EduBull

BIOLOGY

for NEET & BOARD

STRATEGIES FOR ENHANCEMENT OF FOOD PRODUCTION

Key Features

1. All-In One Study Material (For Boards/Medical/Olympiads).
2. Concise, Conceptual & Trick – Based Theory.
3. NTA Based Solved Multiple Choice Questions With Answers.

Strategies For Enhancement Of Food Production

Chapter – 9

India's First Trick Based Study Material

1 PLANT BREEDING

GENETIC IMPROVEMENT AND DEVELOPMENT OF NEW VARIETIES

- **Trait :** Trait or character is any morphological, anatomical, biochemical or behavioural feature of an organism.
- **Variety :** A group of plant that has the same genotype, but it differs for one or more characters from other varieties of the same crop. An improved variety is superior to the other existing varieties of the same crop in one or more characters.
- **Plant breeding :-** The branch of agricultural sciences which leads to development of new and improved variety of crop plant. It is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yield and have disease resistance.
- It was started about 9000-11000 year ago.
- 1871 – Department of Agriculture Ist time organized.
- 1905 – Imperial Agriculture Research Institute Pusa (IARI), Bihar.
- 1936 – Rebuilt in Delhi with same name
- 1946 – Name changed to Indian Agriculture Research Institute, Pusa.

OBJECTIVES OF PLANT BREEDING

1. Development of high productivity crop variety.
2. Development of variety with high nutritional quality.
3. Development of variety with high water use efficiency.
4. Development of variety with high mineral use efficiency.
5. Development of abiotic stress (Drought, Salinity) tolerant variety.
6. Development of biotic stress and insect pest resistant variety.
7. Development of early maturing variety.
8. Development of variety with less post harvest loss.

SOME PLANT BREEDING INSTITUTES

1.	I.A.R.I.	Indian agricultural research institute, Pusa, New Delhi
2.	C.P.R.I.	Central potato research institute, Shimla
3.	C.R.R.I.	Central rice research institute, Cuttack
4.	I.S.B.R.I.	Indian sugarcane breeding research institute, Coimbatore
5.	C.A.Z.R.I.	Central arid zone research institute, Jodhpur
6.	N.B.R.I.	National botanical research institute, Lucknow
7.	N.B.P.G.R.	National beauro of plant genetic resources, New Delhi
8.	I.I.S.R.	Indian institute of spice research, Calicut
9.	I.R.R.I.	International rice research institute Manila
10.	I.C.R.I.S.A.T.	
11.	C.Y.M.M.I.T.	International centre for wheat and maize Improvement Mexico

SOME PLANT BREEDER :

1. **Normon E. Bourloug : Father of green revolution.** He developed semi dwarf varieties of wheat **Sonara 64** and **Lerma rojo.** He got Nobel Peace Prize in 1970.
2. **N.I. Vavilov : Father of centre of origin concept** for cultivated plants.
3. **M.S. Swaminathan : Father of green revolution in India. Father of mutational breeding** in India.

   He developed semi dwarf varieties of wheat **Sharbati Sonara** and **Pusa Lerma** through mutation from **Sonara 64** and **Lerma rojo,** respectively. He was the Ist Winner of World Food Prize.
4. **Gurdev Singh Khush : Former director of IRRI.** He is a rice breeder. He developed high yielding rice variety **IR-36**. He got **World Food Prize.**
5. **S.K. Vasil :** Maize Breeder. He developed **biofortified maize varieties (QPM)** which are having high concentration of **Tryptophan** and **Lysine**. He got World Food Prize.

