar Anmol | Resistant to tomato leaf-curl virus |
| Hisar Arun | Extremely early and very high-yielding variety |
| Hisar Lalima | An early variety |

| | |
|---|---|
| Krishna | An early-maturing |
| KS 2 | |
| Matri | Suitable for processing. |
| NA 601 | Suitable for distant transportation. |
| Naveen | An early, plants resistant to *Fusarium* and *Verticillium* wilts; hybrid widely adopted. |
| Punjab Chhuhara | Suitable for transportation and processing |
| Pusa Early Dwarf | Early ripening; suitable for autumn season. |
| Pusa Gaurav | Excellent for processing and suitable for long distant transportation. |
| Pusa Hybrid 1 | Suitable for high temperature area |
| Pusa Hybrid 2 | An early variety |
| Pusa Sadabahar | Suitable for summer and winter season. |
| Rajni | A very early, hybrid, resistant to *Fusarium* and *Verticillium* wilt. |
| Rashmi | Ideally adopted for hot and dry climate. |
| Ratna | |
| Roma | Suitable for transportation and processing. |
| Rupali | It can be grown in hot and dry weather. |
| Pusa Rohini | Suitable for long distance transportation. |
| Italian Red Pear | |
| La Bonita | Suitable for long distance transportation. |
| S-12 | |
| Pusa Hybrid-4 | Tolerant to root knot nematode. |
| Pusa Hybrid-8 | |
| Pusa Red Plum | It has been evolved at the IARI by a cross between a cultivated tomato and the wild *L. pimpinellifolium*. It is an early variety suitable for table use. It has high vitamin C and sugar content. |
| Sioux | It is a high yielding American variety, Suitable for short distance market. |
| S-152 | Variety is released by IARI, New Delhi. Suitable for canning purpose. |
| Arka Alok (BER - 5) | Hybrid variety released by IIHR, Bangalore. Resistant to bacterial wilt. |
| Arka Ashish | Developed at IIHR, Bangalore. It is tolerant to powdery mildew. |
| Kashi Vishesh | |
| Kashi Amrit | |
| Kashi Hemant | |
| Kashi Sharad | |
| Sel-120 and Sel-152 | Both are a heavy yielder and resistant to nematode. |
| Vaishali | The variety is suitable for growing in hot and humid weather conditions. Variety is resistant to Fusarium and *Verticillium* wilts. Suitable for tomato juice preparation. |

2. **Indeterminate tomatoes:-** Indeterminate tomatoes will grow and produce fruit until killed by frost. They can reach heights of up to 12 feet although 6 feet is normal. Indeterminate will bloom, set new fruit

and ripen fruit all at the same time throughout the season. They require substantial staking for support. It grows in polyhouse and green house.

| Variety | Characteristics |
|---|---|
| Arka Vikas | A selection from a variable population of American tomato Tip Top. Tolerant to heat and moisture stress. |
| Arka Abhijit (BRH 2) | Resistance to bacterial wilt. |
| Arka Vardan (FM Hybrid-2) | It is resistant to nematodes and is suited for fresh market. |
| Arka Vishal (FM Hybrid-1) | |
| ARTH 4 | |
| BSS 90 | An early, resistant to bacterial wilt. |
| ARTH 4 | |
| BSS 90 | An early, resistant to bacterial wilt. |
| Pant Bahar | |
| Pusa Divya | It is only variety till now developed by utilizing male sterile lines. |
| Pusa Ruby | An early variety, suitable both for rainy and spring seasons. |
| Pusa Uphar | Suitable for processing. |
| Pusa Ruby | |

**Semi-determinate**

| Variety | Characteristics |
|---|---|
| Arka Abha (BWR 1) | Resistant to bacterial wilt, suitable for both kharif and rabi seasons. |
| Arka Saurabh (Sel - 4) | Suitable for table purpose & Sauce and Ketchup processing. |
| Arka Ahuti (Sel 11) | |
| Arka Meghali | Suitable for high rainfall area. |
| Arka Shresta | Resistant to bacterial wilt and suitable for rabi season. |
| Hisar Lalit | Resistant to root-knot nematode. |
| MTH 6 | |
| Pusa 120 | Resistant to root-knot nematode. |
| Pusa Sheetal | Suitable for fruit set at low temperature. |
| Pant Bahar | |

**Introduced varieties:-** Roma, Sious, Best of All, Tip Top, Labonita, Marvel, Monkey Market, Agethe, Marglobe, Keckruth- All are introduced form USA.

**Climatic Requirement:-** The tomato is a warm-season crop. The crop does well under an average monthly temperature of 21$^{o}$C to 25$^{o}$C. Maximum lycopene developed at 20-24$^{o}$C. After 27$^{o}$C temperature lycopene synthesize minimize and totally lycopene synthesize check at 40$^{o}$C. It is sensitive to frost.

**Soils:-** The tomato grows on practically all soils from light sandy to heavy clay. Tomatoes do best in a soil that has a soil reaction from pH 6.0 to 7.0.

**Seed rate:-** For raising the seedlings in nursery bed 400 - 500 g/ha seeds are required while only 125-150g/ha hybrid seeds are required.

**Nursery area requirement for one hectare planting:-** 100-125$m^2$

**Time of planting:-** Tomato is a day neutral plant, it can grow in any season. In the northern plains three crops are taken but in frost affected area rabi crop is not fruitful. The kharif crop is transplanted in July, rabi crop in October - November and zaid crop in February months.

- Seed treatment:- To avoid damping off disease treat the seed with Captan or Thiram @ 2-3 g/Kg seed.
- Test weight of Tomato seed is 3.3g.

**Manuring & Fertilizers:-**

- FYM:- 20-25 t/ha
- N:- 100kg/ha
- $P_2O_5$:- 60kg/ha
- $K_2O$:- 60kg/ha

**Spacing:-** 75 x 60 cm and 75 x 45 cm.

**Irrigation:-** During summer season, irrigation at every 5 to 7 days interval is necessary, whereas in winter 10 to 15 days interval is sufficient.

**Weed control:-** About 2–3 hoeings are essential at the initial stage of plant growth. For chemical control, application of Fluchloralin and Pendimethalin @ 1kg per ha is effective.

**Staking:-** Staking is essential for semi-determinate and determinate type variety.

**Harvesting Stage:-** Tomatoes are harvested at several stages:-

1. **Mature Green Stage:-** At this stage, tomato harvest for early availability in market. It gain high price in market because of less availability of tomato.
2. **Turning stage:-** At this stage tomato harvest for distant marketing.
3. **Pink Stage:-** At this stage tomato harvest for local marketing.
4. **Ripe Stage:-** At this stage tomato harvest for salad or fresh eating purpose.
5. **Over Ripe Stage:-** At this stage tomato harvest for processing purpose.

**Yield:-**

- Local Varieties:- 300-350q/ha
- Hybrid Varieties:- 500-6000q/ha

**Insects**

1. **Gram pod borer:-** *Heliothis armigera*
2. **Serpentine leaf miner**
3. **Tobacco caterpillar**
4. **White fly**
5. **Aphid**
6. **Thrips**

**Diseases:-**

1. **Root-Knot Nematode** (*Meloidogyne spp.*)
2. **Bacterial Wilt** (*Pseudomonas solanacearum)*
3. **Damping off** (*Pythium aphanidermatum*)
4. **Early Blight** (*Alternaria solani)*
5. **Wilt** (*Fusarium oxysporum*)
6. **Late blight:-** It is caused by *Phytophthora infestans*, a fungal disease most famous for the Irish potato famine. It is a serious disease of tomato causing dark green to purple-brown water-soaked spots that grow quickly on leaves and stems.
7. **Tomato Mosaic/Tobacco mosaic virus, Cucumber mosaic virus:-** It is transmitted by Seed.
8. **Tomato spotted wilt virus (TSWV):-** It is transmitted by thrips.

9. **Leaf curl virus:-** It is transmitted by White Fly.
10. **Fern leaf virus:-** It is transmitted by Aphid.
11. **Big bud disease of tomato:-** It is due to mycoplasma and is transmitted by leaf hopper.

# Cole Crops

## Cauliflower

**S.N:-** *B. oleracea var. botrytis.* **Family: –** Cruciferae/Brassicaceae.

**Origin:-**Mediterranean Region. **Chromosome No. (2n)** = 18.

- Cole crops are cross pollinated crops.
- Pollination is generally by Honey Bee.
- The edible portion:- Curd (Flower).
- The term cauliflower is derived from two Latin words "caulis" means cabbage and "floris" means flower.
- Cauliflower was introduced in India in 1822 from England by Dr. Jamson, Incharge of Company Bagh Saharanpur, UP from Kew Botanical garden.
- India is leading producer of cauliflower production in world.
- WB is leading producer of cauliflower production in India.
- Cauliflower is good source of vitamin-A & C.
- Sinigrin is a poisonous compound found in all cole crops.
- Aroma in cole crops is due to sulphur compounds.

**Climate:-** It is a cool season vegetable. Climatic factors particularly temperature plays important role during transformation from vegetative to curding & curd development & from curd to bolting (emergence of flower stalks) & flowering. The temperature range for curding in:-

- A tropical variety (early/Indian varieties) is 20 – 27$^{o}$C.
- A temperate variety (mid season) is 12 – 16$^{o}$C.
- A temperate variety (late season) is 10 – 12$^{o}$C.
- The adaptability of tropical varieties is from higher to lower temp. Whereas that of temperate varieties is from lower to higher temp.

**Soil:-** It can be grown in all type of soil but soil with high OM, high fertility & good drainage is preferred. Optimum pH is 6 – 6.5.

**Varieties:-**

Cauliflower varieties are very sensitive to season. So, cauliflower varieties are categorized into 3 major groups:-

**Early cauliflower (Harvesting Time- Sep-Oct):-** Pusa Deepali, Pusa Katki, Early Kunwari, Early Patna, Pusa Early Synthetic, Pant Gobhi-3, Improved Japanese, Pant Gobhi-2.

**Mid-season varieties (Harvesting Time- Nov-Dec):-** Pusa Aghani, Poosi, Patna main crop, Early snowball, Ktm local, Japanese Improved, Pusa Subra, Pant Shubra, Pusa Himjyoti, Pant Gobhi-4, Pusa Synthetic, Hisar-1, D-86, IIHR-105, IIHR-101, Pusa Shard, Pusa Hybrid-2, Punjab Giant-26, 35.

**Late season varieties (Harvesting Time- Last Dec-Jan):-** Dania, Late Dania, Snowball-16, Pusa Snowball-1, Pusa Snowball K-1, Pusa Snowball-2 etc.

- **Pusa Snowball-K1:-** Resistant to black rot and Inflorescence Blight.

The early varieties are smaller in size & have curd of yellowish tinge. The mid-season varieties produce the largest curds of dirty white in color. The late season varieties are compact & milky white in colour.

**Raising of seedlings in the Nursery, Seed rate & spacing, and production:-**

| Crops | Time of nursery | Time of Transpl- | Seed rate | Spacing | Harvesting Time | Yield |
|---|---|---|---|---|---|---|

| | preparation | anting | | | | |
|---|---|---|---|---|---|---|
| Early | End of May-End of June | July-Aug | 600-700g/ha | 45x30cm | Sep-Oct | 100-150 qt/ha |
| Mid | July-Aug | Aug-Sept | 375-500g/ha | 60x45cm | Nov-Dec | 150-200 qt/ha |
| Late | Sep-Oct | Oct-Nov | 375-500g/ha | 60x45cm | Dec-Jan | 200-250 qt/ha |

**Blanching:-** It is the process by which the outer leaves are covered over the head & tied. It is done to exclude light from the curd (head). A perfect head of cauliflower is pure white. It is necessary to exclude sun light to obtain this. The common practice in blanching is to bring the outer leaves of over the head & tie them with a twine or rubber band. If it is not possible place a cauliflower leaf over the head to protect it from the sun. Blanching should be done only when the head (curd) has grown fully, leaves should not be left tied over for more than 4 – 5 days.

- Blanching is required in early and late varieties.
- Pusa Himjyoti, Snowball and late varieties are self-blanched varieties.

**Manures & Fertilizers:-**

- FYM:- 20-25 t/ha.
- N:- 150kg/ha.
- $P_2O_5$:- 125kg/ha.
- $K_2O$:- 100kg/ha.

**Irrigation:-** Irrigation should be done at 5-7 days interval.

**Storage:-** Curds can be stored for 3–4 days at ordinary temperature where as it can be stored for 30 days at $0^oC$ with 85 – 90% RH.

Seed yield varies from 250 – 400 Kg/ha.

## CABBAGE

**B.N.:-***Brassica oleracea* var. *capitate.* **Family: –** Cruciferae/Brassicaceae.

**Origin:-**Mediterranean Region. **Chromosome No. (2n)**= 18.

**Edible Part:-** Head.

- It is a herbaceous annual for vegetable whereas for seed production it is biennial. The edible portion which is made up of numerous thick overlapping leaves covering a terminal bud is known as "head".
- The word 'cabbage' is derived from French word "coboche" meaning head.
- India rank II in cabbage production after China.
- West Bengal is leading state in cabbage production in India.
- Cabbage is rich source of Vit-A, B and C.
- Flavour in cabbage leaves is due to glucoside sinigrin.
- Cabbage has anti-cancer property due to presence of Indole-3-Carbinol.
- Cabbage juice was used as remedy against poisonous mushroom and as a garlic against hoarseness.
- Aroma in raw cabbage is due to allyl isothiocyanate.
- Aroma in cooked cabbage is due to dimethyl disulphide.

**Climate:-** It is a cold season crop. It thrives best in a relatively cool moist climate. It can withstand extreme cold & frost relatively better than cauliflower. It loses its flavor in warm weather. The optimum seed germination is obtained at 12.8 – $15.6^oC$.

**Soil:-** It can be grown in all type of soil but soil with high OM, high fertility & good drainage is preferred. Optimum pH is 6 – 6.5.

**Varieties:-**

Broadly the cabbage varieties are classified in the following groups:-

**Round head or ball head types:-** e.g. Golden Acre, Pride of India, Copenhagen Market, Express, Mammoth Rock Red, Pusa Sambandh, Green Express etc.

**Flat head or drum head types:-** e.g. Pusa Drum Head, Large Drum Head, Pusa Mukta (resistant to black rot), etc.

**Conical head type:-** e.g. Jersey Wakefield, Charleston Wakefield.

**Savoy type:-** e.g. Chieftain, Drum Head Savoy, etc.

**Read cabbage:-** e.g. Red Acre, Red Rock, etc.

- Generally round head types are early variety followed by the conical types. The drum head & Savoy types are commonly late variety.

| Crops | Time of nursery preparation | Time of transplanting | Seed rate | Spacing | Harvesting Time | Yield |
|---|---|---|---|---|---|---|
| Early | July-Aug | Aug-Sept | 500-600g/ha | 45x45cm | 60-80days after planting | 200-300qt/ha |
| Mid | September | October | 375-400g/ha | 60x45cm | 80-100days after planting | 300-450qt/ha |
| Late | Oct-Nov | Nov-Dec | 375-400g/ha | 60x45cm | 100-120days after planting | 300-500qt/ha |

**Early Varieties:-** Golden Acer, Pride of India, Pusa Synthetic, Pusa Ageti, Pusa Sambandh, Copenhagen Market, Shri Ganesh, Green Boy, Early Drum Head etc.

**Mid-Season Varieties:-** Pusa Mukta:- Resistant to Black rot.

- September:- Introduced from Germany.

**Late Varieties:-** Pusa Drum Head, Late K-1, Late Large, Drum Head

**Manures &Fertilizers:-**

- FYM:- 20-25 t/ha.
- N:- 150kg/ha.
- $P_2O_5$:- 125kg/ha.
- $K_2O$:- 100kg/ha.

**Storage:-** The marketable heads can be stored for 4 – 5 days under ordinary conditions, where as in cold storage at $0^oC$ – $1.7^oC$ with 85 – 87% RH it can be stored for several days.

**Seed yield:-** 500 – 650 Kg/ha.

**Physiological disorders:-**

1. **Buttoning:-** Buttoning is a term applied to the development of small heads just like buttons.

   **Causes:** Over aged seedlings. Poor supply of N. Overcrowding of the plants. Wrong cultivar-planting early varieties late may also cause buttoning.

2. **Riceyness:-** When the surface of the curd is loose & has velvety (pleasantly smooth & soft) appearance due to elongation of pedicel & formation of small white flower buds at the curding stage.

   **Causes:-** Temperature range fluctuation i.e. temps higher or lower than the optimum required for a particular variety. Heavy application of N.

3. **Blindness:-** Complete absence of cauliflower head of terminal bud is termed as blindness. Leaves of blind cauliflower are large, thick, leathery & dark green.

   **Causes:-** Low temp. Mechanical injury or injury by insect & pests to the terminal buds.

4. **Browning or brown rot or red rot**:- Browning is due to deficiency of boron in soil. Boron deficiency is common in soils having high pH value. Water soaked area develops on the leaves & curd. These spots later develop & ultimately become dark or brown in color. Sometime the curd & leaves start decaying. Hollow stem is also a symptom of browning.

   **Control:-** Apply 20 Kg/ha. Borax in the soil or spray 0.2% Boric acid.

5. **Whiptail:-** This result from the deficiency of Molybdenum. Mo becomes unavailable in very acidic soil less than 6.5 normal leaf blade development fails & only strap like savoyed leaves are formed. In extreme cases only mid-rip develops, hence the name "whiptail" is given to this disorder.

   **Control:-** Apply Sodium or Ammonium Molybdate @ 1kg/ha. Since the crop is harvested at 10% pod maturity, curing becomes essential curing, threshing & other operation should be completed before the rain starts.
6. **Browning/Red rot/brown rot:-** It is due to B deficiency.
7. **Chlorosis:-** It is due to Mg deficiency.
8. **Fuzziness:-** It is velvety in appearance, and formed when the flower pedicels elongate. It is due to late harvesting, off season cultivation and environmental stress condition.

**Diseases of Cole crops:-**

1. **Damping off:-** *Phytopthora infestens*
2. **Club root (deformed root):-** *Plasmodiophora brassicae* (fungal soil borne)

- This disease is prevalent in the acidic soil.
- Soil is kept alkaline by liming.

3. **Black rot:-** *Xanthomonas campestris* (bacterium seed borne)

- Hot water treatment of seeds at 52$^{o}$C for 30 minutes gives good results.
- Variety Pusa Mukta is resistant to this disease.(Cabbage)

4. **Black spot or Alternaria leaf spot:-** *Alternaria brassicae* (fungal)

- Treat the seed in hot water at 50$^{o}$C for 30 min.

5. **Black leg:-** *Phoma lingam* (fungus)

- Variety Pusa Drum head of cabbage is resistant of this disease.
- Proper crop rotation to avoid cruciferous crops.
- Seed treatment by hot water or fungicides.

6. **Downy Mildew:-** *Pemospora parasicita* (fungus)
7. **Sclerotinia rot or White mould** (*Sclerotinia sclerotiorum*)
8. **Erwinia soft rot** (*Erwinia carotovora*):- This bacterial soft rot is generally more of a problem on the harvested product than in the field, but it can affect growing crops. It is most serious problem in all storage vegetables.

**Insect Pests of Cole crops:-**

- Cabbage butterfly
- Semi Lopper
- Mustard Aphid
- Diamond Back Moth (*Plutella xylostella*):- Serious pest of Cole crops. Pale green small slender larvae, feed on leaves & make hole in them. The mouth of this pest has diamond shaped wings.

# Spinach

**Botanical Name:-**

- *Beta vulgaris var. bengalensis* (Indian spinach, 2n=18).
- *Spinacia oleracea* (Spinach, 2n=12).

**Family: -** Amaranthaceae / Chenopodiaceae.

**Origin:-** India-China.

**Introduction:-**

- Spinach beet is one of the most common leafy vegetables of tropical and sub-tropical regions.
- World spinach comes from Spanish Hispania.

- The popular palak growing states include Andhra Pradesh, Uttar Pradesh, West Bengal, Maharashtra and Gujarat. However, Palak is not very popular in South India.
- It is primarily used as potherb.
- It is a rich Source of vitamin A, B and C and also contains appreciable amount of protein, calcium and iron.
- The leaves contain low oxalic acid.
- The basic methods employed for the development of palak include introduction, selection especially mass selection and hybridization.
- Mass selection is also employed for the maintenance of cultivars.
- The best individual plants are selected on the, basis of their phenotypic performance and their seeds are composited for raising the following generation of large number of plants are selected to avoid inbreeding depression.
- Long Day Plant.
- Cross pollinated crop

**Varieties of Indian Spinach**

**Punjab Green:** This cultivar was developed by Punjab Agricultural University, Ludhiana, through selection.

**Pusa Jyoti:** This cultivar was developed by the Indian Agricultural Research Institute, New Delhi by polyploidization of the culture as a result of induced mutagenesis using All Green as a source material.

**HS 23:** This cultivar was developed by Haryana Agricultural University, Hissar, Haryana through selection.

**Ooty 1:** It was developed at Horticultural Research Station, Ooty of Tamil Nadu Agricultural University through selection from an introduction from Himachal Pradesh.

**All Green:** It was developed at the Indian Agricultural Research Institute, New Delhi.

**Pusa Harit:** This cultivar was developed by hybridization between sugar beet and local palak at IARI Regional Station, Katrain, HP.

**Jobner Green:** This was developed at SKNAU, Jobner.

**Pusa Bharati:** It is the latest variety at the Indian Agricultural Research Institute, New Delhi.

**Varieties of Spinach**

- Badger Savoy
- Wisconsin Bloomsdale,
- Verginia Savoy:- It is prickly seeded variety.
- Early Smooth Leaf
- Banerjees Giant
- Khara Lucknow
- Khara Palak

(Prickly seed varieties best for autumn winter crop in the hills and smooth seeded varieties best for spring summer crop in this hills)

**Climate**

Spinach is a cool-season crop that should be planted in early spring, about 4 weeks before your area's average date of last frost. Ideal spinach weather is 10 to 15$^{o}$C.

**Indian Spinach**

Although spinach beet is a winter season crop, it can be growth throughout the year under mild temperature conditions. It can tolerate frost better than other vegetables. It can also tolerate warm weather but high temperature leads to premature bolting without giving economic yield.

**Soil**

Palak can be grown on any type of soil possessing good fertility and drainage but sandy loam soil is most suitable. Although, Palak can tolerate alkaline soil; high yields of better quality greens are produced in neutral soils having a pH of 7.0.

**Sowing Time**

The main sowing season of Indian spinach in plains is from last week of August to second week of November. In places with mild climate, it may grow throughout the year. In hilly regions, palak is sown from March-May.

Spinach is typical cool season crop, mainly grown in Oct-Nov.

**Sowing and Spacing**

To improve germination, seeds are soaked in water overnight before sowing. Sowing can be done either by broadcast method or by line sowing. Line sowing is more desirable as it facilities weeding, hoeing and harvesting. Line spacing is maintained at 20cm and thinning is done to maintain plant spacing within lines at about 5cm. Seed rate varies with the crop season.

**Seed rate:-** For winter crop, use 10-15kg seed/ha and for summer crop 25-30kg/ha seed is required.

- Average Seed rate:- 15-20kg/ha.
- Spinach Seed rate:- 37-45kg/ha

**Manuring and fertilizer**

- FYM:- 20-25t/ha.
- N:- 100kg/ha.
- $P_2O_5$:-50kg/ha.
- $K_2O$:- 50kg/ha.

**Irrigation:-** In case of insufficient soil moisture, apply first irrigation immediately after sowing. Subsequent irrigations may be given at an interval of 4-6 days during summer and 10-12 days during winter. However, rainy season crop does not require much irrigation.

**Interculture and weeding**

Hand weeding is still a common practice to control weed. Generally 2-3 hoeing cum hand weeding are required to control weed. It also helps to loosen soil for proper aeration. Pendemethalin 0.5 kg/ha is used as chemical control.

**Harvesting**

The crop will be ready for harvesting in about 3-4 weeks after sowing. Subsequent cuttings should be taken at an interval of 20-25 days depending upon variety and season. During summer, only one harvesting is recommended. Harvesting is not done early in the morning because there is dew on the crop. After harvesting it is washed, trimmed, graded and bunched before marketing.

**Yield:-**

- Spinach:- 8-10t/ha.
- Indian Spinach:- 8-12t/ha.

**Storage:-** It can storage for 10-14 days at 0°C temperature and 95-99% relative humidity.

**Diseases:-**

- Downy mildew
- Anthracnose
- Cladosporium Leaf spot
- Stemphylium leaf spot
- Damping off and root rot

**Insect-Pest**

- Aphid
- Leaf Eating Caterpillar

# Brinjal

**Botanical Name:-** *Solanum melongena.* **Family: -** Solanaceae.

**Origin:-** India. **Chromosome No.:-** 2n=24.

**Inflorescence: -** Solitary. **Type of fruit:-** Berry.

**Leading Country:-** China.

**Introduction:-**

- India ranks second in brinjal production after China.
- Heterostyly found in brinjal. Four types of style are observed in brinjal; 1. Long Style, 2. Mid Style, 3. Short Style and 4. Pseudo Style. Fruit set in only Long and Mid style.
- Immature fruits are used in curries and a variety of dishes are prepared out of brinjal.
- Fruits are moderate sources of vitamins and minerals like phosphorous, calcium and iron and nutritive value varies from variety to variety.
- Brinjal is also valued for its medicinal properties and has got decholestrolizing property primarily due to presence of poly-unsaturated fatty acids (linoleic and lenolenic) present in flesh and seeds of fruit in higher amount (65.1%).
- Presence of magnesium and potassium salt in fruits also impart de-cholestrolizing action.
- Dry fruit contain Goiterogenic principle.
- Purple colour of brinjal is due to anthocynin pigment.
- Dark purple brinjal have more vitamin-C than those of white skin.
- Brinjal is day neutral plant and often cross pollinated plant.
- It is a good source of vitamin-B.
- In native medicines, role of brinjal in treatment of liver diseases, cough due to allergy, rheumatism, colilithiasis, leucorrhea and intestinal worms has been mentioned.
- It is good for patients suffering from diabetes; particularly white brinjal.
- Fruits of some local cultivars exhibit bitterness due to presence of glycolalkaloids like solanin. Generally glycol-alkaloid content varies from 0.37 to 4.83 mg/ 100g in most of cultivars. High glycol–alkaloids (20 mg/100g fresh weight) produce bitter taste and off flavour.
- Varieties also vary for content of polyphenol oxidase which imparts brown discoloration when the fruits are cut open.
- Isolation distance recommended for brinjal is 200 m for foundation seed and 100 m for certified seed.

**Climate:-** Brinjal is warm season day neutral plant and is susceptible to severe frost. A long and warm growing season with a temperature range of 21-27$^{o}$C is ideal for its production. 25$^{o}$C is best for seed germination. Crop is adversely affected by chilling temperature of winter in North India. Generally late cultivars can withstand low temperature than early ones. Plants grown luxuriantly and yield heavily during rainy season under warm humid climatic condition of Kerala.

**Soil:-** Brinjal is a hardy crop and is cultivated under a wide range of soils. Since a long duration crop with high yield, well-drained and fertile soil is preferred for the crop. Crops grown in sandy soils yield early and those grown in clayey soils yield more. Ideal pH for cultivation of crop is 5.5-6.6.

**Varieties**

| Developing institution | Variety | Special features |
|---|---|---|
| IIHR, Bangalore | Arka Kusumakar | Small green fruits borne in clusters of 5-7 |
| | Arka Sheel | Medium long deep shining purple fruits. |
| | Arka Nidhi (BWR 12) | Resistant to bacterial wilt, medium long blue black glossy fruits. |

| | | |
|---|---|---|
| | Arka Shirish | Extra-long fruits with green colour |
| | Arka Neelkanth | Resistant to bacterial wilt, short purple fruits. |
| | Arka Keshav | Resistant to bacterial wilt, Fruits are long, red purple and glossy. |
| IARI, New Delhi | Pusa Kranti | Oblong |
| | Pusa Purple Cluster | Tolerant to bacterial wilt |
| | Pusa Purple Long | Long |
| | Pusa Anupam (KT4) | |
| | DBR 8 | |
| | Pusa Purple Round | |
| | Pusa Bhairav | Resistant to phomopsis blight. Fruits long and purple |
| | Pusa Uttam | Early variety |
| | Pusa Utkar | Early variety |
| | Pusa Bindu | Early variety |
| | Pusa Ankur | |
| Kerala Agriculture University, Thrissur | Surya (SM 6-7) | Resistant to bacterial wilt. |
| | Swetha (SM 6-6) | Resistant to bacterial wilt, small white elongated fruits |
| | Haritha | Resistant to bacterial wilt. |
| TNAU, Coimbatore | CO 1 | Oblong, pale green fruits |
| | CO 2 | |
| | PKM 1 | Small ovate fruits with green stripes, Developed through mutation breedings |
| | PLR 1 | |
| | MDU 1 | Large, round and purple fruits |
| | KKM 1 | |
| Annamalai University, Tamil Nadu | Annamalai | Aphid resistant. |
| GBPUA&T, Pantnagar | Pant Rituraj | Large purple round fruits |
| | Pant Samrat | Resistant to bacterial wilt and phomopsis blight, less infestation of shoot and fruit borer and jassids. Fruits long and purple. |
| Haryana Agriculture University, Hisar | Hisar Pragati (H 7) | Fruits dark bright purple, tolerant to little leaf round, dark and bright purple fruits oblong dark purple fruits. |
| | Hisar Shyamal (H8) | |
| | Hisar Jamuni | |
| Punjab Agriculture | Jamuni Gol (S 16) | |

| | | |
|---|---|---|
| University, Ludhiana | Punjab Barsati | Tolerant to fruit borer |
| | Punjab Neelam | Long purple fruits |
| | Punjab Sadabahar | Long black purple fruits |
| | PH 4 | |
| CSAUA&T, Kanpur | T-3 | |
| | KS 331 | |
| | Azad Kranti | |
| | Azad B 2 (KS 224) | |
| MPKV, Akola | Aruna | |
| DARL, Pithoragarh | ARU 1 | |
| | ARU 2 C | Resistant to bacterial wilt. |
| CHES, Ranchi | CHBR -1 | |
| JNKV, Jabalpur | JB 15 | |
| | JB 64-1-2 | |
| OUA &T Bhubaneswar | Utkal Tarini (BB 77) | Resistant to bacterial wilt. |
| | Utkal Madhurai (BB 44) | Resistant to bacterial wilt. |
| | Utkal Jyothi (BB 13) | Tolerant to bacterial wilt. |
| | Utkal Kesari (BB 26) | Tolerant to bacterial wilt. |
| RAU, Sabour | Green long | |
| APAU, Hyderabad | Gulabi (Sel 4) | |
| | Shyamala | |
| | Bhagyamathi | |
| PRVV, Akola | Aruna | |
| MPKV, Rahuri, Maharashtra | Vaishali | |
| | Pragati | |

- Quite a large numbers of local cultivars like Banaras Giant, Wayanad Giant, Mukthakeshi and Manjiri Gota are grown in specific areas.

**Hybrid Varieties**

| **Developing institution** | **Hybrid** | **Parents** | **Special features** |
|---|---|---|---|
| IARI, New Delhi | Pusa Anmol | Pusa Purple Long × Hyderpur | |
| | Pusa Hybrid 5 | | |
| | Pusa Hybrid 6 | | Early variety |

| | | | |
|---|---|---|---|
| | Pusa hybrid 9 | | Early dark purple round fruits. |
| IIHR, Bangalore | Arka Navneeth | IIHR 221 × Supreme | |
| | Arka Anand | IIHR -3 × SM 6-6 | Resistant to bacterial wilt. |
| TNAU, University, Coimbatore | COBH 1 | EP 45 × CO 2 | |
| HAU, Hisar | Hisar Shyamal (H8) | Aushey × BR 112 | Resistant to bacterial wilt, tolerant to little leaf, rufts round bright purple |
| KAU, Thrissur | Neelima | Surya x SM 116 | Resistant to bacterial wilt. |
| GAU, Anand | ABH 1 | M2 x M 35 | |
| CSAUA&T, Kanpur | Azad Kranti | Pusa purple Long x BGL | |
| GBPUA &T, Pantnagar | Pant Brinjal Hybrid 1 | PB 121 x PB225 | Tolerant to bacterial wilt. |
| TNAU, University, Coimbatore | COBH 1 | EP 45 x CO 2 | |

**Seed Rate:-**

- **Local Varieties:-** 400-500g/ha.
- **Hybrid Varieties:-** 200g/ha.

**Season:-**

- **Kharif Season:-** June-July.
- **Rabi Season:-** Oct-Nov.
- **Zaid Season:-** Feb-March.
- In hills, brinjal is sown during March and transplanted during April.

**Nursery area requirement for one hectare planting: -** 125-150$m^2$. Seedling should be transplanted 3-4 weeks age.

**Planting distance:-** 60-75 cm x 75-90 cm.

**Manure and fertilizer: -**

- FYM: - 20-25t/ha.
- N: -100-120kg/ha.
- $P_2O_5$:- 60kg/ha.
- $K_2O$:- 40kg/ha.

**Irrigation:-** Though brinjal cannot tolerate water logging, timely irrigation is essential especially for fruit set and development. In plains, irrigation is required at every third or 4th day during summer while in winter it should be at 10-15 days interval.

**Inter-cultivation:-** It is essential to keep the field free of weeds especially at initial stages of crop growth and is usually done by 2-3 light hoeing or earthing up. This facilitates better aeration to root system and gives support to plants. Application of fluchloralin @ 1.5 kg a.i./ha as a pre-emergent weedicide, applied one week after transplanting seedlings, followed by one hand weeding at 30 days after planting controls a broad spectrum of weeds. Use of black polythene mulches is also efficient for suppression of weeds and for better growth of plants.

**Harvesting:-** Brinjal fruits are harvested at immature stage after attaining full size, but before loosing its glossy appearance.

**Yield:-**

- Early short duration varieties: 20-30 t/ha
- Long duration varieties: 35-40 t/ha
- $F_1$ hybrids: 55-80 t/ha

**Storage:-** Fruits can be stored for 7-10 days in a fairly good condition at 7.2-10°C with 85-90% RH.

**Pests**

- Fruit and shoot borer (*Leucinodes orbonalis*)
- Jassids (Empoasca spp.):- Punjab Barsati and Pusa Kranti have tolerance to jassid attack.
- Epilachna beetle
- Mites

**Diseases**

- **Bacterial wilt (*Ralstonia solanacearum*):-** Resistant varieties like Swetha, Haritha, Arka Nidhi, Arka Neelkant, Pant Samrat, Utkal Tarini, Utkal Madhuri and F1 hybrid Neelima.
- **Fungal wilt:-** Fungi like *Fusarium* and *Verticillium* cause wilting of plants.
- **Phomopsis blight**
- **Little leaf:-** This is a serious viral disease of brinjal. The disease is transmitted by leaf hopper.
- **Damping off (*Pythium spp.)***
- **Mosaic:** This is a viral disease caused by Potato Virus Y and transmitted by aphids.

# Cucurbits

**Family:-** Cucurbitaceae

| S.N. | English name | Scientific name | Origin | Chromosome no. |
|---|---|---|---|---|
| 1. | Cucumber | *Cucumis sativus* | India | 2n=14 |
| 2. | Bitter gourd | *Momordica charantia* | Indo-Burma | 2n=22 |
| 3. | Bottle gourd | *Lagenaria siceraria* | Ethiopia | 2n=22 |
| 4. | Watermelon | *Citrullus lanatus* | Tropical Africa | 2n=22 |
| 5. | Melon Long/Musk Melon | *Cucumis melo* | Tropical Africa | 2n=24 |
| 6. | Melon | *Cucumis melo* var. *Flexuosus* | India | 2n=24 |
| 7. | Snapmelon | *Cucumis melo* var. *Momordica* | India | 2n=24 |
| 8. | Ridge gourd | *Luffa acutangula* | India | 2n=26 |
| 9. | Sponge gourd | *Luffa cylindrical* | India | 2n=26 |
| 10. | Pumpkin | *Cucurbita moschata* | Peru and Mexico | 2n=40 |
| 11. | Summer Squash | *Cucurbita pepo* | Peru and Mexico | 2n=40 |
| 12. | Ash gourd | *Benincasa hispida* | South East Asia | 2n=24 |
| 13. | Pointed gourd | *Trichosanthes dioica* | India | 2n=22 |

| | | | | |
|---|---|---|---|---|
| 14. | Ivy or scarlet Gourd | *Coccinia cordifolia* (syn. *C. indica*) | India | 2n=24 |
| 15. | Round gourd | *Praecitrullus fistulosuos* /Citrullus lanatus | Indo-Burma | 2n=24 |
| 16. | Sweet gourd | *Momordica Cochinchinensis* | South East Asia | 2n=28 |
| 17. | Snake gourd | *Trhichosanthus anguina* | India | 2n=22 |
| 18. | Long Melon | *Cucumis melo var utillissimus* | N. India | 2n=24 |
| 19. | Chow-Chow (chayote) | *Sechium edule* | Southern Mexico and Central India | 2n=24 |
| 20. | Snap Melon (Phoot) | *Cucumis melo var. momordica* | | 2n=24 |
| 21. | Gherkin | *Cucumis anguira* | | 2n=24 |

- Cucurbits is the largest group of summer vegetable crop.
- Cucurbits term is coined coined by Dr. Baily.
- Fruit type of cucurbits is Pepo.
- Inflorescence: - Solitary.
- Cucurbits are $C_3$ and Day Neutral Plant.
- Cucurbit has high content of water and they are also rich source of Vit-C.
- Metaxenia common in cucumber and bottle gourd.
- Bitterness in cucurbits is due to cucurbitacins.
- Cucurbits is monoecious in nature but Pointed gourd, Ivy gourd and Kakrol are dioecious in nature.
- Long day and high temperature lead to male flower initiation.
- Short day and low temperature induce female flower in cucurbits.
- Spray of IAA/NAA/ $GA_3$ 50-150ppm induce more female flowers and in other hand spray of and ethylene MH and $AgNO_3$ induce female flowers.
- Plant growth regulator should be spray at 2-3 leaf stage.
- Cucurbits is cross pollinated crop, pollination is done by honey bee.
- Female and male ratio is 3:1 or 2:1.

## Cucumber

- Cucumber is the second most widely cultivated after watermelon.
- In India maximum area cover in poly-house by cucurbits.
- Cucumber has 96.4% of water; It is maximum in vegetable.
- The tender fruits are eaten raw or with salt in salad. They are also used as cooked vegetable and pickle making.
- It is reported that the oil exacted from seeds is good for brain and body.
- Drinking of water immediately after eating cucumber should be avoided, as it sometimes causes severe indigestion.
- India is considered to be the home of cucumber.
- Fruits are good for people suffering from constipation, jaundice and indigestion.

**Climate:-** The cucumber is a warm season crop and grows best at a temperature between 18$^{o}$C -26.4$^{o}$C. Tolerant to low temperature.

**Soil:-** Cucumber can be grown in all types of soil from sandy to heavy soils with 5.5 and 6.7 pH.

**Varieties:-**

| Varieties | Breeding methods | Specific features |
|---|---|---|
| Japanese Long Green | Introduction from Japan | |
| Straight -8 | Introduction from USA | Suitable for growing throughout the year. |
| Pusa Uday | | |
| Pusa Barkha | Extra early variety | Tolerant to high temperature & downy mildew |
| Swarna Ageti | Hybridization | Slicing type |
| Swarna Sheetal | | Slicing type |
| DCH-1 DCH-2 | Tropical gynoecious hybrids | |
| Himangi | | |
| Pusa Khira-1 | | |
| Sheetal | | |
| Priya | | |
| Puna Khira | | |
| Poinsettia | | |
| Balam Khira | | |
| Khira-75, Khira-90 | | |
| Phule Prachi | Hybrid | |
| Phule Champa | Hybrid | |
| Phule Shubhangi | | It is released by MPKV, Rahuri. |
| Pant Parthenocarpic Khira-2 | | Parthenocarpic variety |
| PPK-3 | | Parthenocarpic variety |
| Table Green | | Resistance to TMV |
| Chinese Long | Introduced from China | Resistance to TMV |
| Tokyo long green | Introduced from Japan | Resistance to mosaic virus |
| Ohayo Lines | Introduced from Japan | Resistant to mosaic virus |
| Wisconsin | Introduced from USA | Resist to scab & CMV |
| SMR9 | Introduced from USA | Resist to scab & CMV |
| Stono | Introduced from USA | HYV, Resistant to downy mildew |
| Wantee | Introduced from USA | Resistant to downy mildew |

**Seed Rate:-** 2-2.5kg/ha.

**Sowing Time:-**

- Summer Crop:- January to February.
- Rainy crop:- June-July.
- The seed of cucumber is sown in April in the hills.

**Spacing:-** 1.5-2.5x1.5-2.5m.

**Manure and fertilizer: -**

- FYM: - 20-25t/ha.
- N: -75kg/ha.
- $P_2O_5$: -50kg/ha.

- $K_2O$:- 50kg/ha.

**Weed:-** Shallow cultivation should be given during the early stages of growth to control the weeds. Herbicides (such as Glycophosphate, Paraquat and Chloramben @ gm per acre) may be used to control weeds.

**Harvesting and Yield:-** The rail grown tender fruits should be harvested at an interval of 2-4 days.

**Yield:-** The average yield is about 100 to 150 quintals/ha.

## Bottle Gourd

- Bottle gourd is a very important crop in India.
- The fruit in green stage and leaves with stem are used as vegetable.
- The hard shell of the fruit is used for different purpose like for musical instrument.
- It has medicinal properties. Fruit has cooling effect, cardiatonic and diuretic.
- It has fibre free carbohydrate.
- Rich in fibre, it is used for stomach disorders due to Gastro intestine problems and constipation.
- It is also good source of Vit-B and minerals.
- It is monoecious in nature.
- Kofta is a most popular preparation of bottle gourd.

**Climate:-** Hot and moist climate is favourable for its cultivation. Night and day temperature of 18- 22°C and 30-35°C respectively is optimum for its proper growth and high fruit set. It cannot with stand frost.

**Soil:-** Bottle gourd can be grown in any types of soil. But sandy loam soils with 6-7 pH are best suited for its cultivation.

**Varieties**

- Arka Bahar:- Developed by IIHR, Bangalore. Tolerant to Blossom end rot.
- Narendra Rashmi:- Developed by NDAU&T, Faizabad, UP. This variety is moderately tolerant to Pumpkin beetle pests, and Powdery mildew and Downy mildew disease.
- CO1F-1 Hybrid:- Developed by TNAU by crossing NDBG 121 and Arka Bahar.
- Pusa Meghdhut:- It first hybrid among vegetables developed in 1972.
- **Other Varieties:-** Pusa Naveen, Pusa Summer Prolific Long (PSPL), Pusa summer Prolific Round (PSPR), Pusa Sandhesh, Pusa Hybrid 3, Punjab Komal, Punjab Round, Kalyanpur Hari Lambi, Samrat, Pant Sankar Lauki-1, CO1, Hybrid Kashi Bahar, Hybrid Varad - MGH 4, Pusa Manjiri, Pusa H-3, Gutaka, Harit, Kalyanpur Long Green, Pusa Sneha, Pusa Supria, NDGB-2, Rajendera Chamatkar, PBOG, Kashi Bahar, Kashi Ganga.

**Time of Sowing:-** The seed is sown from January to end of February for summer crops. June–July for rainy season crop in the plains and April in the hills.

**Seed Rate:-** 3-6kg/ha.

**Spacing:-** 2.0 to 3.0 m (row to row) x 1 to 1.5 m (plant to plant).

**Manure and fertilizer: -**

- FYM: - 20-25 t/ha.
- N: - 100 kg/ha.
- $P_2O_5$:- 60 kg/ha.
- $K_2O$:- 60 kg/ha.

**Weeding:-** Two to three hoeing is given to keep down the weeds during early stages of growth.

**Irrigation:-** The summer crop requires frequent irrigation at an interval of 4-5 days. No irrigation is given in rainy season crop.

**Harvesting and Yield:-** Bottle gourd may be harvested 55-75 days after sowing. The fruit should be harvested when the rind of the fruit is very tender and green.

**Yield:-** l50-200q/ha.

# Pumpkin

**Botanical Name:-** *Cucurbita maxima.* **Family: -** Cucurbitaceae.

**Origin:-**Peru and Mexico. **Chromosome No.:-** 2n=40.

**Inflorescence: -** Solitary. **Type of fruit:-** Pepo.

**Introduction:-**

- Pumpkins were used to treat bladder problems and as a pain killer.
- Its seeds are an excellent source of fat and protein.
- Good source of Vitamin A, Beta-carotene, Vitamin C, Phosphorus, Potassium etc.
- The flower of pumpkin are more nutritive than fruit.
- Yerusseri prepared from immature fruits is very popular in Kerala.
- Pumpkin is especially known for its low cost cultivation and long keeping quality.

**Climate:-** Pumpkins are warm season crop and it can also withstand cold temperatures. This crop is sensitive to frost and the ideal temperature of 18°C to 30°C is best for its growth. At higher temperatures, male flowers sometimes predominate, resulting in fewer fruit for that period.

**Soil:-** Need fertile, aerated soil with a pH between 5.5 and 6.5. Well-drained, sandy loam or loamy soil in organic matter is ideal for its cultivation.

**Varieties:-**

Pusa Vishwas, Pusa Vikas, Pusa Hybrid-1, CO-1, CO-2, Arka Chandan, Kashi Harit, Ambili.

Arka Suryamukhi:- It is resistant to fruit fly.

Ambili:- Pure line selection.

**Seed Rate:-** 4-5kg/ha.

**Sowing Time:-** Feb-March and June-July.

**Spacing:-** 2-3x2-3m.

**Manure and fertilizer: -**

- FYM: - 20-25t/ha.
- N: -100kg/ha.
- $P_2O_5$: -60kg/ha.
- $K_2O$:- 60kg/ha.

**Weeding:-** Two to three hoeing is given to keep down the weeds during early stages of growth.

**Training:-** The vines are trained to spread on bowers made from thin coconut rope and bamboo sticks particularly in rainy season to prevent the fruit from rotting and allowing the vines and foliage for better exposure to light and air.

**Irrigation:-** The summer crop requires frequent irrigation at an interval of 4-5 days. No irrigation is given in rainy season crop.

**Harvesting and Yield:-** Maturity can be identified by change in fruit colour to orange or pale yellow colour. At this stage, the pumpkin seeds attain maturity with higher vigour and viability. They can be harvested either in green and mature/ripe stage. It is mature 75-180 days after sowing.

**Yield:-** 250-400q/ha.

**Insect-Pest**

- Red Pumpkin Beetle- *Aulacophora foveicollis*
- Cucurbits Stink Bug- *Cordius janus*
- Pumpkin Fruit Fly- *Bactrocera curcubitae*
- Spotted Beetle- *Epilachna vigintioctopunctata/E. Pussillanima*
- Cutworm- *Agrotis segetum/A. ipsilon*
- Flea Beetle- *Phyllotreta crucifera*
- Aphids- *Aphis gossypii/Myzus persicae*
- Whitefly- *Bemisia tabaci*

- Soybean Hairy Caterpillar- *Spilarctia casigneta*
- Banded Blister Beetle- *Mylabris orientalis*
- Semilooper- *Anadividia (Phytometra) peponis*
- Stem Boring Beetle- *Apomecyna saltator*

**Diseases**

- Alternaria leaf spot:- Fungus – *Alternaria cucumerina* and *Alternaria alternate*
- Downy mildew:- Fungus – *Pseudoperenospora cubensis*
- Powdery mildew:- Fungus – *Podosphaera xanthi*
- Anthracnose:- Fungi – *Colletotrichum orbiculare*
- Scab or gummosis: Fungus – *Cladosporium cucumerinum*
- Septoria leaf spot:- Fungus – *Septoria cucurbitacearum*
- Charcoal rot:- Fungus – *Macrophomina phaseolina*
- Damping-off:- *Pythium, Rhizoctonia* and *Fusarium*
- Angular leaf spot:- Bacterium – *Pseudomonas syringae pv. Lachrymans*
- Bacterial leaf spot: Bacterium – *Xanthomonas campestris pv. Cucurbitae*
- Mosaic:- It is viral diseases transmitted by aphids.
- Phyllody :- It is viral diseases transmitted by leafhopper.

**Physiological Disorder**

- Blossom-end rot:- It is due to Ca deficiency.
- Hollow heart:- It is due to poor pollination.
- Light belly color:- Commonly occurs on fruit lying on cool, moist soil.
- Measles:- Due to unfavourable environmental condition.
- Rind necrosis:- Due to unfavourable environmental condition.
- Pillow:- It is due to Ca deficiency.
- Sunscald:- It is due to high temperature.

❑❑❑❑❑

## (3) Introduction, distribution and economic importance of Flowers – Rose, Gladiolus, marigold.

**Rose**

**Scientific Name:** *Rosa spp.*

**Family:** Rosaceae

**Origin :-** India

**Chromosome Number:-** 2n=14

- It is the national flower of England, Iran, and some American States adopted rose as their emblem.
- Crimson China Rose is considered as the father of modern roses.
- Rose is also known as king of flowers.
- Farm of rose is known as Rosary and farmer who is cultivated rose is known as Rosarian.
- Alpha Garden, England is biggest Garden of rose in world.
- In India, Rose Garden is situated in Chandigarh.
- Attar is discovered by Begum Noor Jahan.
- In India, maximum area and production of flowers crop covered by rose and also in Rajasthan.

- Rose Mehndi is situated in Pushkar, Ajmer in Rajasthan.
- Utter Pradesh is leading state in rose production.
- Ajmer is leading district in rose production.
- These were actually hybrids between *R. odorata* and *R. gigantea*. La France was the hybrid Teas rose, by M. Guillot of France and was developed out of open pollination.
- However, out of over 120 species of roses distributed in the old as well as the new world, only eight species have played a major role in the development of the modern garden roses.
- Fruit of rose is known as Hips.

**Uses of Rose:-**

- **Cut flower:-** Roses are of foremost commercial importance and cut roses have the highest demand throughout the world and year round.
- **Garden Display:-** Roses are also the most important perennial garden plants in almost all parts of the world.
- **Pot plants:-**Roses as pot plants in suitable containers are also commercially grown and kept both indoor as well as outdoors.
- **Rose water**:- Rose water in also an important commercial product from rose petals. It is used as a perfume and in medicines and confectionary. In has the property of cooling the body and is often used in eye lotions and eye drops for its soothing qualities.
- **Rose oil**:- Rose oil is important commercial product obtained from rose petals. Apart from sweet fragrance, it has medicinal property and is often used in Ayurveda. Bulgarian rose otto is largely used in perfuming soaps and cosmetics.
- **Gulkand**:- Rose petals are also preserved for direct consumption, by making gulkand which is prepared by pounding equal proportions of petals and white sugar (1:1). It is considered both as tonic and laxative.
- **Pankhuri**:-Dried rose petals are known as pankhuri which is occasionally used for preparing sweetened cold drinks.
- **Gul-roghan**:- It is rose hair oil prepared from rose petals by effleurage with wet sesamum seeds.
- Rose hips are very good sources of ascorbic acid (119mg/ha)
- Rose are also use for making pot-pourri, conserves, rose vinegar, rose petal wine, jams, jellies etc.

**Climate :-** Rose is belong to temperate region but it is grown in all types of climate.

- Suitable temperature for growth is 15 to 27$^{o}$C

**Soil:-** Loamy soil is best but Rose can be cultivated in all types of soil expected sandy soil

**Propagation**

**a) Budding :-** Hybrid and Floribunda roses mainly propagated through budding. 'T' budding is the common method. Root stocks used are R. *multiflora* (It is also known as Edward Rose it is popular rootstock in Western India), *R. indica* var. *odorata* (It is more suitable rootstock in North India), *R. bourboniana, R. laxa, R. canina* and *R. noisettiana.*

**b) Cutting:-** Scented roses are mainly propagated through cuttings. Hard wood Cuttings in case of polyanthas, climbers, ramblers and soft or semi hardwood cuttings for miniatures are used.

- Best time of budding is Nov-Dec.
- The best planting time is between September and October in plains & in the hills it is during October-November or February-March.

**Planting Distance:-** For cut flower production, a spacing of 60 x 30 cm is recommended. Normally roses are planted at 60 x 60 cm spacing.

**Time of pruning:-** Exactly 60-65 days prior to the date of requirement of flowers during October-December. Pruning is necessary when the yield and quality declines.

**Varieties**

There are different classes of roses according to the type of flowers they bear:

**(A) Tea Rose:-** It has tea like odours so it is called tea rose.

(B) **Hybrid Tea:-** It is cross between Rosa Hybrid Prepechuls and China Tea Rose. This is the most important class of roses. The flower buds of this class are longer and look beautiful. The flowers of this class are slow opening and hence can be kept in vases for a longer time. The flower spikes are also longer. Flowers of wide range of colours are available in this class but red, orange, yellow and some other dark colours are more preferred in the market.

**Red:** First Red, Avon, Happiness, Mr. Lincoln, Raktagandha, Black Lady, Montezuma, etc.

**Yellow:** Aalsmeer Gold, Gold Medal, Golden Star, Golden Time, Yellow Success, Pusa Sonia

**Orange:** Super Star, Summer Hoilday, President and Grand Gala

**Bi-colour:** Anvil Spark, Mudhosh, Double Delight, Supriya, Abhisarika, Kiss of Fire, Tata Centenary.

**Scented:** Avon, Granda, Papa Meilland, Blue Perfume, Eiffel Tower, Oklahoma

(C) **Floribunda:-** It is cross between hybrid tea rose and Dwarf polyantha. There is profuse flowering in this class of roses but the flowers shed soon. That's why this class of roses is largely used for decoration and bedding purpose. The important varieties under this class are as follows:

**White:** Iceberg, Summer Snow, Margette Maril, Chitchor, Chandrama

**Pink:** Prema, Sadabahar, King Arthur, Bridal Pink

**Yellow:** Arthur Bell, Dr. Foun, Allgold, Sea Pearl, Golden Times

**Mauve:** Neelambari, Angel Face, Africa Star

**Orange:** Doris Norman, Suryakiran, Jorina, Jambra

**Bi-colour:** Charisma, Mask Red, Paint Box, Nav Sadabahar, Red Gold, Rare Addition

**Scented:** Angel Face, Delhi Princess

(D) **Polyantha:-** It is cross between hybrid tea rose and floribunda rose. The rose plants of this class are small and the flowers come in cluster. The main varieties of this class are Anjani, Rashmi, Nartaki, Priti, Swati, etc.