STEPS INVOLVED IN VARIETY DEVELOPMENT

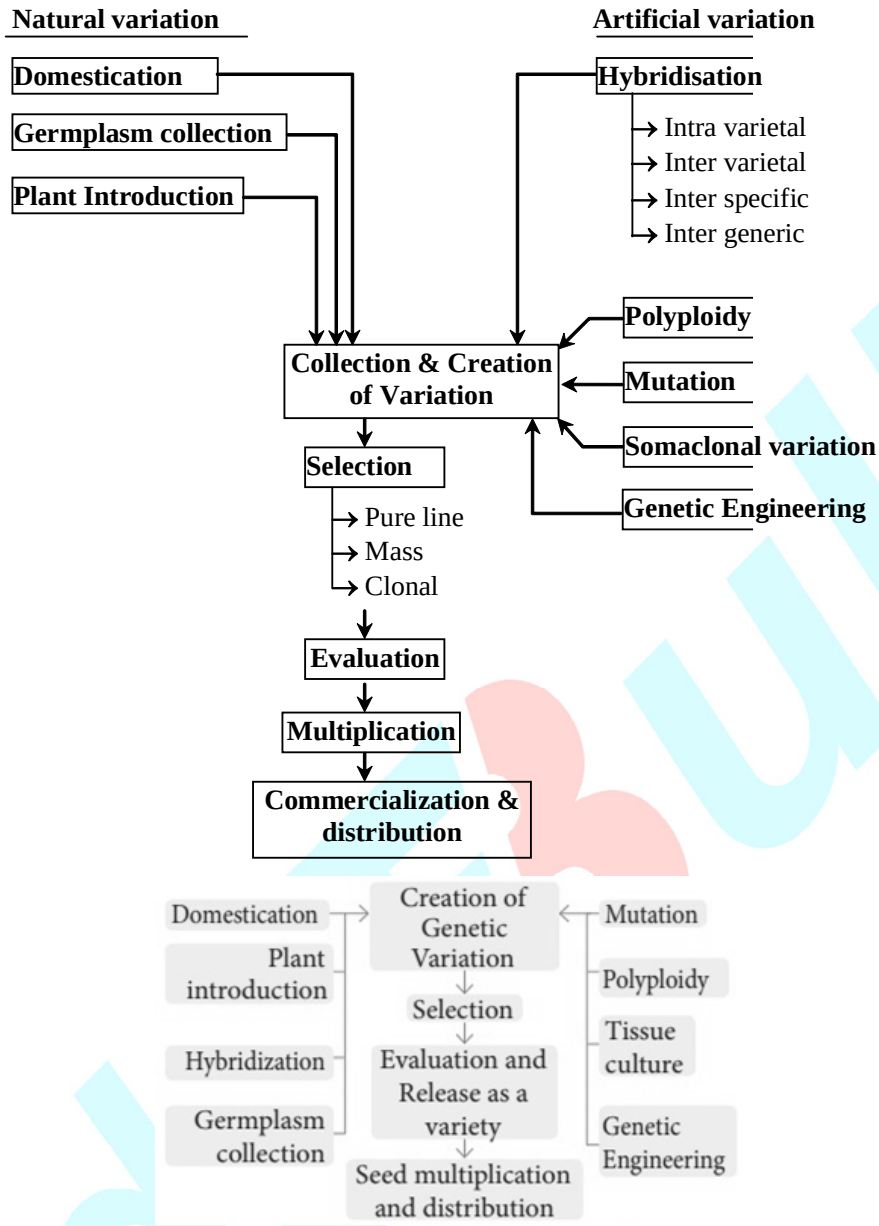


Fig: Steps in Plant Breeding

1. Collection of variability.
2. Evaluation and Selection of parents.
3. Cross hybridization among the selected plant.
4. Selection and testing of superior recombinants.
5. Testing release and commercialization of new cultivar

(1) ***Collection of variability:*** Genetic variability is the root of any breeding programme. In many crops pre-existing genetic variability is available from wild relatives of the crop. Collection and preservation of all the different wild varieties, species and relatives of the cultivated species (followed by their evaluation for their characteristics) is a pre-requisite for effective exploitation of natural genes available in the populations.

- The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called **germplasm collection.**

(2) ***Evaluation and selection of parents:*** The germplasm is evaluated so as to identify plants with desirable combination of characters. The selected plants are multiplied and used in the process of hybridisation.

(3) ***Cross hybridisation among the selected parents:*** The desired characters have very often to be combined from two different plants (parents). This is possible by cross hybridising the two parents to produce hybrids that genetically combine the desired characters in one plant. This is a very time-consuming and tedious process since the pollen grains from the desirable plant chosen as male parent have to be collected and placed on the stigma of the flowers selected as female parent.

(4) ***Selection and testing of superior recombinants:*** This step consists of selecting, among the progeny of the hybrids, those plants that have the desired character combination. The selection process is crucial to the success of the breeding objective and requires careful scientific evaluation of the progeny. This step yields plants that are superior to both of the parents. These are self-pollinated for several generations till they reach a state of uniformity (homozygosity), so that the characters will not segregate in the progeny.

(5) ***Testing, release and commercialization of new cultivars:*** The newly selected lines are evaluated for their yield and other agronomic traits of quality, disease resistance, etc. This evaluation is done by growing these in the research fields and recording their performance under ideal fertiliser application irrigation, and other crop management practices. The evaluation in research fields is followed by testing the materials in farmers' fields, for at least three growing seasons at several locations in the country, representing all the agroclimatic zones where the crop is usually grown. The material is evaluated in comparison to the best available local crop cultivar – a check or reference cultivar. If material is superior than best crop cultivar, than it is released for cultivation by ICAR.

☛ **Wheat and Rice :** During the period 1960 to 2000, wheat production increased from **11 million tones** to **75 million tonnes** while **rice** production went up from **35 million tonnes** to **89.5 million tonnes**. This was due to the development of **semi-dwarf varieties of wheat and rice.** Nobel laureate Norman E. Borlaug, at International Centre for Wheat and Maize Improvement in Mexico, developed semi-dwarf wheat. In 1963, several varieties such as ***Sonalika*** and ***Kalyan Sona***, which were high yielding and disease resistant, were introduced all over the wheat-growing belt of India.

2 METHODS OF NEW VARIETY DEVELOPMENT

(1) Domestication (2) Germplasm collection & conservation

(3) Plant introduction (4) Hybridisation

(5) Polyploidy (6) Mutational breeding

(7) Genetic engineering

(1) Domestication :- All the present species of cultivated plants are of wild type species in origin. Process of cultivation of wild species in order to fulfill human need is called domestication of plant. Many present day crops are the result of domestication in ancient times.

- ✓ Genetic diversity is the occurrence of large number of varieties, biotypes, variations and alleles.
- ✓ Greatest genetic diversity of plants is found in their natural home lands.
- ✓ Germplasm collections are made mostly from an area, where wild relatives of crop plants still live.
- ✓ Genetic diversity refers to intraspecific and interspecific variation.
- ✓ **Vavilov (1926)** Proposed that different crop plants originated in different areas, where their **wild relatives are present** and **genetic diversity is maximum.**
- ✓ **Vavilov** proposed 8 centre and 3 subcentre (11 centre) of origin. He collected 26,000 varieties of wheat.
- ✓ Presently 12 centre of origin is present. Australia is the 12th centre
- ✓ Cotton has developed in both old and new world.
- ✓ The original homeland of some important crops are listed below :-

CENTER OF ORIGIN	MAJOR CROP
NEW WORLD	
(1) Peruvian andes	Potato, tomato Capsicum
(2) Brazil	Pineapple, rubber, Cashew
(3) USA	Sun flower
(4) Mexico and Central America	Maize
OLD WORLD	
(5) Asia minor/Afghanistan	Almond, Apple, Pear, Lentil, Rye, pomegranate
(6) Ethiopia	Barley, Sorghum Coffee
(7) Mediterranean sea	Cabbage, Beet, Lettuce, Oat, Olive
(8) China	Soyabean, Tea, Onion
(9) South-West Asia	Wheat
(10) South-East Asia	Rice, Banana, Mango, Orange, Black pepper, Brinjal, Pigeon Pea, Sugar Cane
(11) European Siberia	Cherry
(12) Australia	Mecaderq Nut

- **Natural home :-** It is the centre of origin of a crop, which often abounds in its wild relatives and maximum genetic diversity.
- **Secondary home :-** It is the major centre of production of a crop plant, which is away from centre of origin and lacks wild relatives.

Important crop	Centre of Origin	Centres of Production
(1) Cocoa	Brazil	Africa
(2) Coffee	Ethiopia	Brazil & Central America
(3) Maize	Mexico and Central America	Mid West USA
(4) Pineapple	Brazil	Hawali
(5) Monterey pine	California	Australia
(6) Potato	Peru	Eastern Europe
(7) Wheat	Central Asia	North America, Asia
(8) Rubber	Brazil	Malaysia, Indonesia
(9) Oil plam	Tropical Africa	Malasiya
(10) Ground nut	Peru, Brazil	India

- **Wild relatives :-** Species related to cultivated plant that occur in the wild in areas of their origin.

(2) Germplasm collection & conservation :-

- **Germplasm** is the sum total of all the alleles of the genes present in cell of a crop species and its related species. The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called germplasm collection.

  It is consist of –

  (i) Cultivated improved varieties

  (ii) Improved varieties that are no more cultivated

  (iii) Old local or desi varieties.

  (iv) Varieties produced by plant breeders (undistributed)

  (v) Wild species related to the crop species
- The sum total of different types of all the genes and their alleles present in a population is called **gene pool.** The gene pool of a population is not static.
- **Genetic erosion –** The loss of genes from a gene pool is called genetic erosion.
- Genetic erosion occurs due to **deforestation, urban expansion, damage to ecosystem and adoption of genetically uniform modern variety of crops.**
- 11 million hectares of tropical forest disappear every year.
- **There are four basic way to conserve plant germplasm.**

  (i) Conservation of plant in wild state i.e. in natural habitat like forests.