(E) **Miniature:-** The roses of this class are dwarf in stature and the twigs and the leaves are also small. The flowers of this class are used in flower arrangement and pot planting.

**Red:** Beauty Secret, Dark Beauty, Fast Fire

**White:** Green Ice, Z-Trail, Aany

**Pink:** Windy City, Sweet Fairy, Dizzler

**Yellow:** Baby Gold Star, Kale Gold, Delhi Star Late

**Mauve:** Silver Tip, Blue Bird

**Orange:** Angel Ripyance, Petayit Foly

**Bi-colour:** Star and Strip, Jainy Williums, Over the Rainbow

(F) **Climber:-** The branches of these roses are soft and spread like climber. They flower at the end of the branches in small clusters. They are used for raising over the pergolas and the walls. The important varieties are as follows:

**Red:** Climbing Crimson Glory, Blaze, Cocktail, Black Boy

**White:** Delhi White Pearl, Shelderer White, Rambler, American Pear, Lamark

**Pink:** Climbing Show Girl, Lady Water Loo, Climbing of Silk, Soft Silk, Climbing Piece, Pink Meradan

**Lemon:** Miracle Neel, All Gold, Golden Shower, High Moon

(G) ***Rosa indica:-***It is also known as Pushkari Gulab. It is commercial propagated in Ajmer district of Rajasthan.

(H) ***Rosa hybrid prepechuls*:-** It is also known as Ganganagari Gulab. It is commercially cultivated in Sriganganagar and Hanumangarh district of Rajasthan.

(I) ***Rosa damascene*:-** It is also known as Cheti Gulab. Khamnor Tehsil of Rajsamandh is famous for *Rosa damascena* production. *Rosa damascena* has maximum Essential oil content among all Rose species. It has 0.04% essential oil contents. It is mostly use in oil extraction.

(J) ***Rosa canina*:-** It is also known as dog rose.

(K)***Rosa moschata*:-** It is known as musk rose or Kunj Gulab.

(L) ***Rosa centifolia*:-** It is also known as cabbage Rose. It has 0.01% essential oil contain but oil quality is superior. But well quality is superior than other special

(M) ***Rosa gallica:-***It is also known as French Rose.

**Harvesting:-** Flowering starts from 1st year onwards. Economic yield 2nd to 10th year. Flowers are harvested when the flower buds are in half open stage. For cut flowers, they are harvested at tight bud stage with long stalks.

**Yield**

- Loose flowers : 2.5-3.0 t/ha
- Cut flowers : 2.5-3.0 lakh flowers

**Insect-Pest**

Aphids (*Macrosiphum rosae*)

Red scale (*Lindigapsis rosae*)

Chaffer beetles (*Onycetonia varsicolor*)

**Disease**

Black spot (*Diplocarpon rosae*)

Powdery mildew (*Sphaerotheca pannosa* var. *rosae*)

**Physiological Disorder:-**

**Dieback:-** It is due to Cu deficiency.

**Limp neck in rose**

**Blueing of rose**

## Marigold

**Scientific Name:**

*Tagetes erecta* (African marigold, 2n=24): cultivating it for medicinal, ceremonial and decorative purposes. This plant reaches heights of between 50–100 cm. The colour range is from white and cream to primose, yellow, gold and orange.

*Tagetes patula* (French marigold, 2n=4x=48): The flower is an annual, occasionally reaching 0.5 m by 0.3 m stem is reddish in colour and the foliage is darker than African marigold. The colour of flower varies from yellow to red, either single or double and borne on proportionately long peduncle.

*Tagetes tenufolia*( Syn. T. signata); it is a dwarf and bushy plant. Flowers have 5 rays, roundish and obovate with spicy tarragon flavor.

*Tagetes lucida* (sweet scented marigold): The plants are tender, perennial, leaves are sessile, small and lanceolated. Flowers are usually 2-3 rayed.

**Family:** Asteraceae or Compositae (Daisy Family)

**Origin :-** Mexico

- Marigold is one of the most commonly grown commercial flower crops after rose in India.
- It occupies an important place among loose flowers. It has nearly two third of total loose flower growing area in India.

- Major growing states are Karnataka, Tamilnadu, Andhra Pradesh, West Bengal and Maharastra.
- It is use as trap crop in solanaceae crops for protection of nematode.
- It is cross pollinated crop.
- Day Neutral Plant.

**Climate:-** Mild climate of 15-180C for night and 18-250C for Day are favourable for its growth. In severe winter plant dies by frost. It needs full sunlight and in open place it grows well.

**Soil:-** Well drained sandy loam soil that are rich in organic matter are best suited for marigold. The pH 7.0-7.5 with EC less than 1.0 mmhos/cm is most desirable.

**Varieties:-**

**African Marigold Hybrid Varieties:-** New Alaska, Aapricot, Glitters, Happiness, Primrose, Fiesta,Cracker Jack,Climax, Yellow Supreme, Hawai, Pusa Narangi Gainda, Pusa Basanti Gainda, Pusa Arpita, Serakal.

**French Marigold Hybrid Varieties:-** Petit spray, Harmony, Gypsy, Lemon drops,Rusty red, Star of India, Red Bokardo, Flash.

**Interspecies Hybrids:-** Pusa Shankar, Pusa Shankar-1, Nugget, Red and Gold, Red 1, Nugget, Red and Gold, Red, Seven Star and Show Boat.

**Seed Rate:-** 1-1.5kg/ha.

**Sowing Time**

| Season | Sowing time | Transplanting time | Harvest time |
|---|---|---|---|
| Rainy | June-July | July-Aug | September-October even up to December |
| Winter | September-October | October-November | November-December |
| Summer | January | February | March- April |

**Spacing:-**

- African Marigold: 40 x 30 cm 40 x 30 cm
- French Marigold: 30 x 30 cm 30 x 30 cm
- Dwarf cultivars: 30 x 20 cm

**Manuring & Fertilizers:-**

- FYM:- 20-25 t/ha
- N:- 100kg/ha
- $P_2O_5$:- 75kg/ha
- $K_2O$:- 75kg/ha

**Weeding:-** Hoeing once or twice during first 40 days is ideal to control most of the weeds and to maintain soil in good tilth. Atrazine or Basalin @ 1-1.5 kg /ha is ideal for spay as pre-planting.

**Staking:-** String or rope is erected at 20, 35 and 50 cm above the ground level in three rows at the same distance along the rows.

**Pinching:-** Pinching is generally done for the 40 days after transplanting, late pinching at 50-60 days proved less effective for branching.

**Harvesting:-** After transplanting plans take 40-50 days to flower. Loose flowers are plucked when attain full size depending upon the variety. Flowers should be harvested in the morning hours. Irrigation before plucking gives better flower quality. Plucking of flowers regularly and removal of dried flowers enhance the yield.

**Yield:-** African marigolds yields about 15-28 t/ha whereas the French marigold yields 1012 t/ha.

**Diseases management**

- Damping off (*Rhizoctonia solani*)
- Collar rot (*Pythium sp., Phytophthora sp. And Sclerotium rolfsii*)
- Alternaria leaf spot (*Alternaria tagetica, A. zinnia and A. alternate*)
- Botrytis flower Blight (*Botrytis cinerea*)
- Fusarium Wilt (*Fusarium oxysporum*)
- Powdery mildew (*Oidium sp.* and *Leveillula taurica*)
- Viral disease (cucumber mosaic)

**Pest management**

- Red spider mite (*Tetranychus sp*.)
- Hairy cater piller (*Diacrisia oblique*)
- Aphid
- Leaf Hopper (*Empoasca fabae*)

## Gladiolus

**Botanical name: -***Gladiolus x grandiflorus*
**Family: -** Iridaceae
**Centre of Origin: -**Africa & Asia (Diploid) Europe (Tetraploid).
**Chromosome Number: -** 2n = 30, 2n=4x=60.
**Inflorescences Type: -** Spike.
**Introduction**

- The name gladiolus was originated from the Latin word *gladius*, meaning a sword, on account of the sword-like shape of the foliage.
- The common name of gladiolus is 'sword lily' because of its sword-shaped foliage.
- Gladiolus is popularly known as Queen of bulbous ornamental plants.
- Gladiolus is a very popular flowering plant in international cut flower trade.
- Its magnificent inflorescence with a variety of colour has made it attractive for use in herbaceous borders, beddings, pots, for cut flowers bouquets and floral arrangements..
- For cut flowers, primulinus types are better as more spikes often come out from a corm and they may be planted in isolated borders.
- Grandiflorus and primulinus types look very attractive in mixed flower borders, but primulinus types are preferred as these do not need staking, and so, are also good for bedding.
- Corms are very rich in vitamin C, carbohydrates and proteins.
- Tetrazolium test use for evaluation of corm dormancy.

**Climate:-** Subtropical and temperate climatic conditions are suitable but it is also cultivated in tropical belt. The crop performs well under a temperature range of 27 - 30°C. It requires full exposure to sunlight and performs well with long day conditions of 12 to 14 hour photoperiod.

**Soil:-** Gladiolus can be grown wide range of soils from a light sandy to a clay loam but deep, well drained, friable, rich in organic matter and nutrients are preferable.

For best result they require a slightly acidic soil of ph 5.5 to 6.5 where most of the nutrients become available to plants.

**Varieties:-**

**Kum-Kum:-** Resistant to Fusarium wilt.

**Dhiraj:-** Resistant to Fusarium wilt

Cartago, Eurovision, Priscilla, Spic & Span, Nova, Peter Pears, Mayur, American Beauty, Sylvia, Red Beauty, Her Majesty and Topaz.

**Varieties release from IARI, New Delhi:-** Pusa Manmohak, Pusa Red Valentines, Pusa Vidushi. Agnirekha, Anjali, Archana, Bindiya, Chandani, Chirag, Dhanvantari, Gulal, Gunjan, Kamini, Mayur, Neelam, Neelkanth, Noopur, Pusa Kiran, Pusa Shubham, Pusa Suhagin, Rangmahal, Shabnam, Sanjeevni, Sarang, Shweta, Suchitra, Sukanya, Sunayana, Swapnil, Swarnima, Urmil and Vandana.

**Varieties release from IIHR, Bangalore:-** Arka, Naveen, Arka Gold, Arka Amar, Arka Kesar, Aarti, Apsara, Darshan, Dhiraj (Resistant to Fusarium), Kum Kum, Meera, Nazrana, Poonam, Sagar, Sapna, Shakti, Sindhoor and Shobha (Mutant).

**Propagation:-** Gladiolus is propagated by corms of at least 4-5 cm diameter 150000 to 160000 require fore one hector. Dip corms for about 20 minutes in a solution of Thiram (0.3%) or Captan (0.2%) or Bavistin (0.2%) for avoid fungal diseases.

**Methods to break dormancy of gladiolus corms:-**

- Low temperature storage for 2 Low temperature storage for 2-3 months at 4 3 months at 4-7$^{o}$C
- Ethylene chlorohydrin (4 Ethylene chlorohydrin (4-5 drops/ litre container 5 drops/ litre container for a week)
- Dip corms in thiourea 500 ppm solution for 24 hours
- Dip corms in GA3 50 ppm solution for 30 min.
- Dip corms in BA 25 Dip corms in BA 25-50 ppm solution or 10% H 50 ppm solution or 10% $H_2S$ for 30 min.
- Dip corms in Garlic paste for 30 min.

**Planting Distance:-** 30x20cm. **Depth:-** 7-10cm.

**Planting time:-** Generally gladiolus is grown in the winter (Sep-Nov). However in moderate weather conditions (In South India), it can be grown round the year except for the summer months when sun burn will be severe.

## Manure and fertilizer: -

- FYM: - 20-25t / ha.
- N: -100-120kg / ha
- $P_2O_5$: -120kg / ha
- $K_2O$:- 120kg/ha

**Irrigation:-** Depending upon weather 8-12 irrigations (7 to 10 days interval) of 2.5-5 cm depth are required. Stage immediately after sprouting and 4-6 leaf stage are very sensitive to water deficit.

**Earthing Up:-** Earthing up to 10 Earthing up to 10-15 cm height is done when 15 cm height is done when plants are at 4 plants are at 4-6 leaf stage or when plants are 5-6 leaf stage or when plants are 15-20 cm high.

**Staking:-** Staking with bamboo or wooden sticks is done in beds.

**Weed Control:-** Three-four hand weeding are sufficient four hand weeding are sufficient. Atrazine (1.5 kg/ha), Oxyfluorfen (0.5 kg/ha) are sprayed as pre-emergence.

**Harvesting:-**

- For local market gladiolus is harvested when the lower most pair of floret is fully opened.
- For distant market harvesting is usually done when the lower most pair of floret has just shown the colour.

**Yield:-** 2-2.5 Lack Spike/ha.

**Corm Harvesting and Yield:-** Generally, the corms and cormels required 30-35 more days after harvest to get properly matured. After harvesting of the spikes water should be withheld and allow the plants to remain in the field itself. When the lower leaves starts turning yellow the corm should be harvested. Yield approximately 40t/ha.

**Storage of Corm:-** Corms are stored in single layers in wooden trays having a wire bottom. Before storage corm/cormals should be treated with fungicides, than air dried and stored. For gladiolus 4-10$^0$C cold temperature are required.

**Diseases:-**

- Wilt (*Fusarium oxysporum f. sp. gladioli*)
- Corm-rot (*Fusarium, Curvularia, Stromatinia, Botrytis, Penicillium spp.*)
- Blight (*Curcularia trifoli, C. eragrostidis*)
- Blue/ gray mould (*Botrytis elliptica B. gladiolorum*)
- Leaf spots (*Septoria gladioli*)

**Insect-Pest:-**

- Aphids
- Thrips
- Caterpillars
- Mites

## D. Types of seed-foundation and certified and methods of plant propagation layering and cutting, and Tissue culture. Important farm implements and their maintenance

## Seed

**In broad sense:-** Seed is a material which is used for planting or regeneration purpose.

**Scientifically:-** Seed is a fertilized matured ovule together covered with seed coat is called seed or it is a propagating material.

**Technological point of view:-** Seed is a fertilized ripened ovule consisting of three main parts namely seed coat, endosperm and embryo, which in due course gives rise to a new plant.

**It also refers to:-** Propagating materials of healthy seedlings, tuber, bulbs, rhizome, roots, cuttings, setts, all types of grafts and vegetatively propagating materials used for production purpose.

- In India only 12% Best Seed (Good Quality Seed) can rich at farmer.

**Characteristic of Best Seed (Good Quality Seed)**

1. Good quality seeds of improved varieties ensures higher yield at least 10 – 15 % than local varieties.
2. Genetic purity should be more than 99%.
3. Moisture percentage of seed should be 8-12% (should not more than 12%).

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \text{ X } 100\%$$

Where, $W_1$ – Wt. of seed sample before drying

$W_2$ – Wt. of seed sample after drying

4. Physiological purity should be more than 98% (Maize , Bhendi - 99%, All crops ( most) - 98%, Carrot - 95%, Sesame, soybean & jute - 97%, Ground nut - 96%)

$$\text{Physiological Purity} = \frac{\text{Weight of pure seed (g)}}{\text{Total weight of working samples (g)}} \text{ X } 100\%$$

5. Germination percentage should be more than 60% according to crops.

$$\text{Germination \%} = \frac{\text{Total no. of seeds germinated}}{\text{Total no. of seeds kept}} \text{ X } 100\%$$

Sample size for seed germination test

- According to International Seed Testing Association:- 400seeds
- According to National seed Corporation:- 200seeds.
- According to Rajasthan State Seed Corporation:- 200seeds.

| **S. N.** | **Crop** | **Pure seed (min.)** | **Moisture (max)** | **Germination (min)** |
|---|---|---|---|---|
| 1 | Hybrid maize(other than single cross) | 98 | 12 | 90 |
| 2 | Maize | 98 | 12 | 90 |
| 3 | Sorghum and | 98 | 12 | 80 |
| 4 | Millet | 98 | 12 | 75 |
| 4 | Rice | 98 | 13 | 80 |
| 5 | Wheat | 98 | 12 | 85 |
| 6 | Barley | 98 | 12 | 85 |
| 7 | Cotton varieties and hybrids | 98 | 10 | 65 |
| 8 | Gram | 98 | 9 | 85 |
| 9 | Arhar | 98 | 10 | 75 |
| 10 | Urid | 98 | 9 | 65 |
| 11 | Mung | 98 | 9 | 75 |
| 12 | Rapeseeds and mustard | 97 | 8 | 85 |
| 13 | Sesamum (til) | 97 | 9 | 80 |
| 14 | Groundnut | 96 | 9 | 70 |

| | | | | |
|---|---|---|---|---|
| 15 | Sunflower | 98 | 9 | 60 |
| 16 | Linseed | 98 | 7 | 80 |
| 17 | Soyabean | 97 | 12 | 70 |
| 18 | Peas | 98 | 9 | 75 |
| 19 | Cowpeas | 98 | 9 | 75 |
| 20 | Tomato | 98 | 8 | 70 |
| 21 | Cauliflower | 98 | 7 | 65 |
| 22 | Bhindi | 99 | 10 | 65 |
| 23 | Watermelon and other cucurbits | 99 | 7 | 60 |
| 24 | Onion | 98 | 8 | 70 |
| 25 | Carrot | 95 | 8 | 60 |
| 26 | Chillies | 98 | 8 | 60 |
| 27 | Radish | 98 | 6 | 70 |
| 28 | Brinjal | 98 | 8 | 70 |
| 29. | Cluster Bean | 98 | 8 | 70 |
| 30. | Berseem, Lucerne | 98 | 10 | 80 |

**Seed Germination Testing**

- Petri dish test
- Towl Test
- Sand Test
- Peg dol Test

6. Real Value of seed should not be less than 75.

$$\text{Real Value} = \frac{\text{Germination\% x Physical Purity}}{100}$$

7. Seed should be viable

**Tetra Zolium Method:** It determines the percentage of viable seeds which may be expected to germinate. The chemical 2, 3, 5 – tetrazolium chloride in short, is colourless but it develops intense red colour when it is reduced by living cells.

Seeds are soaked in tap water overnight and are split longitudinally with the help of a scalpel so that a portion of the embryo is attached with such half of the seed. One half of each seed is placed in a Petridis covered with 1% aqueous solution of tetrazolium chloride for 4 hours. The seeds are then washed in tap water & the no. of seeds in which the embryo is stained red is determined.

$$\text{Viable seed \%} = \frac{\text{No. of half seeds stained red}}{\text{Total no. of half seeds}} \text{ X } 100\%$$

8. Other varieties seed should be not more than 0.1%.
9. Weed should not be more than 0.1-0.5%.
10. Seed should be free from Inset-Pest and Diseases.

11. Seed should be matured.
12. Seed should be Higher physiological vigour and stamina

**Seed Index:-** 100 seeds weight is called seed index.

**Test Weight:-** 1000 seeds weight is called test weight.

| Crops | Test Weight (g) |
|---|---|
| Wheat | 40 |
| Rice | 25 |
| Basmati Rice | 21 |
| Barley | 37 |
| Maize | 200 |
| Hybrid Maize | 285 |
| Lucerne | 2.4 |
| Onion | 4 |
| Millet | 5-7 |
| Mustered | 3-4.5 |
| Mung Bean | 40-42.5 |

**Types of Seed:-**

**Nucleus seed:-** This is the 100% genetically pure seed with physical purity and produced by the original breeder/Institute /State Agriculture University (SAU) from basic nucleus seed stock. A pedigree certificate is issued by the producing breeder.

It is not sold in Market.

**Breeder seed:-** The progeny of nucleus seed multiplied in large area as per indent of Department of Agriculture and Cooperation (DOAC), Ministry of Agriculture, Government of India, under supervision of plant breeder / institute / SAUs and monitored by a committee consisting of the representatives of state seed certification agency, national / state seed corporations, ICAR nominee and concerned breeder.

This is also 100% physical and genetic pure seed for production of foundation seed. A golden yellow colour certificate is issued for this category of seed by the producing breeder.

**Foundation Seed:-** The progeny of breeder seed produced by recognized seed producing agencies in public and private sector, under supervision of seed certification agencies in such a way that its quality is maintained according to prescribed field ad seed standards.

A white colour certificate is issued for foundation seed by seed certification agencies.

It has 98% genetic purity.

**Registered seed:-** It is a progeny of foundation seed. It is not prepared in India. It has purple colour tag.

**Certified seed:-** The progeny of foundation seed produced by registered seed growers under supervision of seed certification agencies to maintain the seed quality as per minimum seed certification standards.

A blue colour certificate is issued by seed certification agency for this category of seed.

- ✓ The foundation and certified seeds can be multiplied at stage 1 and II, but the reproduction cannot exceed three generations after breeder seed.

**Truth Full Level Seed:-** It is the category of seed produced by cultivators, private seed companies and is sold under truthful labels. But field standard and seed standard should maintain as per seed act and certified seed stage. Under the seed act, the seed producer and seed seller are responsible for the seed.

**Isolation Distance:-** The crop raised for seed production should be separated from other fields of the same crop species by a minimum distance, which varies from one crop to the other. This distance is known as isolation distance. Isolation is essential to prevent pollination from unwanted pollen in the case of cross-pollinated and often cross-pollinated species and to avoid mechanical mixture and chance of cross-pollination in self-pollinated species.

| Crop | Distance for Foundation seed (m) | Distance for Certified seed (m) |
|---|---|---|
| Self-Pollinated Crop | | |
| Rice, Wheat, Ragi, Groundnut, Greengram, Cowpea, Tomato, Soybean | 3 | 3 |
| Tomato | 50 | 25 |
| Cowpeas, Sem, Rajma | 50 | 10 |
| Peas | 20 | 10 |
| Sesame | 100 | 50 |
| Cross-Pollinated Crop | | |
| Hybrid Maize | 600 | 300 |
| Hybrid bajra | 1000 | 200 |
| Maize, Millet, Rapeseed and mustard | 400 | 200 |
| Check Pea | 10 | 5 |
| Castor | 300 | 150 |
| Lucerne | 400 | 100 |
| Shun hemp | 200 | 100 |
| Sunflower | 1000 | 500 |
| Carrot | 1000 | 800 |

| | | |
|---|---|---|
| Onion | 1000 | 400 |
| Cucurbits | 800 | 400 |
| Radish, Cole Crop and turnip | 1600 | 1000 |
| Often-cross pollinated crop | | |
| Okra, Chilli | 400 | 200 |
| Brinjal, Sorghum | 200 | 100 |
| Pigeonpea | 100 | 50 |
| Cotton | 50 | 30 |

**Roughing:-** Removal of off type plant is called roughing.

## Plant Propagation

**Definition:-**Plant propagation can be defined as controlled reproduction of a plant by a man in order to perpetuate a selected individuals, or group of individuals which is having specific values to him.

**Types of Propagation**

**Sexual Propagation in Plants**

**Asexual Propagation in Plants/Vegetative propagation**

A. **Sexual Propagation in Plants:-**Multiplication of plants by using seed is called as sexual propagation.

**Advantages:-**

- It is easy and chip method of propagation.
- They are hardy for adverse environment condition and insect-pest or diseases with deep root system.
- Sexual propagation lead to genetic variability, it is essential for development of new varieties development.
- The polyembryony phenomenon of propation of more than one seedling from a single seed, produce true to type, nuclear embryonic seedling which could be used as rootstock for uniform performance. E.g. South Indian mango variety, citrus and Jamun.
- Seed propagation is necessary when vegetative propagation is unsuccessful or expenses e.g. papaya, coconut, phalsa and Areca nut.
- Roots stocks are usually raised by seed e.g. Rangpur lime and Jamberi for citrus.
- When seedling is required in large number, seed propagation is the only easy mean e.g. Dry land fruit, and Forest spp.

**Disadvantages:**

- When progenies are not true type an so they become inferior because in the commercial orchard, it is necessary to have uniform quality, growth and yielding capacities.
- Choice tree or any hybrid trees cannot be perpetuated true to type by seed.
- Seedling has a long juvenile period. In crops like citrus, coca, and rubber. The seeds must be sown afresh. i.e. immediately after extraction. Many varieties are seedless.
- Seeds loose its viability in short period
- Seeded plant start bearing late.

**Asexual Propagation in Plants:-** Asexual propagation or vegetative propagation refers to the multiplication or perpetuation of any plant from any vegetative parts as plant other then the seed.

**Advantages of Vegetative Propagation:-**

- The progenies are true to type like mother plant.
- Vegetative propagation is the only alternate where no seed is formed or germination of seed is very slow or no viable seed is formed. (e.g. Banana, Pine apple and roses, seedless grape ).
- Certain rootstock has the capacity of resisting or tolerating the adverse environment factors such as frost and adverse soil factors like salinity or alkalinity. E.g. frost resistance, foncirus trifoliate (Trifoliate orange). Rangpur lime.
- The ability of certain rootstock to resistant pest and diseases can be advantageously expected. An apple when grafted on rootstock like Merton 778,793 is resistant for wholly aphid.
- Vegative propagated plants are generally dwarfed in nature than the seedlings. Dwarf trees facilitate pruning spraying and harvesting easy seedling. Dwarf trees facilate pruning, spraying and harvesting easy and more number of plants can be accommodated in a unit area.
- To replant an undesirable existing tree either with reference to its quality or susceptibility to pests and diseases. The defect can be overcome easily by vegetative propagation through grafting or budding of desirable scion to the existence tree by top working technique.
- Many plants are propagated by vegetative means because of the speedy easy of multiplication.
- Novelty can be developed by grafting or budding on single plant many varieties. E.g. Roses.
- To convert inferior varieties in superior, side grafting in mango.

**Disadvantages:-**

- Plant is not vigorous and long lived.
- No new varieties are evolved or developed.
- These methods are expensive and labourious and time consuming.

**Method of Asexual Propagation:-**

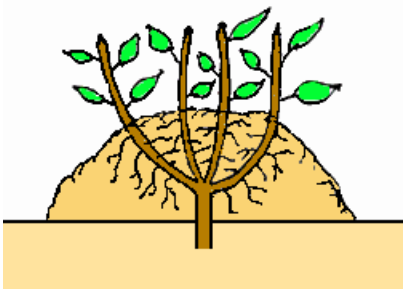
**A. Layering:-** Layering is the development of roots on a stem while it is still attached to the parent plant. The rooted stem is stem is then detached to become a new plant growing on its own roots. Thus rooted stem stem is known as layer.

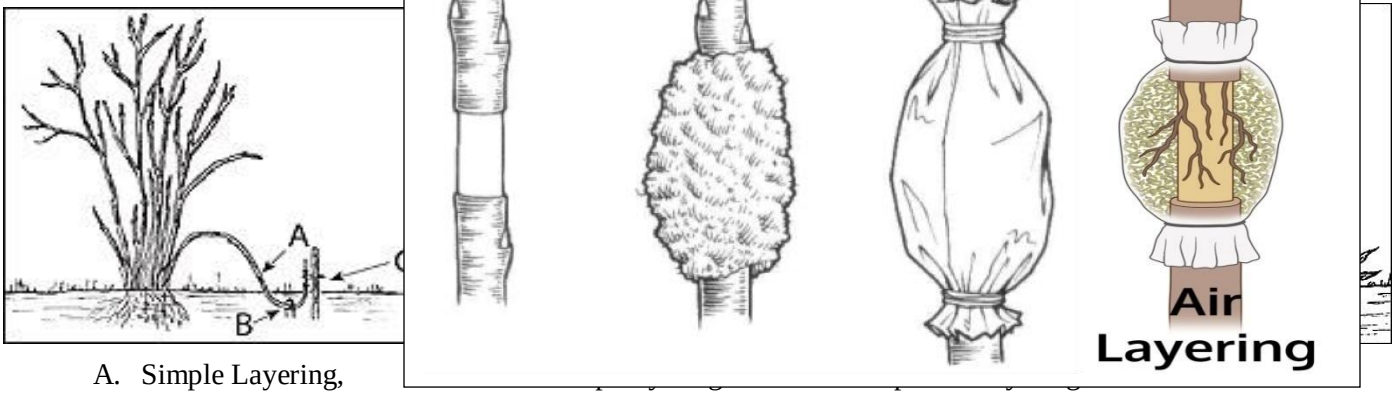
**Method of layering:-**

1. **Simple layering:-** In this method a branch is bent to the ground and some portion of it, is covered by soil leaving the terminal and of the branch exposed. Root initiation takes place at the buried portion. After the root initiation. i.e. after allowing sufficient time the layer is separated from the mother plant by cutting the layered shoot. E.g. Buganvilia, jasmine, calodendron etc.
2. **Tip layering:-** Tip layering is similar to simple layering and happens naturally with plants such as black raspberry and trailing blackberries. The tip of a branch touches the ground and roots form. Tip layering simply mimics this natural process.

   To tip layer, dig a small hole several inches deep, insert the tip of a current season's shoot or cane, and fill around it with soil. The tip will turn and grow upwardCamera icon, while the bend of the stem that stays in the soil will grow roots. Care for the layered plant is the same as that used for simple layering.

3. **Compound layering/ Serpentine layering:-** If there is a particularly long and healthy stem, you may want to consider compound layering. This works in precisely the same way as simple layering except because the stem is long, you are able to bury more than one section, potentially giving you multiple clones from one stem. Compound layering works particularly well with plants that naturally have long stems such as vine plants. If there is a particularly long and healthy stem, you may want to consider compound layering. This works in precisely the same way as simple layering except because the stem is long, you are able to bury more than one section, potentially giving you multiple clones from one stem. Compound layering works particularly well with plants that naturally have long stems such as vine plants. Eg.- Jasmine and strawberry.






A. Simple Layering,

4. **Mound layering/Stooling:-**In this method a plant is cut back at the ground during the dormant season, and soil is covered at the base of the newly developing shoots. After allowing sufficient time for root initiation, the rooted shoots are separated and taken as individual layers

Mound Layering

5. **Air layering/Chains layering/ Marcottage layering:-**In air layering, roots, from on an aerial shoots. The rooting medium will be tied to the shoots for getting root initiation. Best rooting medium for air layering is sphagnum- moss as it holds large amounts of water so as to supply moisture to the layered shoot till proper root initiation takes place. Eg- Citrus, Pomegranate, sfig, guava.

**B. Cutting:-** Cutting is a method of asexual propagation in which a portion of any vegative part such as stem, leaf or root is cut from the parent plant and is placed under favorable environmental condition to form roots and shoots, thus producing a new independent plant.

**Stem Cutting:**

This is the most important type of cutting and can be divide into three types based on the nature of the wood used in marketing the cutting.

i) Hard wood cutting ii) Semi- hard wood cutting iii) Soft- wood cutting.

In propagated by stem cuttings, segment of shoots containg lateral or terminal buds handled under proper condition to develop adventitious roots and form independent palnts.

**i) Hard Wood Cuttings:-** E.g. Grape, pomegranate, fig, mulberry, Acalypa, Rose, Bougainvillea etc. This is last expensive and easiest method. Hard wood cuttings are not readily perishable and may be shifted safely over long distance, if necessary.

The cutting usually prepared during the dormant season and from the wood of the previous season growth.

- Length:- 20-25cm (22.5cm), Thickness:- 0.5-1.0 cm.

**ii) Semi – hard Wood Cuttings:-** E.g. Eranthemum, pomegranate, fig. The cuttings are prepared from now shoot just after a flush of growth which is partially matured.

- Length:- 20-25cm (22.5cm), Thickness:- 0.5-1.0 cm.

iii) **Soft Wood Cutting:-** E.g. Coleus, pilea, alternanthea, Bignonia, Chrysanthemum, Colliose, Geranium, Guava etc. these types of cuttings are also made from succulent, herbaceous green plants such as carnation, portulaces, etc. These cuttings are always made with leaves attached to stem.

**Leaf Cuttings:-** In these type cuttings, the leaf blade, sometimes with petiole, is utilized in starting a new plant. In most cases adventitious roots and an adventitious shoot develop at the leaf base. The following are the various types of leaf cuttings.

**i) Leaf Blade Cuttings:-** The long tapering leaves into 2 to 3 pieces are inserted into sand, and after some time a new leaf from at the base of the piece. E.g. snake plant.

**ii) Leaf Vein Cutting:-** In this type of cutting the new plant develops from the leaf vein at the base of the leaf piece. E.g Begonia rex and bryophyllum.

**iii) Leaf Margin Cutting:-**In this case new plants arise from foliar embryos in the notches at the leaf margin.

**iv) Leaf Bud Cutting:-**This type of cutting consists of a leaf blade, petiole, and a short piece of the stem with the attached axillary bud. E.g blackberry, camellia.

**Root Cuttings:-**In preparing root cuttings the period when the plant is in rapid growth must be avoided. It is important to maintain the correct polarity when planting the root cuttings. E.g. Guava, Litchi, plum, pahadi gulab, India cork tree.

**Tissue culture propagation:-** It is a technique of growing cells, tissues, organs or whole organism in vitro (in glass) on artificial culture medium under aseptic and controlled conditions. It is rapid vegetative propagation of several agricultural and horticultural crops. It replacing the conventional methods of propagation. The mass multiplication of agricultural, horticultural, medicinal and other desirable plants by tissue culture techniques is known as micro propagation/clonal propagation.

Or

Plant tissue culture is a collection of techniques used to maintain or grow plant cells, tissues or organs under sterile conditions on a nutrient culture medium of known composition. Plant tissue culture is widely used to produce clones of a plant in a method known as micro propagation.

# SECTION – 2

# Genetics and Plant Breeding

## Unit – IV Genetics, and Plant Breeding

### A. Cell structure, Cell Division-Mitosis and Meiosis significance in plant growth and development

**Introduction**

All organisms are composed of structural and functional units of life called 'cells'. The body of some organisms like bacteria, protozoans and some algae is made up of a single cell whereas the body of higher fungi, plants and animals are composed of many cells. Human body is built of about one trillion cells.

Cells vary in size and structure as they are specialized to perform different functions. But the basic components of the cell are common to all biological cells.

**Landmarks in the study of a cell**

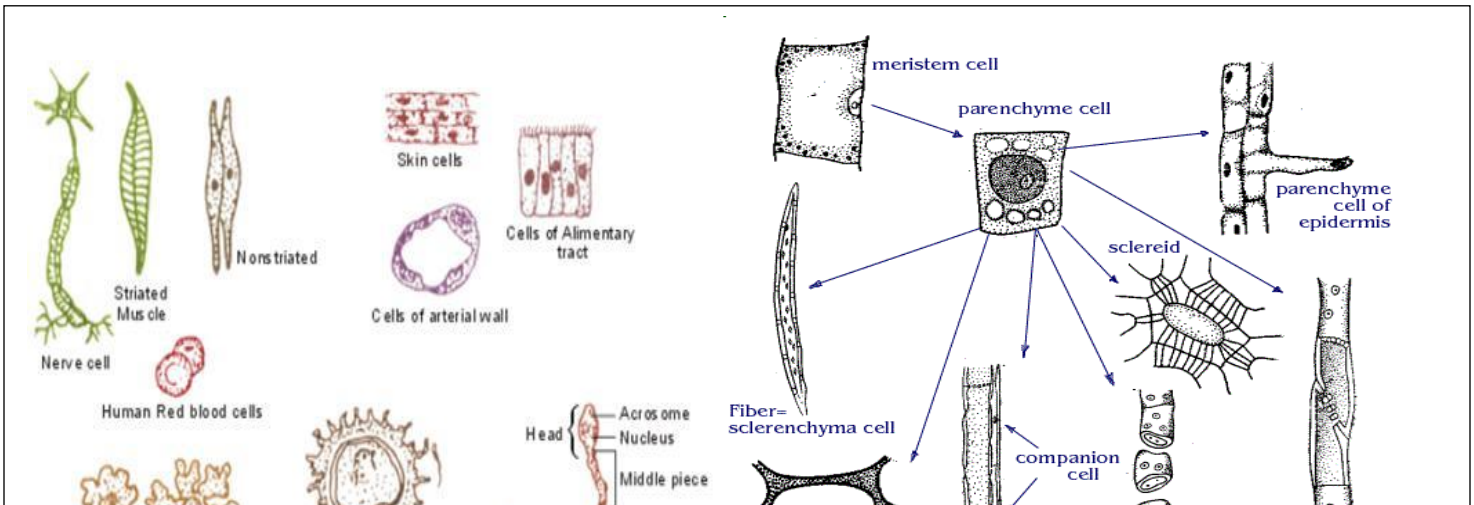
Soon after Anton Van Leeuwenhoek invented the microscope, Robert Hooke in 1665 observed a piece of cork under the microscope and found it to be made of small compartments which he called "cells" (Latin cell = small room). In 1672, Leeuwenhoek observed bacteria, sperms and red blood corpuscles, all of which were cells. Much later, in 1831, Robert Brown, an Englishman observed that all cells had a centrally positioned body which he termed the nucleus.

**The cell theory**

In 1838 M.J. Schleiden and Theodore Schwann formulated the "cell theory." Which maintains that:

- All organisms are composed of cells.
- Cell is the structural and functional unit of life, and
- Cells arise from pre-existing cells.

The cells vary considerably, in shapes and sizes . Nerve cells of animals have long extensions. They can be several centimeter in length. Muscle cells are elongated in shape. Egg of the ostrich is the largest cell (75 mm). Some plant cells have thick walls. There is also wide variation in the number of cells in different organisms.



## The Cell

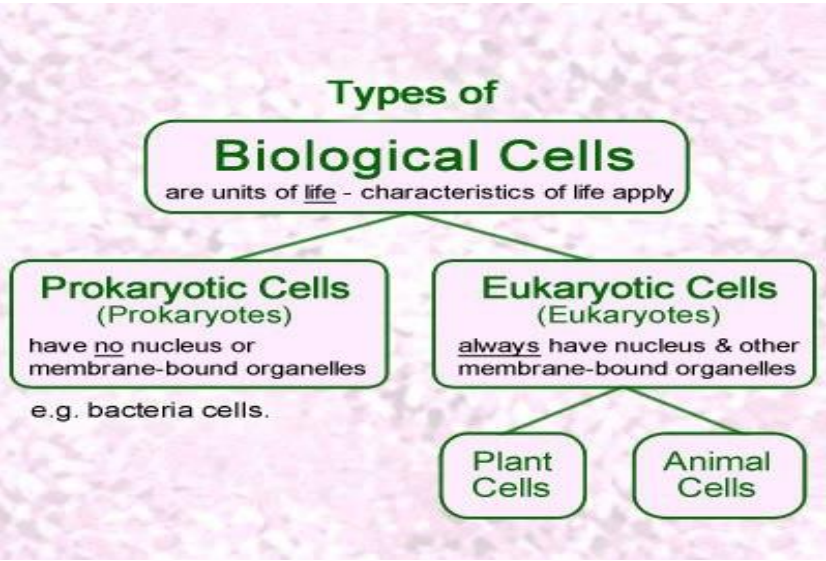
A cell may be defined as a unit of protoplasm bound by a plasma or cell membrane and possessing a nucleus. Protoplasm is the life giving substance and includes the cytoplasm and the nucleus. The cytoplasm has in it organelles such as ribosomes, mitochondria, golgi bodies, plastids, lysosomes and endoplasmic reticulum. Plant cells have in their cytoplasm, large vacuoles containing non-living inclusions like crystals, and pigments. The bacteria have neither defined cell organelles nor a well formed nucleus. But every cell has three major components:

- Plasma membrane
- Cytoplasm
- DNA (naked in bacteria) and enclosed by a nuclear membrane in all other organisms

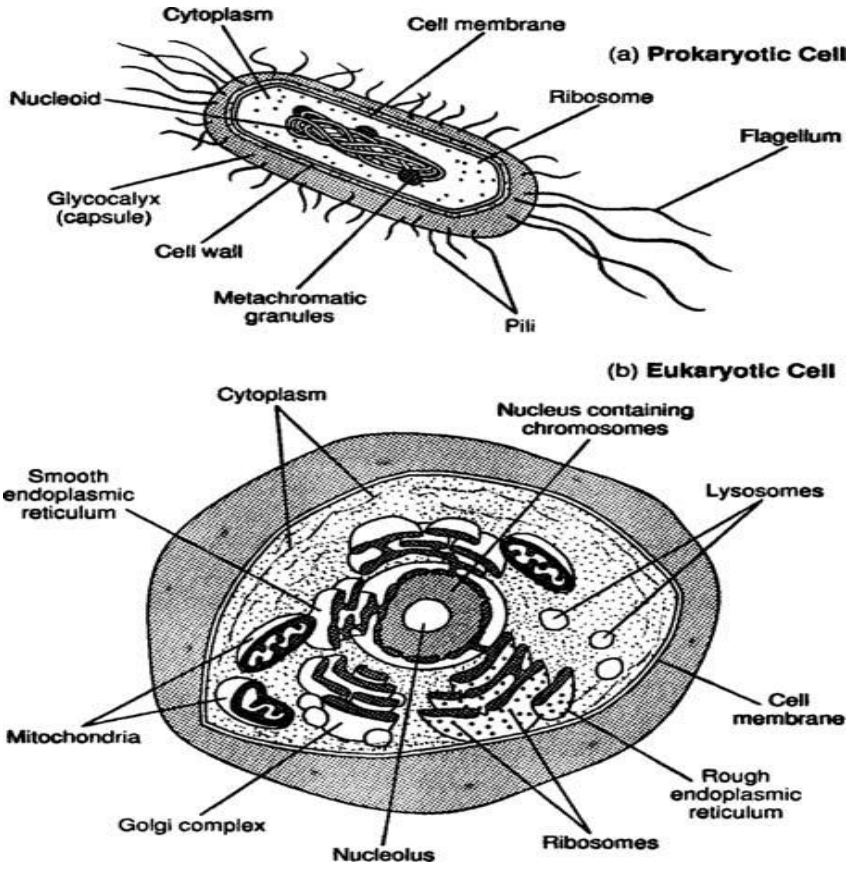
## Two basic types of cells

Cytologists recognize two basic types of cells. Their differences have been tabulated below in Table. Organisms which do not possess a well formed nucleus are **prokaryotes** such as the bacteria. All others possess a well defined nucleus, covered by a nuclear membrane. They are **eukaryotes.**

**Differences between Eukaryotic and Prokaryotic cells**



| **Eukaryotic cell** (eu = true, karyon = nucleus) | | **Prokaryotic cell** (Pro = early/primitive) | |
|---|---|---|---|
| 1. | Nucleus distinct, with well-formednuclear membrane. | 1. | Nucleus not distinct, it is in the formof a nuclear zone 'nucleoid'. Nuclearmembrane absent. |
| 2. | Double-membraned cell organelles(Chloroplasts, mitochondria, nucleus)and single membraned (Golgi apparatus,lysosomes, vacuole, endoplasm reticulum)are present | 2. | Single-membraned cell bodies likemesosomes present. Endo-plasmicreticulum, plastids, mitochondriamicrobodies like lysosomes, andGolgi body absent. |
| 3. | Ribosomes - 80 S | 3. | Ribosomes - 70 S |
| 4. | Distinct compartments in the celli.e. the cytoplasm and the nucleus | 4. | No compartments. |
| 5. | Depending upon the species number ofchromosomes per nucleus varies fromtwo to many. | 5. | There is only one chromosome per cell. |
| 6. | Each chromosome is linear with its twoends free. | 6. | The chromosome is circular and remainsattached to cell membrane at one point. |
| 7. | Each chromosome has one linear double-stranded DNA complexed with histones | 7. | The chromosome has single double-strandedcircular DNA molecule and is not associatedwith histones. |
| 8. | Each chromosome has one centromerethat divides a chromosome into twoarms. However, if the centromere isterminal, the chromosome would haveonly one arm. | 8. | The chromosome lacks a centromere. |


(a) Prokaryotic Cell
Cytoplasm
Cell membrane
Nucleoid
Ribosome
Flagellum
Glycocalyx
(capsule)
Cell wall
Metachromatic
granules
Pili
(b) Eukaryotic Cell
Cytoplasm
Nucleus containing
chromosomes
Smooth
endoplasmic
reticulum
Lysosomes
Cell
membrane
Mitochondria
Rough
endoplasmic
reticulum
Golgi complex
Nucleolus
Ribosomes

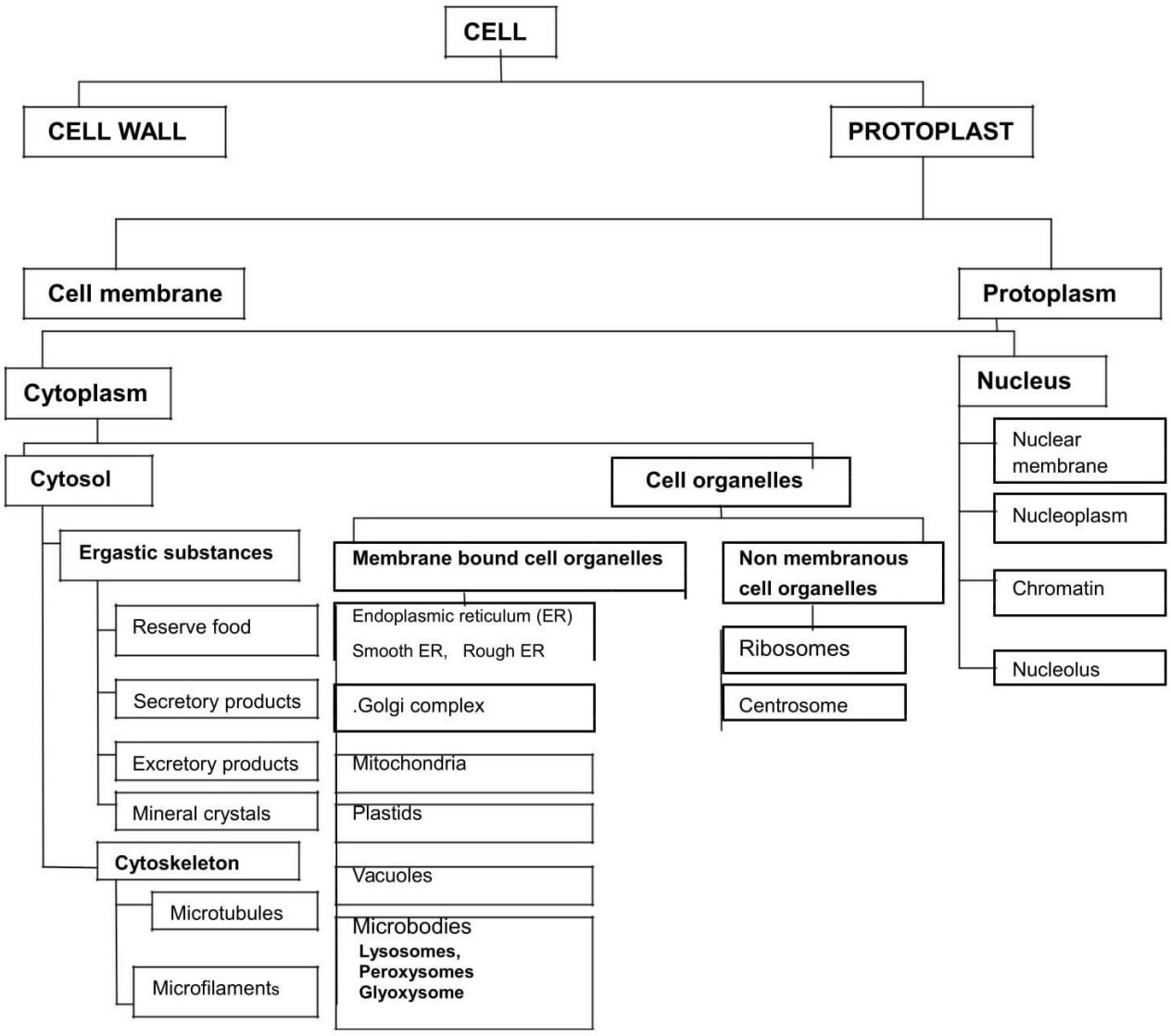
**Svedberg unit:-** When the cell is fractionated or broken down into its components by rotating in an ultracentrifuge at different speeds the ribosomes of eukaryotic and prokaryotic cells sediment (settle down) at different speeds. The coefficient of sedimentation is represented in Svedberg unit and is depicted as S.

**Difference between plnat and animal cell**

| | **Plant cell** | | **Animal cell** |
|---|---|---|---|
| 1. | Cellulose cell wall present external to cellmembrane. | 1. | No cell wall, outermost structure is cellmembrane or plasma membrane |
| 2. | Vacuoles are usually large. | 2. | Generally vacuoles are absent and ifpresent,are usually small.. |
| 3. | Plastids present. | 3. | Plastidsabsent. |
| 4. | Golgi body present in the form of unitsknown as dictyosomes. | 4. | Golgi body well developed having 2Cisternae |
| 5. | Centriole absent. | 5. | Centriole present. |

## COMPONENTS OF THE CELL

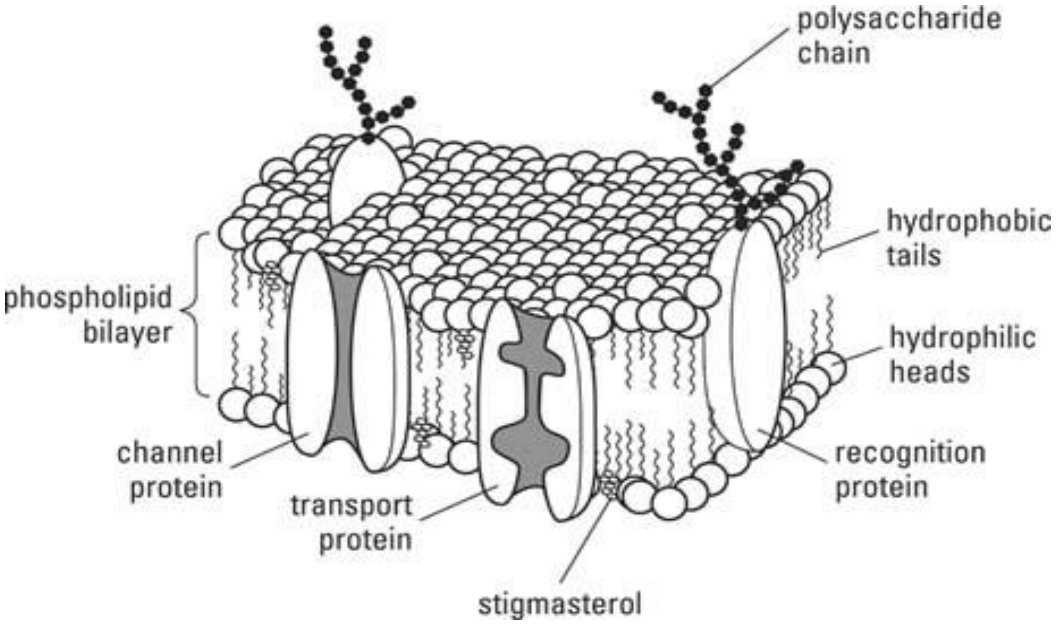
The major components of the cell are (1) cell membrane, (2) cytoplasm, and (3) nucleus.




**Cell membrane (Plasma membrane)**

Each cell has a limiting boundary, the cell membrane, plasma membrane or plasmalemma. It is a living membrane, outermost in animal cells but internal to cell wall in plant cells.It is flexible and can fold in (as in food vacuoles of *Amoeba*) or fold out (as in the formation of pseudopodia of *Amoeba*).

The plasma membrane is made of proteins and lipids and several models were proposed regarding the arrangement of proteins and lipids. The fluid mosaic model proposed by Singer and Nicholson (1972) is widely accepted.




**According to the fluid mosaic model:**

The plasma membrane is composed of a lipid bilayer of phospholipid molecules into which a variety of globular proteins are embedded.

(i) Each phospholipid molecule has two ends, an outer head hydrophilic i.e. water attracting, and the inner tail pointing centrally hydrophobic, i.e. water repelling
(ii) The protein molecules are arranged in two different ways:
  (a) Peripheral proteins or extrinsic proteins: these proteins are present on the outer and inner surfaces of lipid bilayer.
  (b) Integral proteins or intrinsic proteins: these proteins penetrate the lipid bilayer partially or wholly.

**Functions**

(i) The plasma membrane encloses the cell contents.
(ii) It provides cell shape (in animal cells) e.g. the characteristic shape of red blood cells, nerve cells, and bone cells.
(iii) It allows transport of certain substances into and out of the cell but not all substances so much it is termed 'selectively permeable'.

**Transport of small molecules (such as glucose, amino acids, water, mineral ions etc).**

Small molecules can be transported across the plasma membrane by any one of the following three methods:

(i) **Diffusion**: molecules of substances move from their region of higherconcentration to the regions of lower concentration. This does not require energy. Example: absorption of glucose in a cell.
(ii) **Osmosis:** movement of water molecules from the region of their higherconcentration to the region of their lower concentration through a semipermeablemembrane. There is no expenditure of energy in osmosis. This kind of movement is along concentration gradient.
(iii) **Active Transport:** When the direction of movement of a certain molecule isopposite to that of diffusion i.e. from region of their lower concentration towards the region of their higher concentration, it would require an "active effort" by the cell for which energy is needed. This

energy is provided by ATP (adenosine triphosphate). The active transport may also be through a carrier molecule.

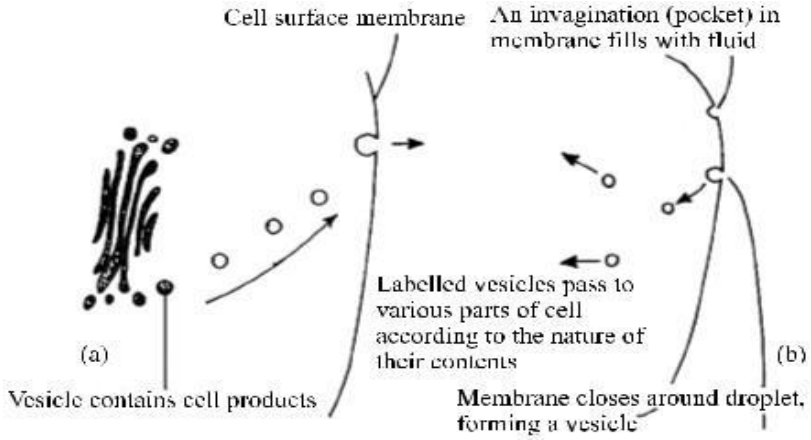
**Transport of large molecules (bulk transport)**

During bulk transport the membrane changes its form and shape. It occurs in two ways:

(i) Endocytosis (taking the substance in)
(ii) Exocytosis (passing the substance out).

Endocytosis is of two types :

| | **Phagocytosis** | | **Pinocytosis** |
|---|---|---|---|
| 1. | Intake of solid particles | 1. | Intake of fluid droplets |
| 2. | membrane folds out going round theparticle, forming a cavity and thusengulfing the particle | 2. | membrane folds in and formsa cup-like structure and sucksin the droplets. |




Diagrammatic representation of (a) phagocytosis; (b) pinocytosis

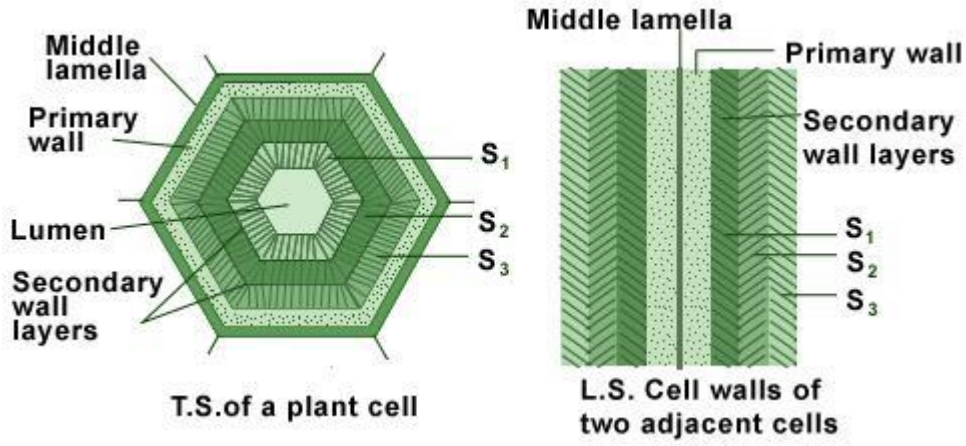
Cell membrane regulates movement of substance into and out of the cell. If the cell membrane fails to function normally, the cell dies.

**1. Cell wall**

In bacteria and plant cells the outermost cell cover, present outside the plasma membrane is the cell wall about which we shall study now.Bacterial cell wall is made up of peptidoglycan. Given below is the structure and function of the plant cell wall.

**(a) Structure**

- Outermost non-living layer present in all plant cells.
- Secreted by the cell itself.
- In most plants, it is chiefly made up of cellulose but may also contain other chemical substances such as pectin and lignin.
- The substance constituting the cell wall is not simply homogeneous but it consists of fine threads or fibres called microfibrils.
- It may be thin (1 micron) and transparent as in the cells of onion peel. In some cases it is very thick as in the cells of wood.




**(b) Functions**

- The cell wall protects the delicate inner parts of the cell.
- Being rigid, it gives shape to the cell.
- As it is rigid, it does not allow distension of the cell, thus leading to turgidity of the cell that is useful in many ways
- It freely allows the passage of water and other chemicals into and out of the cells.
- There are breaks in the primary wall of the adjacent cells through which hcytoplasm of one cell remains connected with the other. These cytoplasmic strands which connect one cell to the other one are known as plasmodesmata.
- Walls of two adjacent cells are firmly joined by a cementing material called middle lamella made of calcium pectinate.

## THE CYTOPLASM AND THE CELL ORGANELLES

The cytoplasm contains many cell organelles of which we shall learn about:

1. Those that trap and release energy e.g. Mitochondria and chloroplasts;
2. Those that are secretory or involved in synthesis and transport e.g. Golgi, ribosomes and endoplasmic reticulum
3. The organelles for motilily - cilia and flagella
4. The suicidal bags i.e. Lysosomes
5. The nucleus which controls all activities of the cell, and carries the hereditary material

**2. Mitochondria and chloroplast - the energy transformers**

Mitochondria (found in plant and animal cells) are the energy releasers and the chloroplasts (found only in green plant cells) are the energy trappers.

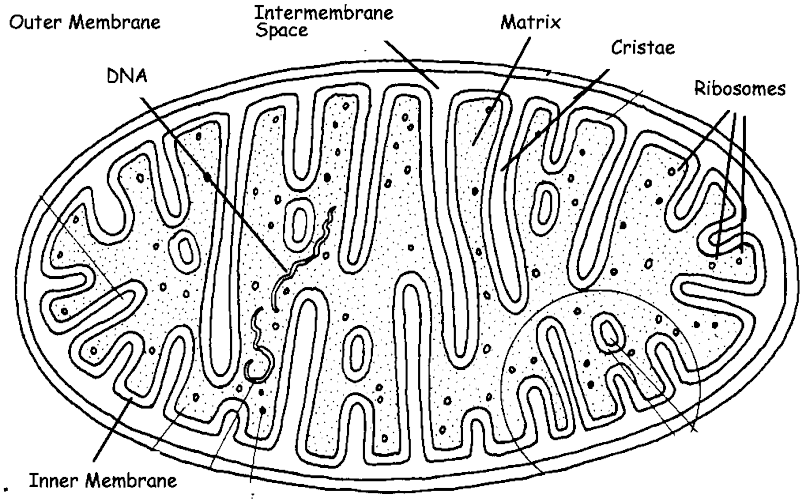
**Mitochondria (Singular = mitochondrion)**

Appear as tiny thread like structures under light microscope. Approximately 0.5 - 1.00 μm (micrometer)Number usually a few hundred to a few thousand per cell (smallest number is just one as in an alga, Micromonas**.**

**Structure:**

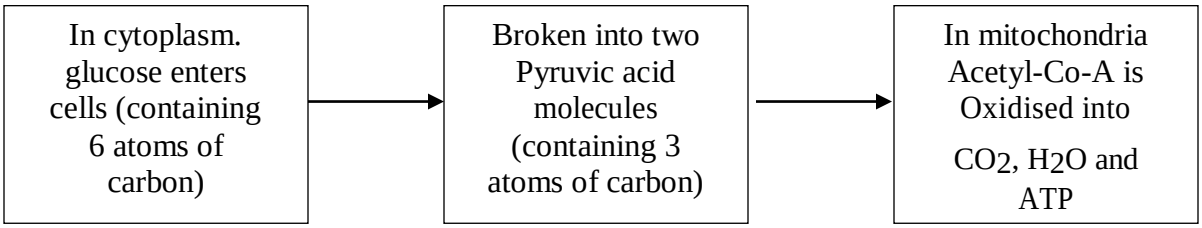
The general plan of the internal structure of a mitochondrion observedby means of electron microscope.

- Wall made up of double membrane.
- The inner membrane is folded inside to form projections called 'cristae' which project into the inner compartment called the 'matrix'.




**Function:**Oxidises pyruvic acid (breakdown product of glucose) to release energywhich gets stored in the form of ATP for ready use. This process is also called cellular respiration. That is why mitochondria are called the 'power house' of acell.

A highly simplified flow-chart of the fate of glucose to release energy is shown below:



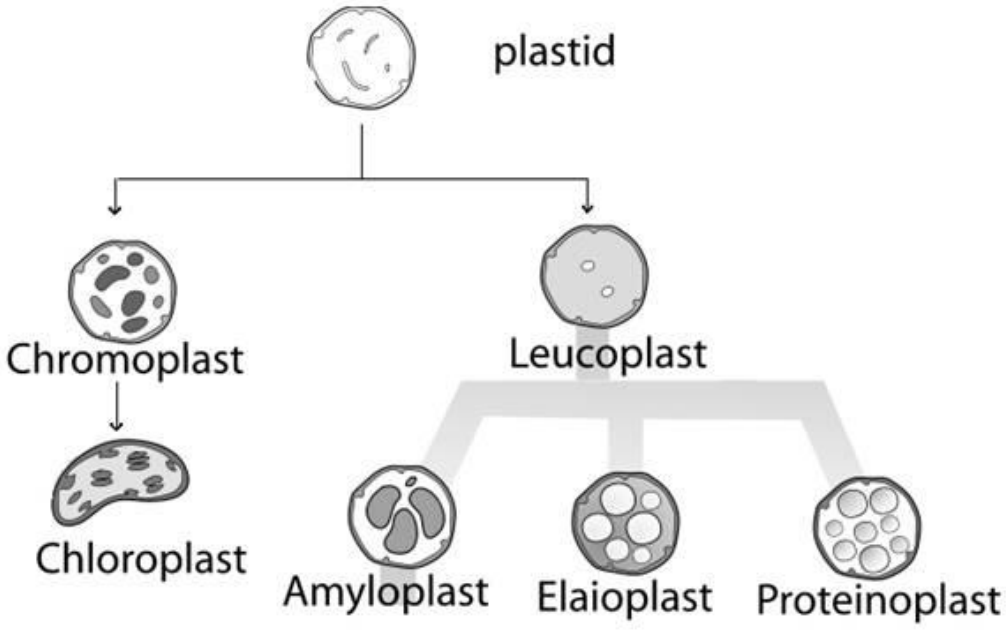

**Plastids**

Plastids are found only in a plant cell. These may be colourless or coloured. Based on this fact, there are three types of plastids.

(i) Leucoplast - white or colourless

(ii) Chromoplast – blue, red, yellow etc.

(iii) Chloroplast – green

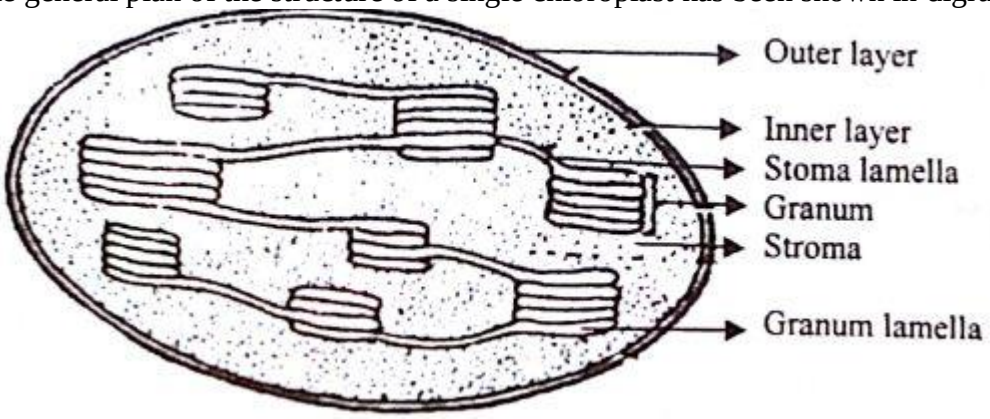



**Chloroplast**

Found in all green plant cells in the cytoplasm.
Number 1 to 1008 (how so definite)

**Shape:** Usually disc-shaped or laminate as in most plants around you. In some ribbon - shaped as in an alga *Spirogyra* or cup-shaped as in another alga *Chlamydomonas*.

**Structure:** the general plan of the structure of a single chloroplast has been shown in digram.




**Note the following parts:**

- Wall made up of double membrane i.e. outer membrane and inner membrane enumerous stack-like (piles) groups or *grana* (singular = granum) are interconnected by *lamellae*.
- Sac-like structures called thylakoids placed one above the other constitute a granum.
- Inside of the chloroplast is filled with a fluid medium called stroma.

**Function:** chloroplasts are the site of photosynthesis (production of sugar, from carbon dioxide and water in the presence of sunlight).

**Chloroplast versus mitochondria**

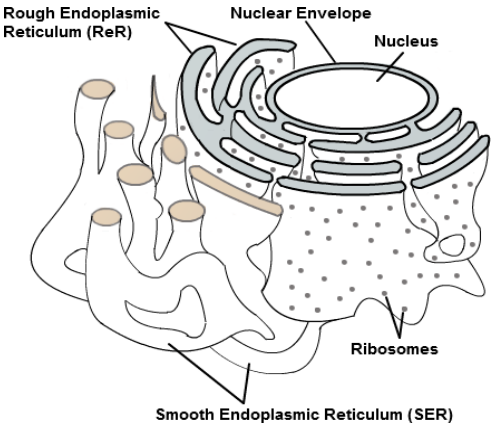
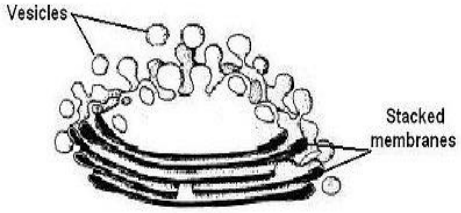
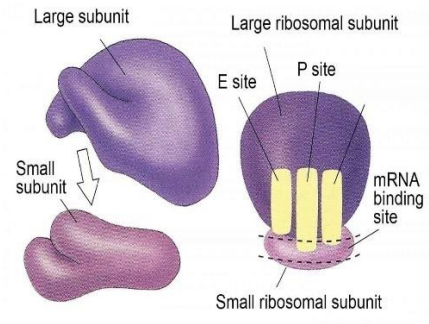
Can you now visualize how these two organelles are opposite to each other, one traps the solar energy locking it in a complex molecule (by photosynthesis), the other releases the energy by breaking the complex molecule (by respiration).

**Similarities between mitochondria and chloroplasts:** both contain their ownDNA (the genetic material) as well as their own RNA (for protein synthesis). Thus, they can self-duplicate to produce more of their own kind without the help of nucleus.

Thought the chloroplasts and mitochondria contain their own DNA the hereditary molecule and also their own ribosomes, they are termed as semi-autonomous only because they are incapable of independent existence outside the cytoplasm for a long time. Since most of their proteins are synthesised with the help of the nuclear DNA.

### 3. Endoplasmic reticulum (ER), golgi body and ribosomes

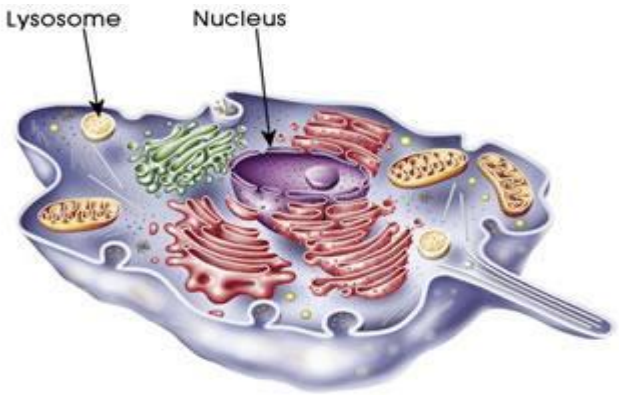
The Endoplasmic reticulum (ER) and Golgi body are single membrane bound structures. The membrane has the same structure (lipid-protein) as the plasma membrane but ribosomes do not have membranes. Ribosomes are involved in synthesis of proteins in the cell, Golgi bodies in secreting and the ER in transporting and storing the products. These three organelles operate together.

| **Endoplasmic reticulum (ER)** | **Golgi body** | **Ribosomes** |
|---|---|---|
| **ructure**<br><br>A network of membranes with thickness between 50 - 60A°. It is of two types–<br><br>Rough endoplasmic reticulum (RER) i.e. when ribosomes are attached to it and Smooth endo-plasmic reticulum (SER) when no ribosomes are present.<br><br>Distributed throughout the cytoplasm and is in contact with the cell membrane as well as the nuclear membrane. | Is a stack of membranous sacsof the same thickness as ER. Exhibit great diversity in size and shape.<br><br>In animal cells present around the nucleus, 3 to 7 in number.<br><br>In plant cells, many in number of and present scattered through out the cell called dictyosomes. | Spherical about 150 – 250Å in diameter, made up of large molecules of RNA and proteins(ribonucleoproteins)<br><br>Present either as free particles in cytoplasm or attached to ER. Also found stored in nucleolus inside the nucleus.80Stypesfound in eukaryotes and70S in prokaryotes (S-svedbergunitofmeasuring ribosomes). |
| **Function**<br><br>Providesinternalframework,compartmentand reaction surfaces,transportsenzymesandothermaterials throughout the cell. RER isthe site for protein synthesis and SERforsteroidsynthesis,storescarbohydrates. | Synthesisandsecretionasenzymes,participatesintransformation of membranesto give rise to other membranestructuresuchaslysosome,acrosome,anddictyosomes,synthesizewallelementlikepectin, mucilage. | Site for protein synthesis. |
|  |  |  |

| | | |
|---|---|---|
| | | |

**4. Lysosomes (lysis = breaking down; soma = body)**

Lysosomes are present in almost all animal cells and some non-green plant cells. They perform intracellular digestion.




**The main features of lysosomes are as follows:**

(i) Membranous sacs budded off from Golgi body.
(ii) May be in hundreds in a single cell.
(iii) Contain several enzymes (about 40 in number)
(iv) Materials to be acted upon by enzymes enter the lysosomes.
(v) Lysosomes are called "suicidal bags" as enzymes contained in them can digest the cell's own material when damaged or dead.

**Importance of intracellular digestion by the lysosomes**

(i) Help in nutrition of the cell by digesting food, as they are rich in various hydrolysing enzymes which enable them to digest almost all major chemical constituents of the living cell.
(ii) Help in defence by digesting germs, as in white blood cells.
(iii) Help in cleaning up the cell by digesting damaged material of the cell.
(iv) Provide energy during cell starvation by digestion of the own parts of the cells (autophagic, auto : self; phagos: eat up).
(v) Help sperm cells in entering the egg by breaking through (digesting) the egg membrane.
(vi) In plant cells, mature xylem cells lose all cellular contents by lysosome activity.
(vii) When cells are old, diseased or injured, lysosomes attack their cell organelles and digest them. In other words lysosomes are autophagic, i.e. self-devouring.

**5. Peroxisomes**

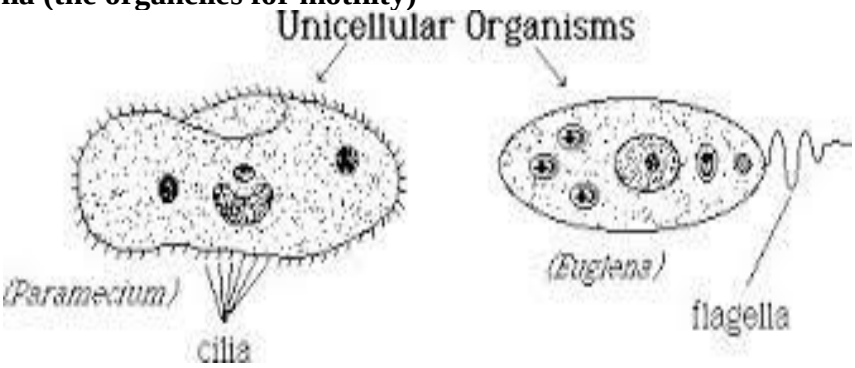
Found both in plant and animal cells. Found in the green leaves of higher plants. They participate in oxidation of substrates resulting in the formation of hydrogen peroxide.

- They often contain a central core of crystalline material called nucleoid composed of urate oxidase crystals.
- These bodies are mostly spherical or ovoid and about the size of mitochondria and lysosomes.
- They are usually closely associated with ER.
- They are involved in photorespiration in plant cells.
- They bring about fat metabolism in cells.

**6. Glyoxysomes**

- The microbodies present in plant cells and morphologically similar to peroxisomes.
- Found in the cell of yeast and certain fungi and oil rich seeds in plants.
- Functionally they contain enzymes of fatty acid metabolism involved in the conversion of lipids to carbohydrates during germination.

**7. Cilia and flagella (the organelles for motility)**




(i) Some unicellular organisms like *Paramecium* and*Euglena* swim in water with the help of cilia and flagella respectively.

(ii) In multicellular organisms some living tissues (epithelial tissues) have cilia. They beat and create a current in the fluid in order to move in a given direction e.g. in the wind pipe (trachea) to push out the mucus and dust particles.

(iii) Cilia beat like tiny oars or pedals (asin a boat) and flagella bring about whiplash like movement.

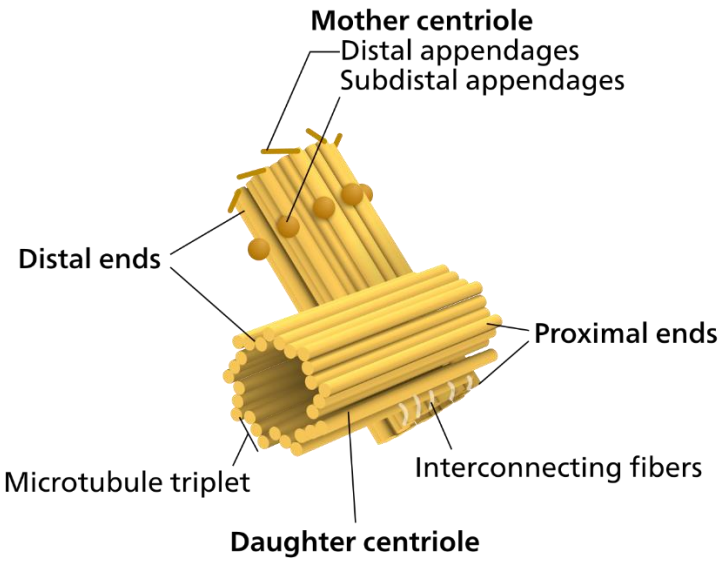
(iv) Both are made up of contractile protein tubulin in the form of microtubules.

(v) The arrangement of the microtubules is termed as 9 + 2, that is, two central microtubules and nine duplet sets surrounding them.

| **Cilia** | **Flagella** |
|---|---|
| Shorter (5 to 10 μm) | Longer (15 μm) |
| Several 100 per cell structure : protoplasmicprojection and membrane bound | Usually 1 or 2 in most cells |
| Consist of 9 sets of peripheral duplet microtubulesand 1 set of two singlet tubules in the center. | Same as in cilia |

**8. Centriole**

It is present in all the animal cells (but not in *Amoeba*), located just outside the nucleus. It is cylindrical, 0.5 μm in length and without a membrane. It has 9 sets of peripheral triplet tubules but none in the centre (9 + 0). Each set has three tubules arranged at definite angles. It has its own DNA and RNA and therefore it is self-duplicating.




**Function:**Centrioles are involved in cell division. They give orientation to the‘mitotic spindle’ which forms during cell division

**Basal bodies**

These are structures similar to centrioles. They have the same nine sets of triplet organization (9 + 0), as in the centrioles. The cilia and flagella appear to arise from the basal bodies.

**NUCLEUS (THE HEREDITARY ORGANELLE)**

General structure of the nucleus:

(i) It is the largest organelle seen clearly when the cell is not dividing.
(ii) It stains deeply, is mostly spherical, WBC have lobed nuclei.
(iii) It is mostly one in each cell (uninucleate, some cells have many nuclei; multinucleate).
(v) Double layered nuclear membrane having fine nuclear pores encloses nucleoplasm which contains chromatin network and a nucleolus.

**Functions**

- Maintains the cell in a working order.
- Co-ordinates the activities of other cell organelles.
- Takes care of repair work.
- Participates directly in cell division to produce genetically identical daughter cells. This division is called mitotic cell division.
- Participates in production of meio-gametes and meiospores through another type of cell division called meiotic cell divisioin.

**The parts of a nucleus are given here:**

**Nuclear membrane**

- Double layered membrane is interrupted by large number of nuclear pores.
- Membrane is made up of lipids and proteins (like plasma membrane) and has ribosomes attached on the outer membrane which make the outer membrane rough.
- The pores allow the transport of large molecules in and out of nucleus, and the membranes keep the hereditary material in contact with the rest of the cell.

**Chromatin**

- Within the nuclear membrane there is jelly like substance (karyolymph or nucleoplasm) rich in proteins.
- In the karyolymph, fibrillar structures form a network called *chromatin fibrils*, which gets condensed to form distinct bodies called chromosomes during cell division. On staining the chromosomes, two regions can be identified in the chromatin material heterochromatin, dark and euchromaticn (light).
- Heterochromatin has highly coiled DNA and genetically less active than euchromatin which has highly uncoiled DNA and genetically more active.
- The number of chromosomes is fixed in an organism. During mitotic cell division chromosomes divide in a manner that the daughter cells receive identical amounts of hereditary matter.

**Nucleolus**

- Membraneless, spheroidal bodies present in all eukaryotic cells except in sperms and in some algae.
- Their number varies from one to few, they stain uniformly and deeply.
- It has DNA, RNA and proteins.
- Store house for RNA and proteins; it disappears during early phase of cell cycle and reappears after telophase in the newly formed daughter nuclei.
- Regulates the synthetic activity of the nucleus.
- Thus nucleus and cytoplasm are interdependent, and this process is equal to nucleo–cytopalsmic interaction.

## CELL DIVISION

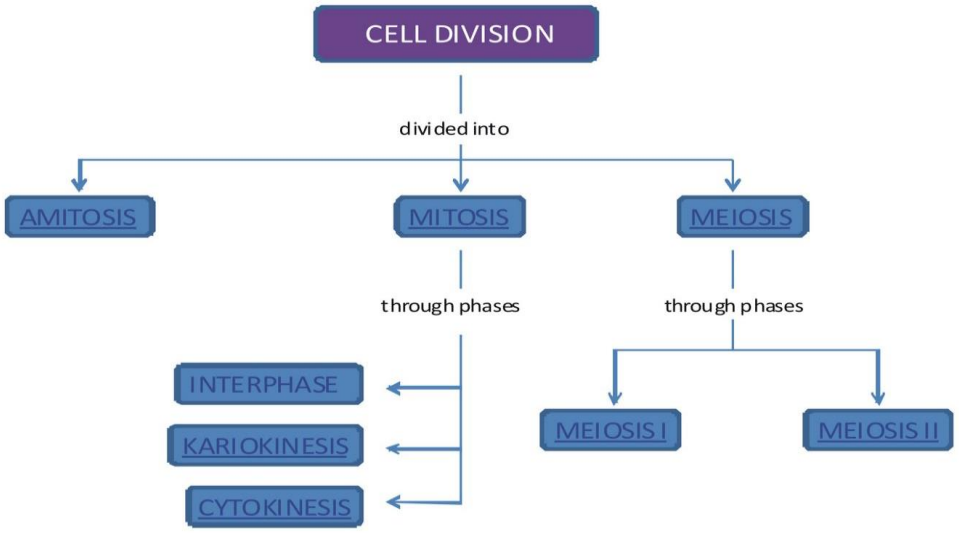
**Introduction**

Growth in shape (width), size (height), and number (population), is characteristics of all living being including plants all are due to cell division. Growth in number means reproduction -a process by which living plants produce one of their own kind.

**Rudolf Virchow** 1855 first proposed that new cells arise from pre-existing cells by division- "Omnis cellula e cellula" or "All cells from cells." and are thus called daughter cells. Continuity of life depends on cell division. In unicellular plants reproduction takes place asexually by binary fission, or splitting into two cells. The two new daughter cells that are produced are identical to each other and to the parent cell.All multicellular plants start their life as a single cell-the zygote which is a product of the fusion (fertilisation) of usually two haploid gametes- a female and a male gamete. The zygote (diploid) divide and redivide to give rise multicellular plants have a huge variety of different types of cell, specialised for different functions.

1. **Haploid(n)**-Plants/cells have only one set of chromosomes, denoted as N.
2. **Diploid(2n)**-The union of two haploid gametes(male gametes N + female gametes N= zygote 2N) results in the diploid zygote, plants with two (di) sets of chromosomes are known as diploid and denoted as 2N.Ploidy is a term denoting the number of sets of chromosomes.
3. **Polyploid**- Plants with more than two sets of chromosomes are termed polyploid.
4. **Homologous chromosomes**-Chromosomes that carry the same genes are termed homologous chromosomes

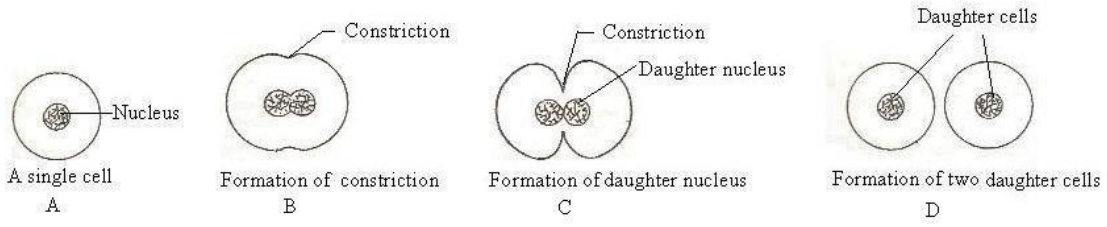
**Types of cell division**




Three types of cell division occur in plants. These are:-

1. **Amitosis** or direct cell division (Robert Remak -1855)
2. **Mitosis** or indirect cell division (Flemming -1882)
3. **Meiosis** or reduction division (Farmer and Moore -1905)

1. **Amitosis :-** Cell division in which there is first a simple cleavage of the nucleus without change in its structure (such as the formation of chromosomes), followed by the division of the cytoplasm; direct cell division; as opposed to mitosis. It is not the usual mode of division, and is occur mainly in highly specialized cells which are incapable of long-continued multiplication, in transitory structures, and in those in early stages of degeneration. This type of cell division is found mainly unicellular, prokaryotic plants e.g. cynobacteria, bacteria, yeast, internodal cells of Chara zeylanica and Chara contraria and endosperm cells of developing seed etc.




cell in various stages of amitotic cell division

**Amitosis occurs in two stages:-**

A. **Nuclear division(Karyokinesis):-** The nucleus elongates and a constriction appears in the centreresulting in a dumb-bell shaped structure. The constriction deepens and the nucleus gets divided into two. There is no spindle formation and no formation of chromosomes.

B. **Cytoplasmic division (Cytokinesis):-**The nuclear division is followed by cytoplasm division and the cell gets divided into two daughter cells. The two daughter nuclei are always similar in shape and size. Thus amitosis is only a quantitative division.

2. **Mitosis**

Mitosis is the common method of nuclear division, followed by cytokinesis (cytoplasmic division). It usually occurs in vegetative or somatic cells therefore it is known as somatic division. It occurs in meristematic tissues - shoot, root tip. It results in the increase of size, shape and volume of plant parts and causes growth. The pattern of mitosis is fundamentally the same in all cells.In this division the mother cell produces two genetically identical daughter cells which resemble each other and also parent cell qualitatively and quantitatively.The separation of separate sister chromatids into two new cells with exactly the same number of chromosomes and half the amount of nuclear DNA is known as mitosis Therefore it is also called equational division Mitosis is also known as indirect division because it is an elaborate process involving a series of important changes in nucleus as well as cytoplasm. In mitotic division not only the chromosomes are replicated but all necessary cytoplasm constituents and organelles are precisely divided between two daughter cells. In mitosis there is no change in chromosome number. Mitosis is observed in all types of cells -haploid, diploid or polyploid.If a parental cell has 1000 chromosomes, or even just 1 chromosome, the daughter cells have 1000 and 1 chromosomes, respectively after mitosis.

**Some useful terms which are used:-**

- **Chromosome**:- A gene is made up of DNA which codes for one or more polypeptides. A chromosome is made up of many genes. The DNA in the chromosome is wrapped around histone and non-histone proteins. Before DNA synthesis, there is only one double stranded helix of DNA in each chromosome.
- **Chromatid: -** After DNA synthesis, there are two identical DNA helices connected by a structure called the centromere. Each DNA helix is called a chromatid.These chromatids are called sister chromatids.

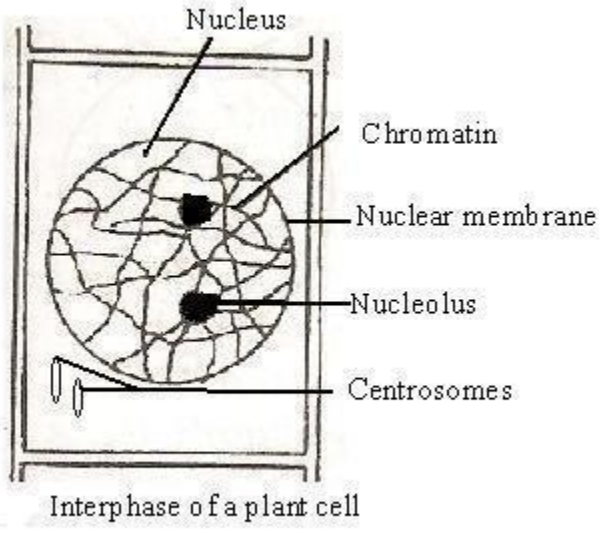
**Cell cycle**

The cell cycle is an ordered set of events, which occurs between the formation of a cell and its division into two daughter cells.

The cell cycle is composed of 4 distinct phases:-$G_1$ phase, S phase, $G_2$ phase, and M phase and C phase. $G_1$, S, and $G_2$ phases (the first three phases) together constitute the interphase and the M stage stands for mitosis and C phase for cytokinesis.In the simplest sense, a cell duplicates its contents and then divides in two.The cycle of duplication and division is known as the cell cycle.

**Interphase + Nuclear division(mitosis) + Cytokinesis = Cell cycle**

1. **Interphase**:- During interphase, the cell is growing and preparing for mitosis (M phase) by accumulating nutrients and replicating DNA.Interphase is the longest phase in cell cycle.Though this phase is sometimes called resting stage, but it is in fact the most active phase of the cell cycle.



Interphase of a plant cell

**a. $G_1$ phase:-**$G_1$ stage separates the end of mitosis and the start of the S phase. The timing of the cell cycle and the relative lengths of the various stages depends on the specific type of cell and on the local conditions. Cell cycle ranges 8 hours to 100 days or more. Differences in cell cycle times are mainly due to the variations in the length of $G_1$ phase. Cells in a rapidly developing tissue have thus a short $G_1$ phase. Slowly dividing cells stay in $G_1$ phase for days or more or in many organisms takes up most of the cell's life.

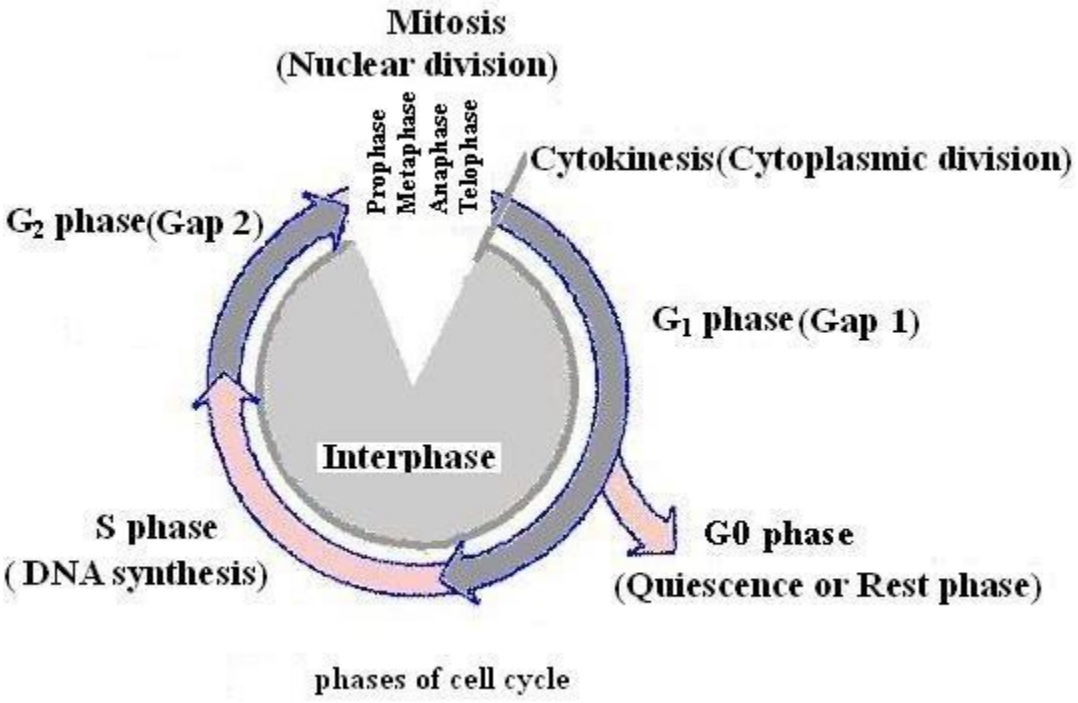
Beginning after cytokinesis, the daughter cells are quite small and low on ATP. They acquire ATP and increase in size during the $G_1$ phase. In this phase cytoplasmic growth occurs and the cell is preparing its enzymatic machinery to be ready for the next stage S phase(synthesis). The daughter cells become as large as the mother cell, the chromosomes are thread-like and invisible(dispersed state), no change in DNA amount or chromatin. Each chromosome contains only a single molecule of DNA is called an unduplicated or unreplicated chromosome. In $G_1$ (first gap) intensive formation of biochemicals and cellular synthesis, production of mitochondria, plastids, endoplasmic reticulum, lysosomes, golgi apparatus, vacuoles takes place. Nucleolus produces rRNA, Synthesis of rRNA, mRNA and ribosomes. Structural and function (enzymes) proteins, amino acids for histone formation, nucleotides and energy rich substance ATP - synthesized. Cell metabolic rate high, controlled by enzymes.

**During $G_1$phase, a cell may follow one of the three options**:

1. Cell has reached the restriction point (R point). After a short rest it continue on the cycle and divide.
2. The cell permanently stop division and enter $G_0$ or quiescent stage.
3. The cell cycle have been arrested at a specific point of $G_1$ phase. The cell in the arrested condition is said to be in the $G_0$ state. The cell in the $G_0$ may be considered to be withdrawn from the cell cycle.When conditions change and growth is resumed the cell re-enters the $G_1$.

b. **S (synthetic phase) Synthesis of DNA and histones phase:-** It is bordered by both of the $G_1$ and $G_2$gap phases.During the S phase, new DNA is synthesized by the cell resulting in each chromosome with two molecules of DNA.The DNA content of the nucleus is doubled and proteins are synthesized. During this stage every double-helical DNA molecule is duplicated, making two strands of DNA that are exactly identical(the DNA breaks apart at different points along the strands. New single strands join the two halves of original strands). Two new DNA strands are formed,which are attached together by specific proteins, at a short sequence of DNA (which is found on each double helix) and called a centromere. The two DNA copies that result from S phase are not visible through a light microscope because they have not yet condensed to form chromosomes (i.e., they remain chromatin). Each chromosome has become two chromatids. Once duplication is complete, histones proteins synthesized which cover each DNA strand (chromatin synthesis). The number of chromosomes remain same as were present in the newly formed cell(1n or 2n) but each chromosome is changed from single stranded form to two stranded form.

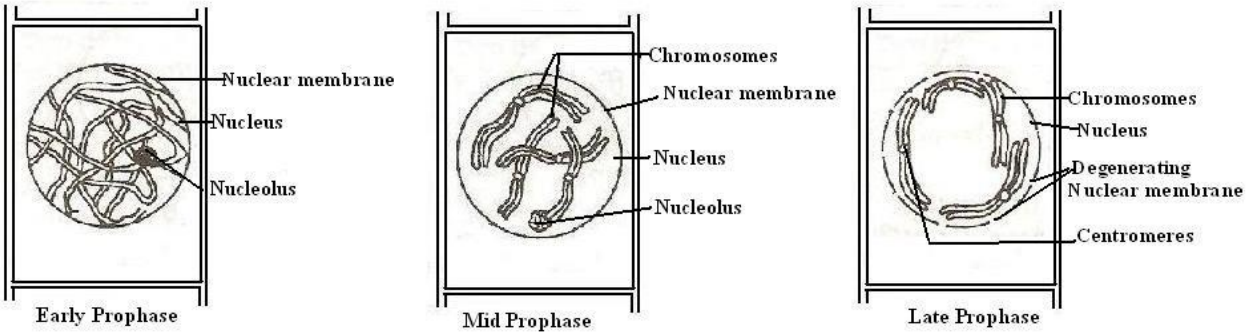
c. **$G_2$ phase:-**Since the formation of new DNA(S phase) is an energy draining process, the cell undergoes a second growth and energy acquisition stage, the $G_2$ phase. The energy acquired during $G_2$ is used in cell division (in this case mitosis).During the pre-mitotic gap phase ($G_2$), synthesis of RNA and protein continues, but DNA synthesis stops.The mitotic spindle proteins are formed. The mitotic spindle is structure that is involved with the movement of chromosomes during mitosis. The multiplication of the chloroplasts and mitochondria (by binary fission!) and production of materials needed for mitosis (a nuclearevent) takes place. During $G_2$ phase chromatin begins to condense into the relatively compact structures called chromosomes (which, as a result of condensation, become visible through a light microscope). These chromosomes remain attached through their centromeres. Preparation for segregation: Preparation is made for chromosomal segregation, though actual segregation is not yet initiated (e.g., the nuclear membrane remains intact). The durations of the S phase, the $G_2$ phase and mitosis is generally constant in most cell types.




phases of cell cycle

2. **Mitosis** phase is the shortest phase in cell cycle. Although mitosis is a continuous process, the mitosis itself involves the condensation and separation of the replicated chromosomes. Mitosis has been subdivided into five phases:

**A. Prophase** (condensation):- A stage of chromosome condensation.



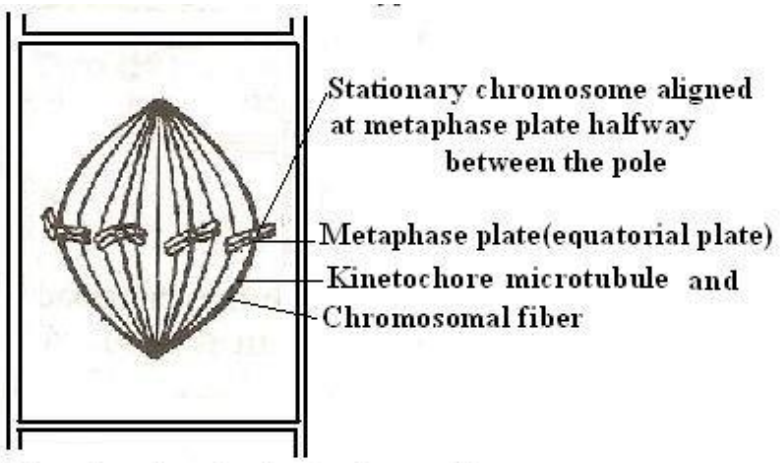

Stages in mitosis of a plant cell(different stages of prophase)

- At the beginning of prophase chromosomes appear as thin, filamentous uncoiled structures.
- Chromosomes become coiled, shortened and more distinct in prophase, which is of much longer duration than other stages.
- Nucleoli disappear.
- Each chromosome longitudinally splits into two sister chromatids. Double structure of each chromosome is visibleat late prophase.
- The duplicated chromosome subunits (each one called chromotid) join together at the centromeres.
- And two chromatids are attached to spindle tubules(Chromosomal fibers) with the help of protein plates called kinetochores a specialised structures develop on either surface of centromere of each chromosome.
- The kinetochore is the actual site of the insertion of the spindle threads and is a permanent part of the chromosome.

**B. Prometapase**

- The nuclear membrane disintegrates.When the nuclear membrane dissolves, there is no differentiation between cytoplasm and nucleoplasm. The chromosomes are attached to the spindles through their centromeres. Such a mitosis is called extra-nuclear mitosis or eumitosis. The mitosis takes place within the nuclear membrane and is called intranuclear mitosis or premitosis e.g.many protozoans and some animals cells
- The chromosomes move freely and proceed towards the equator.
- Microtubules A system of microtubules needed to move the chromosomes begins to form during prophase.The microtubules, also called spindle fibers, form from an area of the cell called the centrosome. During interphase, the cell has one centrosome but just before prophase, the centrosome duplicates, producing a second centrosome. During prophase, microtubules radiate from each centrosome. Some of the microtubules extend from one centrosome toward the other.
- Spindle fibers:-Spindle fibers extend from the poles to the equator.
- The spindle apparatus forms.The spindle apparatus which moves the chromosomes consists of two proteins actin and tubulin. The entire complex of centrosomes and spindle fibers is called the spindle apparatus.
- The two centrosomes move to the opposite poles of the nucleus, elongating their + ends. At the end of prometaphase, the two centrosomes are at opposites poles of the cell, and some of the spindle microtubules are attached to the chromosome at the knietochore.
- The microtubule from one pole may attach to the knietochore first, and the chromosome and the chromosome begins to move toward the other pole aligning the chromosomes at the equatorial plane.
- Microtubules can only remain attached to a kinetochore where there is a force exerted on the chromosome from the opposite end of the cell.
- Kinetochore microtubules are spindle fibers that attach to the kinetochores and move the chromosomes to the center of the cell.
- The next phase (Metaphase) begins when the chromosomes become aligned in the center of the cell.

**C. Metaphase**:-




Metaphase in mitosis of a plant cell

- The chromosomes line up in one plane to form the equatorial plate or metaphasic plate.
- Chromosome lies in the middle of the spindle apparatus and is perpendicular to its axis.
- In actuality, only the centromere lies on the equatorial plate, while the chromosome arms (chromatids) are directed away from the equator.
- Smaller chromosomes are usually central in position whereas the larger ones are peripheral

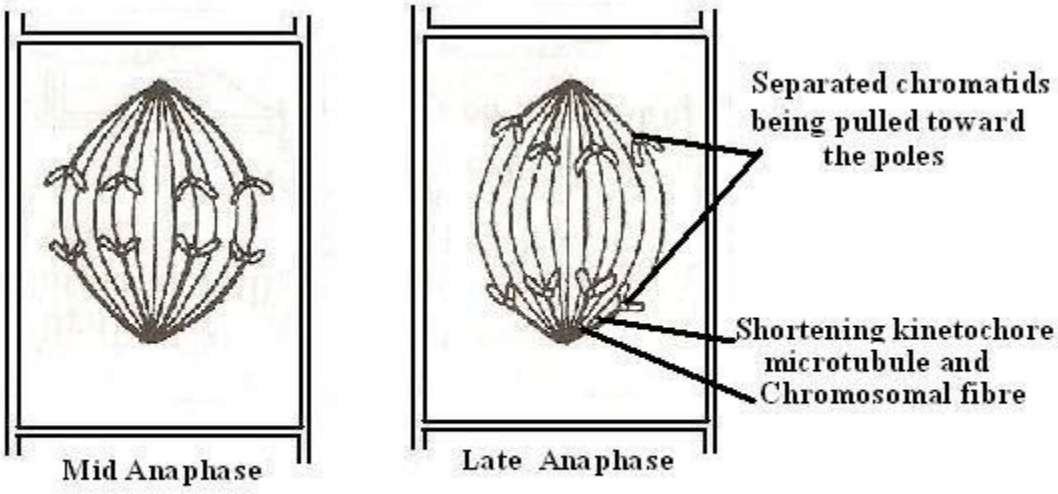
- At metaphase, the chromosomes are aligned on the cell's midline. Approximately 15-35 mircotubules are attached to the kinetochore (by kinetochore microtubules).

**There are also two types of non-kinetochore microtubules:-**

a. Some microtubules radiate from the centrosome toward the metaphaseplate without attaching to chromosomes. Others are too short to reach the metaphase plate.

b. Still others extened across the plate and overlap with non-kinetochore microtubules from the opposite pole of the cell.

**D. Anaphase** (centromere separation and chromatid migration):-




Anaphase in mitosis of a plant cell

I. Anaphase begins when the centromeres divide and the spindle apparatus starts pulling the kinetochores to the opposite poles (progressive shortening of the microtubular spindle fibers pulls the chromosomes in opposite directions toward the poles).

II. The daughter kinetochores move apart dragging the chromosomes (each now a single strand) to the poles.The chromosomes appear in the shape of V,L, J or I.

III. Two cells begin to form. In anaphse the centromeres divide and two sister chromatids separate and move to the opposite ends of the cell.

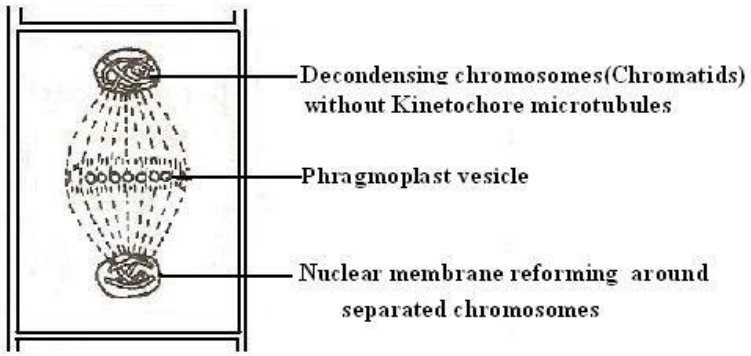
IV. Microtubules pull a chromosome towards a pole by losing protein subunits are their centrosome and at the end (attached to the kinetochore). The non-kintetochore microtubules are responsible for elongating the whole cell along the polar axis during anaphase.

When the chromosomes split in anaphase, the chromosome number is doubled. For example, the number of chromosomes and chromatids during each phase in a pea (Pisum sativum) cell is:-

| Phase | Chromosomes | Chromatids |
|---|---|---|
| Prophase | 14 | 28 |
| Prometaphase | 14 | 28 |
| Metaphase | 14 | 28 |
| Anaphase | 28 | 28 |
| Telophase | 28 | 28 |

Cytokinesis (division of the cytoplasm) begins in anaphase. Two cells will be produced as this process continues.

**E. Telophase** (recovery of nuclear envelope and decondensation). Telophase begins when chromosomes reach the poles of the daughter cells. Many of the events in telophase are the reverse of prophase, but there are now two nuclei instead of one.

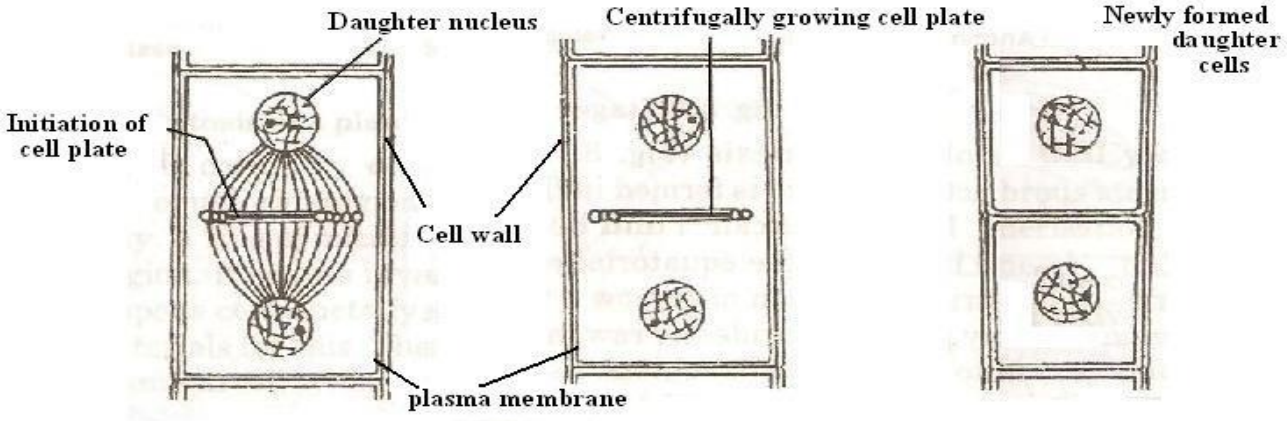



Telophase stages of mitosis

i. Chromosomes decondense (uncoil).
ii. Nuclear membrane reappears around daughter nuclei.
iii. Spindle Fibers become disorganized.the spindle apparatus breaks down.
iv. The nucleolus reappears.
v. The cell pinches in the middle, beginning the formation of the two cells. The new cell plate expanding centrofugally.

Each daughter cell gets the same complement of chromosomes and nucleoli as of the mother cell.During division, cell organelles like mitochondria, plastids, golgi complex, lysosomes and the cytoplasmic matrix are distributed into the two daughter cells.

**f. Cytoplasmic division (Cytokinesis)**:-




Stages of cytokinesis through cell plate formation in a plant cell

Plant cells divide by formation of a new cell wall (cell plate) between daughter nuclei at the end of the telophase, soon after the formation of daughter nuclei, the spindle fragments and gather at the equator region and form a barrel shaped structure called phragmoplast. The vacuoles of golgi complex enter the phragmoplast and release pectins into it. At the end of anaphase, golgi-derived secretory vesicles carrying cell wall materials are transported to the equator of a dividing cell. Fusion of these vesicles gives rise to a membrane-bound compartment, the cell plate. The cell plate expands from the middle out (centrifugally) until it reaches the "zone of attachment" or division site on the mother cell wall. Cell plate gradually undergoes physical and chemical changes to form middle lamella thus

dividing cytoplasm into parts. On both sides of the middle lamella the primary wall materials like cellulose and hemi cellulose are deposited.As a result two daughter cells are formed

The places where vesicles of the cell plate fail to fuse, the cytoplasmic contact between the daughter cells is maintained.Such cytoplasmic channels are lined by plasma membrane to form plasmodesmata.

**Function of mitosis:-** Cell division is a fundamental part of a plant's existence and development

- Growth:- The number of cells in a plant increases due to mitosis leading to growth.
- Asexual reproduction, regeneration and cell replacement:- A number of plants propagate (vegetatively)by mitotic divisions ofhe cells.Regeneration of lost parts, and cells replacement (tissue repair) occurs by mitosis in multicellular plants.
- As a result of mitosis, two nuclei are formed which have same number of chromosomes as the parent cell.