  (ii) Conservation of plant in botanical gardens.

  (iii)Introduction of plant for cultivation in agriculture and horticulture.

  (iv) Preservation of plants in seed form or some other suitable form.

METHODS OF GENETIC CONSERVATION

(i) In-situ conservation – It means maintenance of biological diversity in natural habitats like forests and natural reserve like national park, wildlife sanctuaries and bio-sphere

reserves. In situ conservation of wild plants help in protecting species threatened with extinction.

(ii) Ex-situ conservation – It is the conservation of selected or rare plant in a place outside the natural home. In this conservation rare or selected plant material are grown in specific gardens.

Ginkgo biloba plant is preserved by Ex-situ conservation.

Ex-situ conservation includes offsite collections and gene bank.

(a) Offsite collection : They are living collections of wild and domesticated species in botanical garden, zoo etc.

(b) Gene bank : The place or institution, where different plant material (genes) are kept or preserved, is called **''Gene bank''**

- In gene bank, storage of germplasm is done either in the form of seed or vegetative material, but best and convenient way is storage of seed.
- Seed means, any plant part that is used to grow a crop. Thus 'seed' would include grains of wheat, rice, tubers of potato, stem of sugarcane etc. which are used for producing new plants.
- **Cryopreservation :-** Preservation of germplasm at ultra low temperature at –196° C (liquid nitrogen) called cryopreservation.
- Storage of dry seeds is done at low temperature (–10 to –20°C), because under these conditions the metabolic activites are minimum, prevent their germination.
- Seeds are of two types-

(a) Orthodox seed :- The seeds can not be killed or damaged as a result of decrease in moisture content& temperature. e.g. seeds of **wheat, rice, maize, oat barley** (Cereals) and also different pulses or legumes.

(b) Recalcitrant seeds :- The seeds which can be killed or damaged as a result of drying and decrease in temperature. These can be stored for a short span. eg. seeds of **rubber, tea, coconut, Jack fruit** (Artocarpus), **litchi, oil palm** etc.

- Conservation of crop with recalcitrant seed, can be made by in situ conservation method and also by tissue culture method.
- Plants with recalcitrant seed are grown in **orchard,** where all possible strains and varieties are maintained.

STORAGE OF GERMPLASM BY TISSUE CULTURE

- The tissue culture technique for storage of germplasm is used in case where :-
  (a) No seeds are produced (banana, sugar cane)
  (b) Non viable seeds
  (c) Crop with recalcitrant seed

(d) Specific clone is to be maintained

- Best method of tissue culture for germplasm storage is **''Shoot tip culture''.**
- Shoot tip culture rapidly, becoming preferred material for international exchange of germplasm as they are more stable, easier to regenerate in to whole plants and produce virus free clonal plants.
- Nowadays germplasm of potato, Cassava, and banana are exchanged by this method.
- The main advantage of tissue culture storage of germplasm are :-

(a) Economical

(b) Requires small area for storage of many genotype

(c) Can be used for multiplication of rare and endangered species.

SIGNIFICANCE OF GERMPLASM OF WILD SPECIES

- It is very important to conserve wild species of plant as these are highly resistant to insects, pests, disease and unfavourable growth conditions, which are necessary for survival of plants.
- The loss of wild plants, will reduce the genetic variability and will be a great loss to gene pool.
- Potato and sugarcane has been improved by use of germplasm of wild species having many characters like disease resistance and resistance to environmental stress.
- In potato **(*Solanum tuberosum*)** gene for resistance to **potato virus-X** and **potato leaf roll virus** have been obtained from a wild species **''*Solanum acaule*''.**
- Resistance to wilt fungus **(Fusarium)** and cyst nematode **(Globodera)** has been introduced from ***''Solanum spegazzini''.***
- Potato got resistant gene to **potato virus–Y** from a wild relatives ***''Solanum stoloniferum''***
- Resistance to **late blight of potato** (Caused by fungus ***Phytophthora infestans***) has been derieved from **''*S.demissum*''**
- Similarly, sugarcane (***Saccharum officinarum***) got resistance to **red rot of sugarcane** and adverse environment from a wild species ***''Saccharum spontaneum''.***

(4) Hybridization

- Mating between two or more individuals or lines, which are different in genotype.
- **Hybridization is the most common method for creation of genetic variations.** It is performed very often to combine character from two different plants.