**Endomitosis:-** Replication of chromosomes without division of the nucleus is called endomitosis; it leads tothe formation polyploids.Endomitosis without separation of chromatids leads to polyteny**.**

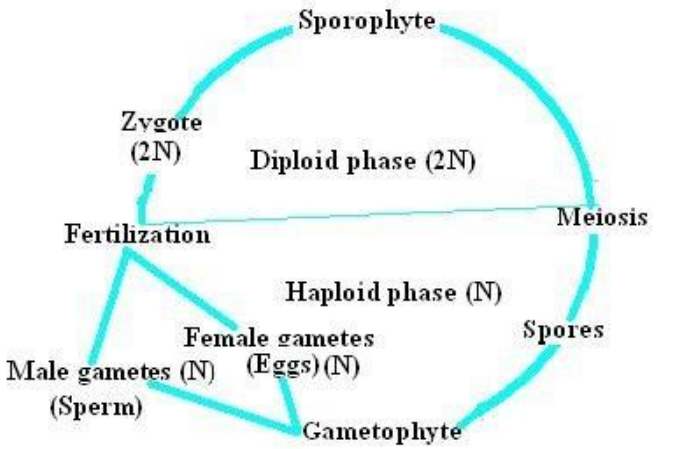
4. **Meiosis**

Meiosis is the process by which gametes, sex cells, are formed. In this division the mother cell produces four daughter cells called gametes in which the chromosome number reduced to half, so this division is called reductional division. The gametes carry genetic recombination and therefore unidentical with that of mother cell, because of that this division is known as heterotypic division Thus if the parental cell has 14 chromosomes, each daughter has 7.

Sexual reproduction involves the two alternating processes of meiosis and fertilization.

a. In meiosis, the chromosome number is reduced from the diploid to the haploid number.
b. In fertilization, the nuclei of two gametes fuse, the zygote is formed and the chromosome number changes from haploid to diploid.

In most plants meiosis and fertilization divide the life of the organism into two distinct phases or "generations".



Life cycle of plant (alternation of generation)

1. The gametophyte generation begins with a spore produced by meiosis. The spore is haploid, and all the cells produced from it (by mitosis) are also haploid. This multicellular structure produces gametes — by mitosis — and sexual reproduction then produces the diploid sporophyte generation.
2. The sporophyte generation thus starts with a zygote. Its cells contain the diploid number of chromosomes.Some reproductive cells undergo meiosis, forming spores and starting a new gametophyte generation.

**Farmer and Moore (1905)**- Proposed the namemeiosis (= reduction) to the whole process of the two successive nuclear divisions.It is the type of cell division, results in each daughter cell having half the number of chromosomes as the parent. This division maintains the chromosome number constant in all sexually reproducing plants.

Meiosis occurs in diploid or polyploid cells, absent in haploid cells.

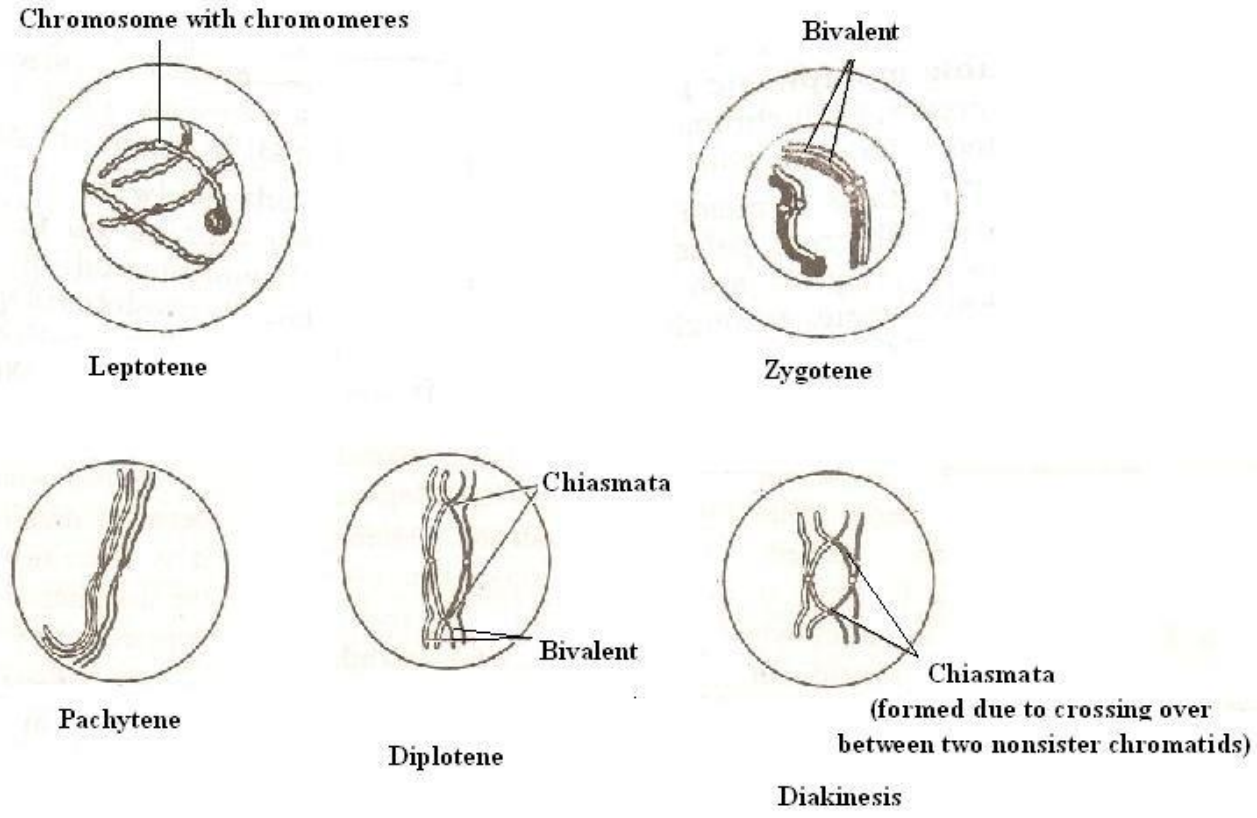
In lower plants, meiosis takes place in the zygote, this type of meiosis is known as zygotic meiosis (or initial meiosis) e.g. Chlamydomonas.

**Premeiotic interphase:-** An interphase in meiosis is just like that of mitosis. It consists of $G_1$,S and $G_2$phases. $G_2$ phase in meiosis is either very short or is completely absent. Meiotic division starts just after DNA synthesis is complete. During meiosis, the nucleus divides twice but chromosomes divided only once, Gregoire (1904) called the first division as meiosis I and the second one as meiosis II.

**Phases of Meiosis:-** The end result of one round of meiosis will be four cells with half the number of chromosomes as the parent cell. There are two successive divisions in meiosis, which in plants occur without a pause.

i. **Meiosis I /Reduction division:-** The chromosome number is reduced to half the parent cell chromosome number. As a result two haploid cells are from one diploid cell. It comprises four phase:-

1. **Prophase I**:-



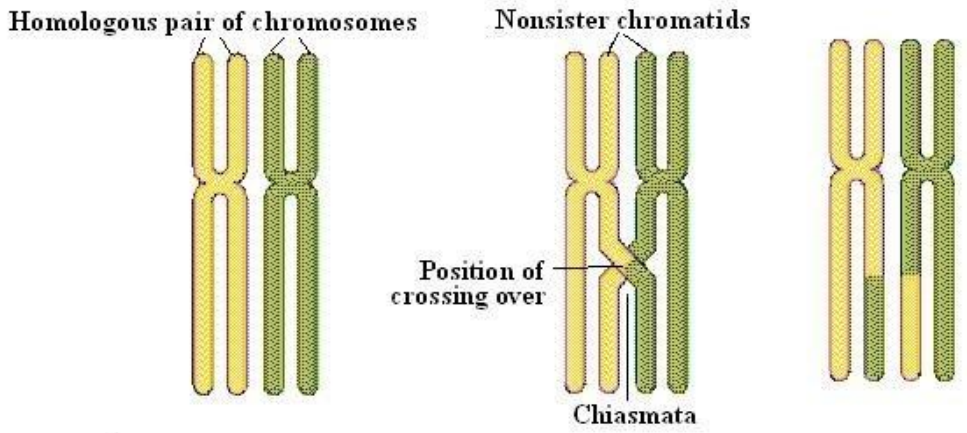

Different stages of Prophase I Meiosis

First prophase is of a very long duration. It has five stages:-

a. **Leptotene(leptonema)**:-The chromatin condenses into long thin thread- like chromosomes.The bead-like thickening called chromomeres are found all along the length of chromosomes.The number, size and position of chromomeres is constant.The chromosomes are arranged parallel and well separated but at the end of leptotene the homologous paternal maternal chromosomes come close together at a point. This condition is known as bouquet stage.

b. **Zygotene (zygonema)**:- The chromosomes each derived from one parental gamete nuclei (homologous chromosomes) come together and form pairs. This process of pairing is called synapsis and the resulting structure synaptic complex. The process pairing starts one or many points and extends in a zipper-like manner across the whole length of the homologous chromosomes. Synapsis is either:- Procentric (starting at the Centromere) or Proterminal (starting at the end) or Localized/random (starting at various points).

c. **Pachytene (pachynema):-** The paired chromosomes are now called a bivalents. They become shorter and thicker. Each of the homologous chromosomes in meiotic prophase-I consists of two closely apposed sister chromatids, thus each bivalent contains four chromatids, and is also called tetrad (two chromosomes of two chromatids each, or four total chromatids). At this stage, large recombination nodules appear at intervals on the synaptonemal complex. These recombination nodules are believed to mediate for chromosomal recombination -crossing over. Two non-sister chromatids (chromatids of different chromosomes of a homologous pair) of each tetrad get coiled around each other and exchange segments. For this, transverse breaks occur at the same level of non-sister(of the homologues) chromatids, exchanged their parts mutually at one , two, or many points between non-sister(of the homologues) Such points where the chromatids physically contact each other are called chiasmata at this stage the chromosomes appear as X shaped structure. During the formation of chiasmata the chromatids first break due to the action of an enzyme called endonuclease. The broken chromatid segments mutually exchange with each other and get united by the action of enzyme ligase. The formation of chiasmata leads to the exchange of genetic material and results in the recombination of characters, this process is known as crossing over. It is responsible for the origin of new species and thus leads to evolution



Crossing Over and result of Crossing Over

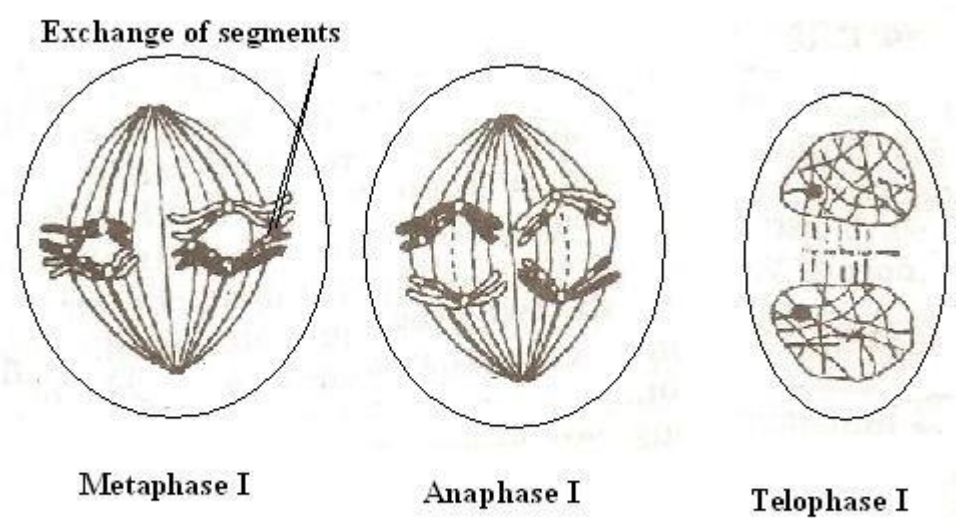
d. **Diplotene (diplonema):-** The synaptonemal complex dissolves allowing the two homologous chromosomes of the bivalent to pull away from each other .The separation is however not completed. The homologous chromosomes remain attached at one or more points where crossing over has occurred. These points of attachment are called.

**Chiasmata** by **Janssens** (1909):- This state is marked by the formation of cross-like structures, single or multiple loops. The chromosomes decondense and engage in RNA synthesis. Due to crossing over genes from one chromosome(parental) get exchanged to genes

of other chromosomes resulting in the formation of new gene combination -this process is extremely important for creating genetic diversity.

**e. Diakinesis:-** Diakinesis is marked by terminalisation of chiasmata (displacment of chiasmata):- the chiasmata begin to move towards the chromosome ends. RNA synthesis stops and the chromosomes condense, thicken, and get detached from the nuclear envelope. Each pair (bivalent) of chromosomes has four chromatids and they have a centromere attached in the center holding the four strands together.whereas non-sister chromatids of homologous chromosomes are linked by chiasmata. Single chiasma on bivalent forms cross, two and three chiasma prouce rings and loops respectively. Nucleolus disassociates and nuclear envelope dissolves. Some spindle fibers are forming and some are attaching to the centromeres of the chromosomes. The fibers extend from each pole of the cell.

**2. Metaphase I—**




Different stages of Meiosis I

The bivalents become arranged in the plane of the equator forming the equatorial plate. The centromere of each chromosome is directed towards the opposite poles and the arms of chromosomes face the equatorial plate. The two chromatids, from each chromosome, function as a single unit.

**3. Anaphase I:-**

One entire chromosome, consisting of two chromatids, migrates from the equator to a pole. From each tetrad, two chromatids joined by their centromere, move as a unit (dyad) to one pole of a spindle, while remaining two chromatids bound by their centromere migrate to opposite pole. Thus each pole receives half the number of chromosomes or the haploid set of the chromosomes. Thus, actual reduction in number of chromosomes occurs. The movement of chromosomes is brought about by the shortening of spindle fibres, similar to that in during mitosis. When sister chromatids go to same pole it is called reductional or disjunctional division; on the other hand, when they separate and go to two poles it is an equational division as in mitosis.

**4. Telophase I**

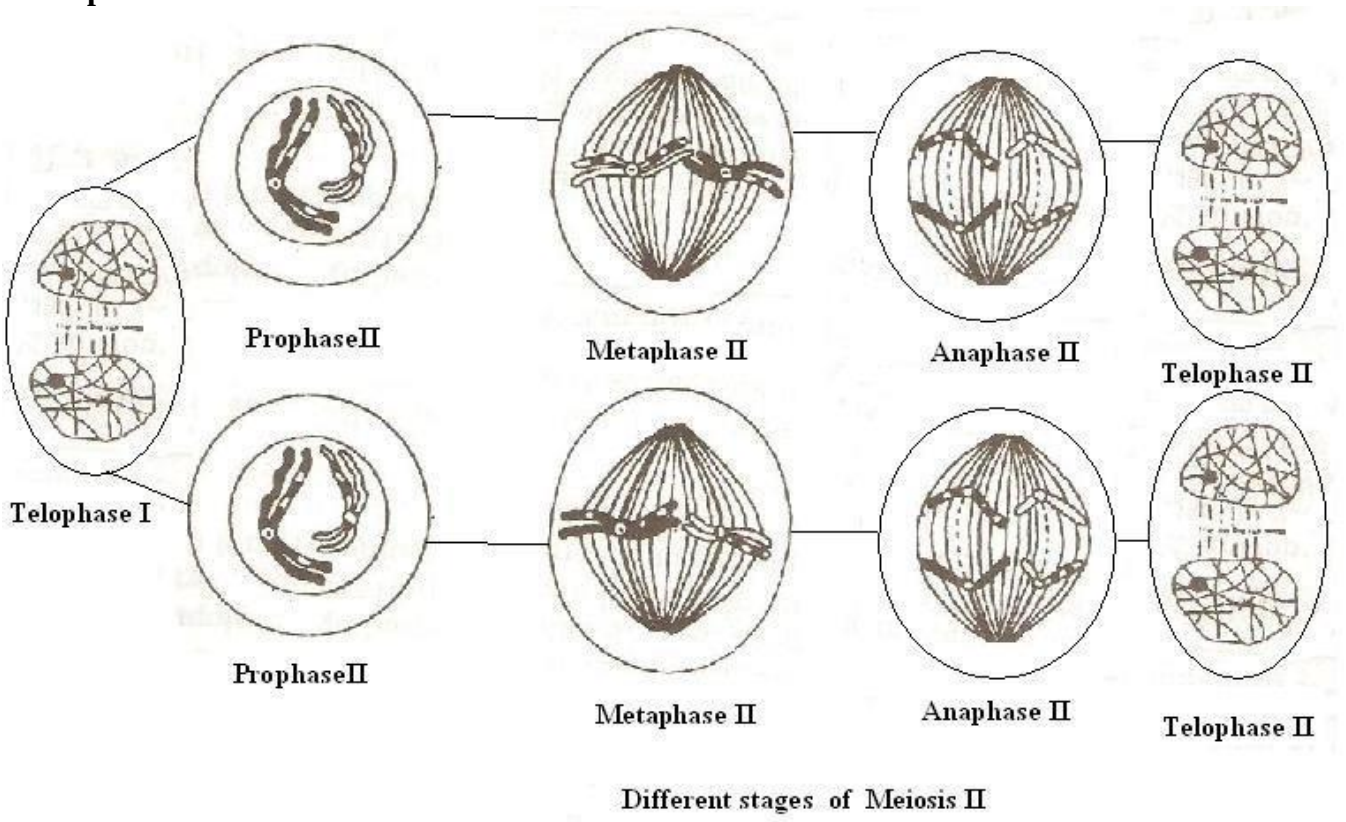
The nuclear membranes are formed during this stage by the endoplasmic reticulum around the groups of daughter chromosomes with the appearance of one nucleolus in each nucleus. It results in the formation of two daughter cells each with haploid number of chromosomesand only half amount of DNA.

**Cytokinesis:-** It occurs by cell wall formation in plants.But in many plants cytokinesis doesnot take place and cell directly passes into meiosisII.

**Meiosis II- equational division**

First meiotic division is followed second meiotic division with or without intervening interphase. Meiosis II is necessary due to crossing over, the chromatids are not identical and must be separated similar to mitosis and is also called equational division. It consists of a transient interphase II,in which S phase is absent- no further DNA replication occurs, followed by :-

**a. Prophase II**:-




Different stages of Meiosis II

Chromosomes of both nuclei become shorter and thicker. The two-stranded nature becomes apparent once again and the nuclear membrane disappears.

**b. Metaphase II**

Spindle formation takes place. The chromosomes become oriented on the equatorial plate and have the same relationship to the spindle as in mitosis. The spindles in meiosis II are oriented at right angleto that in meiosis I.

**c. Anaphase II**

The centromere divides and the two sister chromatids of each chromosome separate and move towards the poles. After separation, each chromatid behaves as a chromosome. Thus, a chromosome has one chromatid before and two chromatids after replication.

**d. Telophase II**

At this stage, the four groups of chromosomes become organised into four haploid nuclei. The chromosomes return to the interphase condition. The endoplasmic reticulum forms the nuclear envelope around the chromosomes and the nucleolus reappears due to association of rRNA with ribosomal proteins synthesised on rDNA templates. Each nucleus at this stage contains the haploid number of chromosomes and forms four cells.

Cytokinesis occurs and the two nuclei are separated as in mitosis.

**Significance of Meiosis**

- The meiosis maintains a definite and constant number of chromosomes in the sexually reproducing organisms by producing haploid gametes.
- During synapsis of the homologous chromosomes, pieces of chromosomes can exchange with one another. This allows for exchange of genetic information. The ultimate result is to increase genetic variability. By crossing over, the meiosis provides an opportunity for genetic variation through gentic material by crossing over and random distribution of maternal and paternal chromosomes.
- Ariation is necessary for natural selection; natural selection favors individuals with characteristics that are best adapted to their environments. Variation is therefore necessary for species to become adapted to their environment and it enables them to change when the environment changes.

**Karyotype**

Chromosomes can be seen distinctly only at metaphase. They are then photographed, cut and arranged in pairs according to size. Such an arrangement of homologous chromosomes of an individual in descending order according to size, is termed as a karyotype.

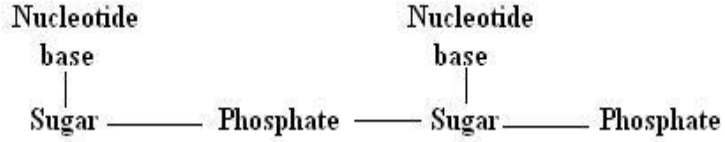
**Difference between Mitosis and meiosis**

| **Mitosis** | | **Meiosis** |
|---|---|---|
| 1. | Cell divides only once. | There are two cell divisions. First meioticdivision and the second meiotic division. |
| 2. | Takes place in somatic cells as well as in reproductive cells which may be haploid or diploid or polyploid. | Takes place only in diploid germ cells. |
| 4. | Duration of prophase is short(few hours). | Prophase-I, is comparatively longer (takes many days). |
| 5. | Prophase simple. | Prophase I is complicated having five sub-stages namely leptotene, zygotene,pachytene, diplotene and diakinesis. |
| 7. | Synapsis does not occur. | Synapsis of homologous chromosomestakes place during prophase-I. |
| 8. | No exchange of segments duringprophase between two nonsisterchromatids of chromosomes. | Exchange of segments during crossingover between non-sister chromatids of twohomologous chromosomes takes place. |
| 9. | Each chromosome consists of twochromatids united by a centromere. | Each bivalent has four chromatids andtwo centromeres. |
| 10. | Chromosomes are duplicated at thebeginning of prophase. | In prophase I, chromosomes appear singlealthough DNA replication has taken placein interphase I. |
| 11. | In metaphase all the centromeresline up in the same plane. | In metaphase I, the centromeres are lined upin two planes which are parallel to oneanother. |
| 12. | The metaphasic plate is made upof duplicated chromosome. | The metaphasic plate is made up of pairedchromosomes. |
| 13. | Centromere division takes placeduring anaphase. | No centromere divisions during Anaphase I,centromeres divide only during Anaphase II. |

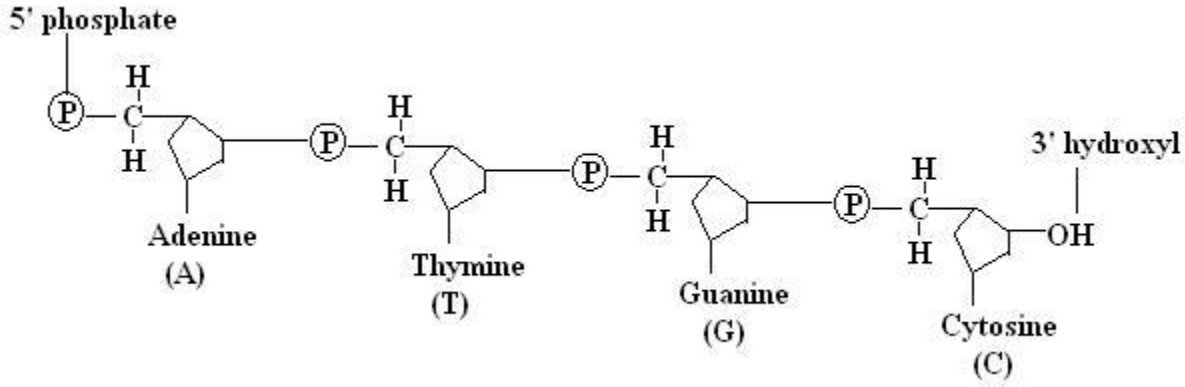
| | | |
|---|---|---|
| 14. | Spindle fibres disappearcompletely in telophase. | Spindle fibres do not disappear completelyduring telophase I. |
| 15. | Reappearance of nucleoli attelophase. | Nucleoli do not appear in telophase I. |
| 16. | The chromosome number does notchange at the end of mitosis. | There is reduction in the chromosomenumber from diploid to haploid. |
| 17. | The genetic constitution of chromosomes daughter cells is absolutelyidentical to that of parent cells. | The genetic constitution of chromosomes indaughter cells is different as compared to the parentcells. The daughter cell chromosomescontain a mixture of maternal and aternalgenes. |
| 18. | Mitosis is of shorter duration. | Meiosis is of longer duration. |
| 19. | It is the basis of growth and repairand reproduction in vegetatively orasexually reproducing organisms. | It is basis of maintaining same chromosomenumber in different generations of a speciesreproducting sexually as well as for providinggenetic variation in the progeny. |

## B. Introduction to - DNA, RNA, and their differences

**Nucleic:-**First isolated in 1868 F.Miescher and called nuclein in 1889 Altman renamed nucleic acid. The nucleic acids are linear unbranched polymer of purine and pyrimidine nucleotides linked in a chain through phosphodiester bonds. The backbone of a nucleic acid is made of alternating sugar and phosphate molecules bonded together in a long chain , each of the sugar groups in the backbone is attached to a third type of molecule called a nucleotide base, as shown:



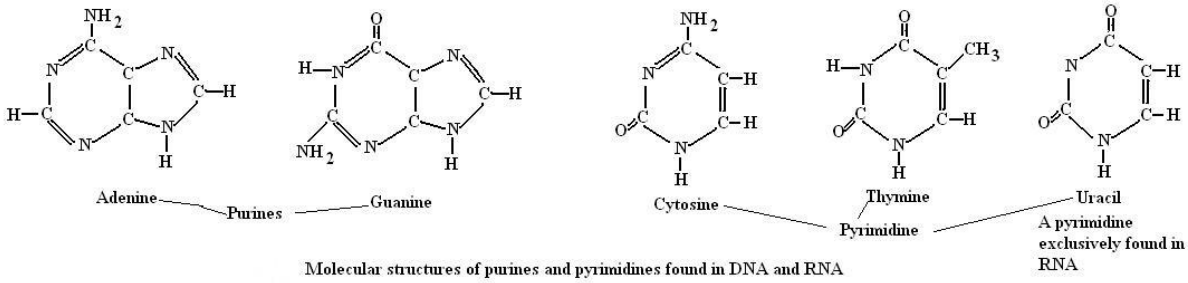

Long chains of nucleotides are called polynucleotides, and short chains of nucleotides are called oligonucleotides. The whole nucleic acid chain is usually synthesized by RNA polymerase or DNA polymerase.




An important feature of all nucleic acids is that they have two distinctive ends: the 5' (5-prime) bears a phosphate, and 3' (3-prime) ends a hydroxyl group. A nucleic acid chain (phophodiester linkages) has a direction: called polarity; unless otherwise indicated, the convention is 5' to 3' going from left to right. Synthesis of a nucleic acid chain always proceeds from 5' to 3' (left to right).The arrangement (or order) of specific nucleotides along the chain is called the sequence. The sequence is genetic information.

**Nucleotides are small, complex molecules:-**

1. Which is made up of C, H, O, N and P.
2. Each nucleotide made up of a 5- carbon sugar (pentose), a nitrogenous base and phosphoric acid. The acidic character of the nucleic acids is due to presence of the phosphoric acid.
3. The pentose sugar is either ribose or deoxyribose. Ribose- In ribose, the carbon atoms 1',2', 3' and 5' has hydroxyl group. Ribose sugar occurs in nucleotides of RNA as well as nucleotides present free in cytoplasm or inside coenzymes. Deoxyribose- In deoxyribose the hydroxyl groups are found on 1', 3', and 5' and 2' group is replaced by hydrogen, the deoxyribonucleotides, are the monomers of DNA.
4. The two bicyclic (two ring structure) bases Adenine (A) and Guanine (G) are major purines and monocyclic bases (single ring structure) are Thymine (T), Uracil (U exclusively found in RNA) andcytosine (C) are major pyrimidines.



Molecular structures of purines and pyrimidines found in DNA and RNA

5. Erwin Chargaff (1950) found that in any DNA molecule, purine and pyrimidines are present in equal amount i. e. A + G = T +C. Amount of adenine (A) always equal to the amount of thymine (T) i.e A=T, and the amount of guanine (G) always equal to the amount of cytosine (C) i.e.G = C. They are all polyfunctional bases, and may exist in tautomeric forms.
6. Nucleotides form a part of the information transfer system and participate in energy transfer system.
7. In cells, a free nucleotide may contain one (mono), two (di) or three (tri) phosphate groups. The energy carrier AMP (adenosine monophosphate) has one; ADP (adenosine diphosphate) has two; ATP (adenosine triphosphate) has three phosphate groups.
8. These are mono -, di-, and triphosphate of adenosine, when more than one phosphate group present in the nucleotides it is known as higher nucleotides (e. g. ATP and ADP).
9. Individual nucleotides play important roles in cellular activity of cell. In a molecule of ATP, two terminal chemical bonds that link the O and P atoms are known as high energy phosphate bonds. The replacement of one of these bonds by H-O bonds liberates two or three times as much energy as most chemical bonds. In living cells, the energy is made available by the hydrolytic splitting of the ATP molecule at the outermost high-energy phosphate bond. When one phosphate group is removed the adenosine troposphere becomes adenosine- di-phosphate and energy is released:-

ATP ⟶ ADP + (P) + energy (equivalent to 7000 calorie)

The production and utilisation of ATP molecules is an essential characteristic of all living organisms.
10. Purines and pyrimidines nucleotides polymerise to give rise nucleic acids.
11. Nucleotides of vitamins nicotinamide - Nicotinamide adenine dinucleotide (NAD+) and Nicotinamide adenine dinucleotide phosphate (NADP+) and the nucleotides of riboflavin - Flavin mononucleotide (FMN) and Flavin adenine dinucleotide (FAD) play a role in oxidation reactions occurring in the cell.

**Nucleoside: -**When all phosphate groups of a nucleotide are removed, a nucleotide becomes a nucleoside. The combination of a base and a pentose is called a nucleoside. Example adenosine is made up of ribose + adenine.

The following table lists various nucleosides and their mono- NMP (nucleoside monophosphate) or dNMP (deoxynucleoside monophosphate), di- NDP (nucleoside diphosphate) or dNDP (deoxynucleoside diphosphate), and triphosphates-NTP (nucleoside triphosphate) or dNTP (deoxynucleoside triphosphate). For DNA, these are dATP, dCTP, dGTP, and dTTP. For RNA, these are ATP, CTP, GTP, and UTP.):-

| **Nucleosides** | **Composition (pentose sugar +base )** | **Symbol** | **Nucleotides (= Nucleosides + Phosphate)** | **Composition (pentose sugar +base + phosphate)** | **Symbol** |
|---|---|---|---|---|---|
| **RNA** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Adenosine | Ribose + Adenine (A) | A | Adenosine Monophosphate , Diphosphate and Triphosphate | Ribose + Adenine (A) + phosphate | AMP , ADP, ATP |
| Guanosine | Ribose + Guanine(G) | G | Guanosine Monophosphate , Diphosphate and Triphosphate | Ribose + Guanine (G)+ phosphate | GMP, GDP, GTP |
| Cytidine | Ribose + Cytosine(C) | C | Cytidine Monophosphate , Diphosphate and Triphosphate | Ribose + Cytosine(C) + phosphate | CMP, CDP, CTP |
| Uridine | Ribose +Uracil (U) | U | Uridine Monophosphate , Diphosphate and Triphosphate | Ribose + Uracil (U) + phosphate | UMP, UDP, UTP |
| **DNA** | | | | | |
| Deoxyadenosine | Deoxyribose + Adenine (A) | dA | Deoxyadenosine Monophosphate , Diphosphate and Triphosphate | Deoxyribose + Adenine (A) + phosphate | dAMP, dADP, dATP |
| Deoxyguanosine | Deoxyribose + Guanine (G) | dG | Deoxyguanosine Monophosphate , Diphosphate and Triphosphate | Deoxyribose + Guanine (G) + phosphate | dGMP, dGDP, dGTP |
| Deoxycytidine | Deoxyribose + Cytosine (C) | dC | Deoxycytidine Monophosphate , Diphosphate and Triphosphate | Deoxyribose + Cytosine (C)+ phosphate | dCMP, dCDP, dCTP |
| Deoxythymidine | Deoxyribose +Thymine (T) | dT | Deoxythymidine Monophosphate , Diphosphate and Triphosphate | Deoxyribose + Thymine (T) + phosphate | dTMP, dTDP, dTTP |

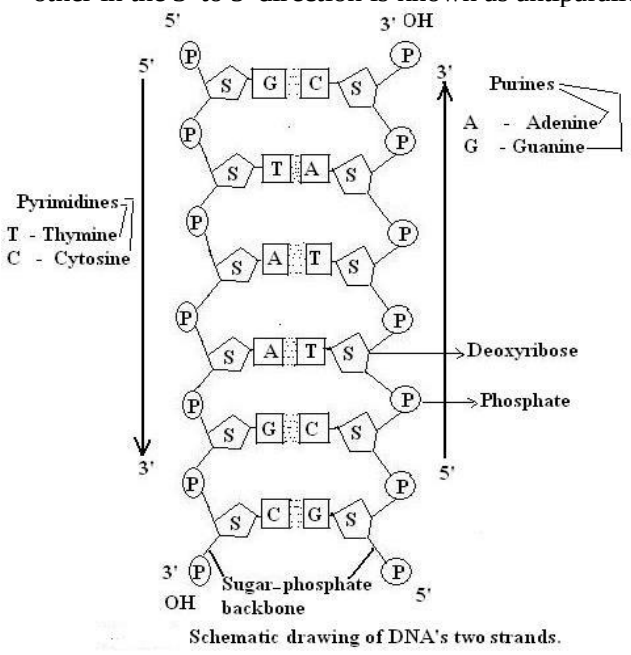
**Types of nucleic acids**

There are two main types of nucleic acids Deoxyribonucleic acid (DNA) occurs mainly in the nucleus, but also in chloroplasts and Ribonucleic acid (RNA) though also found in nucleus, stored in the nucleolus but moves out into the cytoplasm.In DNA or RNA, a nucleic acid chain is also called a strand. DNA (DeoxyriboNucleic Acid) is considered as the repository of the genetic information and a DNA molecule typically contains two strands whereas most RNA molecules contain a single strand and RNAs (RiboNucleic Acids) may be regarded as vectors and translators of the information.

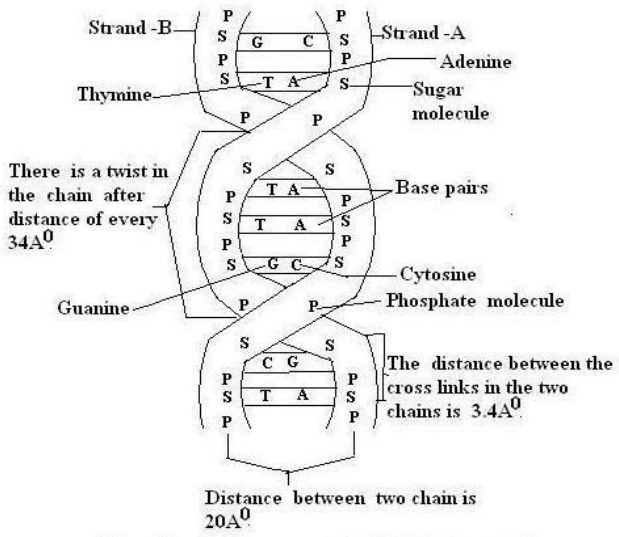
The length of a nucleic acid chain is represented by the number of bases. In the case of a double-stranded nucleic acid, bases are paired between two strands.

**DNA or Deoxyribonucleic acid:** -J. Watson & S. Crick (1953) determined the double helix structure of DNA, owing to the important X-ray diffraction works made by Wilkins, R. Franklin and Astbury.

- The DNA Molecule consist of two polynucleotides chains (strands), held together by the hydrogen bonding between their bases.
- The two strands are wrapped plectonemically to form a double helix.
- Each strand forms a right handed helix, with ten base pairs per spiral turn.
- The two strands of the DNA double helix run in opposite directions, one in the 5' to 3' direction, the other in the 3' to 5' direction is known as antiparallel. .



Schematic drawing of DNA's two strands.



Showing structure of double helix (a spiral) DNA molecule (Watson and Crick)

- The sugar-phosphate backbone is on the outside of the helix, and the bases are on the inside, stacked on top of each other like the steps of a spiral staircase, whereas the bases in the middle form the rungs of the ladder.
- Each rung is composed of two base pairs. Either an adenine-thymine pair that form a two-hydrogen bond together, or a cytosine-guanine pair that form a three-hydrogen bond. The base pairing is thus restricted.
- Due to restriction when the DNA is being copied: the DNA-helix is first "unzipped" in two long stretches of sugar-phosphate backbone with a line of free bases sticking up from it, like the teeth of a comb. Each half will then be the template for a new, complementary strand.
- dA-dT and dG-dC base pairs are the same length, and occupy the same space within a DNA double helix. Therefore the DNA molecule has a uniform diameter.
- dA-dT and dG-dC base pairs can occur in any order within DNA molecules.
- The N-glycosic bonds (sugar-base) are not directly opposite one strand another, therefore two alternating grooves are evident, a wide and deep major groove, and a shallow and narrow minor groove, between ribose-phosphate chains on the surface of the molecule.Which may facilitate binding with specific proteins.
- The double helix diameter is 2.0 nanometers (there are one billion nanometers in a meter).

- The distance between two neighboring base pairs is 0.34 nmnanometers and the helix makes a turn every 3.4 nm (distance along the axis per 360 degree turn).
- Denaturation (also known as melting):- The conversion of double helical DNA into single strands(uncoil and separate) due to presence of heat or alkali is called denaturation. The conversion of single strands back to the double-stranded structure is called renaturation or annealing.
- There are three natural forms of DNA (A, B and Z). The origin of these different forms are related to the conformation of the sugar (C2'-endo/ C3'-endo) and the orientation of the base relative to the sugar (syn/anti):-
- B-form is the common natural form, found at a very high degree of hydration and low ionic strength. B-DNA arranges 10 nucleotides per helix tour, all of conformation C2'-endo/anti. The plane of the bases is nearly perpendicular to the helix axis and the helix surface exhibits two prominent grooves (major and minor).
- A-form is sometimes found in some parts of natural DNA in presence of high concentration of cations or at a lower degree of hydration (< 65%). A-DNA possess 11 nucleotides per tour (all C3'-endo/anti) and two grooves (a narrow deep major and a wide shallow minor).
- C-form and D-form are unusual sub-classes of B-type. C-DNA is sometimes observed under 45% of hydration while D-DNA is only found in artificial DNA.
- Z-form (Zigzag chain) is observed in DNA G-C rich local region. Z-DNA is longer, thinner and possess an unusual left-handed helix (of 12 bases pairs/tour) with a single narrow deep groove. These Zigzag form mainly results from the alternation of purines (C3'-endo/syn) and pyrimidines (C2'-endo/anti).

**Difference between DNA and RNA**

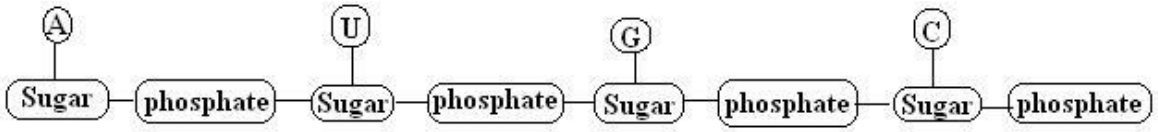
| DNA | RNA |
|---|---|
| 1. It is mainly confined to the nucleus. A small quantity occurs in mitochondria and chloroplasts. | 1. It mainly occurs in the cytoplasm. A small quantity is found in the nucleus. |
| 2. Its quantity is constant in each cell of a species. | 2. Its quantity varies in different cells. |
| 3. It contains deoxyribose sugar. | 3. It contains ribose sugar. |
| 4. Its pyrimidines are adenine and thymine. | 4. Its pyrimidines are adenine and uracil. |
| 5. The amount of adenine is equal to the amount of thymine, also the amount of cytosine is equal to the amount of guanine. | 5. Adenine and uracil are not necessarily in equal amounts, nor are cytosine and guanine necessarily in equal amounts. |
| 6. It consists of 2 polynucleotide chains held together by hydrogen bonds, and coiled into a double helix. Some viruses ($\phi \times 174$) have single-stranded DNA. | 6. It consists of a single polynucleotide chain. It may fold on itself and get hydrogen-bonded and coiled into a pseudohelix. Some viruses (rheovirus) have double-stranded RNA. |
| 7. Its molecular weight varies from 2 to 6 million. | 7. Its molecular weight varies from 25,000 to 2 million. |
| 8. It is of 2 types : linear intranuclear and circular extranuclear. | 8. It is of 3 types : mRNA, tRNA, rRNA. Each type is further of many subtypes. |
| 9. It can replicate itself. | 9. It cannot replicate itself. It is formed by DNA. Some RNA viruses (paramyxo virus) can produce RNA from RNA template. |
| 10. It controls structure, metabolism, heredity, differentiation and evolution. | 10. It brings about protein synthesis. It also starts replication. |
| 11. It is a component of chromosomes. | 11. It is a component of ribosomes. |
| 12. It is a genetic material in all organisms. | 12. It is a genetic material in certain viruses. |
| 13. It does not contain unusual bases. | 13. It may contain unusual bases in addition to the normal ones. |
| 14. A primer is needed for replication. | 14. No primer is needed for transcription. |
| 15. Its renaturation after melting is slow. | 15. Its renaturation after melting is quick. |
| 16. It transfers its information to mRNA (transcription). | 16. mRNA transfers its information to polypeptide (translation). |
| 17. DNA is hydrolysed by the enzyme DNA-ase. | 17. RNA is hydrolysed by the enzyme RNA-ase. |

**DNA Replication**:- Before a cell divides into two daughter cells, all the DNA molecule must be duplicated. In eukaryotes, this occurs during S phase of the cell cycle. Duplication of an old DNA molecule into two new DNA molecules is called replication.

The double-stranded DNA molecule has the unique ability that it can make exact copies of itself, or self-replicate. During replication, the hydrogen bonds between the nucleotide bases break and the two single strands of DNA separate.Then each DNA strand serves as a template for the synthesis of a new complementary strand. New complementary bases are brought in by the cell and paired up with each of the two separate strands, thus forming two new, identical, double-stranded DNA molecules. Each daughter DNA molecule is identical copy of its parent molecule, consisting of one old and one new DNA strand. Thus the replication is semi-conservative.

**RNA or Ribonucleic acid:-**

A. RNA differs from DNA in that each RNA (Ribonucleic acid) molecule is usually consist of a single strand of ribonucleotides (or ribotides) and is much shorter. But in Reovirus and Rice dwarf virus it is double-stranded.

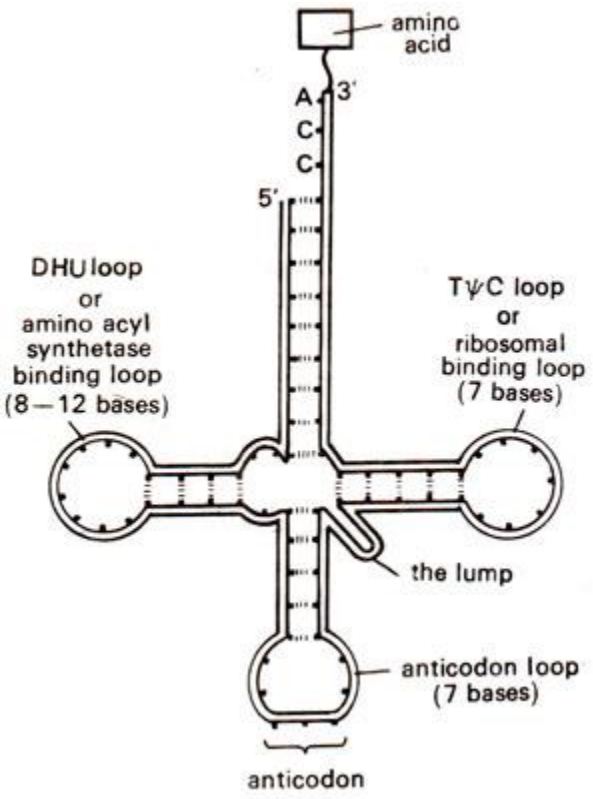



structure of RNA molecule

B. An RNA molecule is a linear polymer in which the monomers (nucleotides) are linked together by means of phosphodiester bridges, or bonds. These bonds link the 3' carbon in the ribose of one nucleotide to the 5' carbon in the ribose of the adjacent nucleotide.
C. The molecule folds on itself forming structures called hairpin loops. In the base paired region, the RNA molecule adopts a helical structure as in DNA.
D. RNA has four different bases: adenine, guanine, cytosine, and uracil.
E. In RNA, guanine and cytosine pair (GC) by forming a triple hydrogen bond, and adenine and uracil pair (AU) by a double hydrogen bond; additionally, guanine and uracil can form a single hydrogen bond base pair.
F. One of the major differences between DNA and RNA is the sugar, with 2-deoxyribose being replaced by the alternative pentose sugar ribose in RNA and the pyrimidine base uracil of RNA replaces the thymine base of DNA.
G. Ribose sugar is more reactive because of C-OH (hydroxyl) bonds. Not stable in alkaline conditions. RNA on the other hand has larger grooves which makes it easier to be attacked by enzymes
H. RNA does not follow Chargaff's rules i.e.,1:1 ratio does not exist between purines and pyrimidines bases due to single-stranded nature and lack of complementarity.

**The non-genetic RNA is synthesized on DNA template and is of three types:-**

a. Messenger RNA (mRNA Jacob and Monod 1960) - messenger RNA, is produced in the nucleus and carries the information for protein synthesis.
b. Transfer RNA or soluble RNA or Adoptive RNA (s-RNA, t-RNA - Hoagland 1955). It is smallest type of RNA which constitutes about 10-15% of total cellular RNA and, having on average 80 nucleotides per molecule. Each amino acid has its own tRNA molecule which transfers amino acids present in the cytoplasm to the ribosome, where they translate mRNA into amino acid sequences.




The 5'-end of the tRNA always ends in the base guanine while the 3'-end always ends in the base sequence CCA. The triplet base sequence at the anticodon is directly

related to the amino acid carried by that tRNA by its own form of the enzyme amino-acyl-tRNA synthetase.

c. **Ribosomal RNA ( rRNA):-** It is the most stable and largest type of RNA .Constitutes about 80% of total cellular RNA and rRNA is a major structural component of ribosomes (site of protein synthesis).In prokaryotes, the ribosomal RNA (rRNA) has three types: 23S, 5S, and 16S. Eukaryotic ribosomes contain four different rRNA molecules: 18 s, 5.8 s, 28 s, and 5 s rRNA. In which three of the rRNA molecules are synthesized in the nucleolus, and one is synthesized elsewhere. The unit "S" stands for Svedberg, which is a measure of the sedimentation rate. After rRNA molecules are produced in the nucleus, they are transported to the cytoplasm, where they combine with tens of specific proteins to form a ribosome. In prokaryotes, the size of a ribosome is 70S, consisting of two subunits: 50S and 30S. The size of a eukaryotic ribosome is 80S, comprising a 60S and a 40S subunit. t-RNA molecule is folded to form a clover leaf -like structure.

**snRNA:-** Small nuclear RNA (snRNA) is the name used to refer to a number of small RNA molecules found in the nucleus. These RNA molecules are important in a number of processes including RNA splicing (removal of the introns from hnRNA) and maintenance of the telomeres, or chromosome ends. They are always found associated with specific proteins and the complexes are referred to as small nuclear ribonucleoproteins (SNRNP) or sometimes as snurps.

**Protein synthesis:-**

**Proteins:-**

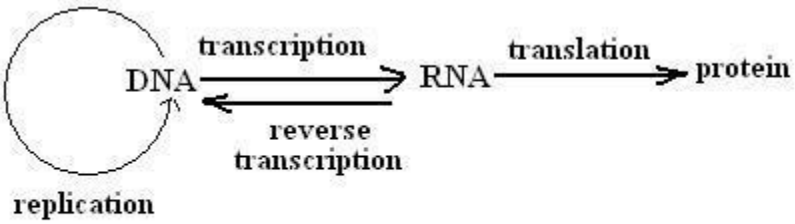
1. Proteins are linear polymers of amino acids linked together by peptide bonds joining the amino and carboxyl groups of successive amino acids.
2. Proteins are formed by one or several polypeptide chains. Polypeptides usually refer to long peptides whereas oligopeptides are short peptides (< 10 amino acids). Proteins are made up of one or more polypeptides with more than 50 amino acids.
3. The sequence of the polypeptide chain is defined by a gene with genetic code.
4. While all proteins are polypeptides, not all polypeptides are proteins.
5. There are only 20 standard amino acids are exists in living organism, consisting of carbon, hydrogen, nitrogen, oxygen, and two that contain sulfur.
6. Ten of these amino acids have side groups that are attracted to water, while the other ten do not. Therefore, when a protein is in a water-based environment, the hydrophobic amino acids fold inwards while the hydrophilic remain on the outside. The backbone of amino acids form strong covalent bonds and the actual amino acids form temporary weak bonds. These weak bonds allow the amino acids to change shape, remain mobile, and attain flexibility.

**Protein synthesis:-** Protein synthesis occurs in the cytoplasm and involves ribosomes. All the three non - genetic RNAs i.e. mRNA, tRNA and rRNA involved in protein synthesis are synthesized directly on DNA which acts as a template for RNA synthesis. Proteins are molecules that have a variety of functions in cells such as providing structure, storing energy, providing movement, transporting other substances, catalyzing biological reactions, and protecting against disease. Proteins make up more than 50% of a cell's dry weight.Amount of RNA in each cell is directly proportional to the amount of protein synthesis.

In eukaryotes, three different RNA polymerases (I, II, III) catalyse the synthesis of ribosomal RNA (rRNA), mRNA and tRNA respectively.In prokaryotes a single RNA polymerase performs this function.

**Two major steps are involved in protein synthesis**

1. **Transcription:-** Francis Crick proposed that information flows from DNA to RNA in a process called transcription, and is then used to synthesize polypeptides by a process called Translation.




DNA makes messenger RNA makes protein

2. **Translation (mRNA to Protein in cytoplasm):-**Translation is the mechanism by which the triplet base sequences of mRNA molecules are converted into a specific sequence of amino acids in a polypeptide chain. Several ribosomes may get attached to a molecule of mRNA like beads on a string know as polysome. Translation occurs at ribosomes located on the surface of rough endoplasmic reticulum and as groups of ribosomes (polysomes) found free-floating in the cytoplasm.

## C. Role of Genetics in Plant breeding, self and cross-pollinated crops, methods of breeding in field crops-introduction, selection, Hybridization, Mutation

**Plant Breeding**

**Definition of Plant Breeding:-** Plant breeding is an applied branch of Botany, which deals with improvement of agricultural crops. This branch of agricultural science has contributed maximum to the increase in food production all over the world and therefore, now a day it assuming ever increasing importance in field of agriculture in every country.

Riley, 1978 defined plant breeding as a technology of developing superior crop plants/ varieties for various purpose.

Frankel, 1958 defined plant breeding as the genetic adjustment of plants to the service man.

Plant breeding is a branch of biology concerned with changing the genotype of plant so that they become more useful.

**Nature of Plant Breeding:-** Plant breeding is an art or science and is as old as agriculture, started since man learnt to cultivate the plants.

**Genetic in Relation to Plant Breeding**

Plant breeding is an application of Genetic principles to the improvement of plants. The following genetic principles are useful to improve the heredity of plants:-

**Variation:** Differences among be due to genotype or environment. Environmental variation may be observed by growing the plants with similar genotypes under different environment. Ex. Rice, Wheat plants grown on fertile soil will show more vigorous and productivity than infertile soil. These variations in growth and development result from the effect of particular environment in which the plants are grown. Genotypic variation is the results of plant processing different genetic characters and it remains unaltered by environmental conditions. Generally they may be observed it different varieties or species are grown under similar environment. Ex. Colour of the seed, presence of awn etc. Heritable variation in plants originates from gene recombination after hybridization, spontaneous mutating and polyploidy this processes plant species have been evolved in nature and reached present stage of development. These two types of variation are not independent of each other, but they interact and affect on the plant.

**Mechanism of Heredity** The mechanism of heredity is dependent upon the behaviour of chromosome and the gene they carry some facts regarding characters.

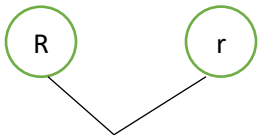
I) A mixed population of plant species having heredity variation is used by the breeder to select plants with traits or characters for development of improved variety. E.g. Seed colours, size, plant height, leaf size, shape, disease resistant etc. Heritable variation results when different plants exhibit contrasting form of these characters. The contrasting traits are determined by alternative form of gene and their interaction.

II) The genes are located on the chromosome and are determine of the characters of a plant. These genes are having specific position on the chromosome and are duplicated when the chromosome divide.

- The alternative form of a gene called alleles, which determine contrasting form of characters. The genes may be dominant or recessive (R or r).
- The plant with similar identical genes at a given locus on homologous chromosome are said to be homozygous and with unlike genes are said to be heterozygous.
- The appearance of plant is phenotype, while genetic constitution is genotype. The chromosomes are red shape body present in a nucleus of cell. They carry genes hence important in heredity.
- A chromosome occurs singly (haploid) in spores and in pairs (diploid) in body cell. The chromosome number is constant in any species and it divides longitudinally during mitosis and homologue chromosome separate during moysis. The mechanism of heredity can be explained with a single gene characters.

Phenotype:- RR (Red) X rr (White)

Gametes




$F_1$: Rr [Red (dominant and heterozygous)]

$F_2$: $F_1$ X $F_1$

| ♂ / ♀ | R | R |
|---|---|---|
| R | RR | Rr |
| R | Rr | Rr |

- Genotypic Ratio: 1:2:1
- Phenotypic Ratio: 3:1

**III. Linkage:** The tendency of genes to be inherited in a group on to the next generation is known as linkage which occurs due to the residence of genes on the same chromosome. The string of gene in a chromosome is linkage group. The number of linkage group in any species is equal to the pairs of chromosome. If the genes are completely linked on a chromosome, there would be no combination of genes within the same linkage group, and due to this there would be certain restriction on breeders to obtain new recombination of linked genes. Recombination of linked genes occurs due to crossing over (Exchange of segment between non-sister chromatides of homologous chromosome). A breeder may select plants with recombination of linked genes for desirable characters. Linkage may be coupling phase or repulsion phase. In coupling phase two dominant genes are linked with recessive gene (AB/ab). In repulsion phase one dominant and recessive genes are linked with one recessive and dominant genes ( Ab/aB).

**IV) Gene Interaction:-** The phenomenon of two or more gene affecting the expression of each other in a various ways for the development of a single character of an organism is known as gene interaction or it is the phenomenon in which two pairs of non-alleic gene affect the same character.

In gene interaction when two dominant genes come together, they usually produce different phenotype than their own and it result into the modification of normal $F_2$ phenotypic ratio. Gene interaction effect the expression of one character of an individual. It adds variability by producing new phenotype.

**V) Heterosis or Hybrid Vigour:-** When two homozygous inbred of genetically unlike constitution are crossed together the resulting hybrid are usually vigorous, productive taller and sturdier than either parents. This increased productivity or superiority of the hybrid over the parents is known as heterosis or hybrid vigour.

The term heterosis was coin by G.H. shull (1914). He derived from the Greek word heterosis mean different and Osis means condition, therefore, literally means a different condition.

**VI) Polyploidy and Plant Breeding:-** Polyploidy is the condition in which an organism having more than two sets of chromosome or genomes in their somatic cell. In contrast to the normal of ploid they may be triploid (3n), tetraploid (4n), penataploid (Sn) and so on. Polyploids may be Euploids (An organism having the exact multiple of the basic chromosome number in 3n, 4n, etc) or Aneuploid (An organism having unequal number of chromosome i.e monosomic (2n-1), nullisomic (2n-2), Trisomic (2n +1), Tetrasomic (2n+2) etc.

**Pollination:-** Pollination refers to the transfer of pollen grain from anthers to stigmas. Pollen from an anther may fall on the stigma of the same flower leading to self-pollination or auto gamy. Sometimes

pollen from an anther may fall on the stigma of another flower of different plants leading to cross pollination or allogamy. Sometimes pollen from an anther fall on the stigma of the anther flower of same plant leading to the geitonogamy.

**Self Pollination:** It is transfer of pollens from and to the stigma within the same flower, is always found in bisexual flower. In most of these species self-pollination is not complete and cross- pollination may occur up to 5%.

**There are various mechanism / contrivances that promote / facilitate self- pollination.**

- **i)** **Bisexuality:-** Male and female sexual organs present in the same flower e.g Wheat, rice, groundnut, etc.
- **ii)** **Homogamy:-** Male and female sexual organs mature at the same time e.g wheat, groundnut, etc.
- **iii)** **Cleistogamy:-** In this condition flowers does not open at all and ensure complete self-pollination e.g Oat, Barley, Wheat, Grasses, etc.
- **iv)** **Chasmogamy:-** In some species, flower open but only after pollination has taken place. E.g Barley, Wheat, Oat, and many cereals.
- **v)** In crop like Tomato and Brinjal stigma are closely surrounded by anthers , hence pollination occurs after opening of flower but the position of anther in relation to stigma ensure self – pollination.
- **vi)** In crop like pea, bean, soybean, the flower open but stigma and anther are hidden by floral organ and ensures self – pollination.
- **vii)** In few species stigmas become receptive and elongate through staminal column, ensures self-pollination.

**Genetic Consequences of Self – Pollination:-**

- i) It leads to a very rapid increase in homozygosity; therefore self pollinated species highly homozygous in nature.
- ii) Self pollinated species do not show inbreeding depression, exhibit considerable heterosis.

**Cross Pollination:-** The transfer of pollen from a flower to the stigma of the other flower of different flower plant. In cross pollinated species pollination may be brought about by wind, water insect or animals. Wind (anemophily), water (hydrophily), insect (entomophily) and animal (Zoophily). In most of the cross pollinated sp. Viz. Bajara, maize, sunflower, alfalfa, castor, cross pollination is not complete and self-pollination may occurs 5-10%.

**There are several mechanism contrivances that facilitate cross pollination:-**

**i) Dicliny (Unisexuality):-** It is a condition in which flower is either staminate or pistilate.

**a)Monoecy:-** Staminate and pistilate flowers occur in the same plant either in the same inflorescence. E.g Maize, Cucurbit, Aonla etc.

**b) Dioecy:-** The male and female flowers are present on different plants i.e. the in such species are male or female i.e. sec is governed by a single gene. E.g. Papaya, hemp, date, palm, etc.

**ii) Dichogamy:-** Anther and stigma of hermaphrodite flower mature at different time, facilitating cross pollination.

**a) Protogyny:-** Gynoecium matures earlier than the androecium E.g. Bajara.

**b) Protandry:-** Androecium matures earlier than gynoecium. E.g. marigold, maize, cotton, etc. iii) Heterostyly: Different length of style and filaments E.g Linseed.

**iv) Herkogamy:-** Presence of physical barrier or mechanical obstacles between the anther and stigma ensures cross pollination. E.g. Rui (*Calotropic gigantia*).

v) In lucerne or alfalfa stigma are covered by waxy film and it does not become receptive unless this waxy film is broken by honeybees.

vi) A combination of two or more of the above mechanism may occurs in some species, E.g Maize, - Monoecy and Protandry.

**viii) Self –Incompatibility:-** It refers to the failure of pollen from a flower to fertilize the same flower or other flowers on the some plants. It may be saprophytic or gametophilic e,g mustard , tobacco, sunflowers, reddish.

**ix) Male Sterility:**- It refers to the absence of functional pollen grains in hermaphrodite flower.

# Introduction

**Introduction**:- According to Allard (1960) plant introduction is the acquisition of superior varieties by importing them from other areas. Or plant introduction is the process of taking / introducing plants/ genotype or group of genotype into new environment where they were not being grown before. Introduction may involve new varieties of a crop already grown in the area wild relatives of the crop species or totally new crop species for that area. Plant introduction may within the country between the countries or confirmed between the states or within the state. The plant may be introduced from the country of another continent. Ex. Introduction of Ridley wheat varieties from Australia.

- Introduction may be classified into two categories:

a**) Primary Introduction:-** When the introduced variety is well suited to the new environment and is directly released for commercial cultivation without any change the original genotype, known as primary introduction. Ex. Introduction of semi dwarf wheat varieties Sonora, Lerma Rojo and semi dwarf Rice Var. TN-1, IR-8, IR-28, and IR-36.

b) **Secondary Introduction:**- The introduced variety is subjected to selection, to isolate superior variety or may be hybridized with local variety to transfer one or few desirable characters to the local variety, known as secondary introduction. Secondary introduction is much more common than primary introduction particularly in countries having well- organised crop improvement programme. Ex. Kalyan sona and sonalika varieties selected from the material introduced from CIMMYT. Mexico (Centro International de Mejoramieno de maize 'Y' Trigo) commonly known as Internation centre for maize and wheat Research.

# Selection

**Selection:-** One of the oldest method of breeding and is the basis for all crop improvement, practised by farmer in ancient times. Selection is essentially based on the phenotype of plants. Consequently the effectiveness of selection primarily depends upon the degree to which the phenotypes of plants reflect their genotype.

Selection may be natural or artificial by which individual or group of plants are isolated from a mixed population. Before domestication, crop species were subjected for natural selection. Natural selection is the rule and has resulted in evolution of several local varieties of crop. After domestication man has knowingly or unknowingly practiced some selection known as the artificial selection.

For a long period under domestication natural selection was perhaps the more selection is a little value and current breeding method entirely depends on artificial selection. Selection has two basic characteristics or limitation

i) Selection is effective for heritable differences.
ii) Selection does not create variation, it only utilise the variation already present in the population.

**Thus the two basic requirement of selectionare:-** a) Variation must be present in the population and b) Variation must be heritable.

## Hybridization

**Hybridization:-** Individual produced as a result of cross between two genetically different parents is known as hybrid. The natural or artificial process that results in the formation of hybrid is known as hybridization.

The production of a hybrid by crossing two individuals of unlike genetical constitution is known as hybridization. Hybridization is an important method of combining characters of different plants. Hybridization does not change genetic contents of organisms but it produces new combination of genes.

- The first natural hybridization was recorded by Cotton Mather (1716) in corn. The first artificial interspecific plant hybrid was produced by Thomas Fairchild in 1717. It is commonly known as **'Fairchild Mule'**.
- Hybridization was first of all practically utilized in crop improvement by German botanist Joseph Koerauter in 1760. Mendel onward, the hybridization had become the key method of crop improvement. Today, it is the most common method of crop improvement, and the vast majority of crop varieties have resulted from hybridization.

**Objectives of Hybridization:**

I. To artificially create a variable population for the selection of types with desired combination of characters.

II. To combine the desired characters into a single individual, and

III. To exploit and utilize the hybrid varieties.

**Types of Hybridization:**

**Hybridization may be of following types:**

**(i) Intra-varietal hybridization:-** The crosses are made between the plants of the same variety.

**(ii) Inter-varietal or Intraspecific hybridization:-** The crosses are made between the plants belonging to two different varieties.

**(iv) Interspecific hybridization or intragenric hybridization:-** The crosses are made between two different species of the same genus.

**(v) Introgressive hybridization:-** Transfer of some genes from one species into the genome of the other species is known as introgressive hybridization. The crosses between different species of the same genus or different genera of the same family are also known as distant hybridization or wide crossing. Such crosses are called distant crosses.

**Procedure of Hybridization:**

**(i) Selection of parents:-** The selection of parents depends upon the aims and objectives of breeding. Parental plants must be selected from the local areas and are supposed to be the best suited to the existing conditions.

**(ii) Selfing of parents or artificial self-pollination:-** It is essential for inducing homozygosity for eliminating the undesirable characters and obtaining inbreeds.

**(iii) Emasculation:-** It is the third step in hybridization. Inbreeds are grown under normal conditions and are emasculated. Emasculation is the removal of stamens from female parent before they burst and shed their pollens.

It can be defined as the removal of stamens or anthers or the killing of the pollen grains of a flower without affecting in any way the female reproductive organs. Emasculation is not required in unisexual plants but it is essential in bisexual or self-pollinated plants.

**(iv) Bagging:-** It is the fourth step and completed with emasculation. The emasculated flower or inflorescence is immediately bagged to avoid pollination by any foreign pollen. The bags may be made of paper, butter paper, glassine or fine cloth. Butter paper or vegetable parchment bags are most commonly used.

The bags are tied to the base of the inflorescence or to the stalk of the flower with the help of thread, wire or pins. The bagging is done with the emasculation in bisexual plants and before the stigma receptivity and dehiscence of the anthers in unisexual plants. Both male and female flowers are bagged separately to prevent contamination in male flowers and cross-pollination in female flowers.

**(v) Tagging:-** The emasculated flowers are tagged just after bagging. Generally circular tags of about 3 cm or rectangular tags of about 3 x 2 cm are used. The tags are attached to the base of flower or inflorescence with the help of thread.

**The information on tag must be as brief as possible but complete bearing the following information:**

(i) Number referring to the field record

(ii) Date of emasculation

(iii) Date of crossing

(iv) Name of the female parent is written first followed by a cross sign (x) and then the male parent, e.g., C x D denotes that C is the female parent and D is the male parent.

**(vi) Crossing:-** It is the sixth step. It can be defined as the artificial cross-pollination between the genetically unlike plants. In this method mature, fertile and viable pollens from the male parent are placed on the receptive stigma of emasculated flowers to bring about fertilization.

Pollen grains are collected in petridishs (e.g., Wheat, cotton etc.) or in paper bags {e.g., maize) and applied to the receptive stigmas with the help of a camel hair brush, piece of paper, tooth pick or forceps. In some crops (e.g., Jowar, Bajra) the inflorescences of both the parents are enclosed in the same bag.

**(vii) Harvesting and Storing the $F_1$ Seeds:-** Crossed heads or pods of desirable plants are harvested and after complete drying they are threshed. Seeds are stored properly with original tags.

**(viii) Raising the $F_1$ generation:-** In the coming season, the stored seeds are sown separately to raise the $F_1$ generation. The plants of $F_1$ generation are progenies of cross seeds and therefore are hybrids.

## Mutation

Mutation is a sudden heritable change in a characteristic of an organism. Mutations produced by changes in the base sequences of genes are known as gene or point mutations. The term mutations was introduced by Hugo de Vries in 1900.

**Type of Mutation**

1. **Spontaneous mutation:-** Mutations occur in natural populations (without any treatment by man) at a low rate. These are known as spontaneous mutations. The frequency of natural mutations is generally one in ten lacs.
2. **Induced mutation:-** Mutations may be artificially induced by a treatment with certain physical or chemical agents. Such mutations are known as induced mutations, and the agents used for producing them are termed as mutagen. The utilization of induced mutations for crop improvement is known as mutation breeding. Induced mutations have a great advantage over the spontaneous ones, they occur at a relatively higher frequency so that it is practical to work with them.

**Characteristics of mutations**

1. Mutations are generally recessive, but dominant mutations also occur.
2. Mutations are generally harmful to the organism, but a small proportion (0.1 percent) of them is beneficial.
3. Mutations are random i.e., they may occur in any gene. However some genes show higher mutations rate than others.
4. Mutations are recurrent, that is the same mutations may occur again and again.
5. Induced mutations commonly show pleiotropy, often due to mutations in closely linked genes.

**Mutagen:-** Agents used for induction of mutations are known as mutagens. The mutagens are classified into two groups, physical and chemical mutagens.

**Type of Mutagen**

1. **Physical mutagen**:- The mutations inducing radiation's are of two kinds.

a. **Ionizing radiation:-** Alpha, Beta and gamma rays of radio active substances, Neutrons and X rays are examples of ionizing radiation. When ionizing radiations passes through matter, atoms, absorb energy from them and lose electrons. When an atom becomes ionized, molecule of which it is a part undergoes chemical change. If the molecule is a gene and if this changed gene duplicate its new pattern, the result of the change is a mutation.

b. **Non-ionizing radiation:**- When compounds absorb energy from non-ionizing radiations, their electrons are raised to higher energy levels (excitation). It results in increased reactivity of the affected molecules leading to mutations.

The only one non-ionizing radiation capable of inducing mutations is ultra violet light. U-V radiation can be obtained from a mercury vapour lamp. U V rays have much longer wave lengths (about 2500 Angstroms)

2. **Chemical mutagens:-**

i. Alkylating agents - eg., EMS (Ethyl Methane Sulphonate) MMS (Methyl Methane Sulphonate).

ii. Acridine dyes eg., Ethidium Bromide, acriflavine proflavine 3.

iii. Base analogue - eg. 5 Bromouracil, 5 - Chlorouracil

iv. Others - eg., Nitrous acid, hydoxyl amine , sodium azide.

**Mutagenesis:-** Treating a biological material with a mutagen in order to induce mutations is known as mutagenesis. Exposure of a biological material to radiation (x-rays, gamma rays etc.,) is known as irradiation.

## D. Genetics − Mendel's laws of Inheritance −Illustrative depiction of the experiments, their importance in plant breeding

**Heredity:-** The transmission of characters from one generation to the next, that is from parents to offsprings is known as heredity.

**Variation:-** Variation means differences between parents and their offsprings or between offsprings of same parents or between members of the same population. Heritable Variations generally arise because of mutation and recombination.

Variation in a population is very important. It has survival value for the population. This is because if the environment changes, some individuals (variants) may be able to adapt to new situations and save the population from dying out. Variation arises due to mutation or sudden change in the genes.

Variation also arises because genes get shifted and exchanged during meiosis at the time of formation of gametes, giving rise to new gene combinations. At fertilization, there is random mixing of paternal and maternal chromosomes with different gene combinations. Such a source of variation which is most common is called genetic recombination.

**Genetics:-** It is a branch of science in which study of heredity and variation.

**Gregor Johann Mendel was first person who is open knot of genetic secret so he is known as father of genetics.**

**Gregor Johann Mendel life history:-** Johann Gregor Mendel was born the son of Anton and Rosine Mendel on July 22, 1822 in Heinzendorf (present day Czechoslovakia). He was born into a family of Moravian peasants and proved to be very talented. With the help from his parents and private tutoring, he was able to obtain further education. With the limited financial resources offered by his parents, he attended the Gymnasium in Opava. Mendel was forced to provide for himself in 1838, due to his father's debilitating farming accident. In 1840, he attended a two-year course at the Philosophy Institute at Olomouc University. Once again, Mendel struggled for money, but was indebted to his younger sister for renouncing part of her dowry to finance his studies. At the age of twenty-one, Mendel entered the Brno monastery, which would become "his only chance of realizing his intellectual ambitions. Fr. Matthaeus Klacel, a botanist who was regarded as an expert in natural sciences (also engaging in crossing plants), became his mentor. Mendel spent a short time as chaplain at a nearby hospital, until 1849 when he taught mathematics and classics at the Gymnasium in Znojmo. A year later, Mendel failed his teacher's examinations at Vienna University due to his weakness in zoology. During a professor's illness in 1851, he taught natural history at the Technical College. Later that same year, he studied physics at Vienna University, where he gained the empirical, methodological, and scientific knowledge that would eventually prepare him for his future research with plants. Even after his studies at Vienna, he once again failed the teacher's examinations in 1856.

But Mendel would not give up easily. His interest in growing plants led him to conduct numerous experiments on plant hybridization, which eventually led to his theories surrounding the science of heredity. Between 1856 and 1863, he studied nearly 28,000 plants. He reported on his plant hybrid experiments to the Brunn Natural Science Society with title of “Hybridization in Plants” in 1865 and had his paper on this topic published a year later. In 1868 Mendel was elected abbot of the monastery and also vice president of the Natural Science Society. In the following year, he conducted more experiments with different plant species and reported his findings to the Society. Gregor Mendel died on January 6, 1884, at the age of 61.

At the beginning of the twentieth century (1900), however, Mendel and his laws were "rediscovered" by Hugo Marie de Vries, Karl Franz Joseph Correns, and Erich Tschermak von Seysenegg, firmly attaching Mendel's name to the basic laws of genetics.

**Important terms in genetics:-**

1. **Factor:-** The unit of inheritance and expression of a particular character is controlled by inheritable units called factor (gene) which are present in pairs in parental cells and singly in the gametes.
2. **Gene:-** A segment of DNA molecule which determines the unit of inheritance and expression of a particular character.

3. **Alleles or Allelomorphs:-** Two or more alternative forms of a gene are called alleles. For example in pea plant, the gene for producing seed shape may occur in two alternative forms: smooth (S) and wrinkled (s). Genes for smooth wrinkled seeds are alleles of each other, and occupy same locus on homologous chromosomes.
4. **Trait:-** is the morphologically or physiologically visible character, e.g. colour of flower, and shape of seed.
5. **Dominant trait:-** Out of the two alleles or allelorrorphs of a trait, the one which expresses itself in a heterogygous organism in the $F_1$ hybrid is called the dominant trait (dominant allele) and the one that remains masked in $F_1$ individual but gets expressed in the next generation ($F_2$), is called recessive. Thus, if the allelic combination in an organism is Tt, and T (tallness) expresses itself but t (dwarfness) cannot, so T is the dominant allele, and tallness is dominant on dwarfness represented by "t'.
6. **Recessive trait:-** Out of the two alleles for a trait, the one which is suppressed (does not express) in the $F_1$ hybrid is called the recessive trait (recessive allele). But the Recessive allele does express itself only in the homozygous state (e.g. tt).
7. **Genotype:-** A class of individuals recognised based on its genetic constitution and breeding behaviour is called the genotype, e.g., the genotype of pure smooth seeded parent pea plant is SS and it will always breed true for smooth-seeded character, but plants having Ss on selfing would give rise to a population represented by 3 : 1 ratio for smooth seeded plants and wrinkled seeded plants.
8. **Phenotype:-** A class of individuals recognised based on outward appearance of a trait in an individual is the phenotype, e.g. Smooth-seeded shape or wrinkled shape of seeds represent two different phenotypes.
9. **Homozygous:-** An individual possessing identical alleles for a trait is termed homozygous e.g. TT is homozygous condition for smooth seeded character in garden-pea.
10. **Heterozygous**:- An individual with dissimilar alleles for a trait is termed heterozygous for e.g. Tt represents the heterozygous condition for smooth seeded character in garden pea.
11. **Parent generations:-** The parents used for the first cross represent the parent (or $P_1$) generation.
12. **$F_1$ generation:-** The progeny produced from a cross between two parents ($P_1$) is called First filial or F1 generation.
13. **$F_2$ generation:-** The progeny resulting from self pollination or inbreeding of $F_1$ individuals is called Second Filial or $F_2$ generation.

## Reasons for Mendel's success

1. Mendel succeeded in postulating laws of inheritance because of his choice of experimental plantgarden pea which has a short life cycle, has self-pollinatedbisexual flowers so that cross-pollination is not allowed and the true breeding behaviour of parents could be maintained. Because of the property of self-pollination in garden pea plants, a large number of pure line of plants with several pairs of contrasting characters could be obtained in the same field.
2. **His selection of traits:-** All the seven pairs of contrasting characters of pea plantsconsidered by Mendel in his experiments showed complete dominance that helped Mendel to postulate the law of dominance and the law of segregation.
3. The factors for all the seven traits selected by Mendel for his experiments were either present on separate homologous chromosomes or if they were present on the same chromosome, they were apart so that the factors segregated independently & were not inherited together so that Mendal failed to discover linkage and crossing over.

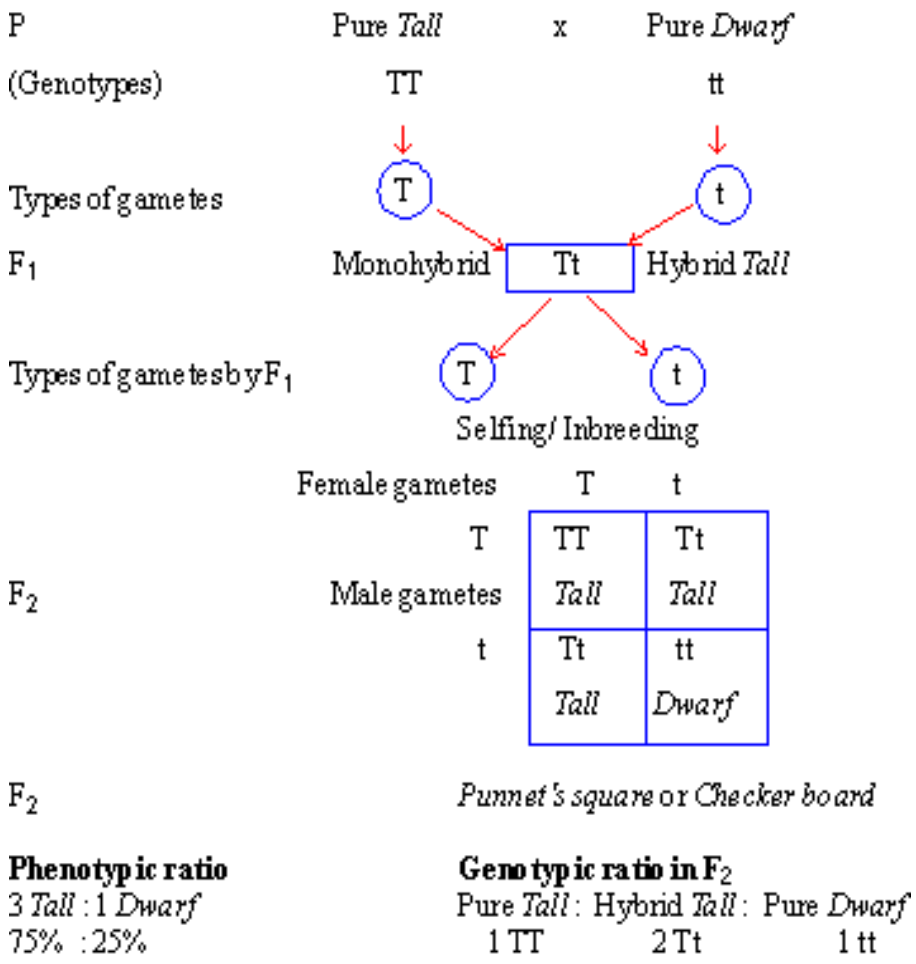
4. **Mendel's methodology:-** His technique of experimentation also helped him indiscovering the Laws of Heredity :
   (i) Homozygous pure line plants with contrasting characters were crossed.
   (ii) Self-pollination was prevented by removing stamens to bring about cross-pollination between the desired parents.
   (iii) Female plants were dusted with pollen grains from another plant with the contrasting feature and were tied in a bag to prevent any further pollination.
   (iv) Seeds were collected from plants of different generations and sown in time.
   (v) The results of different generations were maintained, and analysed statistically, by counting the individuals exhibiting different traits.
   (vi) He considered the inheritance of one character at a time, then he considered inheritance involving individuals differing in two contrasting characters.
   (vii) He performed reciprocal crosses and test crosses to confirm the results and formulated the basic laws of heredity.

**Seven Traits of pea selected by Mendel**

| S.No. | Characteristic | Contrasting Traits | |
|---|---|---|---|
| | | **Dominant** | **Recessive** |
| 1. | Stem Height | Tall | Dwarf |
| 2. | Flower Colour | Violet | White |
| 3. | Flower Position | Axial | Terminal |
| 4. | Pod Shape | Swelled | Shrinkage |
| 5. | Pod Colour | Green | Yellow |
| 6. | Seed Shape | Round | Wrinkled |
| 7. | Seed Colour | Yellow | Green |

**Mendel's Experiments**

1. **Monohybrid:-** A monohybrid cross is a mating between two individuals with different alleles at one genetic locus of interest. The character(s) being studied in a monohybrid cross are governed by two or multiple alleles for a single locus.




**Law of Dominance:-** Law of dominance is known as the first law of inheritance. Each character is controlled by distinct units called factors, which occur in pairs. If the pairs are heterozygous, one will always dominate the other.

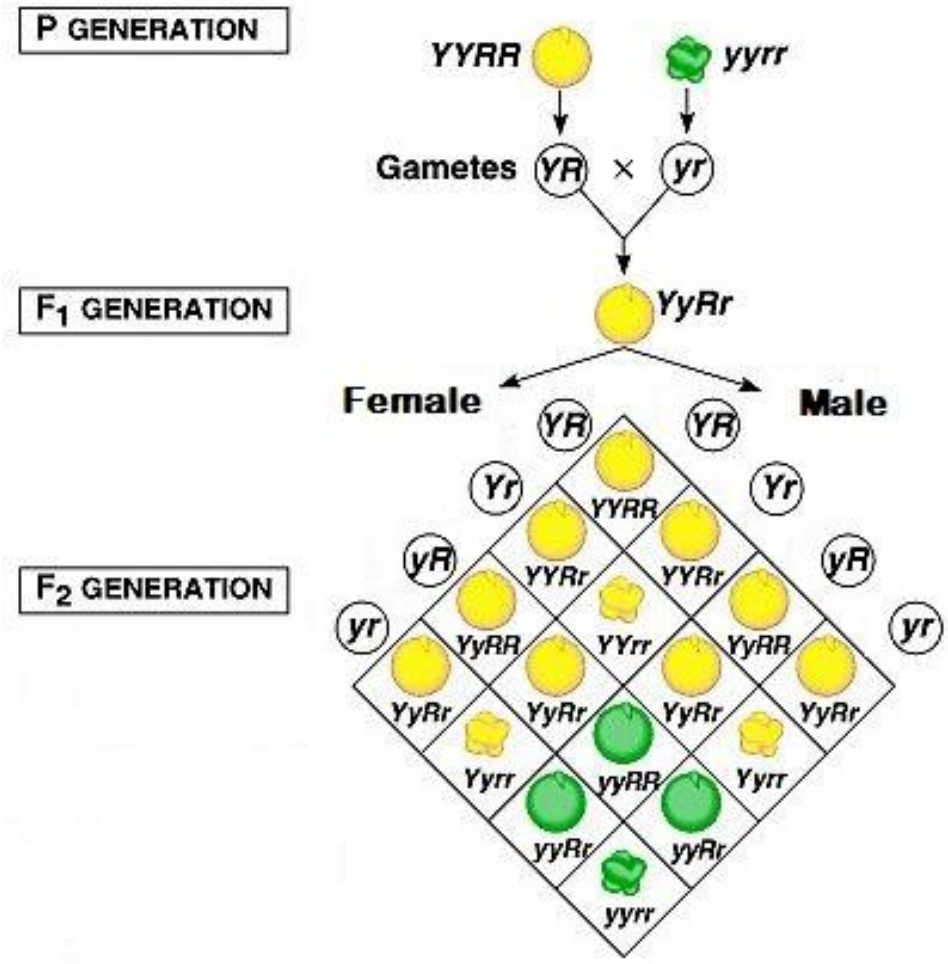
Law of dominance explains that in a monohybrid cross between a pair of contrasting traits, only one parental character will be expressed in $F_1$ generation and both are expressed in $F_2$ generation in the ratio 3:1. The one which expressed in $F_1$ generation is called dominant trait and the one which is suppressed is called recessive trait. In simple words, the law of dominance states that recessive traits are always dominated or masked by dominant trait.

**Law of Segregation:-** Law of segregation is the second law of inheritance. Law of segregation states that the pair of alleles segregates from each other during meiosis (gamete formation) so that only one allele will be present in each gamete. In a monohybrid cross, both the alleles are expressed in the $F_2$ generation without any blending. Thus, the law of segregation is based on the fact that each gamete contains only one allele.

2. **Dihybrid:-** It is a cross involving two pairs of contrasting characters. For this experiments on dihybrid inheritance. Mendel selected the contrasting characters in the seed coat and cotyledons. He conducted a cross pollination between a pure breeding plant with round seed coat and yellow coloured cotyledons and a pure breeding plant with

wrinkled seed coat and green coloured cotyledons. In the $F_1$ generation, all the resulting plants had round seed coat and yellow coloured cotyledons.

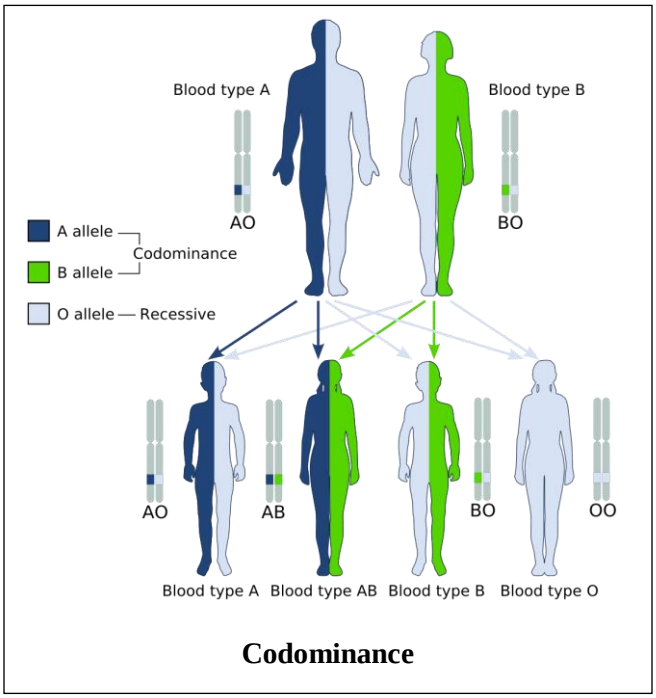
When he allowed these $F_1$ plants to undergo self pollination, in the $F_2$ generation, four types of plants were obtained with round yellow, round green, wrinkled yellow and wrinkled green seeds in the ratio of 9:3:3:1. And genotype is 1(YYRR):2(YYRr):2(YyRR) :4(YyRr):1(YYrr):2(Yyrr):1(yyRR):2(yyRr):1(yyrr).




**Law of Independent Assortment**:- Mendel's experiment always portrayed that the combinations of traits of the progeny are always different from their parental traits. Based on this, he formulated the Law of Independent Assortment. The Law of Independent Assortment states that during a dihybrid cross (crossing of two pairs of traits), an assortment of each pair of traits is independent of the other. In other words, during gamete formation, one pair of trait segregates from another pair of traits independently. This gives each pair of characters a chance of expression.

**Incomplete dominance:-** The discovery of incomplete dominance is usually credited to German Botanist Carl Correns who studied four o'clock plants. Incomplete dominance is a form of intermediate inheritance in which one allele for a specific trait is not completely expressed over

its paired third expressed combination of alleles. Unlike inheritance, dominate or

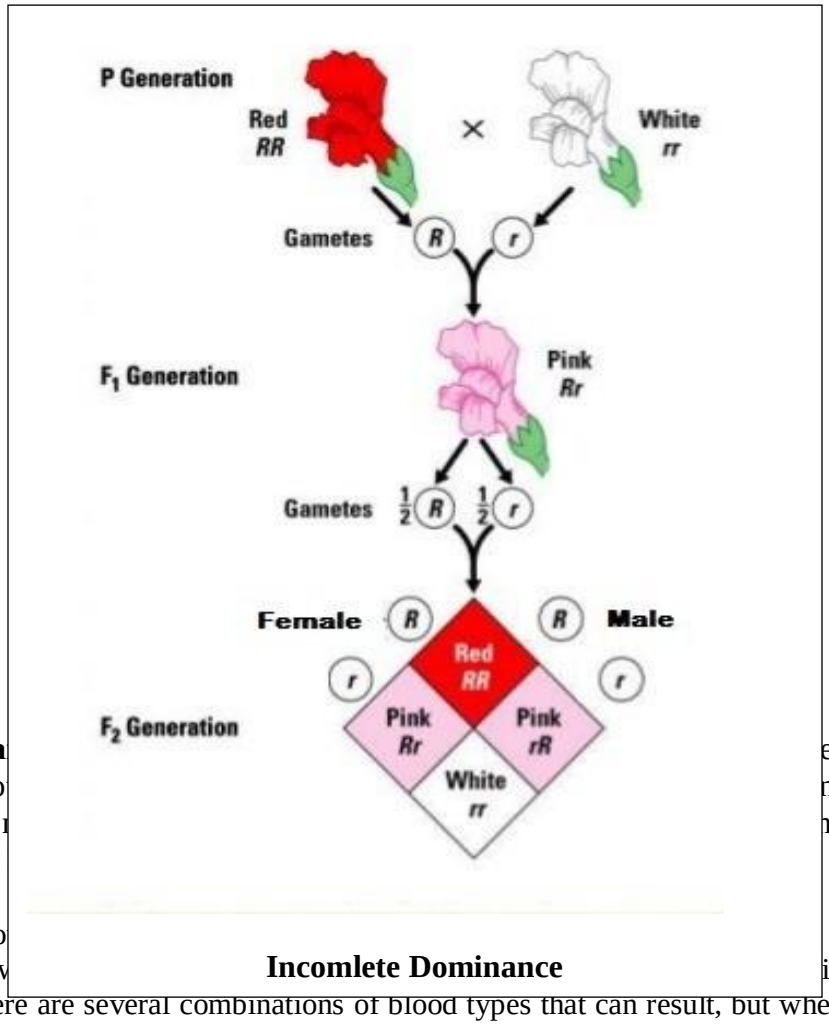



**Codominance**

allele. This results in a phenotype in which the physical trait is a the phenotypes of both in complete dominance one allele does not mask the other allele.

dominance is experiments snapdragon cross, the color (R) is not the allele that (r). The pink. The White (rr) =

Incomplete seen in cross-pollination between red and white plants. In this monohybrid allele that produces the red completely expressed over produces the white color resulting offspring are all genotypes are: Red (RR) X Pink (Rr).




**Incomlete Dominance**

**Codomina** es of a gene pair in a heterozygo notype that is neither dominant r he ABO blood group system ex.

Peo time. The ABO gene determine v is gene, one from each parent. There are several combinations of blood types that can result, but when a person has both an A and a B allele, it will lead to blood types visible in the blood, AB.

| Genes from Mom and Dad | | Genes of Offspring | Blood Type Result |
|---|---|---|---|
| Mom | Dad | | |
| A | A | AA | A |
| A | o | Ao | A |
| A | B | AB | AB |
| B | B | BB | B |
| o | B | Bo | B |
| o | o | oo | O |

**Back Cross or Test Cross:-** When $F_1$progeny crossed with parents(both male & female)called back cross.$F_1$ progeny crossed with recessive parents called test cross.WhenF1 progeny crossed with dominant parents called out cross. Back cross is done for character transfer while test cross is done for evaluation of genotype of parents and offspring.

**Linkage:-** Tendency of genes to remain together in their original combination during inheritance is called linkage". The phenomenon of linkage was firstly reported by Bateson and Punnet in 1906.

T H Morgan (1910) put forth the theory of linkage and concluded that coupling and repulsion were two phases of single phenomenon, linkage.

i. Linkage involves two or more genes which are located in same chromosome in a linear fashion.
ii. Linkage reduces variability.
iii. Linkage may involve either dominant or recessive alleles (coupling phase) or some dominant and some recessive alleles (repulsion phase).
iv. Linkage usually involves those genes which are located close to each other.
v. The strength of linkage depends on the distance between the linked genes. Lesser the distance, higher the strength and vice versa.
vi. Linkage can be determined from test cross progeny data.

**Chromosomal crossover:-** Chromosomal crossover (or crossing over) is the exchange of genetic material between homologous chromosomes that results in recombinant chromosomes during sexual reproduction. Crossing over occurs during prophase I at meiosis I of the time of gamete formation. The point where crossing over occurs is called chiasma.

**Chromosome and Chromosome Theory:-** Sutton and Boveri in 1902-03 observed that chromosomes from two parents come together in the zygote as a result of the fusion of two gametes and again separate out during meiosis at the time of formation of gametes. Gametes have half (n) number of chromosomes or are haploid and zygote is diploid or has (2n) or double the number of chromosomes when compared to chromosome number in the gametes.

The observations proved that there is a remarkable similarity between the behaviour of Mendelian factors or genes during inheritance and that of chromosomes during meiosis.

This led Sutton and Boveri to propose 'chromosomal theory of inheritance' and its salient features are as follows.

1. The somatic or body cells of an organism, which are derived by the repeated division of zygote have two identical sets of chromosomes i.e. they are diploid. Out of these, one set of chromosomes is received from the mother (maternal chromosomes) and one set from the father (paternal chromosomes). Two chromosomes of one type (carrying genes controlling the same set of characters) constitute a homologous pair.
2. The chromosomes of homologous pair separate out during meiosis at the time of gamete formation.
3. The behaviour of chromosomes during meiosis indicates that Mendelian factors or genes are located linearly on the chromosomes. With progress in molecular biology it is now known that a chromosome is made of a molecule of DNA and specific sets of segments of DNA are the genes.

# SECTION -3

# Livestock Production

## Unit – V: Scope and Importance

### A. Importance of livestock in Agriculture, National Economy and Nutritional security

**Importance of Livestock in Agriculture, National Economy and Food Security**

Livestock plays an important role in Indian economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. Livestock provides livelihood to two-third of rural community. It also provides employment to about 8.8 % of the population in India. India has vast livestock resources. Livestock sector contributes 4.11% GDP and 25.6% of total Agriculture GDP.

**Live Stock Resource**

- India is world's highest livestock owner at about 512.05 million
- India is first in the total buffalo population in the world - 105.3 million buffaloes
- India is second in the population of cattle and goats - 140.5 million goats
- India is second largest poultry market in the world - production of 63 billion eggs and 649 million poultry meat.
- India is third in the population of sheep (72 millions).
- India is fifth in in the population of ducks and chicken.
- India is tenth in camel population in the world.

**Contribution of livestock in India Economy:-**

The livestock provides food and non-food items to the people.

1. **Food:** The livestock provides food items such as Milk, Meat and Eggs for human consumption. India is number one milk producer in the world. It is producing about 156 million tones of milk in a year (2015-16). Similarly it is producing about 74.75 billions of eggs, 8.89 million tonnes of meat in a year. The value of milk group and meat group at current prices was Rs 4,06,035 crores in 2013-14.
2. **Fibre and skins:** The livestock also contributes to the production of wool, hair, hides, and pelts. Leather is the most important product which has a very high export potential. India is producing about 47.9 million Kg of wool per annum.
3. **Draft:** Bullocks are the back bone of Indian agriculture. Despite lot of advancements in the use of mechanical power in Indian agricultural operations, the Indian farmer especially in rural areas

still depend upon bullocks for various agricultural operations. The bullocks are saving a lot on fuel which is a necessary input for using mechanical power like tractors, combine harvesters etc. Pack animals like camels, horses, donkeys, ponies, mules etc are being extensively used to transport goods in different parts of the country in addition to bullocks. In situations like hilly terrains mules and ponies serve as the only alternative to transport goods. Similarly, the army has to depend upon these animals to transport various items in high areas of high altitude.

4. **Dung and other animal waste materials:** Dung and other animal wastes serve as very good farm yard manure and the value of it is worth several crores of rupees. In addition it is also used as fuel (bio gas, dung cakes), and for construction as poor man's cement (dung).
5. **Storage:** Livestock are considered as "moving banks" because of their potentiality to dispose off during emergencies. They serve as capital and in cases of landless agricultural labourers many time it is the only capital resource they possess. Livestock serve as an asset and in case of emergencies they serve as guarantee for availing loans from the local sources such as money lenders in the villages.
6. **Weed control:** Livestock are also used as Biological control of brush, plants and weeds.
7. **Cultural:** Livestock offer security to the owners and also add to their self esteem especially when they are owning prized animals such as pedigreed bulls, dogs and high yielding cows/ buffaloes etc.
8. **Sports / recreation:** People also use the animals like cocks, rams, bulls etc for competition and sports. Despite ban on these animal competitions the cock fights, ram fights and bull fights (jalli kattu) are quite common during festive seasons.
9. **Companion animals:** Dogs are known for their faithfulness and are being used as companions since time immemorial. When the nuclear families are increasing in number and the old parents are forced to lead solitary life the dogs, cats are providing the needed company to the latter thus making them lead a comfortable life.

**Role of Livestock in Agriculture**

The livestock plays an important role in the economy of farmers. The farmers in India maintain mixed farming system i.e. a combination of crop and livestock where the output of one enterprise becomes the input of another enterprise thereby realize the resource efficiency. The livestock serve the farmers in different ways.

1. **Income**: Livestock is a source of subsidiary income for many families in India especially the resource poor who maintain few heads of animals. Cows and buffaloes if in milk will provide regular income to the livestock farmers through sale of milk. Animals like sheep and goat serve as sources of income during emergencies to meet exigencies like marriages, treatment of sick persons, children education, repair of houses etc. The animals also serve as moving banks and assets which provide economic security to the owners.

2. **Employment:** A large number of people in India being less literate and unskilled depend upon agriculture for their livelihoods. But agriculture being seasonal in nature could provide employment for a maximum of 180 days in a year. The land less and less land people depend upon livestock for utilizing their labour during lean agricultural season.
3. **Food:** The livestock products such as milk, meat and eggs are an important source of animal protein to the members of the livestock owners.
4. **Social security:** The animals offer social security to the owners in terms of their status in the society. The families especially the landless which own animals are better placed than those who do not. Gifting of animals during marriages is a very common phenomenon in different parts of the country. Rearing of animals is a part of the Indian culture. Animals are used for various socio religious functions. Cows for house warming ceremonies; rams, bucks and chicken for sacrifice during festive seasons; Bulls and Cows are worshipped during various religious functions. Many owners develop attachment to their animals.
5. **Draft:-** The bullocks are the back bone of Indian agriculture. The farmers especially the marginal and small depend upon bullocks for ploughing, carting and transport of both inputs and outputs.
6. **Dung:** In rural areas dung is used for several purposes which include fuel (dung cakes), fertilizer (farm yard manure), and plastering material (poor man's cement).

**Livestock population (Livestock census, 2012)**

| Sl. No | Species | Number (in millions) | Ranking in the world population |
|---|---|---|---|
| 01 | Cattle | 190.9 | **Second** |
| 02 | Buffaloes | 108.7 | **First** |
| | **Total** (including Mithun and Yak) | **300** | **First** |
| 03 | Sheep | 65.0 | **Third** |
| 04 | Goats | 135.2 | **Second** |
| 05 | Pigs | 10.3 | - |
| 06 | Others | 1.7 | - |
| | **Total livestock** | **512.3** | |
| | **Total poultry** | **729.2** | **Seventh** |

| | | | |
|---|---|---|---|
| 07 | Duck | - | Fifth |
| 08 | Chicken | - | |
| 09 | Camel | - | Tenth |

**Role of livestock in food security**

If food security is defined as "Access to enough food for an active healthy life" livestock can make a major contribution. An adequate quantity of balanced and nutritious food is a primary indicator of quality of life, human welfare and development. Animals are an important source of food, particularly of high quality protein, minerals, vitamins and micronutrients. The value of dietary animal protein is in excess of its proportion in diets because it contains essential amino acids that are deficient in cereals. Eating even a small amount of animal products corrects amino acid deficiencies in cereal-based human diets, permitting more of the total protein to be utilized because animal proteins are more digestible and metabolized more efficiently than plant proteins

**Production of Livestock in 2015-2016**

| Si. No. | Product | Quantity | Ranking in the world production |
|---|---|---|---|
| 01 | MILK in million tonnes | 155.5 | FIRST |
| 02 | EGGS in billions ( nos) | 82.93 | THIRD |
| 03 | MEAT million tonnes | 7020 | - |
| 04 | WOOL in million kgs. | 43.6 | - |
| 05 | FISH in lakh tonnes | 107.90 | SECOND |

## B. Important animal based food products and their role in our diet

**Animal base food product**

Animal source foods (ASF) include many food item that comes from an animal source such as meat, milk, eggs, cheese and yogurt. Many individuals do not consume ASF or consume little ASF by either personal choice or necessity as ASF may not be accessible or available to these people.

1. **Meat:-** Meat products belong to one of the six major food groups. Poultry, red meat (such as beef, lamb and pork), game and fish all provide the body with essential nutrients, minerals and vitamins in order for it to remain healthy.

**Minerals:-** Meat has a very high mineral content including body essentials like magnesium, zinc and iron.

- **Magnesium** is important for bone strength as it improves vitamin D synthesis as well as help decrease net acid production. It's thought the consumption of magnesium through diet could assist in preventing osteoporosis.
- **Zinc** is vital for the body's immune system and is essential for muscle growth and repair.
- Most importantly, **iron** helps to maintain energy levels as well as maximize oxygen transport throughout the body. If there isn't enough iron being consumed people run the risk of developing anemia and fatigue. Red meat and turkey are particularly iron rich.

**Protein:-** Meat is an excellent source of protein, which is essential for any healthy diet. It helps build and repair muscle as well as help maintain healthy hair, bones, skin and blood.

Due to its High Biological Value (HBV), protein obtained from meat is easily digested and thus absorbed quickly and effectively by the body.

Red meat, chicken and turkey are extremely high in protein.

## Vitamins

- Vitamins are vital in maintaining a healthy body. Meat is a particularly good source of vitamin E and B vitamins including $B_2$, $B_6$ and $B_{12}$.
- Vitamin E has very strong antioxidant properties and helps reduce damage caused by oxygen to cells thus allowing faster muscle repair and recovery.
- B vitamins all work together to help convert food into energy but they also have individual uses. $B_2$ is essential for the manufacture of red blood cells, which then transport the oxygen around the body. $B_6$ is vital for protein synthesis and $B_{12}$ is imperative for good nerve functions.

**Other Benefits:-** Minerals, protein and vitamins aside, meats, especially fish, provide the body with essential unsaturated fats like Omega-3 fatty acids.

Omega-3 can actually help reduce cholesterol levels, blood pressure and the risk of developing cardiovascular diseases.

2. **Egg:-** Chicken egg is one of the most common foods all over the world. Eggs have biological value of 93.79 % comparable values are 84.5 % for milk, 76 % for fish and 74.3 % for beef.

   Since the domestication of the chicken, people have been enjoying and nourishing themselves with eggs. Egg has 33% proteins.

   Eggs are a very good source of inexpensive, high quality protein. More than half the protein of an egg is found in the egg white along with vitamin $B_2$ and lower amounts of fat and cholesterol than the yolk. The whites are rich sources of selenium, vitamin D, $B_6$, $B_{12}$ and minerals such as zinc, iron and copper. Egg yolks contain more calories and fat. They are the source of cholesterol, fat soluble vitamins A, D, E and K and lecithin - the compound that enables emulsification in recipes such as hollandaise or mayonnaise.
3. **Milk:-** Milk is a valuable source of calcium, riboflavin and protein to our diet. For vegetarians it can be a valuable source of vitamin A (carotene) & $B_{12}$. However they should not rely on sterilized ofUHT milks for vitamin $B_{12}$ as they don't contain as much as pasteurised milk.
4. **Dairy & Milk Products**:- Dairy products are commodities which have been produced by primary processing or secondary processing of milk. All mammals produce milk which contains the

correct balance of nutrients with which to feed their young. This milk can also be produced and used commercially; for example sheep, goat and cows milk.

**Different dairy products**:-

a. **Cheese:-** Cheese is made from cows, ewes or goats milk and it takes approximately 5 litres of milk to produce ½ kg of cheese.

   Cheese is a highly concentrated form of food. Fat, protein, mineral salts and vitamins are all present. Therefore it is an excellent bodybuilding, energy-producing, protective food.

b. **Butter:-** Butter is a natural product made from cow's and buffalo's milk. Like hard and soft margarine's and spreads, butter contains 81 % fat, so all have the same number of calories.

   No preservatives or colourings are added although salt may be added for extra flavour. Butter is made simply by churning fresh cream.

c. **Yogurt:-** Yogurt is a cultured product made from whole or skimmed milk. To improve the flavourand texture, skimmed milk solids or cream may also be added.Yogurt is highly nutritious and is an excellent source of protein, calcium and potassium. It provides numerous vitamins and minerals and is relatively low in calories.

d. **Cream:-** Cream is a yellowish substance that is created when milk is heated. When milk is heated, a layer of high content butter rises to the surface. This layer is called cream. It is good source of fat, protein and carotene.

e. **Curd:-** Curds are a dairy product obtained by coagulating milk in a process called curdling. The coagulation can be caused by adding rennet or any edible acidic substance such as lemon juice or vinegar, and then allowing it to sit. This food is low in Saturated Fat and Cholesterol. It is also a good source of Protein, Vitamin B12, Pantothenic Acid, Potassium and Zinc, and a very good source of Riboflavin, Calcium and Phosphorus.

f. **Butter Milk:-** Buttermilk refers to a number of dairy drinks. Originally, buttermilk was the liquid left behind after churning butter out of cream. This type of buttermilk is known as traditional buttermilk. Butter milk content less saturated fat, good source of protein, calcium, potassium, sodium, Vit-$B_{12}$.

## C. Concept of Anand Pattern cooperative system of milk procurement and marketing

**THE ANAND PATTERN**

Maximizing farmer profit and productivity through cooperative effort is the hallmark of the Anand Pattern.

The Anand Pattern is an integrated cooperative structure that procures, processes and markets produce. Supported by professional management, producers decide their own business policies, adopt modern production and marketing techniques and receive services that they can individually neither afford nor manage.

The Anand Pattern succeeds because it involves people in their own development through cooperatives where professionals are accountable to leaders elected by producers. The institutional

infrastructure - village cooperative, dairy and cattle feed plants, state and national marketing - is owned and controlled by farmers. Anand Pattern cooperatives have progressively, linked producers directly with consumers.

**Three tier structure**

1. **Village Society:-** An Anand Pattern village dairy cooperative society (DCS) is formed by milk producers. Any producer can become a DCS member by buying a share and committing to sell milk only to the society. Each DCS has a milk collection centre where members take milk every day. Each member's milk is tested for quality with payments based on the percentage of fat and SNF. At the end of each year, a portion of the DCS profits is used to pay each member a patronage bonus based on the quantity of milk poured.
2. **The District Union:-** A District Cooperative Milk Producers' Union is owned by dairy cooperative societies. The Union buys all the societies' milk, then processes and markets fluid milk and products. Most Unions also provide a range of inputs and services to DCSs and their members: feed, veterinary care, artificial insemination to sustain the growth of milk production and the cooperatives' business. Union staff train and provide consulting services to support DCS leaders and staff.
3. **The State Federation:-** The cooperative milk producers' unions in a state form, a State Federation, which is responsible for marketing the fluid milk and products of member unions. Some federations also manufacture feed and support other union activities.

# Unit – VI: Livestock Care and Management

## A. Principles of feeding −Feeding practices, Important fodder crops, Silage and Hay preparation.

**Milk feeding of calves**

Calves are to be fed with milk @

- 1/10th of body weight up to 4th wks of age including the colostrums feeding from 0 – 5 day,
- 1/15th of body weight during 5th and 6th week. and
- 1/20th of body weight during 7 – 8th week.

The milk is to be warmed up to the body temperature before feeding and should be discontinued after 8th week. The calf starter provided at the rate of 300 gm per day starting from 2nd week of age and increased @ 200 gm / week till it becomes 1.5 kg per calf per day. The green fodder fed *adlib* starting from 2nd week of age.

**Importance of Colostrum Feeding:**

In cattle the antibodies (gamma globulins) are transferred from mother to the calf through colostrum. These gamma globulins will be absorbed as such by the calf and will enter its system forming a readymade antibody resistance system for the calf against all the disease producing agents and other antigens the mother has had, encountered during its lifetime. This will protect the calf against diseases in the early stages, until their own 'antibody manufacturing system takes over. Thus, if colostrum is not fed, the calves are denied antibody cover and, therefore, will remain susceptible to many diseases. Most likely, they will perish due to some disease or the other. Besides, colostrum is highly nutritious. It is slightly laxative and prevents constipation. This is helpful because the diet of the young calf being totally devoid of crude fibre is constipatory. Artificial colostrum: In absence of colostrum and fostering by other mother cows, artificial colostrum can be prepared.

**Artificial colostrum ingredients**

Warm water:- 275 ml
Raw egg:- (55g) One
Castor oil:- 3 ml
Vitamin A:- 10000 IU
Warm whole milk :- 525 ml
Antibiotics:- 80 mg

| **Age** | **Whole Milk** | **Skim milk/butter milk** | **Concentrate** mixture **(g)** |
|---|---|---|---|
| 0-5 days | 1/10th of the body weight (colostrum) | Nil | Nil |
| 5-30 days | 1/10th of the body weight | Nil | Nil |
| 1-2 months | 1/15th of the body weight | 1/25th of the body weight | 125 |

| | | | |
|---|---|---|---|
| 2-3 months | 1/25th of the body weight | 1/15th of the body weight | 250 |
| 3-4 months | Nil | 6.5 kg | 650 |
| 4-5 months | Nil | 6.5 kg | 1000 |
| 5-6 months | Nil | 5.0 kg | 1500 |

- Maize/Barley/Oats:- 45%
- Groundnut cake/Linseed/Til cake:- 35%
- Fish meal :- 7%
- Wheat bran/rice bran/chuni:- 10%
- Mineral mixture:- 3%

**Feeding of Milk replacer:** Milk replacer is a constituted feed through cheaper ingredients which resembles the biological and chemical composition of milk. It is usually fed in gruel form. Feeding of milk replacer helps in reducing the calf mortality, better growth and development of calves and in economical raising of calves. Milk can also be substituted with milk replacer to make calf raising economical. Milk replacer resembles milk in biochemical composition and saves cost of calf rearing. It contains minimum 22% crude protein and very less fibre. The milk replacer is diluted with water.