Types of Hybridization :

- Hybridization is divided in following categories.

(i) Intravarietal hybridization : The crosses between the plant of same variety.

eg., ***Triticum aestivum*** var. kalyansona × ***T. aestivum*** var. K. sona

(ii) Intervarietal hybridization : The crosses are made between the plant belonging to two different varieties of same species (also known as intraspecific hybridization).

eg., ***Triticum aestivum*** var. kalyansona × ***T. aestivum*** var. sonalika

(iii) Interspecific hybridization : The plants or two different species belonging to the same genus are crossed together

eg., ***Solenum tuberosum*** × ***S. acuale***

(iv) Intergeneric hybridization : The crosses are made between the plant belonging to two different genera. **e.g.** ***Triticale, Raphanobrassica*** are the example of intergeneric cross.

(5) Polyploidy :-

- The organism (Plant) which contains more than two complete sets of chromosomes is called polyploid.
- Depending up on number of chromosomal sets, the individual are given different names-monoploid, diploid, triploids, pentaploids and hexaploid (eg-wheat)
- Polyploids are characterized by **gigantism.**
- These polyploids are used in crop improvement
- Triploids are present naturally in different crop plants and generally triploid crop plants are seedless.
- Most of the varieties of banana are triploids, so their fruit are seedless.
- Polyploidy can be induced artificially by **Colchicine treatment.**
- Colchicine is an alkaloid obtained from **Colchicum automanale** (fam. **Liliaceae**) plant from **Bulb** and **Seeds**.
- In some plants triploids are having much vigour and increased fruit size e.g. apple & pear.
- Humans have produced *a* new alloploploid crop called **Triticale** in the following manner.
- Allotetraploid wheat *(Triticum turgidum)* was hybridised with rye *(Secale cereale;* a diploid grass).

- The chromosome number of the resulting F_1 was doubled to produce *Triticale.*

Triticale is cultivated in some areas of Punjab and in the hilly regions of the country.

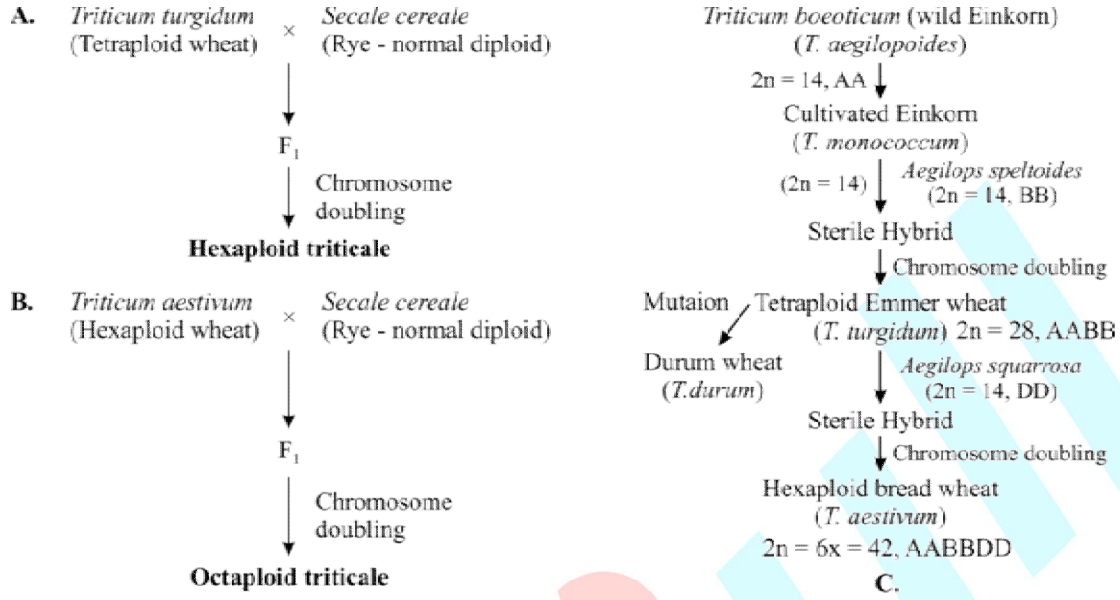


Fig. A. - B. *Production of Triticale* ***C.*** *Origin of Bread and Durum Wheat*

Selection and Testing of Superior Recombinations :