**Ingredients of Milk Replacer**

| **Name of the ingredients** | **Quantity (kg)** |
|---|---|
| Wheat | 10 |
| Fish meal | 12 |
| Linseed meal | 40 |
| Milk | 13 |
| Coconut oil | 07 |
| Linseed oil/cotton seed oil | 03 |
| Citric acid | 1.5 |
| Molasses | 10 |
| Mineral mixture | 03 |
| Butyric acid | 0.3 |
| Antibiotic mixture | 0.3 |
| Rovimix-A,B2, D3 | 0.015 |

**Calf Starter:** Calf starter has been evolved for use with limited whole milk. It is offered from 2nd week to 3 months of age with the main aim for an early development of rumen. It is a solid feed mixture of grains, protein feeds, minerals, vitamins and antibiotics. A good calf starter should be palatable enough, rich in energy content (75% TDN) and should contain approximately about 24% protein and fibre less than 7 percent. Antibiotics help in preventing calf scour.

**Feeding Milch Animals**

Feeding management of dairy cows during the entire period of lactation is vital for harvesting the optimum milk production from the dairy animal. Proper management of the dairy animal during first few days after calving and during early lactation is of particular importance. The following management principles must be observed.

1. Soon after calving the animal must be fed laxative feed and warm gruel for first few days. The animal at this time must be managed separately. Special care may be taken regarding emptying the udder as frequent emptying may result in occurrence of milk fever especially in high yielding animals and those poorly managed during previous dry period.
2. Feeding management during early postpartum must focus on attaining higher peak milk production and better persistency. This could be achieved by: i. Feeding the animal with higher energy diets and ii. Maximising dry matter intake
3. Monitor the body weight and condition regularly during early stages of lactation. It must be ensured that the animal does not lose excessive condition during this phase as this may result in fat infiltration of liver also called 'fatty liver syndrome'
4. Attempt must be made to return the animal in the positive energy balance soon as the long phase of negative energy balance results in poor persistency of milk production and lower reproductive efficiency. This can also be achieved by improving the quality as well as quantity of the feed.
5. After the peak milk production has been achieved the feeding must be based on the level of milk production.
6. The milk is most economically produced from fodders. All attempts must therefore be made to ensure supply of green fodders/silage/hay round the year. Concentrates should also be supplemented whenever necessary and depending on the level of production.
7. A combination of leguminous and non-leguminous fodders is best to meet the maintenance and production requirement of a cow weighing 400 g and yielding up to 8 litres of milk. With only 1 g concentrate supplementation. Non leguminous fodder feeding would necessitate additional half-g concentrate supplementation. Same cow if fed on hay would need proportionality higher quantities of concentrates 2.5 and 4.5 g respectively.
8. In case of dairy cows producing higher quantities of milk (>20 litres/days), no suitable combination of concentrates and fodders (even at high intake levels) can sustain this level of production without the mobilisation of body reserves. Such cows can also be supplemented with oils/fats in their diets at 300 g per day level.
9. Moderate levels of milk can be sustained on a suitable combination of green and dry fodders supplemented with desired amounts of concentrates. While feeding a mixture of straw and green fodders, it will be desirable if 1 kg of straw is mixed with every 4-5 kg of chaffed green fodder for each 100 kg body weight.
10. If plenty of quality green fodder is not available and the ration is based on low quality straws/stovers then additional concentrate feeding is required.
11. The feed intake of moderate yielding lactating dairy cows in dry matter equivalent is about 2.5 kg dry matter per 100 kg body weight. The dry matter intake in high yielding animals could go up to 3.5 percent or higher.
12. In case of non-producing adult cows, dry matter requirement is about 2.0 percent of their body weight.
13. For optimum results the protein requirement of total ration should be adjusted at 13-14 percent level. Leguminous fodder (like berseem, Lucerne) contain about 12-14 percent crude protein, non-leguminous fodder (like maize, sorghum, oats and grasses etc) contain about 7-8 percent protein. Straws like wheat and paddy straws contain only 3-4 percent crude protein. The crude protein content of the concentrate mixture should be so adjusted to provide about 13-14 percent crude protein in total ration.
14. Roughage must be chaffed. However, very fine chaffing may be avoided, as it is likely to effect the regurgitation process adversely.

15. Grain portion of concentrates should be crushed else part of it may pass off undigested in the faeces. It is desirable to moisten the concentrate mixture and mix it with straws before feeding.
16. Ample availability of clean drinking water must be ensured to the milch cows.
17. Due care should also be taken to feed the advanced pregnant cows and buffaloes as the feeding management at these critical stages will determine the age at maturity and ensure adequate built up of body reserves for use during early stages of lactation when the energy intake of the animal often fails to keep pace with the level of milk production.
18. A suitable combination of Berseem along with oats, maize, wheat/paddy straw and concentrates (based on the level of production) is most practical strategy of feeding dairy cows and buffaloes during winters. The total dry matter content of such ration should be about 22 percent and the crude protein content should be about 14 percent. The respective dry matter and crude protein contents of the above feeds are (Berseem (12 and 14%), Oats (15 and 10 %), Maize (16 and 10%), Straws (90 and 4%) and Concentrates (90 and 20%) respectively. Cultivation of improved varieties of fodder crops have potential not only to improve the yield of the fodder but prolong the availability period also. The important varieties in the category are fodder Maize, Berseem and Oats.
19. If enough green fodders are not available and we have to depend on straws, we can improve the quality of these straws by treating them with urea under expert guidance.

**Feeding based on body condition:**

Body condition gives as indication of how the animal has been fed over the preceding weeks/months. The level of milk production of the dairy cow also affects it. To assess the body condition of dairy cows objectively a procedure culled body condition scoring may be followed.

**Guidelines to feed high yielders:**

1. Include optimum proportion of forage and concentrates in the ration. Good results are obtained by feeding a ration that derives 30 – 40% of the feed units from grains and 60-70% from forages.
2. The forage should be of excellent quality, at optimum stage. A short delay to cut the fodder can adversely affect its quality.
3. The feeding schedule should be such that it will maintain a continuous fermentation in the rumen. The cows should be fed minimum of four times a day at 6 hours intervals. Each feeding should comprise both grain and forage.
4. When high levels of grains are fed, feed it mixed with the roughages or feed it after the animal has consumed some roughage.
5. Processing of feed & fodder may be done.
6. During the late lactation, intake ability of a cow exceeds nutrient needs. This is the time when the cow starts needing extra allowances for the growing foetus. From 7th month to of gestation cows may be fed 1 to 2 kg concentrate feed in addition to their nutrient requirement. The cows may be made to gain 20-25 kg body weight during this period.
7. For challenge feeding, 2 weeks before expected date of calving, start feeding ½ kg of concentrate mixture increases this amount by 300-400 g daily until the cow is consuming
½ to 1 kg concentrate for every 100 kg body weight.
8. Complete feedsi.e. intimate mixture of concentrates and roughages in a desired proportion. This is done to avoid selective eating. This can be done by pelleting process.
This will cause more uniform fermentation in the stomach.
9. Feed processing: grinding of grains, chaffing of dry roughages and fodders and soaking of straw & oilcakes in water.

**FEEDING OF MATURE BULLS**

Concentrate is provided to the bulls to the tune of 2.0 to 2.5 kg per bull during morning hours. Seasonal green fodder such as maize, cowpea, berseem, jowar etc. depending on their availability, along with mixture of maize and oat silage during lean period was fed *ad lib.* to the animals. The bulls have free access to clean drinking water throughout the day. When energy intake is restricted, growth rate is

decreased, testis growth is retarded, age at puberty is increased and sperm output is decreased. The bulls should be fed such that they are neither lean nor obese.

- Over feeding or under feeding results in reduced libido.
- Adult bulls should consume 2.0 to 3.0 percent dry matter.
- Concentrate: 2-3 kg.
- Quality green grass: 25-30 kg.
- Dry roughage: 3-4 kg.
- Quality drinking water: Adlib.
- Vitamin A supplementation during lean season.
- Supplementation of mineral mixture and salt.
- Mineral mixture should be supplemented as follows:
  - ✓ 50 g mineral mixture for bulls up to 200 kg body weight
  - ✓ 70 g mineral mixture for bulls between 200 to 350 kg body weights.
  - ✓ 100 g mineral mixture for bulls above 350 kg body weight

| **Bull groups** | **DCP (%)** | **TDN (%)** | **Dry Fodder** | **Conc.** | **ME** | **Ca** | P | **Vit A** |
|---|---|---|---|---|---|---|---|---|
| Growing bull | 12-15 | 70 | 1 kg/ 100 kg body weight | 1.5-2 kg | 3.5M.cal/ 100 kg body weight | 4.5 g/100 kg body weight | 3.3 g/ 100 kg body weight | 4000 IU/ 100 kg body weight |
| Service bull | 10-15 | 70 | 1 kg/ 100 kg body weight | 2.5-3 kg | 3.3M.cal/ 100 kg body weight | 4.0 g/100 kg body weight | 3.0 g/ 100 kg body weight | 4200 IU/ 100 kg body weight |

**Hay:-**

The forages like grasses and legumes that have been cut, and then dried under sunlight. It is used when there is shortage of forages. Hay making is preferred mode of conserving the food of all green forages.

**Advantage:-**

- It is used when there is less availability of fodder.
- The chances of spoilage will be less than the silage.
- It require less space for its storage

**Disadvantage;-**

- It also require a lot of time and extra labour.
- During hay making process 10-15% loss of nutrient occur.
- Hay making is done in presence of sun light. If sun light not available it difficult the hay making process.

**Principle of Hay making:-**

- Fast drying maximizes green color and palatability.
- The rapid drying is more suitable for hay making as it minimize the microbial growth.

- The basic principle is to reduce moisture content in order to inhibit the action of microbial enzymes.
- In order to store green crops in a stack the moisture content should be reduced to 15-20%.

**Suitable Time for hay making**

- For leguminous fodder harvesting is done at the start of flowering.
- Grasses should be harvested for hay making when there is emergence of head.
- At this stage there are maximum nutrients and green matters.
- March and April are best season for hay making from leguminous fodder.
- For grasses after rainy season.

**Best Crops for Hay making:-** In case of leguminous fodder lucerne and oat is best for making of hay and all over barseem is best. In case of grasses like sudan grasses and sadabahar.

**Method of Hay Making:-** There are two methods of hay making.

- Traditional method
- New mechanized technique

**Traditional method:-**

- Cut the crop, when easy to break the stem by hand.
- Dry the crop under sunlight in the field.
- Turn the forage before sunset or sunrise to avoid shattering of leaves.
- Then hang with a rope.
- Stack it by using 3 bamboos..

**New mechanized technique:-**

**Moving:-**To cut the grasses a machine is used which is called mower. It is the first step in making of hay.Mowing is done in the morning. It can be at the end of the day when the grass is drier. So that it can increase the energy level of the forage by capturing some of the sugars.

**Tedding:-** For spreading of hay tedding is done. Hay tedders have several orbital wheels that lift hay by a turn. Tedding is immediately after mowing to spread the swath. It may require a second tedding the next day to speed up the drying process. More tedding can shatter leaves of alfalfa.

**Raking:-** To collect the hay.Hay rake is used. When the hay has tedded and is nearly dry, it is ready to rake. Raking turns the hay one more time to ready to be baled. Hay is gathered loose and stacked without being baled first. Spontaneous combustion may occur if hay becomes wet while in storage.

**Baling:-** A baler is a machine that coiled the cut hay in to round shape. After cutting, drying and raking baling is done. Then should be hauled to a central location for storage. It depend on geography, region and climate. In this process hay is usually gathered in the form of bales.

**Storage:-** Hay can be stored under a roof when resources permit. It is frequently kept inside sheds and may be stacked inside a bale. Hay never exposed to any possible source of heat. Because dry hay and the dust it produces are highly flammable.

**Chemical changes & losses during drying**

- Bacterial fermentation may occur in the forages that has been laid in the field.
- It may lead to production of acetic acid and propionic acid.
- Mouldy hay is unpalatable and harmfull.
- It may lead to production of mycotoxin.
- The provitamin and carotene may be reduced from 150-200mg/kg in the dry matter.

**Characteristics of good hay:-**

- Moisture contents should be less than 15%.
- More leafy and green.

- It should be free from dust and mold.
- It should be easily palatable.
- It should be less expensive.

**Silage:-**

Fodder is packed in airtight condition to preserve its nutritional value, improve its quality and taste and to make it easily digestible. This is called silage or pickle of the fodder.

**Principle of silage making:-** In this process, green fodder is fermented through special bacteria which can survive without oxygen. The resulting fodder is rendered tasty and easily digestible for animals.

**Process of Silage Making:-** The preparation of good quality silage depends on

1-Timely harvesting of fodder,

2-Quantity of air in it at the time of packing

3-Preservation method

In this process useful bacteria converts soluble starches into lactic acid. It decreases its acidic quality (pH) to 3.0-4.0, which stops the growth of harmful germs and makes the fodder safe for animal consumption. If moisture content is high in fodder, wheat straw or crushed cobs of maize can be added for silage making.

**Types of crops suitable for silage making**

Crops having good percentage of sugar and appropriate (35-40% dry matter; 65-60% moisture.) moisture are good for silage making.

- Crops like:- maize, jowar, bajra, hybrid napier, oat are most suitable for silage making.
- Leguminous crops like berseem, Lucerne, cowpea is not suitable, unless molasses are sprayed on these crops while filling silo pit.
- Best silage is prepared by maize.

**Harvest at proper stage**

1. Crops at pre flowering to flowering stage should be harvested.
2. Crops should not contain more than 75% moisture while silage making.
3. Crops with hollow stems like maize, jowar, bajra, hybrid napier should be chaffed to an inch size to prevent trapping of air and spillage of silage.
4. High moisture crops can be dried in sunshine for 4 hours to reduce moisture content by 15%. Some dry hay or straw 5-20% can also be added.
5. If the crop is over ripe and too dry or it over dried, add water during packing silo.

**Add any of the following additives when needed**

Molasses: When legumes (berseem, Lucerne, etc.) and low sugar grasses are ensiled adding molasses improve quality of silage and its palatability. Molasses may be added at the rate of 3.5-4 percent of green weight of silage.

Urea: Cereal forages can be enriched for nitrogen (protein) content by spraying urea at the rate of 0.5 to 1.0 percent of fresh forage.

Lime: This can be added at a level of 0.5-1.0 percent to maize silage to increase acid production.

**Filling and sealing of the silo pit**

1. The filling should be rapid with proper pressing by use of tractor after each filling to remove air.
2. Silo pit filling should be completed within 4-7 days.

3. After thorough pressing, top should be covered with polythene followed by soil layer of 6 inches depth.
4. Top of silo pit after filling and compressing should be higher than surrounding. Plug all possible areas of air or water entry.

**Removing silage from pit**

1. Silage should be ready within a period of 2-3 week of sealing.
2. Once opened the pit should be fed completely.
3. Silage may be fed from top, layer by layer, daily.
4. On exposure to air for longer period silage get spoiled. Hence, try to prevent entry of air.

**Characteristics of good silage**

1. Good silage should be green, brown or golden colour (black colour indicate poor silage).
2. It should not contain mould.
3. Its smell should be good smell of lactic and acetic acid (like dahi and viniger).
4. Taste should be pleasant and acidic.

## B. Concept of grazing and stall feeding including poultry feeding

**Grazing**

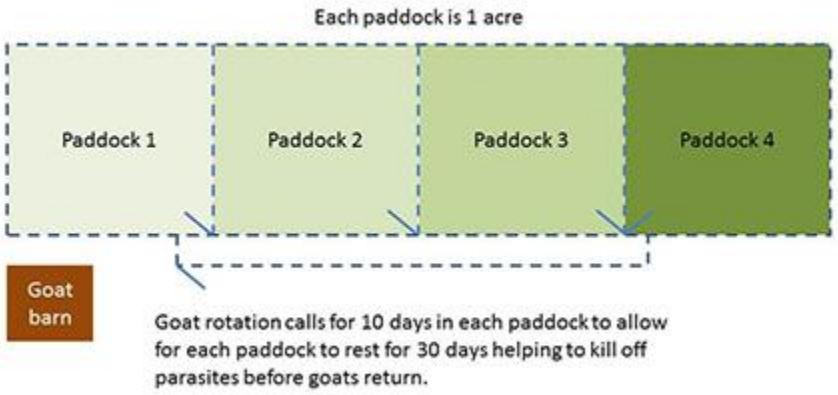
Grazing animals (such as cattle, sheep and goats) feed on the leaves and shoots of grass and other short plants (forage). A grazing system is the pattern in which a farmer allows livestock to graze a pasture. The grazing system used depends on the type of animals, available space and the amount of animals being reared.

**The major systems of grazing are**:

**Rotational grazing**

In rotational grazing, the pastures are sub-divided into paddock. The animals are then moved from one paddock to another in a certain sequence. The animals are allowed to graze in one paddock for a period of time and they are then moved another paddock. When the animals have grazed in the final paddock, they begin the whole rotation from the first paddock again. This system gives the pasture in each paddock enough time to recover before the animals return.

A rotational grazing system (pasture is allotted into different paddocks (1,2,3,4) animals will move from one paddock to the next starting at paddock 1).




**Rational grazing system**

**Zero grazing:-** In this type of grazing system, the animals are not allowed to go out into the pasture to graze. Instead, forage is cut and brought to the animals in their .The forage can be harvested manually or mechanically. In the Caribbean they are mostly harvested manually with a cutlass, knife or a scythe. It is essential that farmers know the correct time to harvest grass. If forage is harvested when it is too young it can cause diarrhoea in animals and it can also cause the plants to die or stunt their growth. If forage is harvested when it is too old, it will become too woody and loose its palatability.

**Continuous grazing:-** In a continuous grazing system, there is a single pasture and the animals are allowed to graze in it for a long period of time such as for a whole year .Continuous grazing is a simple system to implement and usually practiced where there is no fencing.

| Grazing system | Advantages | Disadvantages |
|---|---|---|
| **Rotational grazing** | • Reduces weed growth<br>• Reduces soil erosion<br>• Limits the compaction of soil<br>• Helps to maintain healthy forage and grass<br>• Animal wastes add nutrients to the soil<br>• Prevents over grazing<br>• Forage and grass are consumed more efficiently. | • Requires additional labour<br>• Starting costs can be very high (these include materials and labour needed to construct fences)<br>• Fence requires proper maintenance |
| **Zero grazing** | • Reduces praedial larceny<br>• Allows monitoring and control diseases<br>• Reduces missing animals<br>• No fencing and water supplies required<br>• Requires less space<br>• Highly productive | • Time consuming as it requires a lot of time to harvest grass or forage and transport it to animals<br>• Increased production costs as people have to employed to cut and transport grass or forage<br>• Requires proper managing of forage and grass and knowledge of the most suitable time of for harvesting |

| | | |
|---|---|---|
| **Continuous grazing** | • Low start-up costs<br>• Most cost-effective method of grazing<br>• Abundance of forage and grass in the rainy season<br>• Requires less management and resources | • Causes overgrazing<br>• Encourages straying of animals<br>• Encourages the build-up of internal and external parasites |

**Stall feeding:-**

Stall fed is such a goat farming system where goats are kept inside the shed or house and not allowed to graze outside. Inside the shed or house, the goats are cared and kept separated depending on their age, breed, sex and weight. Stall fed goat farming system is becoming popular day by day. It's pretty new system and has many advantages compared to traditional goat farming system. High profit, fast growth, less care etc. are some main advantages of stall fed goat farming system. If you are planing for starting a goat farm project in a controlled but professional manner, then stall fed goat farming system is the most practical and the best system to follow.

**Why Stall Fed Goat Farming Method?**

Some advantages of this goat farming system.

- Easy to care and require less space.
- Better collection and utilization of manure. Farmer can properly collect and utilize the manure for producing greens or crops (or use for any other purposes).
- Quantity and quality of feed can be differentiated according to the stage and nutritional requirement of different age groups of goats.
- It can prevent unwanted mating which ensures proper breeding and production.
- It can keep farm's record easily.
- Wastage of energy during grazing is avoided.
- Diseases are less. Disease transmission is prevented from outside animals and outside plants. And better control and reduction of parasitic re-infestation.
- In stall feeding goat farming system goats are free from harmful and wild animals and predators.
- Overall, goats gain better body weight, grow healthier and become healthier and farmers can gain more profit in stall fed goat farming system compared to grazing or traditional goat rearing system.

**How to Start Stall Fed Goat Farming**

Stall feed goat farming system is most suitable for meat production purpose. That means, this system makes more profit if you plan for commercial meat production business. Here we are describing about the starting process of stall fed goat farming system.

**Breed Selection:-** In stall fed goat farming system, have to select those goat breeds which are highly meat productive. Boer, Spanish, Kiko, Pygmy, Black Bengal, Sirohi, Frisian etc. are some meat producing goat breeds and are suitable for stall fed goat farming system. Whichever breeds select, don't forget to select and purchase disease free and quality goats. It will be better if can purchase does aged between 5-15

months and bucks aged between 5-7 months. Always try to purchase animals from other farm near area. In case of purchasing from any livestock market, be wise and monitor goat's health and all other related aspects perfectly.

**Housing:-** An adult goat needs about 10 square feet housing space in stall fed goat farming system. The house can be build of either wood, bamboo or concrete. Make proper facilities for cleaning the house. If possible make a drain inside the house. Make big windows so that fresh air can flow inside the house during summer. Cover the house at night with hessian during the winter season and keep some straw, hay or wood shavings in the floor for providing warmth.

**Making the Goats Accustomed to Stay Inside House:-** Don't keep the goats inside the house for all the day after purchasing. For the first time, let the goats graze in the field 6-8 hours daily and keep them confined for rest of the day and provide them sufficient food and clean water. Do this for 1-2 weeks and gradually decrease grazing time. And then goats will be accustomed inside house. But if goats are used to stay inside the house after their birth then this method is not necessary (you can easily raise them in stall feeding system).

**Caring Kids:-** Clean the body of kids after their birth and immediately feed them colostrum (mother's first milk). Colostrum is highly nutritious and very effective for kids. If anyhow can't feed colostrum, then can use colostrum replacer which is available in the market. Domesticater have to feed the kids 10-12 times a day for the first few days or week. Clean and sterilize feeder, nipples or other required feeding equipment with boiled hot water. A goat kid with 1-1.5 kg body weight needs about 250-350 grams milk daily. Increase the amount of milk according to their body weight. Domesticater can wean the kids after 2-3 months. Start introducing greens and supplementary feeds when the kids reach one month of age.

**Feeding:-** Goats usually eat 4-5% food daily of their total body weight. Ensure 60-80% of their daily foods are containing fiber (grass, leaves, hay etc.). And provide them 20-40% supplementary goat feed. A growing castrated buck needs about 1-1.5 kg green feeds and 200-250 gram supplementary feed daily. A doe about 25 kg body weight with 2-3 kids will need about 1.5-2.5 kg greens and 350-450 grams of supplementary feeds daily. An adult breeding buck needs about 1.5-2.5 kg greens and about 200-300 grams of supplementary feeds daily. Here is the general mix of supplementary goat feed for stall fed goat farming system.

| **Feed Ingredients** | **Percentage (%)** |
|---|---|
| Broken Rice/Wheat/Maize | 12.00 |
| Flour, Wheat/Rice Bran | 47.00 |
| Pea Bran | 16.00 |
| Soybean/Sesame/Coconut/Mustard Cake | 20.00 |
| Dried Fish Powder | 1.50 |
| Dicalcium Phosphate | 2.00 |
| Salt | 1.00 |

| | |
|---|---|
| Vitamin Mineral Premix | 0.50 |
| Metabolic Energy (MJ/kg) | 10.00 |
| Metabolic Protein (grams/kg) | 62.00 |

**Cultivate Grass For Goats:-** Grasses are best source of greens for goats. If cultivate grass in farmer own land, then it will decrease feeding cost and increase the quality of goats. Alfalfa, Bahiagrass, Bromegrass, Clover, Fescue, Millet, Ryegrass, Timothy etc. are considered as the best grass for goats. Napier, Splendida, Andropogon etc. are also some highly productive grass and suitable for goats which are raised in stall feeding system. If possible, cultivate various types of grasses. Doing this will make a variety for goat's regular diet. In stall fed goat farming system, can also feed goats hay mixed with urea and molasses. Read what to feed goats in stall feeding system for details.

**Caring Breeding Bucks:-** Keep enough buck in farm for breeding purpose. Usually, 1 buck is sufficient enough for breeding 25+ does. Castrate other bucks in farm which are not necessary for breeding purposes. Castrate the bucks within 2-4 weeks after their birth. Feed breeding bucks with greens only when they are not using for breeding. But during breeding time provide them 200-500 grams of supplementary feeds (may vary depending on the goat breeds) daily along with sufficient amount of greens. Germinated chickpeas is very effective for breeding bucks. Farmer can feed buck about 10 grams of germinated chickpeas daily. Don't let breeding bucks become fatty.

**Health Management:-** Deworm the goats twice a year (once at beginning of rainy season and another at the beginning of winter season). Vaccinate them timely and keep contact with a veterinarian in nearby area. Vaccinate the goats for Enterotoxemia after 3 days of birth (1st dose) and after 15-20 days of birth (2nd dose). Vaccinate for PPR at their age of 4 month and vaccinate for goat pox at the age of 5 months. Diseases and other health problems can be solved by proper care and treatment.

**Other Management:-** Always bring healthy and disease free goats in farm. If bring new goats in r farm, then keep the goats separated for 15 days and take proper care. Introduce the new goats with other goats in herd after keeping them separated for 15 days. If notice the new goats are healthy and diseases free, then vaccinate them PPR vaccine after 15 days and introduce them with the herd. If there are any infected goat in herd, then separate the infected goat as soon as possible and take extra care. Clean the goat house on a regular basis. Wash the goats with 0.5% malathion solution after every 5-6 months. This will keep the goats free from skin diseases.

**Breeding Management:-** Does/female goats become suitable for breeding within their 7-8 months of age (when they reach 12-13 kg body weight). Introduce the does with bucks when they are in heat (usually, after 12-14 hours). For example, if the heat period starts in the morning, then bring her to the buck at the afternoon. After successful breeding, the does become pregnant and give birth of kids after 142-158 days. Always choose healthy and disease free bucks for better result in goat breeding.

**Marketing:-** In proper care, quality feeding and good management the goats become suitable for marketing within their 12-15 months of age (may vary depending on goat breeds).

## Poultry feeds

**Poultry feeds:-** The object of pottery farming is provide healthy food for human being. Poultry farming is a lucrative and popular business throughout the world. But it can be a risky business suddenly, especially if you are not concerned about poultry feed management. Success in the poultry farming business mostly depends on feeding quality feed and feed formulation system. For proper growth, egg production and good health, poultry birds require energy. In order to obtain desired growth rate, must have to purchase and provide highly nutritious poultry feed. In poultry farming 60-70% investment of total investment is spent on only feeding.

**Essential Nutrients**

For healthy life, proper growth, maximum production and suitable breeding, all types of poultry birds need some essential nutrients. Most of these essential nutrients come from the natural sources. Pasture, grains and seeds, bugs and insects, sunshine, gravel etc. meet up the demands of necessary nutrients.

1. **Water:-** It is an universal truth that 'organism can't live without water but can survive longer without food'. Poultry birds are not exception. They also can't live without water. Lack of adequate supply of pure water can causes different types of problems. It hinders the growth of young poultry birds and also causes early moulting in the laying flock, and directly minimize egg production.
2. **Carbohydrate:-** Carbohydrate is essential for a starved flock. This poultry feed materials can be found in grains and grainy products. Carbohydrate provide energy to poultry birds and keep them productive. It is 70-80% part of total food.
3. **Protein:-** The most expensive poultry feed element is protein. But it is a must to provide poultry birds sufficient amount of protein contained feed. There are two types of protein source are available. Animal and vegetable protein. Animal protein is a great source of adding required protein in poultry feed. The animals protein means, that comes from animals sources such as meat, meat meal, milk, liver etc. This type of protein sources are very helpful for proper growth and better egg production, than vegetable protein. It is 10-20% of total food.
4. **Fat:-** Proper ratio of fat in poultry feed is also very essential. It is 2-5% part of total food. Usually fat is available in almost all types of feed elements. But an excess amount of fat that comes from fish products, fish oil or meat can causes digestive problem and lead to various poultry disease.
5. **Minerals:-** It is 0.8-1.0% part of total food. Calcium carbonate (which is present in vitamin D) helps to formulate the egg shell. Calcium and phosphorous make the major part of poultry bird's bone. But excess amount of phosphorous in poultry feed lead to crooked bones and slipped tendons in chickens and poultry birds. Salt is also a reliable source of essential minerals. Small amount of some highly important minerals can be found in green foods.
6. **Vitamin:-** Any vitamin deficiency in poultry feed rations can hinder the natural growth of young poultry birds. The term vitamin describe a variety of essential nutrients that are differ from one another. The activities of different vitamins are different.
    a. **Vitamin A:-** Vitamin A comes from green feed ingredients, yellow corn and fish oils. It is essential to protests the poultry birds against colds and infections.
    b. Vitamin D: Vitamin D help to prevent leg weakness and rickets. It is found in synthetic products and also available in sea fishes. Vitamin D is a must added elements in poultry feed.
    c. **Vitamin B Complex:-** Vitamin B complex is available in milk, green feed, liver, synthetic riboflavin etc. It helps to increase the growth of poultry and chickens. It also helps to prevent

curled-toe paralysis in young chickens. While preparing poultry feed, you must have to be careful about adding adequate amount of Vitamin B Complex in the poultry feed mixture.

**Quantity of poultry ration for 100 birds per week**

| Age (week) | Quantity (per week in kg) |
|---|---|
| 9 | 40 |
| 10 | 43 |
| 11 | 44 |
| 12 | 45 |
| 13 | 46 |
| 14 | 47 |
| 15 | 48 |
| 16 | 49 |
| 17 | 50 |
| 18 | 51 |
| 19 | 52 |
| 20 | 53-55 |
| 21-24 | 70 (10kg/day) |
| 25-28 | 77 (11kg/day) |
| 29-40 | 92 (13kg/day) |
| 41-60 | 98 (14kg/day) |
| 61-75 | 105 (15kg/day) |

**Principal for preparation of ration for poultry**

1. **Starter Ration (8-20 weeks birds):-**

| S.No. | Name of Ration | Ration-1 | Ration-2 |
|---|---|---|---|
| 1. | Rice polish | 25% | 20% |
| 2. | Groundnut cake | 20% | 20% |
| 3. | Yellow Maize | 20% | 15% |

| | | | |
|---|---|---|---|
| 4. | Wheat Bran | 15% | 15% |
| 5. | Sorghum | 10% | 20% |
| 6. | Fish powder | 6.5% | 6.5% |
| 7. | Greet | 1% | 1% |
| 8. | Bone powder | 1% | 1% |
| 9. | Premixes | 1% | 1% |
| 10. | Salt | 0.5% | 0.5% |
| **Total** | | **100%** | **100%** |

**2. Grower's Ration (More than 20 weeks age)**

| S.No. | Name of Ration | Ration-1 | Ration-2 |
|---|---|---|---|
| 1. | Rice polish | 22% | 20% |
| 2. | Groundnut cake | 20.5% | 12.5% |
| 3. | Yellow Maize | 10% | 10% |
| 4. | Wheat Bran | 10% | 20% |
| 5. | Sorghum | 20% | 20% |
| 6. | Fish powder | 7% | 7% |
| 7. | Greet | 3.5% | 3.5% |
| 8. | Bone powder | 1% | 1% |
| 9. | Premixes | 1% | 1% |
| 10. | Salt | 0.5% | 0.5% |
| 11. | | 4.5% | 4.5% |
| **Total** | | **100%** | **100%** |

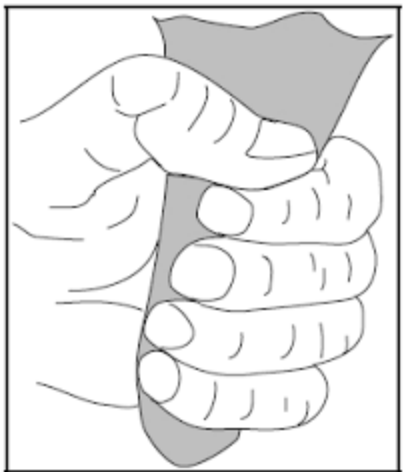
**3. Layer's Ration (Egg producer brides)**

| S.No. | Name of Ration | Ration-1 | Ration-2 |
|---|---|---|---|
| 1. | Rice polish | 22% | 24% |

| | | | |
|---|---|---|---|
| 2. | Groundnut cake | 10% | 10% |
| 3. | Yellow Maize | 12% | 20% |
| 4. | Wheat Bran | 15% | 15% |
| 5. | Sorghum | 25% | 13% |
| 6. | Fish powder | 4% | 5% |
| 7. | Greet | 3% | 3% |
| 8. | Bone powder | 2% | 1% |
| 9. | Premixes | 1% | 1% |
| 10. | Salt | 1% | 1% |
| 11. | | 5% | 7% |
| **Total** | | **100%** | **100%** |

**4. Broiler's Ration (For meat/chicken production)**

| **S.No.** | **Name of Ration** | **Broiler's Starter (1-5 weeks age )** | | **Broiler's Finisher (More than 5 weeks age)** | |
|---|---|---|---|---|---|
| | | **Ration-1** | **Ration-2** | **Ration-1** | **Ration-2** |
| 1. | Rice polish | - | 7.5% | 20.5% | - |
| 2. | Barley | 6.5% | - | 5% | 8% |
| 3. | Groundnut cake | 30% | 28% | 24% | 23% |
| 4. | Yellow Maize | 42% | 35% | 25% | 35% |
| 5. | Wheat Bran | - | 5% | 5% | 3% |
| 6. | Sorghum | 12% | 9% | 13% | 17.5% |
| 7. | Fish powder | 7% | 8% | 5% | 5% |
| 8. | Bone powder | 1% | 1% | 1% | 1% |
| 9. | Premixes | 1% | 1% | 1% | 1% |
| 10. | Salt | 0.5% | 0.5% | 1% | 1% |
| 11. | | - | 5% | - | 6% |
| **Total** | | **100%** | **100%** | **100%** | **100%** |



## C. Systems of milking by hand and by machine − Important considerations in both these methods

**Milking Methods**

Hand milking and machine milking are the two methods being used to remove the milk from the udder

**Hand milking**

In India hand milking of cows is still the most common practice.Cows are milked from left side. The order of milking the various teats also differs. Teats may be milked cross-wise or fore quarters together and then hind quarters together or teats appearing most distended milked first.

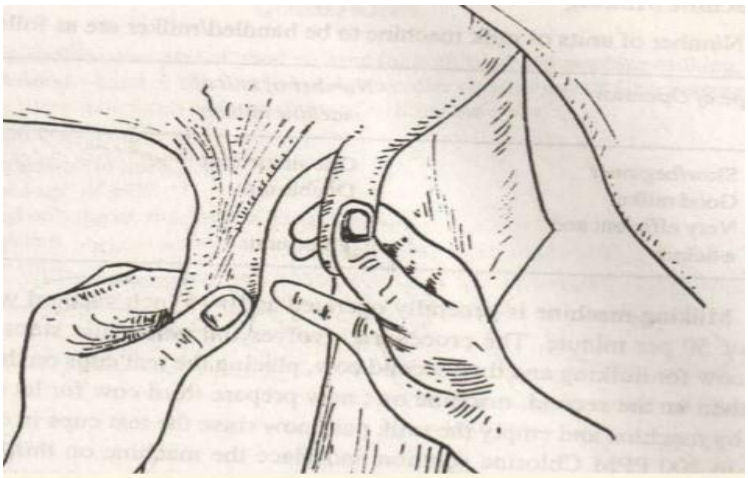
The milk must be squeezed and not dragged out of teats. The first few streams of milk from each teat should be let on to a strip cup to see clues in milk for possible incidence of mastitis. This also helps in getting rid of bacteria which have gained access and collected in the teat canal.

**Methods of hand milking**

Stripping and full-hand milking are the two commonly used methods of milking.

**a. Stripping method**

Stripping consists of firmly seizing the teat at its base between the thumb and forefinger and drawing them down the entire length of the teat pressing it simultaneously to cause the milk to flow down in a stream.The process is repeated in quick succession.



Stripping method of hand milking

Both hands may be used, each holding a different teat, stripping alternately. The full-hand method comprises holding the whole teat in the fist, fingers encircling the teat

**Full hand milking** The base of the teat is closed in the ring formed by the thumb and fore finger so that milk trapped in the teat sinus may not slip back into the gland cistern.

Simultaneously, teat is squeezed between the middle, ring and little fingers and the hollow of palm, thus, forcing the milk out. This process should be repeated in quick succession.

By maintaining a quick succession of alternate compressions and relaxations the alternate streams of milk from the two teats sound like one continuous stream.

Many milkers tend to bend their thumb in, against the teat while milking This practice should be avoided as it injures the teat tissues.

**Advantages of full hand milking**

- Full-hand milking removes milk quicker than stripping because of no loss of time in changing the position of the hand.
- Cows with large teats and she buffaloes are milked by full-hand method,
- Full-hand method is superior to stripping as it simulates the natural sucking process of calf.

Stripping causes more irritation to teats due to repeated sliding of fingers on teats and so discomfort to cows, but stripping has to be adopted for cows with smaller teats for obvious reasons. In spite of these drawbacks when all milk that is available is drawn out by full-hand method, stripping should be resorted to with a view to milk the animal completely the last drawn milk is called strippings and is richer in fat. In India, milkers are mostly accustomed to wet hand milking. They moisten their fingers with milk, water or even saliva, while milking. This should be avoided for the sake of cleanliness. Wet-hand milking makes the teats look harsh and dry chafes, cracks and sores appear which are painful to animal. The hands should be perfectly dry while milking. When cracks and sores are noticed on teats, some antiseptic ointment or cream should be smeared over them after milking.

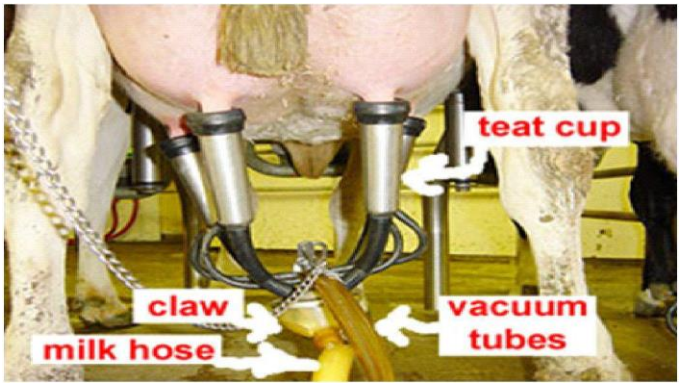
**Machine Milking**

Machine milking is more efficient method of milking compared to hand milking. Modern milking machines are capable of milking cows quickly and efficiently, without injuring the udder, if they are properly installed, maintained in excellent operating conditions and used properly.

**Parts of the milking machine**

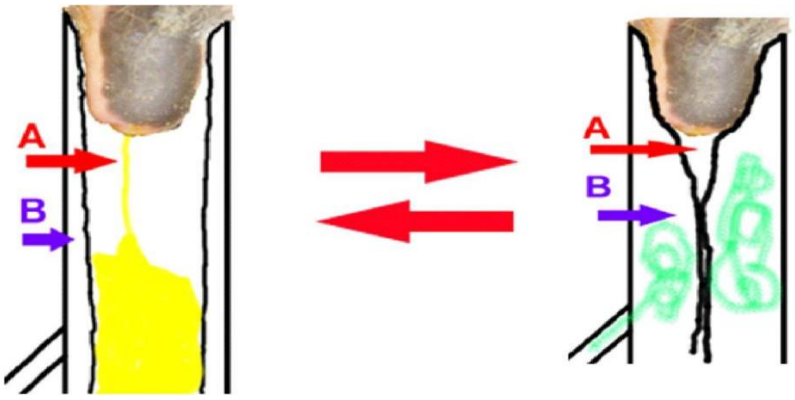
The machine includes teat cups that contact the cow's teats and remove the milk, a claw where milk pools as it is removed from the four teats, vacuum tubes that provide vacuum to the teat cups and a milk tube that removes milk away from the claw, a source of vacuum for the machine, and a pulsator that regulates the on-off cycle of the vacuum.

Many milking machines today have an automatic take-off (ATO or detacher) device that removes the machine from the cow when milking is completed.




**Milking machine on a cow indicating machine parts**

(A) one inside of the liner and (B) one between the metal shell and the outside of the liner. A vacuum is pulled in both chambers; the vacuum in chamber A is continuous, while the vacuum in chamber B alternates between atmospheric pressure and the vacuum.




**(a) Milk phase of the pulsation cycle. 8.7(b) Rest phase of the pulsation cycle.**

When the teat cup is applied to the teat, the end of the inside chamber is filled by the teat.

During the milk phase the vacuum applied inside the liner is constant and keeps a constant negative pressure at the end of the teat, drawing milk (in yellow) from the gland.

The vacuum applied to chamber B, between the shell and the thinner walled part of the liner, keeps the liner from collapsing under the vacuum. During the rest phase, the vacuum inside chamber B is monetarily off. Air (in green) enters chamber B instantly reaches atmospheric pressure, collapsing the rubber liner around the teat end, massaging the teat and maintaining blood flow.

The lower part of chamber A maintains its vacuum (lower part of right diagram), while the upper part around the teat momentarily loses vacuum. This alternating vacuum-atmospheric pressure in chamber B is controlled by a pulsator.

However, if the constant vacuum were left onto the teat end for an extended period, blood and lymph would accumulate in the end of the teat, causing trauma to the teat. This would be like attaching a vacuum hose to the end of your finger.· A proper pulsation rate, that is the number of cycles of vacuum on - vacuum off (in Chamber B above), or milk phase – rest phase cycles, usually is about 45-60 per minute. The ratio of time that the machine is in milk phase vs rest phase should be between 50/50 to 60/40 (pulsation ratio). Pulsation is important for maintaining teat end health.

The area exposed to the hose would turn red with accumulated blood. To prevent teat-end trauma, this alternating vacuum-atmospheric pressure, referred to as:-

**Advantages of milking machines**

- Saving of labour expenses.
- Reduction of dependency on skilled farm workers.
- Enables rearing of larger herd strength.
- 3-4 times faster than hand milking.
- Increase in the milk yield.
- Increase in the quality of milk.
- Reduces stress throughout the lactation by creating good milking routines.

**Limitations**

- Some of the older cows which are accustomed to hand milking may not adjust to machine milking.
- Standby power supply is essential.
- High initial investment and training of staff.
- Negligence in following the strict cleaning procedures would lead to severe contamination and higher incidence of mastitis.
- Greater water requirement for cleaning of equipment.
- Prompt service and availability of spares is essential.

## D. Concept of − Clean milk production, Processing, Value added products from milk, Milk pasteurization, Packaging and milk marketing in India

### Clean Milk Production

Milk containing dirt, dust, foreign materials have high bacterial count and with off flavour is called contaminated milk. Milk is contaminated by various sources like udder, exterior of cow's body, milking barn, flies, milker, uensils etc. On consumption of contaminated milk, one may get a number of health problems. The sources for contamination are discussed below with their relative importance.

### Udder

Un Sanitary conditions of milking barns and bedding of the animal causes bacterial growth. Such bactecia may enter in to the udder through teet canal, which causes infection in the udder like mastitis resulting contamination of milk. The fore milk may be discarded as it contains high bacterial count. Complete milking should be done. Incomplete milking may lead to infection of the udder.

### Exterior of Cow's Body

Bacteria present in the animal body may enter in to the milk at the time of milking. Maintenance of clean skin, washing flank and udder with clean damp cloth before milk reduces the contamination from this source.

### Milking Barns

Milking barns with good ventilation and neat flooring avoids contamination from these sources, dry feeds or forage should be fed after milking.

### Flies and Other Vermin

External parasites like flies, lice, mosquitoes etc. may have their entry in to milk. So that care should be taken to avoid these parasites from the barn by spraying, fly proofs or by fly traps. Breeding places for these parasites like stagnant water, moist atmosphere etc may be avoided.

### Milker

Milker is directly responsible in producing good quality milk. Dirty hands and clothing of the milker may be the source of contamination. Several bacterial diseases may transmit from the milker, or handler to the

consumer through milk. Persons suffering from diseases like T.B, Typhoid fever, diphthiria may not be employed for milking. Dirty habits like smoking, drinking should be avoided.

**Untensils**

Utensils are the containers or equipments in which the milk is handled, processed, stored or transported. Clean sanitized, smooth copper free and dry utensils may be used for handling milk.

**Milking Methods**

Wet hand milking and fisting causes contamination of milk. Milkers generally moisten their fingers with milk, water or even saliva, while milking. This should be avoided. Wet hand milking makes the teats look harsh and dry chokes, cracks and sores appear which causes contamination. Twisting causes damages to the teat tissue which leads to udder infection. So that dry hand milking may be practiced to avoid contamination of milk. Major contamination of milk is caused by bacterial entry. So that steps are to be taken to monitor such bacterial entry like avoiding insanitary conditions of the barn, cleanliness of the milker, utensils and avoiding unfair milking practices.

**Steps in Clean Milk Production**

- The animal should be washed before milking.
- Washing of cows is best practice to minimise the bacterial entry.
- If calf is allowed for sucking, udder may be moist, cleaned with weak disinfectant solution later with fresh, clean water and wiped dry with a smooth and clean cloth.
- Hands of the milker should be clean and dry. Wet hand milking may result in high bacterial count in the milk.
- Nails of hands of the milker should be well trimmed.
- Milker should be free from all diseases.
- Dusty feed like Rice polish should not be fed to the animal at the time of milking.
- Milking barns should be well ventilated free from flies.
- Utensils used for milking should be clean, sanitized, smooth and copper free.
- Flavour producing feeds should be fed only after milking so that flavours will not appear in milk.
- The hind legs and the switch of the animal will be tightened with the help of a milk man's rope at the time of milking.
- Milk is kept in cool place to maintain the flavour and keeping quality.
- Milk should be covered with lids to avoid dust, dirt, entry hot, or cold, day light or strong artificial light, all at which tend to decrease milk quality.

**Pasteurization of Milk**

**Pasteurization:-** Food preservation method in which moderately high (62°C to 100°C) temperatures are used (for about 15 to 30 minutes) to inactivate certain enzymes and kill certain other microorganism (such as those that cause tuberculosis), especially in milk.

It is named for the French scientist Louis Pasteur, who in the 1860s.

Pasteurization is a relatively mild heat treatment, (usually performed below 100°C) which is used to extend the shelf-life of milk for several days. It preserves the milk by the inactivation of enzymes and destruction of heat-sensitive micro-organisms, but causes minimal changes to the nutritive value or sensory characteristics of a food. Some heat-resistant bacteria survive to spoil the milk after a few days, but these bacteria do not cause food poisoning.

The time and temperature combination needed to destroy 'target' microorganisms will vary according to a number of complex inter-related factors. For milk, the heating time and temperature is either 63°C (145°F) maintained for 30 minutes (Low Temperature Long Time/LTLT) or, alternatively, heating to a higher temperature, 72°C (162°F), and holding for 15 seconds (High Temperature Short Time/HTST). Only the former combination is possible on a small scale and for this the simplest equipment required is an open boiling pan. Better control is achieved using a steam jacketed pan, and this can be fitted with a stirrer to improve the efficiency of heating. Both of these are batch processes which are suited to small-scale operation. A higher production rate may be possible using a tubular-coil pasteurizer. This equipment has been tested and has been successful for some fruit products but it is presently still at a developmental stage.

**Packaging of Milk:-**

**Why we need packaged milk:-**

- Risk of Pathogens in the open milk due to surrounding environment and Unhygienic Grazing Conditions
- Risk of Bacteria inside and outside the udder during milking.
- Improper Sanitization while milking manually or mechanically.
- Unsterile storage and transportation equipment.

**Commonly used Milk Packaging Technologies In India**

1. Milk Vending machines:- Bulk Vending by machines through token systems.

**Advantages**

- Can purchase small quantity of milk.
- Cost-effective.

**Disadvantages**

- Hygiene and safety cannot be ensured.
- Handling of milk at variant temperatures while transportation can lead to microorganisms growth.

2. **Milk in Glass Bottles**

**Advantages**

- Transparent and strong bottles.
- Inertness to chemical substances.
- Water and gas barrier.

**Disadvantages**

- Difficulty in transportation.

- Fragile and costly.
- Loss of nutrients ( B vitamins) due to effect of light.
- Glass though 100% recyclable is not environmentally friendly to be recycled.

3. **Milk in Plastic Packets/Flexible Pouch**

**Advantages**

- Light and easy to transport.

**Disadvantages**

- Can be easily adulterated.
- The quality of plastic used should be virgin polyethylene only (LDPE, LLDPE, HDPE or EVA).
- Short shelf life.
- Need to keep at fixed temperature in cold chain constantly.

4. **Aseptically packaged/Milk in Tetra Pak:-** Tetra Pak is the milk that is filled into the six-layered Tetra Pak cartons. Ultra High Temperature-treated milk simply means that the milk has been heated to a very high temperature for a brief period; however, ensuring the milk's taste and nutrition remains intact.

   Tetra Pack Milk has to pass through heating and cooling stages in quick successions. It is then immediately filled into a sterile Tetra Pak carton which is shelf safe. With UHT, the shelf life of milk in Tetra Pak cartons increases and the milk can last up to 4 to 6 months when the carton remains sealed. However, once opened, the milk carton needs to be refrigerated and consumed within 5 days from opening the seal.

**Value Added products of milk**

1. **Whey protein concentrate**: ultrafilteration technology is used to concentrate protein in whey to various levels between 20-80%. High BV & PER.
2. **Skim milk:** fat content reduced to 0.5-2 % by centrifugation. Extensive use in bakery & confectionery. Also used for low calorie diets & children who need high protein.
3. **Evaporated milk**: 50-60% water evaporated, clarified raw milk is concentrated in vaccum pan at 74-77°C. fortified with Vit D, sterilised in cans at 118°C for 15 minutes & cooled. As per PFA condensed milk should contain 26% milk solids of which 8% is fat.
4. **Sweetened condensed milk:** not sterile, made from pasteurized milk concentrated 7 sweetened with 65% sucrose. Contains 9% fat out of 31% milk solids.
5. **Toned milk:** 7% fat; mix of reconstituted from skim milk powder with buffalo milk.
   - Fat content >5% & SNF 8.5%
6. **Double toned milk:** admixture of cow's or buffalo's milk or both with fresh skimmed milk or by admixture with skim milk reconstituted from skim milk powder.
   - Should be pasteurised & show negative phosphatase test.
   - Fat content <1.5% & SNF >9%.
7. **Recombined milk:** homogenised product prepared from milk fat, MSNF & water. Pasteurised; fat content <3% & SNF 8.5%.
8. **Filled milk:** homogensied product prepared from refined vegetable oil & MSNF & water.
   - Fat content > 3% & SNF 8.5%
9. **Malted Milk is** a powdered gruel made from a mixture of malted barley, wheat flour, and whole milk, which is evaporated until it forms a powder.
   - Malt powder comes in two forms:
   - Diastatic malt contains enzymes that break down starch into sugar; this is the form bakers add to bread dough to help the dough rise and create a good crust.

- Nondiastatic malt has no active enzymes and is used primarily for flavor, mostly in beverages. It sometimes contains sugar, coloring agents, and other additives.

10. A **lactose-free milk** is available for people who are lactose-intolerant. This modified milk is made by filtering regular milk to remove half the lactose. The enzmye *lactase* is then added to the milk to break down the remaining lactose into simpler forms which the body can absorb.
11. **UHT processed milk:** packed & aseptically sealed in pre-sterilized containers under aseptic conditions.

- It can be stored Unrefrigerated for atleast 3 months.
- Cooked flavour due to denaturation of β-lactoglobulin.

12. **Standardised milk:** fat is maintained4.5% and SNF 8.5%. Mix of buffalo & skim milk
13. **Dry milk:** made with whole milk or skimmed milk dehydrated to about 97% by spray drying & vaccum drying. Good shelf life. Highly hygroscopic & can be reconstituted to fluid milk.
14. **Khoa:** semi-solid obtained from milk by evaporating in open pans with continuous stirring in circular motion. Yield is about 20% of weight of milk used.
15. **Rabri**: concentrated sweetened product comprising several layers of clotted cream. Sugar is added to milk reduced to 1/3 of its original volume.
16. **Chhaina**: major heat & acid coagulated product. Used in sweets like rasmalai, rasogolla,etc.
17. **Ice-cream**: frozen dairy product consisting of whole milk, skim milk, cream, butter, condensed milk products or dried milk products. MF & MSNF constitute 60% of TS giving it a rich flavour, improved body & texture.

- Also contains sugar, stabiliser, emulsifier, flavoring material, water & air.
- Sugar provides sweetness, smoothness & lowers the freezing point.
- Stabiliser prevent formation of ice crystals. Forms gel with water & thereby improve body & texture. e.g., gelatin, sea weed, china grass & CMC.
- Emulsifier help disperse fat globules throughout the mix & prevent clump formation, further help make ice-cream dry & stiff.

18. **Cream:-**Creamis the high-fat component separated from whole milk as a result of the creaming process. It has a higher proportion of fat droplets to milk than regular fluid milk; and according to federal standards of identity, cream must contain 18% milk fat or more. Due to this high fat content of cream compared to milk, some yellow, fat-soluble pigments may be apparent.

- Various liquid creams available for use in foods include the following:
- Light (coffee) cream: 18–30% butterfat.
- Light whipping cream: 30–36% butterfat.
- Heavy cream: 36% butterfat, minimum.
- "Half-and-half" cream diluted with non-fat milk: 10.5% butterfat.
- Whipping cream packaged under pressure in aerosol cans; may be non-fat or contain various levels of fat, sugar, flavouring, emulsifiers, and a stabilizer.

19. **Butter:-**

- Fat content is generally about 80%.
- Made from sweet or sour cream.
- Butter is a concentrated form of fluid milk produced through churning of pasteurized cream. Churning involves agitation that breaks fat globule membranes so the emulsion breaks, fat coalesces, and water (buttermilk) escapes.
- The original 20/80 *oil-in-water* type of emulsion of milk becomes a 20/80 *water-in-oil* emulsion.
- Milk is churned to form butter and the watery buttermilk. Butter may have a yellow color due to the fat-soluble animal pigment, carotene, or an additive.
- Butter spoil as a result of hydrolysis of TG molecules releasing free butyric & caproic acids.

20. **Ghee**:- It has 99.0 fat content. Ghee a type of clarified butter, is prepared by simmering butter and removing the residue. The texture, colour, and taste of ghee depend on the quality of the butter and the duration of the boiling.
21. **Buttermilk** was the liquid left behind after churning butter out of cream. It is beneficial to health as it contains probiotic microbes also fat content of buttermilk is far lower than milk or curd.
22. **Curd** prepared by cooling boiled milk to body temperature & adding 5-10% starter. After 6-8 hours an acidity of 0.9-1% is formed which coagulate the casein & curd is set.
- Easily digested than normal milk. Contains more vit B than milk.
- Used as marinating & souring agent in cookery.

23. **Yogurt** is a variety of curd. Whole, low fat, skim milks & even cream can be used to make yogurt.
- In production of yogurt, a mixed culture of streptococcus thermophilus, lactobacillus acidophilus is usually added to to the pasteurised milk & incubated at 42-46°C.
- Increase in folic acid concentration during fermentation.
- Fermented milk is useful for a wide variety of disorders like colitis, constipation, diarrhoea, gastroenteritis, diabetes & hyper cholesteremia.

24. **Shrikhand:** fermented product made by concentrating dahi by removing whey & to which sugar, flavor & condiments are added.
25. **Cheese:-** Cheese is a food derived from milk that is produced in a wide range of flavors, textures, and forms by coagulation of the milk protein casein.

## E. Production of – Mike and Egg

### Milk Production

Milk is a complex food that contains vital nutrients for the bodies of young mammals. Milk is the only food of the mammal during the first period of its life and the substances in milk provide energy and antibodies that help protect against infection. For humans, milk and dairy products make a significant contribution to meeting our bodies' needs for calcium, magnesium, selenium, riboflavin, vitamin $B_{12}$ and pantothenic acid (vitamin $B_5$) and therefore play a key role in our development.

**The origins of milk production:-** Today's dairy animals are the product of thousands of years of breeding of untamed animals that lived at different altitudes and latitudes, at times exposed to severe and extreme weather conditions. The techniques used in the production of milk using cows, goats, sheep and buffaloes began around six thousand years ago. The same species of animals are kept for milking today. These herbivorous animals were the natural choice to satisfy humans' need for food and clothing as they are less dangerous and easier to handle than carnivorous animals. The animals used for milk production are ruminants that eat quickly, in great quantities, and later digest their food. Today, the most widespread milking animal in the world is the cow. The cow can be found on all continents around the world. Other animals commonly used in both subsistence and industrial dairy farming are goats, sheep and buffaloes. The milk of these animals is of great importance to rural communities as a source of high-quality protein and other constituents. Sheep and goats are of exceptional

importance in areas such as the Mediterranean and in large areas of Africa and Asia. The number of sheep and goats in the world is in the billions and they are the most numerous of all milk- and meat-producing animals. The contribution of sheep and goats to milk and meat production in the poorest areas is also considerable: Both animals are a cheap source of food and are mainly kept in conditions where climatic, topographical, economic, technical or sociological factors limit the development of more sophisticated protein production systems.

The nutritional qualities of milk:- Among the essential minerals and vitamins in milk are iron and vitamin D. They are, however, not present in sufficient amounts, or in optimum proportions, to fulfil the requirements for complete nutrition. During the first period of its life, the young animal therefore makes up for the shortage of certain nutrients in milk by exploiting the reserves it receives from its mother at birth, which are normally sufficient until its diet includes other foods. To make the nutrients easily consumable and digestible, they are available in a liquid state, partly as a solution, partly as dispersion or suspension. There is a wide variation in the balance of components in milk from various mammals, although the components themselves are basically the same.

Quantities of the various main constituents of raw milk from cows can vary considerably; between cows of different breeds and between individual cows of the same breed. Water is the principal constituent and it is the carrier of all other components. Cows' milk consists of around 87 % water and 13 % dry substance that is suspended or dissolved in the water. Besides 'total solids', the term solids non-fat is used in discussing milk composition.

**MILK COMPOSITION**

**In per cent (%)**

| Breed | Water | Fat | Protein | Lactose | Mineral | Total Solid | Non-Fatty Solid |
|---|---|---|---|---|---|---|---|
| **Cow** | 87.20 | 3.7 | 3.50 | 4.90 | 0.70 | 12.80 | 9.10 |
| **Buffalo** | 82.76 | 7.38 | 3.60 | 5.48 | 0.78 | 17.24 | 9.86 |
| **Sheep** | 80.71 | 7.9 | 5.23 | 4.81 | 0.90 | 19.29 | 11.39 |
| **Got** | 87.00 | 4.25 | 3.52 | 4.27 | 0.86 | 13.00 | 8.75 |

**Secretion and the lactation period**

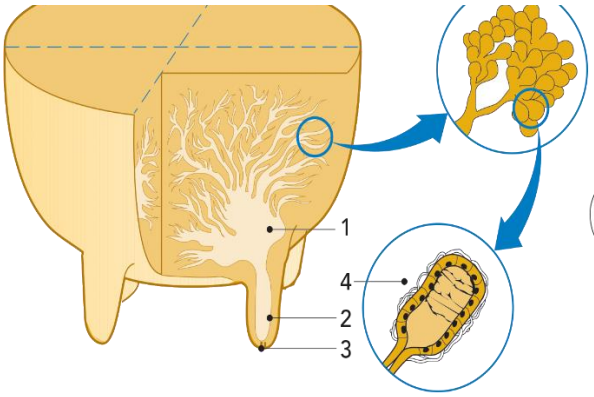
Milk is secreted in the cow's udder – a hemispherical organ divided into right and left halves by a crease. Each half is divided into quarters by a shallower transverse crease. Each quarter has one teat with its own separate mammary gland. It is therefore theoretically possible to get milk of four different qualities from the same cow. The cow's udder is composed of glandular tissue containing milk-producing cells. The external layer of this tissue is muscular, thus giving cohesion to the body of the udder and protecting it against injury. The glandular tissue contains around two billion tiny bladders called *alveoli*. The milk-producing cells are located on the inner walls of the alveoli, which occur in groups of 8-120. Capillaries leading from the alveoli converge into progressively larger milk ducts which lead to a cavity above the teat. This cavity, known as the *cistern of the udder,* can hold up to 30 % of the total milk in the udder.

The cistern of the udder has an extension reaching down into the teat; this is called the teat cistern. At the end of the teat there is a channel 1-1.5 centimetres in length. Between milking, the *teat channel* is closed by a sphincter muscle which prevents milk from leaking out and bacteria from entering the udder. The whole udder is laced with blood and lymph vessels. These bring nutrient-rich blood from the heart to the udder, where it is distributed by capillaries surrounding the alveoli. In this way, the milk-producing cells are furnished with the necessary nutrients for the secretion of milk. Spent blood is carried away by the capillaries to veins and returned to the heart. Large quantities of blood flow through the udder. A cow that produces 60 litres of milk per day will need some 30.000 litres of blood circulating through its mammary gland.

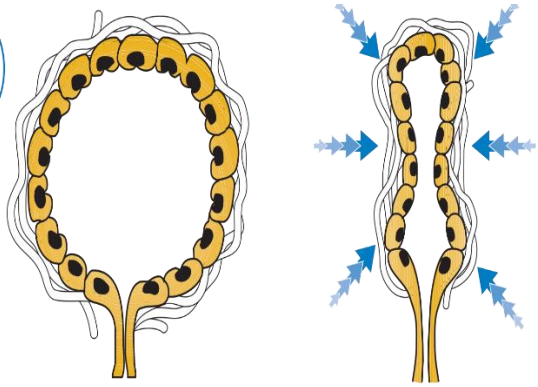
As the alveoli secrete milk their internal pressure rises. If the cow is not milked, secretion of milk stops when the pressure reaches a certain limit. Increase of pressure forces a small quantity of milk out into the larger ducts and down into the cistern. Most of the milk in the udder, however, is contained in the alveoli and the fine capillaries in the alveolar area. These capillaries are so fine that milk cannot flow through them of its own accord. It must be pressed out of the alveoli and through the capillaries into the larger ducts. Muscle-like cells surrounding each alveolus perform this duty during milking.

Secretion of milk in a cow's udder begins shortly before calving, so that the calf can begin to feed almost immediately after birth. The cow then continues to give milk for around 10 months (approximately 305 days). This period is known as lactation. During the lactation period, milk production gradually decreases and after 305 days it can drop to 25-50 % of its peak volume. At this stage milking is discontinued and the cow has a non-lactating period of up to 60 days prior to calving again. With the birth of the calf a new lactation cycle begins.

The udder also contains a lymphatic system. It carries waste products away from the udder. The lymph nodes serve as a filter that destroy foreign substances but also provide a source of lymphocytes to fight infections. Sometimes, around parturition cows giving birth for the first-time suffer from oedema, partly caused by the presence of milk in the udder which compresses the lymph nodes.




A sectional view of the udder



Squeezing of milk from alveolus

1. Cistern of the udder
2. Teat cistern
3. Teat channel
4. Alveolus

**Colostrum:-** Calves are born lacking their own immune protection as their immune system develops slowly. In response, the first milk a cow produces after calving is called colostrum, which differs greatly from normal milk in both composition and nutritional properties. Calves are dependent on receiving maternal antibodies and an essential supply of immunoglobulins via colostrum. Antibodies are globular proteins produced by the body's immune response system to fight diseases. Each individual varies in its

ability to produce antibodies and thus fight disease. Animals receiving inadequate colostrum are extremely vulnerable to intestinal infection and subsequent scours.

A calf needs around 1.000 litres of milk for normal growth and that is the approximate quantity which the primitive cow produced for each calf. To illustrate an individual cow's milk production, milk yield is typically plot against time to get a lactation curve. Yield will rise during the first months after calving, followed by a long period of continuous decline. The shape of the lactation curve will differ from individual to individual and from breed to breed. Feeding and management also influence the shape and have a significant impact on the total amount of milk produced. Lactation is ideally 305 days, but in practice it is usually more, followed by a two-month dry period prior to the next calving.

**Milking:-** During milking, the oxytocin hormone must be released into the cow's bloodstream for the udder to empty. This hormone is secreted and stored in the pituitary gland. When the cow is prepared for milking by the correct stimuli, a signal is sent to the gland, which then releases its store of oxytocin into the bloodstream. In the primitive cow, the stimulus was provided by the calf's attempts to suck on the teat. The oxytocin was released when the cow feels the calf sucking. A modern dairy cow normally has no calf present during milking so stimulation of the milk "let-down" is done by the preparation of milking, *i.e.* the sounds, smells and sensations associated with milking time.

The oxytocin hormone begins to take effect about a minute after preparation has begun and causes the muscle-like cells to compress the alveoli. This generates pressure in the udder and can be felt with the hand; it is known as the let-down reflex. The pressure forces the milk down into the teat cistern, from which it is sucked into the teat cup of a milking machine or pressed out by the fingers during hand milking. The effect of the let-down reflex gradually fades away as the oxytocin is diluted and decomposed in the bloodstream, disappearing after 5-8 minutes. Milking should therefore be completed within this period of time. If the milking procedure is prolonged in an attempt to "strip" the cow, unnecessary strain is placed on the udder and the cow becomes irritated and may be difficult to milk.

Milk fat consists mainly of triglycerides, which are synthesized from glyceroles and fatty acids. Long-chained fatty acids are absorbed from the blood. Short chained fatty acids are synthesized in the mammary gland from the components acetate and beta hydroxybutyrate which have their origins in the blood. Milk protein is synthesized from amino acids also with origin from the blood and consists mainly of caseins and to a smaller extent whey proteins. Lactose is synthesized from glucose and galactose within the milk-secreting cell. Vitamins, minerals, salts and antibodies are transformed from the blood across the cell cytoplasm into the alveolar lumen.

**Milking frequency:-** Due to labour patterns and working hours, milking twice a day has long been the common practice in industrial nations. In countries where labour is inexpensive, more frequent milking is often practiced. During the last few decades, focus has increasingly been put on milking more frequently, in particular in high-yielding herds. There are many benefits associated with more-frequent milking.

Changing from milking twice a day to three times a day markedly increases milk production. Published data shows that one additional milking can produce 5-25% more milk per cow per day. In addition, lactation becomes more persistent and prolonged. The reason why milk production increases with a more frequent milking could be a more frequent exposure of hormones stimulating milk secretion to the mammary gland. However, as mentioned above, milk contains an inhibitor with negative feedback control on milk secretion. More frequent removal of this inhibitor therefore results in higher production. Cows with a small udder cistern are more sensitive to the frequency of milking. Smaller the cisterns are more susceptible to frequent milk removal.

Frequent milking has both short- and long-term effects. In the short term, milk production increases due to enhanced activity in the milk-secreting cells. In the long term, production increases due to increased number of milk-secreting cells. The latter indicates that it is possible to influence the number of milk-secreting cells during an established lactation, which is of importance to the milk producing capacity of the animal.

Among the most important benefits of more frequent milking is improved animal welfare. It has been observed that high-yielding animals will typically not lie down for a few hours before milking. Moreover, many high yielders are producing up to 60 kilograms of milk per day and are milked twice with 8-16 hour milking intervals. These cows yield nearly 40 kilograms of milk during morning milking alone. Cows with such high amounts of milk in the mammary gland are exposed to high udder pressure, which undoubtedly causes discomfort. It has been observed that high-yielding cows prefer to be milked more frequently than two or three times a day when they are given the choice.

**Egg Production:-** Poultry enterprises may vary from basic backyard poultry keeping to mechanized and automated production plants. Various types of poultry enterprises are illustrated in Table 1.

**Types of poultry enterprises**

| | **Backyard Poultry** | **Farm Flock** | **Commercial Poultry Farm** | **Specialized Egg Production** | **Integrated Egg Production** |
|---|---|---|---|---|---|
| Subdivision of egg production | Pullet Growing,Feed Production | Hatchery Production Separate from Farming | Feed Production Separate from Poultry farms | Chicken meatProduction becomes. Independent ofEgg production | Separate Enterprises Reintegrated asa business |
| Main management characteristics | Natural hatching | Artificial hatching and sexing | Feed mixing | Egg processingPlant | Controlled-environment houses |
| Type of Farming | Subsistence Farming | Mixed Farming | Joint egg and meat Production | Eggs industry (single commodity) | Egg complex |
| Labour | Part-time | Part-time | Full-time | Division of Management and labour | Separate daily Work and Random work |
| Building | Free range | Water Feeder | Water Feeder | Manure Disposal Equipment | Egg belt Automatically Controlled House |

1. **Backyard poultry**production is at the subsistence level of farming. Birds livefree range and hatch their own eggs. Their diet is supplemented with crop waste or food leftovers. The labour involved in backyard poultry production is part-time.
2. **Farm flock**production is slightly more specialized. Eggs are hatched at aseparate location where the hatch and the sexing of the birds are controlled.
3. **Commercial poultry**farm production involves full-time labour and is gearedtoward producing on a sufficient scale for the sale of both eggs and poultry meat.
4. **Specialized egg production**consists of separating poultry for meat and eggproduction. In the egg producing plant, specialized employees oversee specific aspects of egg production.
5. **Integrated egg production**is the most advanced enterprise and involves fullmechanization and automation of the egg production cycle including battery egg laying, temperature controls, scientific feeding and mechanized egg collection methods.

All of the above poultry-keeping methods are used in the developing world, but the majority of the enterprises are backyard poultry and farm flock production. The poultry and egg sectors are highly fragmented. Most of the production is carried out by a large number of farmers, each with a very small flock. The greater part of produce is sold in markets close to the farms.

Day-old chicks are usually obtained from local hatcheries licensed by international hybrid breeding companies. Farmers or cooperatives of farmers may choose between varieties of chickens for egg production and meat production.

The small chicks can be either naturally or artificially brooded. If artificially brooded, small chicks must be placed in a separate house from laying chickens and it is necessary to protect the chicks from predators, diseases and catching colds. This stage of brooding lasts for eight weeks. In the first four weeks of life, small chicks need to be housed in a brooding box.

After the first month, small chicks are removed from the brooder box and placed in the brooder house. At two months of age, the chicks enter the grower stage which lasts until they are five months (20 weeks) old. Growers may either be housed separately from small chicks or continue to be reared in brooder-cum-grower houses. It is important to properly manage the growers as their reproductive organs develop during this period and this will affect their egg production capacity in the future.

When the growers reach 18 weeks of age they are moved to laying houses and begin to lay eggs, which are, however, small and unmarketable. It is not until they are 21 weeks old that the growers reach their commercial laying stage. Layers may be placed in intensive, semi-intensive or free-range types of housing.

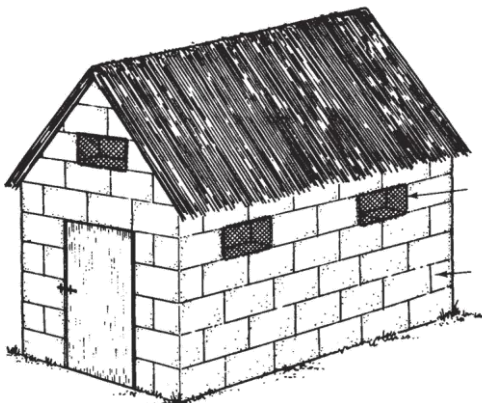
**Factors affecting egg production**

Typically, a layer's production cycle lasts just over a year (52-56 weeks). During the production cycle many factors influence egg production; therefore, the cycle must be managed effectively and efficiently in order to provide maximum output and profitability. The following factors influence egg production.

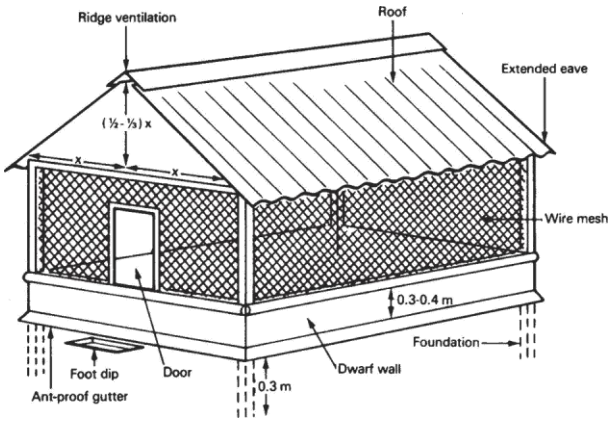
1. **Breed:-** The breed of the laying bird influences egg production. Managementand feeding practices, however, are the key determining features for egg production.

2. **Mortality rate:-** Mortality rate may rise due to disease, predation or hightemperature. The mortality rate of small chicks (up to eight weeks of age) is about 4 percent; that of growers (between eight and 20 weeks of age) is about 15 percent; and that of layers (between 20 and 72 weeks of age) is about 12 percent. The average mortality rate of a flock is from 20 to 25 percent per year.
3. **Age:-** Birds typically begin producing eggs in their twentieth or twenty-firstweek and continue for slightly over a year. This is the best laying period and eggs tend to increase in size until the end of the egg production cycle.
4. **Body weight:-** In general, optimum body weight during the laying period shouldbe around 1.5 kg, although this varies according to breed. Underweight as well as overweight birds lay eggs at a lower rate. Proper management and the correct amount of feed are necessary in order to achieve optimum body weight.
5. **Laying house:-** The laying house should be built according to local climaticconditions and the farmer's finances. A good house protects laying birds from theft, predation, direct sunlight, rain, excessive wind, heat and cold, as well as sudden changes in temperature and excessive dust. If the climate is hot and humid, for example, the use of an open house construction will enable ventilation. The inside of the house should be arranged so that it requires minimum labour and time to care for the birds.

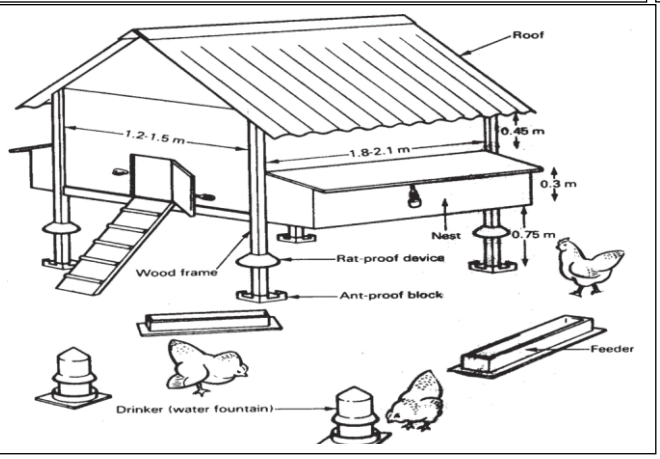
**Types of laying houses**

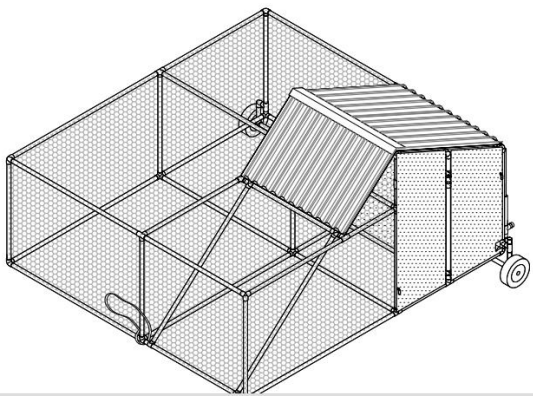



**Poultry Huse for dryclimate**




**Open-house type**



Movable type poultry house

6. **Lighting schedule:-**Egg production is stimulated by daylight; therefore, as thedays grow longer production increases. In open houses, found commonly in the tropics, artificial lighting may be used to increase the laying period. When darkness falls artificial lighting can be introduced for two to three hours, which may increase egg production by 20 to 30 percent.

   In closed houses, where layers are not exposed to natural light, the length of the artificial day should be increased either in one step, or in a number of steps until the artificial day reaches 16 to 17 hours, which will ensure constant and maximized egg production. Effective day length should never decrease during the laying period.

7. **Feed:-** Free-range hens will produce more meat and eggs with supplementalfeed, but only if they are improved breeds or crossbreeds. The selection of local hens is done on the basis of resistance and other criteria rather than feed utilisation for production.

   Fresh and clean water should always be provided, as a layer can consume up to one-quarter of a litre a day.

8. **Culling:-** Culling is the removal of undesirable (sick and/or unproductive) birds,from the flock. There are two methods of culling:

- Mass culling, when the entire flock is removed and replaced at the end of the laying cycle; and
- Selective culling, when the farmer removes individual unproductive or sick birds.
- Culling enables a high level of egg production to be maintained, prevents feed waste on unproductive birds and may avert the spreading of diseases.

9. **Climate:-**The optimal laying temperature is between 11° and 26° C. A humiditylevel above 75 percent will cause a reduction in egg laying. Figure 2 indicates the effect temperature has on egg production.

**Temperature and its effects on egg production**

| Temperature (°C) | Effects |
|---|---|
| 11 – 26 | Good production. |
| 26 – 28 | Some reduction in feed intake.<br>Feed consumption reduced andthin shell. |
| 28 – 32 | Water intake increased; eggs of reduced<br>Size and thin shell. |
| 32 – 35 | Slight panting. |
| 35 – 40 | Heat prostration sets in, measures<br>To cool the house must be taken. |
| 40 and above | Mortality due to heat stress. |

When the temperature rises above 28° C the production and quality of eggs decrease. Seasonal temperature increases can reduce egg production by about 10 percent.

**Management factors:-**Effective and efficient management techniques arenecessary to increase the productivity of the birds and consequently increase income. This entails not only proper housing and feeding, but also careful rearing and good treatment of the birds.

**Vaccination and disease control:-** Diseases and parasites can cause losses inegg production.

Vaccinations are administered to birds by injection, water intake, eye drops and spraying. Clean and hygienic living quarters and surroundings may eliminate up to 90 percent of all disease occurrences.

**Collection of eggs**

Frequent egg collection will prevent hens from brooding eggs or trying to eat them and will also prevent the eggs from becoming damaged or dirty.

**EGG PRODUCTION CYCLE**

Birds usually start to lay at around five months (20-21 weeks) of age and continue to lay for 12 months (52 weeks) on average, laying fewer eggs as they near the moulting period.

The typical production cycle lasts about 17 months (72 weeks) and involves three distinct phases, as follows.

***Phase 1: Small chicks or brooders.*** This phase lasts from 0 to 2 months(0-8 weeks) during which time small chicks are kept in facilities (brooder houses) separate from laying birds.

***Phase 2: Growers***.This phase lasts about 3 months, from the ninth to thetwentieth week of age. Growers may be either housed separately from small chicks or continue to be reared in brooder-cum-grower houses. It is important to provide appropriate care to the growers particularly between their seventeenth and twentieth week of age as their reproductive organs develop during this period.

***Phase 3: Layers.*** Growers are transferred from the grower house to thelayer house when they are 18 weeks old to prepare for the laying cycle. Birds typically lay for a twelve-month period starting when they are about 21 weeks old and lasting until they are about 72 weeks old.

**Production planning**

On average a bird produces one egg per day. Furthermore, not all birds start to lay exactly when they are 21 weeks old. Planning is therefore required for egg production to be constant so as to meet market demand. A schedule similar to the one shown in Table, which indicates on average satisfactory levels of production for a flock of birds, can be used.

In areas where the climate is hot and humid, commercial hybrid laying birds produce on average between 180 and 200 eggs per year. In more temperate climates birds can produce on average between 250 and 300 eggs per year. The table below illustrates a typical production schedule in a hot and humid climate.

Egg production rises rapidly and then starts to fall after 31 weeks of age. When less than 65 percent of the flock are laying eggs (71 weeks of age), it may become uneconomical to retain birds. Feed costs and sales of culled birds for meat must be considered as well as prices for eggs. In some instances when egg prices are high it may be viable to delay culling birds until only 45 percent of the flock is still laying eggs (78 weeks of age).

Clearly, egg production requires planning for costs as well as for profit generation and for meeting market demand. Planning involves not only the number of eggs laid by the flock over a period of time, but also when to hatch chicks to replace birds with diminishing laying capacity.

**Production schedule in temperate climate (100 birds)**

| Age of Flock (in weeks) | % of flock Laying | No. Of Birds Laying | No. Of Eggs Produced Per week |
|---|---|---|---|
| 21 | 5 | 5 | 20 |
| 22 | 10 | 10 | 40 |
| 23 | 18 | 18 | 72 |
| 24 | 34 | 34 | 136 |
| 25 | 52 | 52 | 208 |
| 26 | 65 | 65 | 260 |
| 27 | 74 | 74 | 296 |
| 28 | 84 | 84 | 336 |
| 29 | 88 | 88 | 352 |
| 30 | 92 | 92 | 368 |
| 31 | 94 | 94 | 376 |
| 32 - 39 | 88 | 88 | 352 |
| 40 - 47 | 83 | 83 | 332 |
| 48 - 59 | 77 | 77 | 308 |
| 60 - 64 | 73 | 73 | 292 |
| 65 - 70 | 70 | 70 | 280 |
| 71 - 76 | 65 | 65 | 260 |

## F. Management of – Calves, Bullocks, pregnant and milch animals, chicks and layers

**Care and Management of Calf: -** Good feeding and management are essential for the calves during their growth, so that they attain mature body weight earliest and will be useful as replacement stock. The feeding and care of the calf begins before its birth. The dam should be dried 6-8 weeks before expected date of calving and should be fed well. Underfed animals will give weak and small calves.

**Early Management:-** Immediately after birth remove any mucous or phlegm from those nose and mouth. Normally the cow licks the calf immediately after birth. This helps in dry off the calf and also stimulates breathing and circulation. When the cow doesn't lick the calf or in cold climate, rub

and dry the calf with a dry cloth or gunny bag. Provide artificial respiration by compression and relaxing the chest with hands.

- The naval should be tied about 2-4 cms away from the body and cut 1 cm below the ligature and apply Tr. Iodine or boric acid or any antibiotic.
- Remove the wet bedding from the pen and keep the stall very clean and dry in condition.
- The weight of the calf should be recorded.
- Wash the cow's udder and teats preferably with chlorine solution and dry off with a clean cloth. Allow the calf to suckle the first milk of the mother i.e. Colostrum.
- Normally the calf will be standing and attempts to nurse within one hour. Otherwise help the calve to take colostrum.

**Feeding of Calves:-** Feed colostrum i.e. the first milk of the cow for the first 3 days. The colostrum is thick and viscous. It contains higher proportions of Vit A and proteins. The proteins are immune globulin which gives protection against many diseases. Colostrum contains antitrypsin which avoids digestion of immunoglobulins in the stomach and therefore absorbed as it is.

Whole milk should be given after 3 days. It is better to teach the calf to drink milk from the pail or bucket. Feed twice a day which should be warmed to body temperature. For weak calves feed thrice a day.

The limit of liquid milk feeding is 10 % of its body weight with a maximum of 5-6 litres per day and continue liquid milk feeding for 6-10 weeks. Over feeding causes 'Calf Scours'.

The milk replaces can be given to the calves after 2 weeks to replace whole milk which reduces the cost of feeding.

Give calf starter after one month of age.

Provide good quality green fodder and hay from one month afterwards for the early development of the rumen.

Feeding of antibiotics to calves during early life improves appetite, increases growth rate and prevents calf scours. E.g. Aureomycin, Terramycin etc.

**Other management practices**

- Identity the calf by tattooing on inside of the ear after birth and tagging or branding after one year.
- Dehorn the calf within 7-10 days after birth with red hot Iron or caustic potash stick or with electric dehorner.
- Deworm the calf regularly to eliminate internal parasites using appropriate deworming drugs. Deworm should be done at 7 days after birth, and later every 20 days interval up to 3 months and for every month up to 6 months and for every 3 months up to 1 year. .
- Fresh water should be given from 2nd week onwards.

- House the calves in individual calf pens up to 3 months and afterwards in groups. After six months males and females calves should be housed separately.
- Weigh the calves at weekly interval up to 6 months and at monthly interval afterwards to know the growth rate.
- Mortality in calves is more during first month due to worms (Ascariasis), Diarrhea (calf scous) and pneumonia. Proper deworming and housing under clean conditions is important to prevent mortality in the calves.
- Wetness should be avoided in the calf pen to prevent bloody diarrhoea (coccidiosis).
- Extra teats beyond 4 should be removed at 1-2 months of age in the female calves.
- At 8-9 weeks of age all the surplus male calves should be castrated.
- Keep the body of the calves clean and dry to avoid fungal infection.
- Mineral-block licks should be provided to the calves to prevent mineral deficiency.
- Wean the calf from the mother immediately after birth and feed them through pail feeding system.

## Care and Management of Heifer

- Better care and management of heifer will give high quality replacement stock to the dairy farm. The following care and management practices are recommended for a heifer.
- Feed the heifer sufficiently to produce normal growth.
- During the early stage relatively more protein than energy is required.
- Most heifers grow well if excellent legume hay is given as much they can eat. The amount of growth depends upon the quality of forage fed.
- When the quality of forage is not good, 1 -2 kg concentrate feed supplementation if required.
- The heifers should be provided with a dry shelter free from drafts. A loose housing system with a shelter open to one side is sufficient.
- The size rather than the age of a dairy heifer at breeding time is important.
- Breeding under sized animals is never successful. They may be stunted or slow to reach maximum size. Small heifer is more likely to have difficulty in calving.
- Though the heifer that is bred to calve at an older age yields higher milk yield in the first lactation, the total milk produced by such a cow will be less when compared to the heifers that freshens at an early age.
- Usually the heifer is bred when they attain 60% of its mature body weight.
- The heifer should be growing and in good flesh at calving time. This is necessary so that she can produce milk at the most profitable level.
- Place the heifer in a separate shed about 6-8 weeks before she is due to calve.
- Feed 2-3 kgs of concentrate daily along with adlibitum forage.
- Before calving let the heifer becomes accustomed to handling and to the procedures used in the milking herd. Always handle her gently and with kindness.
- Maintenance of health among heifers is very important for proper growth. The health among the heifers is maintained by hygiene housing, watering balanced feeding and taking necessary preventive steps against common diseases.

- Periodically the heifers in the herd should be checked for their proper growth and other progress. Animals lagging behind below the required standards should be removed from the herd.
- For the heifer that is calving first time may have difficulty in calving. So take extra care should be taken during calving.

## Care and Management of Milch Animal

- To get high milk during any lactation, the milch animal should be properly fed and necessary care and managemental practices should be followed.
- Provide green succulent forage together with leguminous hay or straw to the extent of animal can consume, so that all its maintenance requirements are met with through forage only. Extra concentrate at the rate of 1 kg for every 2 litres of buffalo milk and 2.5 litters of cow milk should be provided. Salt and mineral supplements should be given to maintain the lactation.
- Never frighten or excite the animals. Always treat them gently and with kindness.
- With proper feeding and care, a cow will come to heat within 60 days of calving.
- Do not with hold service unnecessarily after the signs of heat are noticed in a cow. Early service of the milch animal reduces the calving interval.
- By maintaining proper records of breeding and calvings of the animals will ensure a study flow of milk throughout the year.
- Individual attention to feed each animal according to its production is a must. For this purpose maintain individual production records.
- Keep up regularity of feeding. Concentrate mix is fed before or during milking, where as roughages after milking. This practice will avoid dust in the shed.
- Water should be provided to drink at all times.
- Regularity in milking is essential. Increase of milk in the udder will reduce further secretion of milk. Milking thrice is better than twice since 10 -15 % more milk can be produced.

- Rapid, continuous, dry hand milking should be practiced without undue jerking of teats. Milking should be done with full hand milking method, but not with stripping and knuckling.
- Cows should be trained to let down milk without calf suckling. This will help to wean the calves early.
- Loose housing with shelter during hot part of the day should be provided. The animals will get maximum exercise in loose housing system.
- Grooming of the cows and washing of the buffaloes before milking help in clean milk production. Daily brushing will remove loose hair and dirt from the coat. Grooming will also keep the animal hide pliable.

- Wallowing of buffaloes or water spraying on their bodies will keep the buffaloes comfortable especially in summer.
- Common ailments should be properly detected and treated.
- Common vices should be properly detected and care should be taken. Eg. Kicking, licking, suckling etc.
- Provide at least 60 - 90 days dry period between calvings. If the dry period is not sufficient, the milk yield in subsequent lactation will be reduced.
- Vaccinate the cows- against important diseases and also guard against insects and pests.
- Every animal should be numbered and particulars pertaining to milk, fat %, feed taken, breeding, drying and calving dates should be recorded.
- Check for mastitis regularly.

## Care and Management of dry and Pregnant Animal

- The good care and managemental practices given to pregnant animal will give good calf and also high milk yield during the successive lactation.
- Extra concentrate mix of 1to 2kgs should be provided for pregnant animal as pregnancy allowance. Feed good quality of leguminous fodder. The animal should not be lean or fat condition.
- Provide clean drinking water and protection from thermal stress.
- Do not allow them to mix with other animals that have aborted or that are suffering from or carriers of diseases like brucellosis.
- Allow moderate exercise, which helps in calving normally. Do not tire them by making long distances especially on uneven surfaces.
- Do not allow them to fight with other animals and take care that they are not chased by dogs and other animals.
- Avoid slippery conditions, which causes the animal to fall receiving fractures, dislocation etc.
- If accurate breeding records are available, calculate the expected date of calving. Separate it one or 2 weeks before and shifted to individual parturition pens. These pens are thoroughly cleaned and fresh bedding may be provided.
- Feed one kg extra concentrates during last 8 weeks of gestation. Feed laxative diet about 3 - 5 days before and after calving (Wheat bran 3 kg + 0.5 kg of Groundnut cake + 100 g of mineral mixture and salt).
- Symptoms of delivery may be observed i.e. swelling of external genetalia, swelling of udder, usually majority of animals will deliver without any help. If there is any difficulty, provide veterinary help.
- After parturition external genetalia, flank should be cleaned and protect the animal from chill and give warm wafer.
- Placenta will normally shed by the cow within 2- 4 hours after calving. If it fails to shed even after 12 hours, take the help of a veterinarian
- Take care of the animal before calving from milk fever. Give calcium supplement.

- Sometimes the udder will be swollen just before calving. Remove the milk partially.
- Take care, of the animal, if at all any abortion.
- Provide always free access to drinking water.

**Care and Management of Bull**

- The maintenance of breeding bulls in good condition and suitable for breeding is highly essential requirement for the success of breeding programmes.
- A rising condition is better for reproduction than a falling one.
- Fat males may produce semen of inferior quality or they may be slow or fail at service. Breeding bull should receive plenty of exercise will usually produce large ejaculation containing more sperms of higher activity.
- A breeding bull should be housed separately in a bull shed with sufficient area of floor and proper covering.
- It is sound practice to provide cool conditions and adequate drinking water.
- A balanced ration should be fed containing adequate energy, proteins, minerals, and vitamins. Green fodder must be available both before and during breeding season.
- Most of the bulls are ferocious and so control them properly using nose rings etc.
- It is of great importance that males should be fed regularly and not too much at one time and too little at another.
- For bulls two matings a day has been found to be optimum.
- Moderate exercise should be provided to keep the breeding bull in active and non-fatty conditions.
- Regular grooming of the breeding bull should be practiced.
- In buffalo bulls regular shaving may be practiced around prepuse.

**Care and Management of Bullock**

- Bullocks are normally used for agricultural operations and transport purpose. Some bullocks are ferocious and so control them properly with nose rope or nose rings. The hooves of the bullocks should be provided with metal shoes to protect the hooves from wear and tear.
- The working hours for bullocks are recommended as follows
- Normal Work - 6 hours of carting or 4 hours of ploughing.
- Heavy Work - 8 hours of carting or 6 hours of ploughing.
- Sufficient roughages and 1-2 kg of concentrates may be provided for feeding of bullocks. During break period in works, the animal may be left for free grazing.
- The bullocks are housed in separate sheds with sufficient space and protection from hot and cool conditions. Free access to drinking water is essential. Regular grooming of animals should be practiced.

## G. Housing of Dairy animal and poultry

**Selection of Site for Dairy Farm**

The points which should be considered before the erection of dairy buildings are as follows:

**1. Topography**

A dairy building should be at a higher elevation than the surrounding ground to offer a good slope for rainfall and drainage for the wastes of the dairy to avoid stagnation within. A levelled area requires less site preparation and thus lesser cost of building. Low lands and depression and proximity to places of bad odour should be avoided.

**2. Soil Type**

Fertile soil should be spared for cultivation. Foundation soil as far as possible should not too dehydrated or desiccated. Such a soil is susceptible to considerable swelling during rainy season and exhibit numerous cracks and fissures.

**3. Exposure to the sun and protection from wind**

A dairy building should be located to a maximum exposure to the sun in the north and minimum exposure to the sun in the south and protection from prevailing strong wind currents whether hot or cold. Buildings should be placed so that direct sunlight can reach the platforms, gutter and mangers in the cattle shed. As far as possible, the long axis of the dairy barns should be set in north south direction to have the maximum benefit of the sun.

**4. Accessibility**

Easy accessibility to the buildings is always desirable. Situation of a cattle shed by the side of the main road preferably a distance of about 100 meters should be aimed at.

**5. Durability and Attractiveness**

It is always attractive when the buildings open up to a scenic view. Along with this, durability of the structure is obviously an important criterion in building a dairy farm.

**6. Water Supply**

Abundant supply of fresh, clean and soft water should be available at a cheap rate.

**7. Surrounding**

Areas infested with wild animal should be avoided. Narrow gates, high manger curbs, loose hinges, protruding nails, smooth finished floor in the areas where the cows move and other such hazards -should be eliminated.

**8. Labour**

Honest, economic and regular supply of labour should be available.

**9. Marketing**

Dairy buildings should only be in those areas from where the owner can sell his products profitably and regularly. He should be in a position to satisfy the needs of the farm within no time and at a reasonable price.

## 10. Electricity

Electricity is the most important sanitary method of lighting a dairy. Since a modern dairy always handles electric equipments which are also economical, it is desirable to have an adequate supply of electricity.

## 11. Facilities for Improved labour Efficiency

Cattle yards should be so constructed and situated in relation to feed storages, hay stacks, silo and manure pits as to effect the most efficient utilisation of labour. Sufficient space per cow, well arranged feeding mangers and resting areas contribute not only to greater milk yield of cows and make the work of the operator easier but also minimise feed expenses. The relative position of the feed stores should be quite adjacent to the cattle barn. Noteworthy features of feed stores are given below.

- Feed storages should be located at hand near the centre of the cow barn.
- Milk house should be located almost at the centre of the barn.
- Centre cross-alley should be well designed with reference to feed storage, the stall areas and the milk house.

### Systems of Housing - Loose Housing System Conventional Dairy Barn

The most widely prevalent practice in this country is to tie the cows with rope on a katcha floor except some organised dairy farms belonging to government, co-operatives or military where proper housing facilities exist. It is quite easy to understand that unless cattle are provided with good housing facilities, the animals will move too far in or out of the standing space, defecating all rounds and even causing trampling and wasting of feed by stepping into the managers. The animals will be exposed to extreme weather conditions leading to bad health and lower production. Dairy cattle may be successfully housed a wide variety of condition, ranging from close confinement to little restrictions except at milking time. The housing systems of cattle are of two types.

1. The loose housing
2. The conventional barn.

## 1. Loose Housing System

Loose housing may be defined as a system where animals are kept loose except at the time of milking and at the time of treatment. The system is most economical. Some features of loose housing system are as follows.

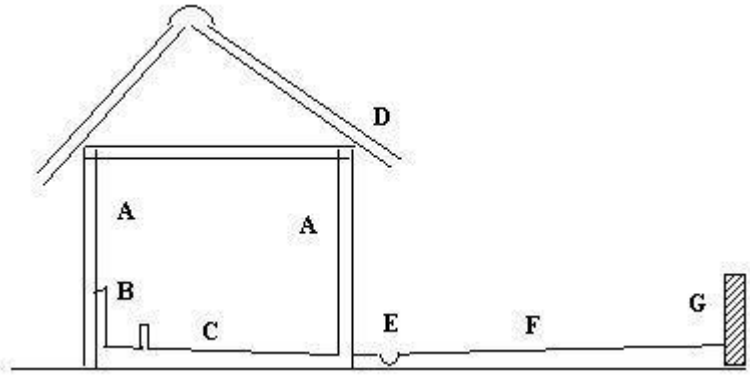
- In loose housing dairy animals are keeping loose in an open paddock expect at milking time.
- The open paddock is provided shelter along one side and enclosed with half walls / wire fences / GI pipes.
- Common watering tank and manger is provided.
- Separate milking parlor is constructed for milking purpose.

**Advantages of loose housing system**

1. Cost of construction is significantly lower than conventional type.
2. It is possible to make further expansion without change
3. Facilitate easy detection of animal in heat.
4. Animals overcome heat stress better by voluntary movement and more comfortable in the loose house
5. Animals get optimum excise which is extremely important for better health and production.
6. 10-15% more stock than standard can be accommodated for shorter periods.

**Space requirements for different classes of animals in loose housing system (BSI)**

| **Type of Animal** | **Space Requirement** | |
|---|---|---|
| | **Covered area ($m^2$)** | **Open area ($m^2$)** |
| Cattle | 3.5 | 7.0 |
| Buffalo | 4.0 | 8.0 |
| Breeding bull | 12.0 | 120.0 |
| Advanced Pregnant | 12.0 | 12.0 |
| Young claves | 1.0 | 2.0 |
| Heifers | 2.0 | 4.0 |



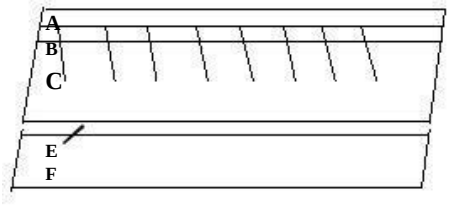

Loose Housing System

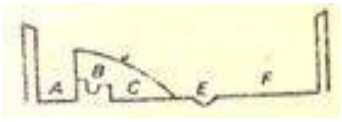
**Section of loose house showing internal details**

**A. Roof supporting structures B. Manager C. Covered Area D. Roof E. Gutter F. Open area and G. Compound Wall**

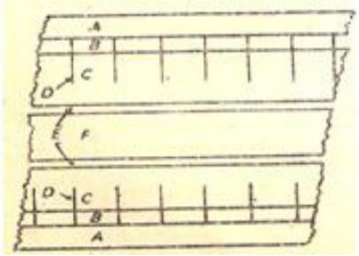
## 2 Conventional Barn

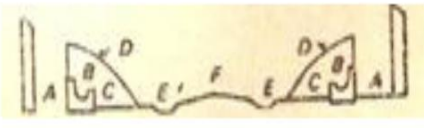
- Animals are confined on a platform and secured at neck by neck chains.
- The barns are completely roofed and the walls are also complete with windows / ventilators located at suitable places.
- Animals are fed and milked in the same place.
- Conventional barns may be preferred in Temperate Himalayan region where the winters are prolonged and severe. In warm parts, the air in the barns tends to be humid and floors become damp during autumn and rainy seasons.
- There shall be individual standings of stalls for stanchions in one or two rows.
- Double rows of stanchions can be arranged either tail to tail or head to head.
- Length and width of standing is 1.5 to 1.7 and 1.05 and 1.20 meters respectively.
- The width of standing is 80% of length.
- Width of central passage is1.5 to 1.8 m and shall have a gentle slope of one in 40 from centre towards the drain.
- Two continuous mangers one on each side along the head side of the standing rows and 0.75m wide feed allay beyond each manger present.
- "U" shaped drain of 30cm on either side of the central passage is present.
- The eaves of the roof shall project 50cm beyond the side walls.



Plan (1) and section (II) of a single row milking barn. A. Feed Alley, B. Manager C. Standing D. Standing partition E. Gutter and F. Passage





Plan (1) and Section (II) of a double row tail to tail type milking barn. Legend same

**Cleaning and sanitation in Dairy Farm**

## 1 Cleaning of Animal Sheds

The easy and quick method of cleaning animal house is with liberal use of tap water, proper lifting and disposal of dung and used straw bedding, providing drainage to the animal house for complete removal of liquid waste and urine. The daily removal of feed and fodder left over in the manger reduces the fly nuisance. Periodical cleaning of water trough eliminates the growth of algae, bacterial and viral contamination and thus keeps the animal healthy.

## 2 Sanitation in Dairy Farm

Sanitation is necessary in the dairy farm houses for eliminations of all microorganism that are capable of causing disease in the animals. The presence of organisms in the animal shed contaminates the milk produced thus reducing its self-life. Milk produced in an unclean environment is likely to transmit diseases which affect human health. Dry floorings keeps the houses dry and protects from foot injury. Similarly, the presence of flies and other insects in the dairy farm area are not only disturbs the animals but also spreads deadly diseases to the animals eg. Babesiosis, Theileriosis etc.

### Sanitizers

Disinfection of animal sheds means making them free from disease producing bacteria and is mainly carried out by sprinkling chemical agents such as bleaching powder, Iodine and lodophor, sodium carbonate, Washing soda, Slaked Lime (Calcium hydroxide), Quick Lime (Calcium oxide) and phenol. Sunlight is the most potent and powerful sanitizer which destroy most of the disease producing organism

**Bleaching Powder**

This is also called calcium hypo chloride. It contains up to 39 % available chlorine which has high disinfecting activity.

**Iodine and Iodophor :**

This is commercially available as lodophores and contains between 1 and 2 % available Iodine which is an effective germicide.

**Sodium Carbonate**

A hot 4 % solution of washing soda is a powerful disinfectant against many viruses and certain bacteria.

**Slaked Lime and Quick Lime**

White washing with these agents makes the walls of the sheds and the water troughs free from bacteria.

**Phenol**

Phenol or carbolic acid is very powerful disinfectant which destroys bacteria as well as fungus.

## Insecticides

Insecticides are the substances or preparations used for killing insects. In order to control flies and disease transmitting ticks, insecticides are used in dairy farms. Ticks usually hide in cracks and crevices of the walls and mangers. Smaller quantities of insecticide solutions are required for spraying. Liquid insecticides can be applied with a powerful sprayer, hand sprayer, a sponge or brush. Commonly used insecticides are BHC, DDT, Gamaxane wettable powders, malathion, sumithion etc. These are highly poisonous and need to be handled carefully and should not come in contact with food material, drinking, water, milk etc.

## Precautions while using Disinfectants and Insecticides.

- Remove dung and used bedding completely.
- Avoid spilling of dung and used bedding while carrying it out.
- Avoid the use of dirty water in cleaning the sheds.
- Never put the fresh fodder over the previous day's left over fodder in the manger.
- Prevent algae to grow in the water troughs
- Use proper concentration of disinfectant / insecticide solutions to avoid any toxic effects.
- Avoid the use of disinfectant solution at the milking time as milk absorbs these quickly.

## Procedure

Remove the dung from the floor and urine channel with the help of a shovel and basket (iron) and transfer it to the wheel barrow. Remove the used bedding and leftovers from the mangers in a similar way.

Empty the water trough and scrape its sides and bottom with the help of a floor brush.

Wash the water trough with clean water and white wash it with the help of lime mixture once a week.

Scrape the floor with a brush and broom and wash with water. Clean and disinfect the splashes of dung on the side walls, railing and stanchions. Remove the cobwebs periodically with the help of a wall brush. Sprinkle one of the available disinfecting agents in the following concentration.

- Bleaching powder should have more than 30% available chlorine.
- Phenol 1-2% solution.
- Washing Soda (4% solution).

Allow adequate sunlight to enter in to the shed.Spray insecticides at regular intervals especially during the rainy season (Fly season).Whitewash the walls periodically by mixing insecticides in it to eliminate ticks and mites living in cracks and crevices.

# Poultry Housing

## General Layout of Poultry House

- Poultry house should be located away from residential and industrial area.
- It should have proper road facilities.
- It should have the basic amenities like water and electricity.
- Availability of farm labourers at relatively cheaper wages.

- Poultry house should be located in an elevated area and there should not be any water-logging.
- It should have proper ventilation.
- Layout should not allow visitors or outside vehicles near the sheds.
- The sheds should be so located that the fresh air first passes through the brooder shed, followed by grower and layer sheds. This will prevent the spread of diseases from layer houses to brooder house.
- There should be a minimum distance of 50-100 feet between chick and grower shed and the distance between grower and layer sheds should be of minimum 100 metre.
- The egg store room, office room and the feed store room should be located near entrance to minimize the movement of people around the poultry sheds.
- The disposal pit and sick room should be constructed only at the extreme end of the site.

**Different Types of Housing for Poultry**

**A. Deep litter**

- In this system the birds are kept in litter floor.
- Arrangement for feed, water and nest are made inside the house.
- Fresh litter materials spread on the floor.
- The birds are kept on suitable litter material of about 3" to 5" depth.
- Usually paddy husk, saw dust, ground nut hulls, chopped paddy straw or wood shavings are used as litter materials.
- This arrangement saves labour involved in frequent cleaning of faecal matter (droppings), however it needs periodical stirring.
- The litter is spread on the floor in layers of 2" height every fortnightly till the required drying is achieved.

**Advantages**

- Vit $B_2$ and Vit $B_{12}$ are made available to birds from the litter material by the bacterial action.
- The welfare of birds is maintained to some extent.
- The deep litter manure is a useful fertilizer.
- Lesser nuisance from flies when compared to cage system.

**Disadvantages**

- Because of the direct contact between bird and litter, bacterial and parasitic disease may be a problem.
- Respiratory problems may emerge due to dust from the litter.
- The cost of litter is an additional expenditure on production cost.

- Faults in ventilation can have more serious consequences than in the cage system.

**B. Cage system**

- This system involves rearing of poultry on raised wire netting floor in smaller compartments, called cages, either fitted with stands on floor of house or hanged from the roof.
- It has been proved very efficient for laying operations, right from day-old to till disposal.
- At present, 75% of commercial layers in the world are kept in cages.
- Feeders and waterers are attached to cages from outside except nipple waterers, for which pipeline is installed through or above cages.
- Auto-operated feeding trolleys and egg collection belts can also be used in this rearing system.
- The droppings are either collected in trays underneath cages or on belts or on the floor or deep pit under cages, depending on type of cages.

**Advantages**

- Minimum floor space is needed.
- More number of eggs per hen can be received.
- Less feed wastage.
- Better feed efficiency.
- Protection from internal parasites and soil borne illnesses.
- Sick and unproductive birds can be easily identified and eliminated.
- Clean eggs production.
- Vices like egg eating, pecking is minimal.
- Broodiness is minimal.
- No need of litter material.
- Artificial Insemination (AI) can be adopted.

**Disadvantages**

- High initial investment cost.
- Handling of manure may be problem. Generally, flies become a greater nuisance.
- The incidence of blood spots in egg is more.
- Problem of cage layer fatigue. (It is a condition, in which laying birds in cages develop lameness. It may be due to Ca and P deficiency but the exact reason is not known)
- In case of broilers, incidence of breast blisters is more, especially when the broilers weight is more than 1.5 kg.

### C. Elevated cage system

- The height of the shed is raised by 6-7 feet using concrete pillars.
- The distance between two pillars is 10 feet.
- Two feet wide concrete platforms are made over the pillars. When 3 'M' type cages are arranged 4 platforms are needed.
- In case of 2 'M' and 2 'L' type cages are arranged 3 platforms are needed.
- When constructing platforms projecting angles or iron rods to be provided to fix the cages.
- The inter-platform distance is 6-7 feet depending upon the type of the cages used.
- The total height of the house is 20-25 feet and the width is 30-33 feet.
- This type of house provides sufficient ventilation in tropical countries.