- This step comprises of selecting, among the progeny of the hybrids, i.e. those plants that have the desired character combination.
- This is the **crucial step for the success of breeding experiment,** so require careful scientific evaluation of progeny.
- The selection process yields plants that are superior to both of the parents.
- These plants are self-pollinated for several generations till they come to a state of uniformity (hornozygosity) so that the characters will not separate in the progeny

Testing, Release and Commercialization of New Cultivars :

- The newly selected lines are evaluated for their yield and other agronomic traits of quality, disease resistance, etc. T
- his evaluation is done by growing these in the research field and recording their performance under ideal fertilizer, irrigation etc.
- The testing of the materials is done in the farmer's fields, for at least **three growing seasons** at different locations in the country, representing all the agroclimatic zones.
- The material is evaluated in comparison to the best available local crop cultivar - a check or reference cultivar.
- Finally the seeds of desirable plants are certified by National Seed Corporation (NSC) for marketing.

GREEN REVOLUTION

- India is an agricultural country. Agriculture contributes about 33% of India's GDP and gives employment of about 62% of the population.
- The development of several high yielding varieties of wheat and rice in mid 1960's increased the yield per unit area. This phase is often referred to as the **Green Revolution.**
- From 1960 to 2000 wheat production increased from 11 million tonnes to 75 million tonnes while rice production increased from 35 million tonnes to 89.5 million tonnes.
- This was due to the development of semi-dwarf varieties of wheat and rice.

Dwarf Wheat

- A dwarfing **gene Norin-10** was reported in Japan.
- American plant breeders produced single dwarf wheat. N. Borlaug developed triple dwarf wheats in Mexico, popularly known as **Mexican Wheats.**
- These had high yield, resistance for lodging, common pathogens and pests, photoinsensitive, fertilizer responsive and have smaller growth period.
- **Sonora-64** and **Lerma Rojo-64** were brought to India and modified through **gamma mutations** so that these can become part of Indian Agriculture.
- In 1963, many varieties like **Sonalika** and **Kalyan sona** were introduced in all wheat growing belts of India.

Dwarf Rice.

- A dwarfing gene **dee-geo-woo-gen,** was reported in Taiwan.
- It was introduced in rice varieties by IRRI, Philippines in varieties IR-8, IR-24.
- **Taichung Native-1** was developed in Taiwan. Later better yielding semi dwarf varieties **Jaya** and **Ratna** were developed in India.

Sugarcane :

- *Saccharum barberi* was originally grown in North India, but had poor sugar content and yield.
- Tropical canes grown in South India *i.e. Saccharum officinarum* had higher sugar content and thicker stems but did not grow well in North India.
- These two species were crossed to get sugarcane varieties combining the desirable qualities of high sugar, high yield, thick stem and ability to grow in the sugarcane belt of North India.

Millets :

- Hybrid bajara, jowar and maize have been developed in India. From hybrid varieties, the development of several high yielding varieties resistant to water stress were taken

over.

(6) Mutational breeding :-

- **Mutation –** Sudden and inheritable change in genetic material of an organism.
- **Mutagens –** The agents, which are used to induced mutation.
- **Chemical mutagen –** Ethyl methane sulphonate (EMS), sodium azide.
- **Physical mutagen –** X-rays, Gamma rays, UV rays
- **Induced mutation –** Mutation which are induced artificially with the help of mutagens.

Mutation breeding :-

- Use of induced mutations in plant breeding to develop improved varieties. Induced mutations are useful in specific situations, when the desired alleles are absent in the germplasm.
- Many important varieties in different crop plants have been produced by mutation breeding
- In wheat : **Sharbati Sonora** and **pusa lerma** are two important varieties of wheat produced by gamma rays treatment of **sonora-64** and **Lerma roja**.
- Sharbati-sonora is amber grain coloured variety of wheat produced by **Dr. M.S. Swaminathan** and is responsible for green revolution in India.
- **In rice : Remei & Atomita-2** are developed through mutation breeding.
- **In barley : Erectoids** and **erectiferum.**
- **In Castor :** World famous variety **Aruna** has been produced , in which life span has been reduced from 270 days to 102 days and also having high oil content and disease resistance.
- **Penicillin production** has been increased enormously by UV-rays treatment of **Penicillium notatum** & **P. chrysogenum.**
- In **mung bean, resistance to yellow mosaic virus and powdery mildew** were induced by mutations.
- Mutation breeding has some important limitations as :
  - **(i)** Most of the mutations are recessive
  - **(ii)** Mutation rate is extremely low.
  - **(iii)** Most of the induced mutation are useless to the breeders and many of them are lethal.
  - **(iv)** Stability of mutant is sometimes doubtful, as some mutants have tendency to revert back to original type.