**Cage Rearing of Broilers**

Broilers can also be reared on cages. Broiler cages are similar to that of grower cages. To prevent the breast blisters, the bottom of the cage may be coated with some plastic materials. The floor space requirement in cages is 50% of the floor space needed in deep-litter. The relative advantages and disadvantages of cage rearing of broilers are,

**Advantages**

- Higher density of rearing possible
- Easy to catch the birds at market time and hence reduces bruising
- No expenditure on litter
- No incidences of coccidiosis
- Reduced cannibalism
- Cleaning and disinfection easier
- Better growth and feed efficiency

**Disadvantages**

- Higher incidences of breast-blisters which increases carcass condemnations
- Higher incidences of crooked keel
- Wing bones will be more brittle which will be a disadvantage for the processor also.
- Birds are not having access to the unidentified growth factors in deep-litter system.
- Cleaning faecal-trays is not labour friendly.
- High initial investment on cages.
- Birds will be uncomfortable especially during summer

**Floor space requirement for poultry – layers**

| Age (weeks) | Deep litter ($ft^2$) | Cages ($ft^2$) |
|---|---|---|
| 0-8 | 0.60 | 0.20 |

| | | |
|---|---|---|
| 9-18 | 1.25 | 0.30 |
| 18-72 | 1.50 | 0.50 |

**Floor space requirement for poultry – broilers**

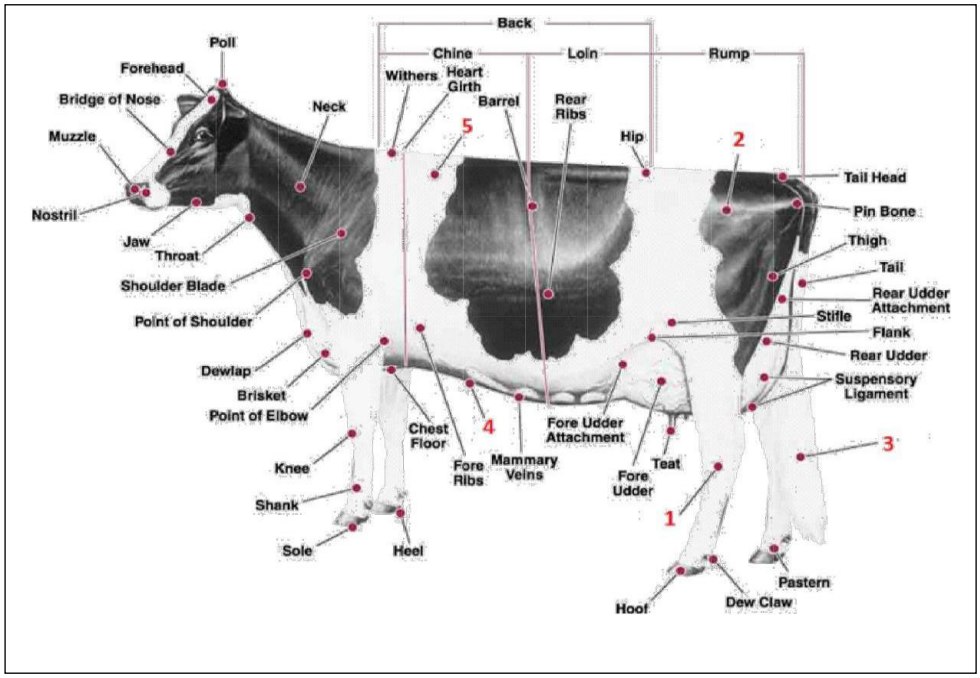
| Age | Floor space/ bird |
|---|---|
| Up to 18 days | 450 $cm^2$ (0.5 sq.ft.) |
| From 19 days to 42 days | 1000 $cm^2$ (1.1 sq.ft.) |

## H. Animal body structure and functions

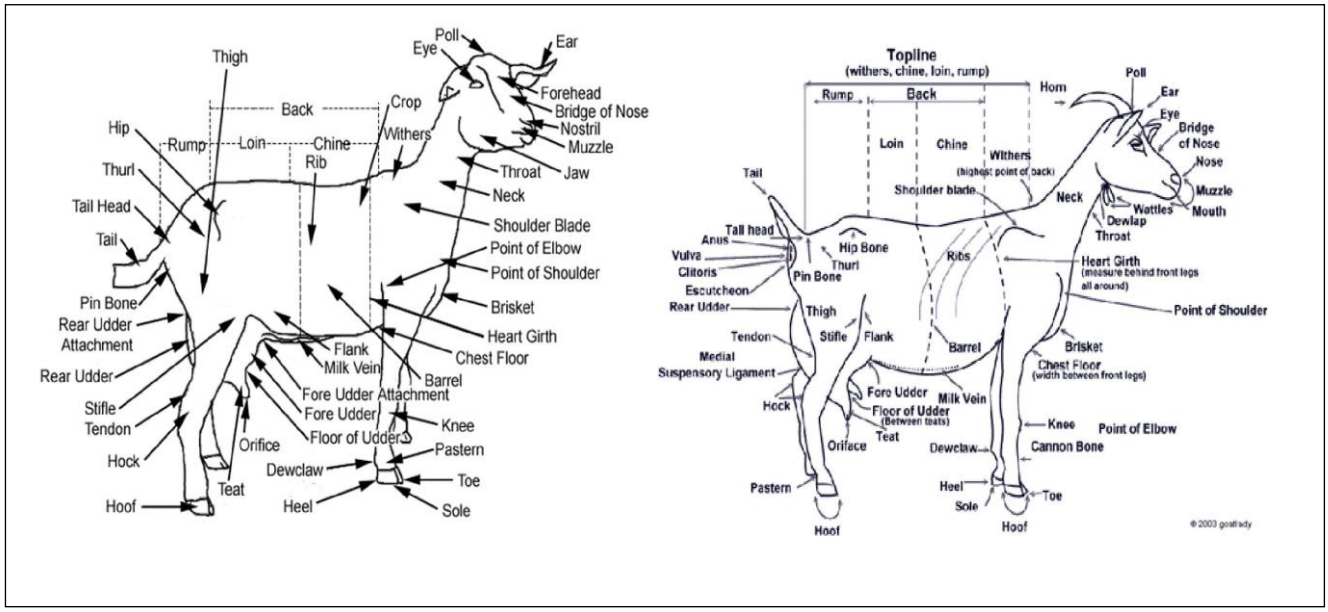
### Animal Body Structure and Function

The basic unit of life is a cell. Groups of cells with similar functions form tissue. There are four basic types of animal tissues: connective, epithelial, muscle, and nervous. An organ is formed by a collection of tissues; while an organ system comprises two or more organs which cooperate with one another in order to perform a certain task. The body is a unique collection of interdependent organ systems.

As far as the outer animal body structure is concerned, there are several basic parts common to cattle and swine, as illustrated in the diagrams below. Sorted roughly from cranial to caudal direction the main parts of large animals are the head, throat (neck), forelimbs, trunk including chest (thorax) and abdomen (stomach), tail and the hind limbs. On the head we find forehead, eyes, muzzle in a cow and snout in a pig, mouth with lips, ears, and horns in a cow. Underneath the snout in pigs there is a jowl, sometimes referred to as pig's chin. The neck is located behind the ears and in front of the shoulder. The belly and ribs are found just behind the shoulders and elbow pocket.




**Body part of Cattel**




**Body part of Sheep** **Body part of Goat**

1. **Skeletal System:-** The skeletal system is a structural framework that provides support and protection to the animal body. The skeletal system is also necessary for motion of animals as muscles are attached to the skeleton and joints are movable. The basic components of this system are bones, cartilages and ligaments. The main factors that influence bone development are stress of animals, level of hormones in the organism and also nutrition of animals represented by well-balanced diet and a certain amount of vitamin D in the foodstuff.
2. **Muscular System:-** The main functions of muscular system are movement as well as producing heat. The system comprises smooth, cardiac, and skeletal muscles. Smooth muscles are directed by autonomic nervous system. They are part of blood vessels, digestive and reproductive system. Cardiac muscle forming the heart is also regulated by autonomic nervous system and cause involuntary movements (e.g. heartbeat). The last type of muscles is represented by skeletal muscles responsible for all voluntary movement as well as for particular involuntary movements as standing or breathing.
3. **Some species have specific body parts and features.**

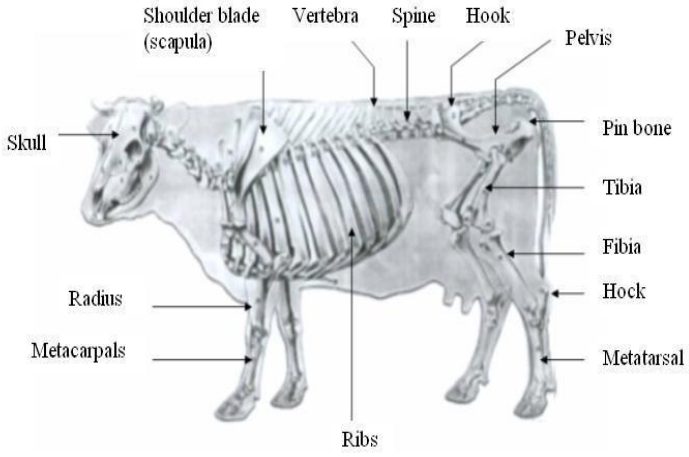
**i. BODY COVERAGE**

a. **Fur:-** Fur is extensive body coverage typical of mammals. It is made of short, very fine and soft hair. Theprincipal function of fur is thermoregulation.

b. **Bristles** are thick, strong animal fibres collected at commercial abattoirs for use in brushes.

c. Specific types of body coverage include wool hair (textile fibre obtained from sheep and other animals e.g. goats, camel, rabbits etc.)

d. Body covering of amphibians, skin, often has protective colouring and is able to absorb water and oxygen from the environments.




**ii. BODY APPENDAGES**

a. **TAILS**:- The section at the rear end of an animal's body.

b. **HOOF/HOOVES:-** The tip of a toe of ungulate mammals, covered with a thick keratin shell, growcontinuously. Most even-toed ungulates /sheep, goats, deer, cattle, bison, pigs/ have two

main hooves on each foot, together called a cloven hoof. Most also have two smaller hoofs called dew-claws. Some odd-toed ungulates have one hoof on each foot; others /rhinoceroses, tapirs/ have three hoofed or heavily nailed toes, or one hoof and two dew-claws.

c. **HORNS:-** a pointed projection of the skin on the head consisting of a keratin covering. One pairof horns is usual, two pairs occur in a few wild species and domesticated breeds of sheep. Horns are usually curved or spiral and occur mainly in males. They grow soon after birth and continue to grow throughout the life.
d. **WHISKERS –** Specialized hairs for tactile sensation that grow around the nostrils, above the lips,and on other parts of the face of most mammals, as well as on the forelegs and feet of some animals. A large part of the brain of many mammals is devoted to processing the nerve impulses from whiskers, because it is important for survival.
e. **SNOUT/MUZZLE** - Protruding portion of an animal's face, consisting of its nose, mouth, and jaw.
f. **TRUNK** - a fusion of the nose and upper lip, elongated and specialized, elephant's most importantand versatile "tool".

**4. Respiration and the Circulatory System**

**Respiration:-** Respiration occurs as a physical and a chemical process; physical inhalation to move gases from the air to the blood stream and expiration to remove waste gases and water, and cell respiration when a chemical reaction takes place to release energy.

Cell respiration is the process that allows plants and animals to release energy for their own use. Energy in chemicals such as glucose is released when oxygen reacts with them to produce smaller molecules; the process is similar to the release of energy by burning fuel such as petrol.

$$\text{Food} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}$$

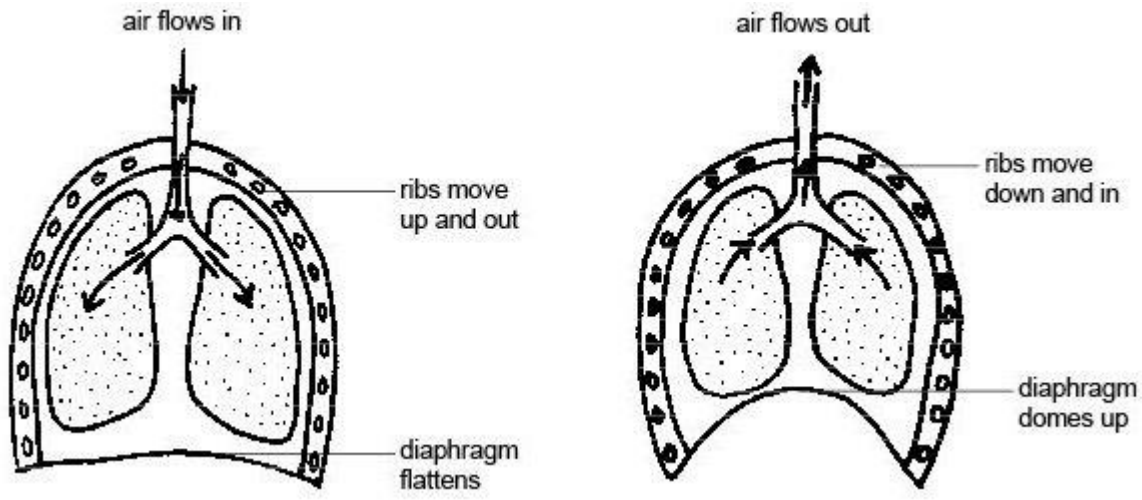
This reaction occurs inside the cells, but the respiratory process must also move oxygen to the cells and remove the waste products. If an animal is unable to move oxygen to the vital organs, it will rapidly die.

**Functions of the circulatory system**

- To take oxygen to muscles and other tissues.
- To remove waste products e.g. carbon dioxide.
- To take the products of digestion to the tissues that need them.
- To carry chemical messages in the form of hormones.
- To transport blood cells and antibodies to fight disease.
- To help with temperature regulation.

**Structure:-**

Gases are exchanged in the lungs. As an animal shortens the muscles in the rib cage and contracts the diaphragm the volume in the chest increases. This draws air into the lungs (the animal breathes in).




**Diagrams of inhalation and exhalation**

Air in the lungs contains more oxygen than tissues therefore oxygen dissolves and passes into the blood stream. The oxygen is carried by red blood cells.

The circulatory system moves oxygenated blood from the lungs to the tissues and deoxygenated blood back to the lungs. The heart pumps the blood through a series of blood vessels (pipes) to the tissues.

- Arteries (carry blood away from the heart). Usually the blood is under high pressure and contains a lot of oxygen
- Veins (carry blood to the heart) . Usually the blood is low in oxygen , but contains the carbon dioxide to be removed by the lungs
- Capillaries these occur where the arteries become very narrow to allow the blood to bathe the tissues so that food and oxygen can go into the cells and waste products can be removed. Blood leaving the capillaries will enter veins so that it can be returned to the heart.

**Blood cells:-** Red blood cells – contain an iron based protein called haemoglobin which binds with oxygen and transports it in the blood. Red cells are made in the red bone marrow of long bones such as the femur and ribs.

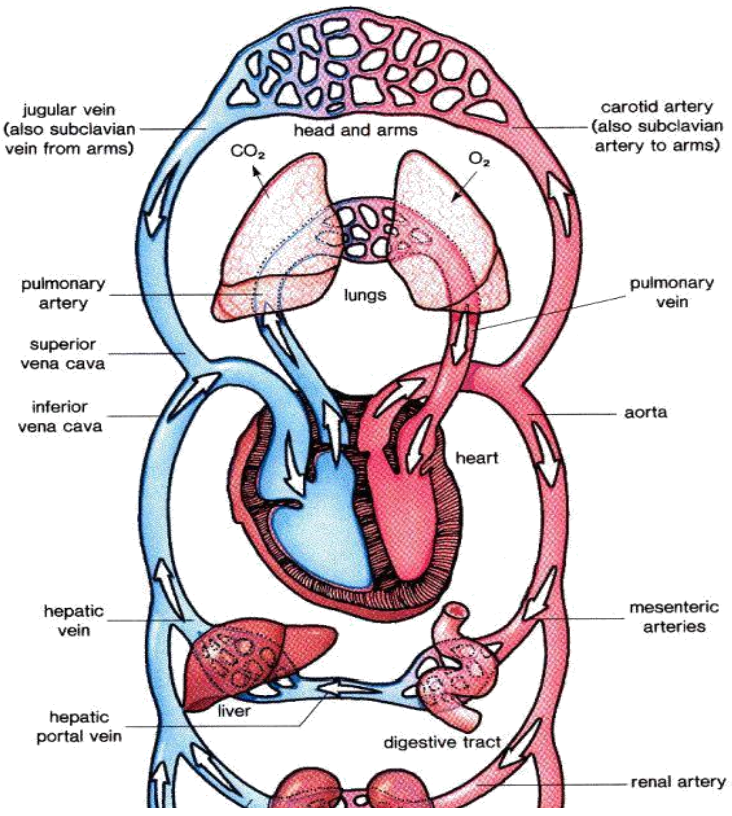



Diagram of the circulatory system

- White blood cells are needed to protect animals from disease.
- Phagocytes are large cells which can attack and engulf bacteria Lymphocytes produce antibodies to fight specific diseases.
- Platelets are require for blood clotting.

5. **The digestive system:-** The digestive system breaks down feed into small molecules that can be absorbed by the digestive tract into the blood and lymphatic systems. The three main processes of digestion are:-

Physical break down:– e.g. Chewing the food

Chemical break down:– e.g. (1) Hydrochloric acid released by the stomach wall;

(2) Enzymes which are chemicals that speed up chemical reactions without getting changed themselves.

Microbial break down:- e.g. Fermentation of food in the rumen (first stomach of a cow or sheep).

Digestive systems have evolved over time to suit the natural diet of the particular animal. The alimentary canal is the term used for the digestive tract.

**The digestive system of a single stomached animal (e.g. the pig)**

**a. The Mouth**

- Teeth – these are used for collecting and chewing food. The types of teeth are:
- Incisors – for cutting food
- Canines – for tearing flesh
- Molars and premolars – for crushing and grinding foods.

The teeth are adapted to the diet for example pigs are omnivores (they eat a wide range of feeds from plant and animal sources) their teeth have smooth enamel and they have incisors on both the upper and lower jaw.

Saliva contains water, electrolytes, mucus and enzymes to break down starch. It moistens feed to make it easier to swallow.

The tongue is made up of muscles that manipulate feed into a bolus (ball) ready for swallowing. It contains taste buds that allow animals to taste the feed. The ability to taste feed allows animals to detect poisons which have a bitter or unpleasant taste and avoid eating them. The animal swallows food when it has been moved to the back of the mouth; a flap called the epiglottis closes off the wind pipe (trachea) to prevent choking.

b. **The Oesophagus:-** This is the tube that connects the mouth to the stomach. Food is pushed along by muscular contractions- this is called peristalsis.
c. **The Stomach:-** This is where the majority of protein breakdown occurs through the activity of an enzyme called pepsin. To make enzymes work effectively, hydrochloric acid is released by the stomach wall to make the contents of the stomach acidic. The muscles in the stomach wall mix the feed before it is gradually released to the next stage of digestion in the small intestine.

Young animals produce rennin in the stomach which clots milk protein into curds which are then broken down by pepsin enzyme.

d. **The Small Intestine:-** Chemicals to complete the breakdown of food are released into the small intestine from:-
   - The wall of the intestine- which releases enzymes.
   - The pancreas- releases pancreatic juice which contains enzymes
   - The gall bladder –bile is produced by the liver, it is stored in the gall bladder and released into the duodenum (the 1st part of the small intestine).



| Chemical | Function |
|---|---|
| Bile | Neutralises the pH so that the enzymes can work better<br>Breaks down (emulsifies) the fats and oils into small droplets so that they have a larger surface area for the enzymes to work on |
| Amylase | Breaks down carbohydrates to sugar |
| Trypsin | Breaks down proteins to amino acids |
| Lipase | Breaks down fats to fatty acids and glycerol |

When the food particles are of molecular size they are small enough to pass through the wall of the intestine into the blood or lymphatic system. To speed up this process the small intestine it is covered in villi which create a large surface area;

Once the absorbed feed particles have entered the circulatory system they will pass through the liver to remove toxic particles. The circulatory system will move the products of digestion around the body so the digested feed particles can be taken to where they are required e.g. sugar to muscles to provide energy.

e. **The large intestine:-** This is where the process of digestion and absorption is completed and water is reabsorbed to the body from the digestive tract. The waste material is held in the rectum until it is passed out through the anus.

**The Ruminant digestive system (e.g. sheep and cattle):-** The digestive system of the ruminant is specially adapted to a diet which contains high levels of plant fibre that is difficult to break down. This has led to the development of a structure that has four stomachs; including a final chamber which works in the same way as the stomach of a pig.

a. The Mouth:-

i.Teeth – these are used for collecting and chewing food. Cattle and sheep have no teeth on the upper jaw at the front of their mouth, rather they have a hard pad of bone and skin. As cattle and sheep get older they will change their first set of teeth (milk teeth) for their adult teeth in a set pattern.

Sheep will tend to graze by biting grass with their incisors cutting up against the hard pad on the upper jaw, cattle tend to use their tongues to collect and pull at the pasture before biting. Ruminants will swallow the food before chewing it thoroughly as they can regurgitate and send it back to the mouth to finish chewing later. Ruminant molars and premolars on both upper and lower jaws at the back of the mouth have a rough surface to physically break down plant fibre.

ii. Saliva – large amounts of saliva are produced by ruminants. The saliva is slightly alkaline to prevent rumen fluid from becoming too acidic.

b. **The Oesophagus:-** This is the tube that connects the mouth to the rumen. The first three stomachs of the ruminant have developed from the oesophagus; they do not produce any digestive chemicals.

c. **The stomachs:-** The stomachs are;

- Rumen
- Reticulum
- Omasum
- Abomasum (or true stomach).

The rumen of a cow has a capacity of around 120 litres but varies according to body size and breed. The sheep rumen has a capacity of 15-20 litres. Feed in the rumen is broken down by microbes, mainly bacteria and protozoa.

- Bacteria use some of the food to reproduce and increase numbers. Bacteria are moved down the digestive system with the rest of the feed and get digested. This is referred to as microbial protein.
- Microbes also add nitrogen to molecules to produce protein.
- Microbes will release waste products, some of these can be used by the cow e.g. volatile fatty acids. Waste gases e.g. methane produced by microbes are removed by belching. Cattle and sheep must get rid of the waste gases to prevent bloat where trapped gases expand the rumen, cause discomfort and put pressure on internal organs. Severe cases can result in death.
- If too much highly fermentable feed (e.g. wheat) is given then too much acid will be produced; this will upset the digestive system and cause acidosis.

Rumen microbes are adapted for specific feed. Diet changes have to be gradually introduced to give the rumen population time to adjust.

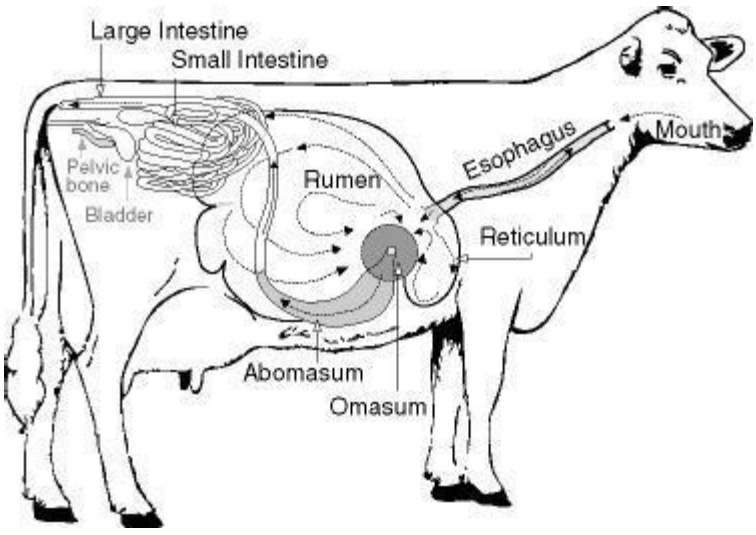
The muscles of the rumen move the food and gases; this helps to remove the gases and mix the food and bacteria. Some chemicals can be absorbed through the wall of the rumen.

The reticulum is much smaller than the rumen. Food passes into the reticulum from the rumen. Large food particles are sent back to the mouth so that they can be chewed again. When the particles in the reticulum are small enough they pass into the next stomach, the omasum.

The omasum is the third stomach. This stomach has folds of tough tissue which can grind fibrous material.

The abomasum is the fourth stomach. This stomach works in the same way as the single stomach of the pig where hydrochloric acid and pepsin break down feeds.

Rumen flora and fauna break down feeds to their constituent parts for absorption in the lower gut. Some feeds, particularly high quality fat and proteins, are already in a form that can be broken down and absorbed in the lower gut therefore it is a waste of energy for such compounds to be



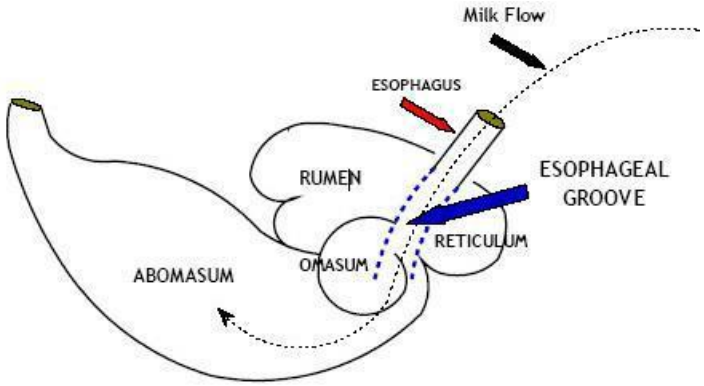

Ruminant digestive system

broken down in the rumen. Due to the cost of high quality fat and protein, it is usual that only highly productive animals have rations designed to contain 'protected' sources of fat and protein that should not be broken down by rumen microbes.

**The small and large intestines:-** Digestion and absorption in the intestines is similar to the process in the single stomached animal (see earlier notes).

**Development of the ruminant digestive system in young animals:-** At birth, the first three stomachs are not well developed and young stock need to get milk into the abomasum for it to be digested. When young ruminants drinks milk a gathering of tissue called the oesophageal groove diverts milk through the rumen, reticulum and omasum directly to the abomasum.

Poor feeding practice e.g. having the buckets at the wrong height, can prevent the oesophageal groove from forming properly and animals lose milk to the rumen, reticulum and omasum which results in digestive problems such as scouring. As the animal eats more feed, especially feed which is high in fibre, the first three stomachs will develop. It is important that the young animal is eating enough solid feed before it is weaned (no longer fed on milk).



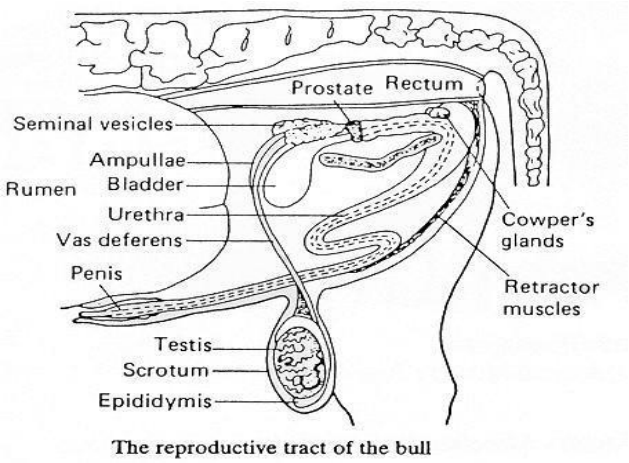

During the first six hours of life lambs and calves are able to absorb large compounds through the wall of the digestive tract. This allows them to absorb antibodies from colostrum (the first milk). The digestive system alters very rapidly thereafter and the ability to absorb antibodies is lost after about six hours. The antibodies provide passive immunity from disease.

## 6. Reproductive systems:-

### a. The male reproductive system

**Functions and Structure of the male reproductive system:-** The male reproductive system produces sperm which fertilise the ova (eggs) in the female so that embryos are produced. Hormones are produced which affect the animals' behaviour and lead to the development of secondary sexual characteristics (such as the development of strong shoulders, head and neck).

| Organ | Function |
|---|---|
| Testes/ testicles | Produce immature sperm. Produce male hormones |
| Scrotal sac | This is the skin surrounding the testes. |
| Epididymis | Very long narrow tubes in which the sperm develop and mature |
| Spermatic cord | This is the blood and nerve supply to the testicles Vas deferens This transports the sperm from the epididymis to the urethra. Fluid from accessory sex glands is added to the |



The reproductive tract of the bull

| | |
|---|---|
| | sperm and this produces semen. |
| Accessory glands | Produce fluid to transport and provide nutrients for the sperm |
| Penis | This is the male organ used for mating; it is used to deposit the semen into the female's vagina |

**b. The female reproductive system**

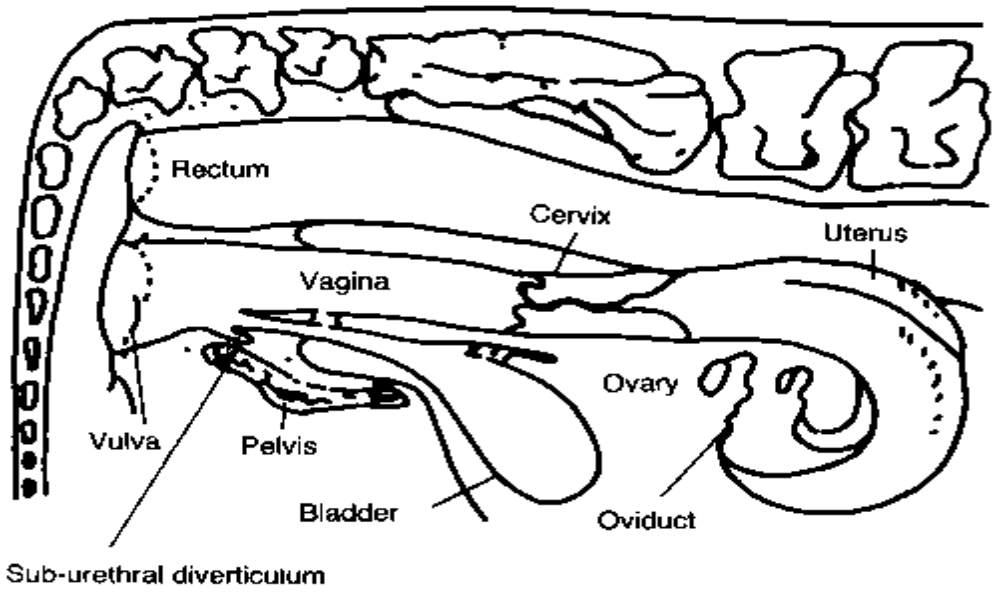
**Functions of the female reproductive system**

- This will produce the ova (eggs) that can be fertilized to produce embryos.
- The embryos will be nourished in the uterus until parturition (birth).
- The female reproductive system will produce a range of hormones that will control the maturing and release of ova; they will also make the female receptive to the male so that she will stand to be mated.

| Organ | Function |
|---|---|
| Ovary | These contain ova that develop inside follicles. The ova only develop a few at a time (the number varies with the species of animal and its condition) |
| Fallopian tubes | Female hormones are produced. These collect the ova when they are released (ovulation) and carry them to the uterus.<br>Fertilization takes place between the ovum and the sperm in the Fallopian tubes.<br>The fertilized egg the travels to the uterus. |
| Uterus | The uterus or womb is where the embryo develops.<br>During pregnancy the embryos will attach to the uterus and nourishment will be transferred from the mother through the placenta. |
| Cervix | A thick band of muscle that closes the neck of the uterus.<br>It allows semen to enter when the animal is on heat and opens for her to give birth.<br>It prevents infections entering the uterus and keeps the Developing foetus inside the uterus. |
| Vagina | Holds the penis during mating so that the sperm will be Deposited in the right place. |
| Vulva | The external opening of the female reproductive tract |

**Puberty:-** Puberty is the stage in an animal's life when it becomes sexually active and is capable of reproducing. The age will vary between individuals and the factors listed below will influence the timing of puberty:

- Breed
- Body weight and nutrition (this may be far more important than age, particularly for females)
- Effect of changing day length (decreasing day length will trigger breeding actuvity in sheep and an increasing day length will trigger breeding activity in horses and birds)
- Environmental factors e.g. the presence of males.




**Female reproductive system**

7. **Nervous System:-** The nervous system is a collection of nerves and cells (neurons) that transmits signals between different parts of the body. It consists of two major parts, the Central Nervous System and Peripheral Nervous System. The Central Nervous System constitute the brain, spinal cord and nerves while the peripheral nervous system consist of sensory neurons, ganglia (clusters of neurons) and nerves that connect to one another and to the central nervous system.
8. **The endocrine system:-** The endocrine system produces chemicals known as hormones which are secreted into the blood stream. These hormones carry messages to other parts of the body and produce specific responses.

# Unit- VII: Bio-waste Management and Government Schemes

## A. Utilization of animals in Bio-wastes and Biogas plant

Farm/Animal waste includes animal excreta, milking parlour waste, bedding, feed residues and also animal mortalities that has been of no use and are required to be eliminated from the house. Dairy farm waste also used interchangeably as "dairy cattle manure" which is a complex material containing feces, urine, bedding, rain or other water, and milk house or washing wastes. Simply farm waste is called waste from animal habitat whereas sewage is the waste from all habitations. Sewage consists of mixture of solids and liquids waste like human and animal excreta, kitchen waste, road washings and industrial wastes etc. Generally in dairy farm the disposal of dead animals or carcasses is done separately to reduce chance of contamination and spread of disease, so this chapter will discuss the collection, utilization and disposal of farm waste except dead animals.

Intensification of dairy farming with more confined housing system, farm waste production becomes more significant as a factor which must be considered by the farm manager in planning and operation. If an adequate handling system is not followed then greater farm waste production in a more confined area is a potential source of pollution to nearby aterways, soil and as a whole the environment. Pollution can occur through runoff or rainwater from dairy farm or from runoff or rainwater from heavily manured fields as well as by effluent from milking parlors and wash rooms. The farm waste if not disposed properly then act as potential breeding place of flies and mosquitoes. Wastes from a dairy farm acts as a potential pollutants if notdisposed of or utilized in a proper manner. So farm waste should be disposed properly without affecting its primary nutrients (N, P, and K) as well as other essential plant nutrients.

**Types of dairy farm waste**: Dairy farm or livestock farm has two types of waste.

**Solid**: Dung, spilled feed and left over fodder etc.

**Liquid**: Urine, wash water etc

**Farm waste or manure collection**

The manure can be collected in two alternative ways, a) collecting solid and liquid manure separately or b) flushing out solid and liquid manure together.

In first method the dung and other solid waste are lifted into wheelbarrows using shovels and then carried out of the shed. If the farm is larger size then scrapper can be used and waste is lifted into the tractor trolley and finally taken to the disposed place and properly disposed to reduce the environmental pollution. The liquid manure, washings from milk parlour and runoff water run out of the shed by a shallow 'U' shaped gutter or drain located longitudinally to the long axis of shed. Then liquid manure from different shed connected to main farm drain which may be closed or sub-terrain drain. Finally the drain conveys the liquid manure to collecting large tanks or cesspools located away from the human habitat as well as farm buildings.

The second method may be good for buffalo farm as buffalo dung contains more moisture compared to cattle and also the place where there is more rainfall then solid dung get missed with rain water and difficult to collect. If the animals are fed with more succulent high moisture fodder like berseem then they void watery dung. The liquid manure generally contains less than 5 percent total solids on wet basis and flows freely without any mechanical assistance to the storage tanks or ponds (lagoons). In these tanks or ponds beneficial organisms stabilize the material so that it can be spread on the land or used as flush water for a recycle cleaning system. This liquid manure can be directly treated to the fodder farm with or without treatment. While collecting manure in liquid for its disposal the settleable and suspended solid can be removed otherwise it may chock the drainage. Several types of traps

and other devices are used to separate the solid waste. In summer condition as the urine volume excretion is less and water scarcity ids there so difficult to collect both solid and liquid manure together.

**Methods of manure disposal**

- The primary objectives of manure disposal are:
- To prevent environmental contamination
- To prevent outbreak of disease.
- To prevent breeding of flies and mosquitoes.
- For hygienic management of animal housing.
- To conserves the maximum nutrients essential for the plant.

There are various methods of disposal of manure and this helps to prevent breeding of flies and mosquitoes and also conserve the fertilizer value of manure. There is no such single method of manure disposal that fulfil all objectives rather a combination different method follows depending on the farm situation and climatic condition. The farm waste can be disposed and utilized by the following methods:

1. **Direct land application to land:** Both liquid and solid dairy waste can be directly spread on the open fields if sufficient land is available. This method is oldest and cheapest method of recycling animal waste and waste is dried by direct sunlight that kills most of the microbes and prevent fly breeding and bad odour. In this method the end products are $CO_2$ and $H_2O$ with an accumulation of N, S, P and minerals in the soil. However, this method is not desirable as it pollutes theenvironment and there is partial decomposition of organic matter leading to significant losses of nitrogen and energy.
2. **Conversion into compost:** Composting is a natural process in which micro-organisms decompose the organic matter into compost or humus like substance. In composting process manure and bedding nutrients are converted into a more stable form that adds humic acid to the soil, increases beneficial soil organisms, improves soil tilth and aeration, and reduces raw manure odours. It is an oldest method practice for centuries by farmers who stock dung into piles or in pits. For composting solid waste is collected in piles or pit of 1.5 m deep and 3 x 4 m dimension or larger as per requirement (3 $m_3$/adult animal unit). During compositing frequent mixing or turning of waste is required. For composting a special type of manure pit called as Allnutt's manure pit which is designed to overcome the turning of manure.

   In Allnutt's manure pit solid wall is constructed upto 4 ft height in three sides and towards open side gutter that contains strong solution of chemical to kill the larva. The surrounding walls and the partition wall on their inner side are provided with few inches ledge projection inwards to prevent the larval migration. The pit is divided into two compartments and in each compartment manure is packed alternately and no times the manure storage reach upto ledge. To prevent falling of debris into the gutter a vertically sliding shutter is fitted to the front of each compartment. A roof either permanent or temporary is made to prevent the quick desiccation of manure or prevent rain water getting into the manure. After pilling within 24 hours temperature rises to $50^0$C and within 3-8 days it reaches to $70^0$C. Thereafter it falls to $50^0$C.
3. **Incineration and burial**: These methods are not so common type of manure disposal but during contagious disease outbreak the manure is not used and disposed either by incineration and burial method. In incineration manure is burnt thoroughly to reduce it into ash. If burning is not possible then infected manure is buried deeply into the soil to restrict the spread of infection. There should be no water source near it and after putting manure a layer of 2-3 ft soil should be laid over it. A deep trench is needed to prevent upward migration of strongyles and fly larvae.

4. **Biogas production**: Biogas is a non-poisonous gas, with a characteristic odour which disappears on burning when mixed with air. It burns a non-luminous blue flame without producing any smoke. In this process organic matter is first converted into volatile fatty acids and then by the action of anaerobic bacteria (methanigenic bacteria) converted to $CH_4$ and $CO_2$. The slurry produced after biogas production called digested slurry is valuable source of essential nutrients required by the plant.
5. **Vermicomposting**: Vermicomposting is a process of composting carried out by earthworms. Worms feed on the organic waste converting it into nutrient-rich end product called vermicompost or worm castings. Vermiculture is the latest technique and 100 times more efficient than the any other conventional techniques. The earthworm casts contain 2-5 times more organic matter, total nitrogen and exchangeable cations that the soil.
6. **Aerobic oxidation**: Liquid slurry can be disposed by keeping it in shallow ditches, lagoon, and tanks. Biological oxygen demand (BOD, defined as the amount of dissolved oxygen needed by aerobic microbes in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period) per acre is generally 20 for proper oxidation. For aerobic oxidation larger area is required and periodically solid sludge has to be removed.
7. **Chemical methods:** Chemical methods are commonly used when manure is used as fertilizer because it is not suitable to use manure contaminated with diseased organisms. This method prevents fly breeding and also controls parasites presents in manure. Chemical treatment of manure is only done to superficial layer of manure that controls the fly breeding. The common chemicals used for fly and mosquito control are Hellebore, Borax, Sodium fluorosilicate, Benzene hexachloride (BHC) or Dichloro- Diphenyltrichloroethane (DDT) etc.

## Bio-gas Plant

Biogas is formed by the natural degradation of organic matter under anaerobic conditions. Microbially controlled production of biogas is an important part of the global carbon cycle.

- Every year 590-800 million tons of methane are released into the atmosphere.
- Biogas contains 50-70% methane and 30% carbon dioxide.
- Methane has a calorific value of 21-24Mj/m3 or around 6KW/m3.
- Biogas is often used for cooking, heating, lighting or electricity generation.

Biogas is produced in three steps:

1. **Hydrolysis:-** Where enzymes degrade complex carbohyderates , proteins and lipids into their constituent units.
2. Acidogenesis: where hydrolysis products are converted to acetic acid, hydrogen and carbon dioxide.
3. Methanogegesis: where obligate anaerobic bacteria control methane production from acidogenesis products.

Sludge produced from the anaerobic digestion of liquid biomass is often used as a fertilizer.

**Design and Working:-**

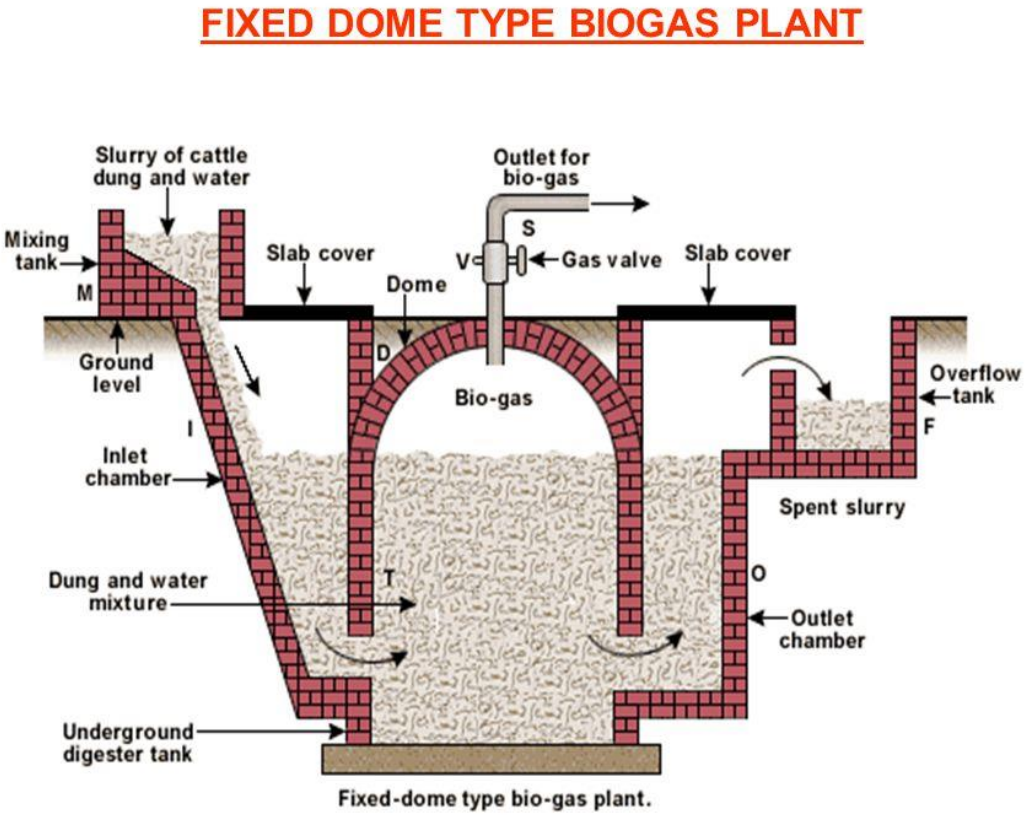
The two types of biogas plants in usage for biogas production are:-

1. The fixed dome type of biogas plant.
2. The floating gas holder type biogas plant.

**1. The fixed dome type of biogas plan**

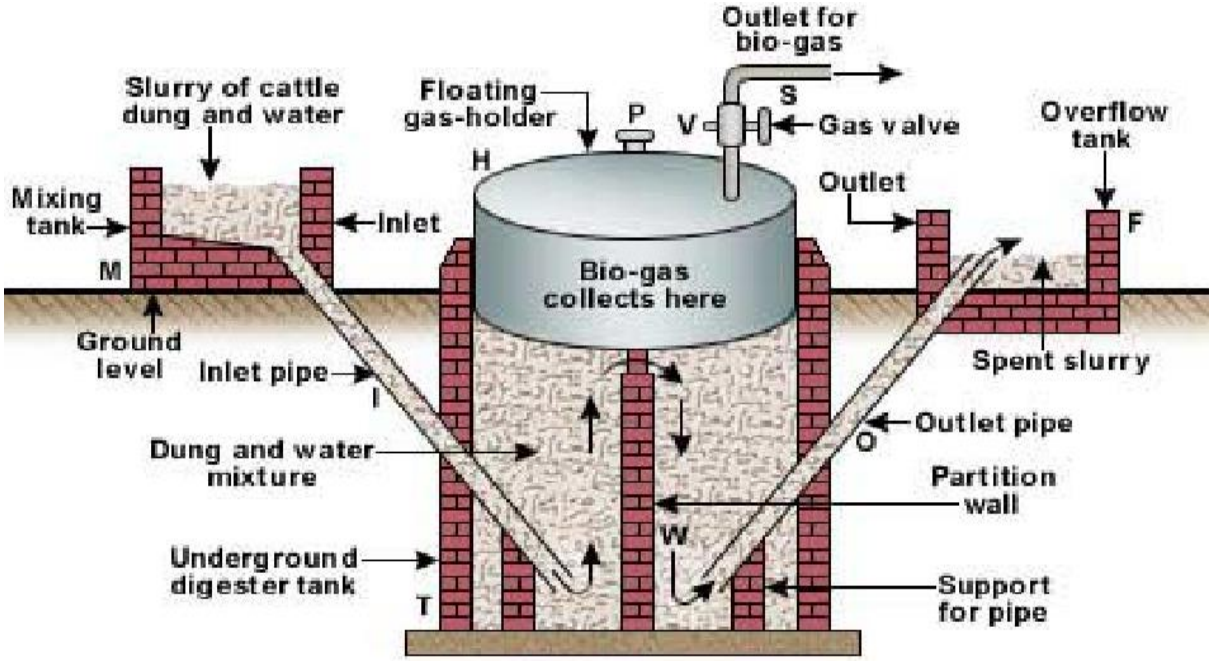
A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a

long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The construction of fixed dome plants is labor-intensive, thus creating local employment. Fixed-dome plants are not easy to build. They should only be built where construction can be supervised by experienced biogas technicians. Otherwise plants may not be gas-tight (porosity and cracks).




2. **The floating gas holder type biogas plant:-**The floating gas holder type bio gas plant consists of a dome shaped gas holder made of steel for collecting bio gas. The dome shaped gas holder is not fixed but is moveable and floats over the slurry present in the digester tank. Due to this reason, this biogas plant is called floating gas holder type biogas plant.

   Slurry is prepared by mixing water in cattle dung in equal proportion in mixing tank. The slurry is then injected into a digester tank with the help of inlet pipe. The digester tank is a closed underground tank made up of bricks. Inside the digester tank, the complex carbon compounds present in the cattle dung breaks into simpler substances by the action of anaerobic microorganisms in the presence of water. This anaerobic decomposition of complex carbon compounds present in cattle dung produces bio gas and gets completed in about 60 days. The bio gas so produced starts to collect in floating gas holder and is supplied to homes through pipes. And the spent slurry is replaced from time to time with fresh slurry to continue the production of bio gas.




Floating gas-holder type bio-gas plant.

**Raw materials required for a biogas plant:**

- Animal dung.
- Poultry wastes.
- Plant wastes(Husk, grass, weeds)etc.
- Human excreta.
- Industrial wastes(saw dust,food processing wastes).
- Domestic wastes(vegetable peels,waste food) etc.

**Principle:** Biogas is produced as a result of anaerobic fermentation of biomass in the presence of water. Fixed dome type biogas plants are much more commonly found than Floating gas holder type biogas plant because: requires only locally and easily available materials for construction and inexpensive and easy to construct.

**Advantages of a biogas plant:**

- Dramatically improves the health of users.
- Rapid fall in diseases like schistosomiasis and tapeworm.
- Reduces burden on forests and fossil fuel.
- Produces a clean fuel-
- Helps in controlling air pollution.
- Provides nutrient rich manure for plants (in nitrogen and phosphorus).
- Controls water pollution by decomposing sewage, animal dung and human excreta.

**Limitations:**

- The construction costs of biogas plants vary between different countries, they are often high relative to the income of the farmers and other potential users.
- Poor farmers are still lacking behind for adopting this technology because:
- Initial cost of installation of the plant is high.

- Number of cattle owned by an average family of farmers is inadequate to feed a biogas plant.

**Advantages of biogas as a fuel:-**

- High calorific value.
- Clean fuel.
- No residue produced.
- No smoke produced.
- Non Polluting.
- Economical.
- Can be supplied through pipe lines.
- Burns readily-has a convenient ignition temperature.

## B. Important government schemes for livestock production in India, The important features and eligibility criteria.

Animal husbandry, dairying and livestock rearing activities play an important role in shaping the national economy and the socio-economic development of the country. They contribute to the food basket, nutrition security and household income of the farmers and generate gainful employment in rural areas, particularly among landless, small and marginal farmers and women, besides providing cheap and nutritious food. Livestock particularly serves as an insurance for farmers who are often ravaged at the hands of natural calamities, droughts and floods.

Increasing urbanisation has led to a structural change in agricultural employment with the sprouting of peri-urban areas. High levels of rural-urban migration have led to extension of rural activities in the cities. Increasing poverty, unemployment and food insecurity have resulted in cultivation of marginal lands. Lack of organised employment in cities is pushing people to take up informal employment. Livestock rearing has become a common practice filling this gap.For the proper management and care of both livestock animals and dairy produce, a number of government policies and schemes have been developed to improve the standard of control of animal diseases, scientific management and upgradation of genetic resources, increasing availability of nutritious feed and fodder, sustainable development of processing and marketing facilities and enhancement of production and profitability.
Some of these schemes and programmes have been listed below.

**Department of animal husbandary, dairying and fisheries**

**1. National livestock mission (NLM):** A centrally sponsored scheme under the Department of Animal Husbandry, Dairying and Fisheries (Ministry of Agriculture), The National Livestock Mission is comprised of four sub missions one of which is Livestock Development. Under this credit based scheme, subsidy is provided for development of livestock to farmers. NABARD (National Bank for Agriculture and Rural Development) is the subsidy channelizing agency under this Sub Mission of Livestock Development. The mission is an attempt to promote livestock, pig development, feed & fodder development and skill development, technology transfer and extension as livelihoods

**2. National dairy plan phase I (NDP I):** The National Dairy Plan Phase I, a centrally sponsored scheme for the period of 2011-12 to 2018-19 aims at carrying out projects in the participating states to provide technical and implementation support to the states. Through a credit based system, funding be provided to the eligible implementing agencies through Department of Animal Husbandry, Dairying and Fisheries (DADF) to the National Dairy Development Board (NDDB). With the International Development Association (IDA) being the nodal funding agency, the scheme is planned to increase productivity of milch animals, increasing milk production to meet the growing demand for milk. Helping rural milk producers' access organized milk processing sector is another objective with which the scheme has been planned.

**3. National programme for bovine breeding & dairy development (NPBBDD):** The programme, being implemented since the 12th five year plan of the country aims to improve the bovine breeding

and dairy services of the country. Managed by the Department of Animal Husbandry, Dairying and Fisheries (DAHD), the programme provides funds to farmers through the infrastructure of the State Livestock Development Board, State Animal Husbandry Departments, State Milk Federations and other supporting NGOs and universities/colleges. The programme aims to not just assist farmers in quality insemination services and inputs in breeding but the dairy arm of the programme, aims to strengthen the infrastructure of quality milk through cold chain. It also aims to create and improve infrastructure for procurement, training for dairy farmers, strengthen dairy cooperatives, increase milk production through technical inputs to dairy farmers, along with rehabilitation of potentially viable milk unions/federations.

**4. Livestock insurance:** As a centrally sponsored scheme, this has been one of the old schemes which helps ensure insurance of high yielding cattle and buffaloes at the maximum of their current price. The premium of the scheme being subsidized to 50%, the entire cost of subsidy is borne by the Central Government. Provided maximum for 2 animals per beneficiary for a maximum of three years, this scheme becomes very critical when dealing with diseased cattle. Implemented through the State Livestock Development Boards, the objective remains to provide protection mechanisms to the farmers and cattle rearers against any eventual loss due to death of animals, demonstrating the benefit of insurance of livestock, ultimately improving livestock health and better products.

**5. Intensive dairy development programme (IDDP):** As a centrally sponsored scheme, the programme was launched in backward, hilly and Non-Operation Flood regions in order to ensure proper care and support of technical services to the dairy farmers in these locations. It also aimed at providing employment opportunities to the local population through dairy farming along with indirectly affecting the social, nutritional and economic status of the families.

**6. Livestock health and disease control (LH & DC):** In order to control emerging and exotic diseases, the Livestock Health and Disease Control, the centrally sponsored scheme was launched in the 12th Five year plan of the government of India. The scheme helps collect, compile and disseminate monthly animal disease status in order to help the States control the spread of diseases. Certain diseases like the Rinderpest, Foot & Mouth Disease, Brucellosis, Classical Swine Fever etc come specially under the scheme as a separate component owing to the seriousness of the disease in livestock. Under this vaccination and awareness component play crucial roles at the ground level. The scheme is also responsible for establishment of Veterinary Council of India at Center and State Veterinary Councils.