Breeding for nutritional quality

- A crop product should provide the optimum nutrition to human and does not contain any antinutritional factor.
- **Antinutritional factors :** Compounds that have harmful effects on animal's/human's growth & development.

  Eg. Glucosinolates (Present in oils and cakes of rapeseed and musturd), N oxalyl aminoalanine (BOAA) neurotoxin found in khesari dal **(Lathyrus sativus)**
- Cereals & millet proteins are deficient in lysine and tryptophan amino acid. (eg. Maize)
- Pulses are deficient in sulphur containing amino acid (i.e. cysteine & methionine)
- Three varieties of maize have been developed in India which are lysine-rich. Shakti, Rattan, Protina.

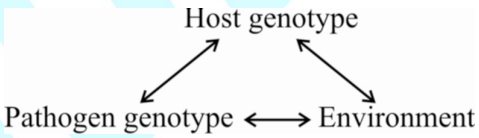
3 PLANT BREEDING FOR DISEASE RESISTANCE

- Fungal, bacterial, viral and nematode pathogens attack the cultivated crops. So crop loss can be upto 20-30 percent, sometimes even total.
- In such situation if the crops are made disease resistant, food production is increased and use of fungicides and bacteriocides would be reduced.

(1) The development of diseases in a plant depends on the interactions among following factors :

(a) Host genotype

(b) Pathogen genotype



(c) The environment

(2) Some host genotypes possess the ability to prevent a pathogen strain from producing disease. Such host lines are called **resistant,** and this ability is called **resistance.**

(3) The term **strain** has a similar meaning for the pathogen as line has for the host, Those lines of a host that are not resistant to the pathogen are called **susceptible. A** successful breeding for disease resistance depends mainly on the following two factors :

(a) A good source of resistance

(b) A dependable disease test. In **disease test,** all the plants are grown under conditions in which a susceptible plant is expected to develop disease.

Some Important Diseases of Economically Important Plants (A Brief Information)

(a) Late Blight of Potato :

- The disease is famous as it caused Ireland famine of 1845.
- The disease occurs in all potato growing areas of the world. It is most destructive under cool and moist conditions.
- The pathogen is *Phytophthora infestans.* The disease kills the foliage of crop because of which the yield is reduced.
- The disease not only infects potato tubers in the field, but also continues to advance inside the tubers under storage conditions.
- **Symptoms :** They appear first as water soaked or hydrotic areas along the margin and tips of lower leaflets. The spots enlarge rapidly, become necrotic, turn brown and then blackish or blighted. The infected leaves become limp, appear blighted and rot away, producing a characteristic odour
- *Control Measures.*

  (i) Seed tubers should be free from infection.

  (ii) Disease Resistant varieties.

  (iii)Fungicides. In susceptible environment and disease prone areas, the crop should be sprayed or dusted with fungicides.

(b) Loose Smut of Wheat

- **Causal organism :** *Ustilago nuda tritici.*
- **Symptoms :** It is recognized as soon as the effected inflorescence emerges from leaf sheaths. In the smutted deformed inflorescence, spikelets are completely filled with black, dry, powdery mass of chlamydospores (brand spores), the skin of fruit wall bursts, soon exposing the spores
- **Control measures :** Disease resistant varieties and fungicides. In susceptible environment and disease prone areas, the crop should be sprayed or dusted with fungicides.

(c) Black Rust of Wheat

- **Causal organism :** *Puccinia graminis tritici.*
- **Symptoms :** Black rust or stem rust of wheat is seen on the stem and leaf sheaths. Both uredosori and teleutosori are seen. Uredospores are brownish, spherical or oblong and teleutospores are black and elongated. As this rust is heteroecious, uredosori and teleutosori are found on Wheat, whereas some other stages are found on other host, Barberry.
- **Control measures :** Disease resistant varieties, fungicides. In susceptible environment and disease prone areas, the crop should be sprayed or dusted with fungicides.

(d) Bacterial Blight of Rice :

- It is caused by bacterium *Xanthomonas oryzae.*
- The infected tissues collapses and are digested by bacteria. Lesions enlarge and become necrotic.
- The stems and the leaves of infected plant give blighted or burnt up appearance.
- Control measures include rogueing, 3-year crop rotation, spray of agrimycin plus copper oxy- chloride and antibiotics besides sowing disease resistant varieties.

(e) Cucumber Mosaic Disease / Beans Mosaic Disease

- It is world-wide disease caused by an isometric single stranded RNA virus called **Cucumovirus** having fragmented genome.
- The virus seems to have the widest range of hosts, attacking different types of plants like cucumbers, melons, squash, gladioli, crucifers, banana, celery, spinach, pepper, beans, chickpea (gram) etc.
- It attacks plants which are 5-6 weeks old. Infected plants develop bunched or bushy appearance.
- There is mottling, distortion, wrinkling, curling and dwarfing of leaves. Later on leaves fall down. Flowers and fruits also develop distortions.
- It is transmitted by a variety of methods including aphids, agricultural implements, farm workers, air, water and other mechanical means.
- **Control measure :** Disease resistant varieties

(f) Root Knot of Tomato and Brinjal

- The disease is quite common in all vegetable growing areas especially where the climate is warm with short or mild winters.
- It devitalizes root tips, develop swelling over roots and reduces flow of water and minerals to the aerial parts.
- As a result, yield and quality of fruits are affected. The disease is caused by root knot nematode *Meloidegyne incognita.*
- **Symptoms :** The main as well as lateral roots develop a number of spherical to elliptical swellings or **galls.** The diameter is 2 to several times the diameter of the root. They include reduced growth, smaller, fewer yellow leaves which tend to wilt. Flowering is reduced. Fruits are fewer and of poor quality.
- **Control.**
  (i) **Biological control.** Nematode infested soil is inoculated with spores of bacterium *Pesteuria penetrans,* fungus *Dactylella oviparasitica* and VAM fungus.
  (ii) **Resistant varieties.** It is always preferred to grow varieties resistant to root knot nematodes.

(iii) Flooding of the fields eliminates the root knot nematodes.

(iv) Steam sterilization and fumigation with nematicides free the soil of nematodes.

Biofortification :-

- Breeding crops with higher levels of vitamins and minerals or higher proteins and healthier fats is known as biofortification. Breeding for improved nutritional quality is undertaken with the objective of improving.
  1. Protein content and quality
  2. Oil content and quality
  3. Vitamin content
  4. Micronutrient and mineral content
- **Maize hybrid** with **twice the amount of amino acid, lysine** and **tryptophan** was developed in **2000**. **High protein content variety Atlas 66** has been used as a donor for improving **cultivated wheat**. It has been possible to develop an iron fortified variety containing over five times as much iron as in commonly consumed varieties.
- The IARI New Delhi has also released several vegetable crop that are rich in vitamins and minerals eg., **vitamin A enriched carrot, spinach, pumpkin, Vitamin C enriched bitter gourd, bathua, mustard tomato, iron and calcium enriched spinach and bathua and protein enriched beans, lablab and garden peas.**

Breeding for disease resistance :

- Methods of breeding for disease resistance : Breeding is carried out by conventional hybridization method and by mutation breeding.

Crop	Veriety	Resistance to diseases
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	**Pusa swarnim** (Karan rai)	White rust
Cauliflower	**Pusa shubhra, Pusa snowball K-1**	Black rot and curl blight
Cowpea	**Pusa Komal**	Bacterial blight
Chilli	**Pusa sadabahar**	Chilly mosaic virus, tobacco mosaic virus and leaf curl

- Conventional breeding is often constrained by the availability of limited number of disease resistance genes that are present and identified in various crop varieties or wild relatives. Thus mutation breeding technique is used.
- **Yellow mosaic virus resistant** and **powdery mildew resistant moong** varieties are developed through mutation breeding.
- **Yellow mosaic virus resistant variety of Okra, Parbhani Kranti** was developed by **gene transfer** from **wild variety.**

Plant breeding for developing resistance to insect pests :

- Another major cause for large scale destruction of crop plant and crop produce is insect and pest infestation.

- Insect resistance in most crop plants may be due to morphological, biochemical or physiological characteristics.
- **Hairy leaves** in several plants are associated with resistance to insect pests, e.g, resistance to **jassids** in **cotton** and **cereal leaf beetle in wheat.**
- In **wheat**, **solid stems** lead to non-preference by the **stem sawfly** and **smooth leaved** and

  nectar-less cotton varieties do not attract **bollworms.**
- High aspartic acid, low nitrogen and sugar content in maize leads to resistance to maize stem borers.

Crop	Variety	Insect Pests
Brassica	Pusa Gaurav (rapeseed mustard)	Aphids
Falt bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Sawani, Pusa A-4	Shoot and fruit borer

New Plant Engineering Techniques / New Breeding Techniques (NBT)

NBT are a collection of methods that could increase and accelerate the development of new traits in plant breeding.

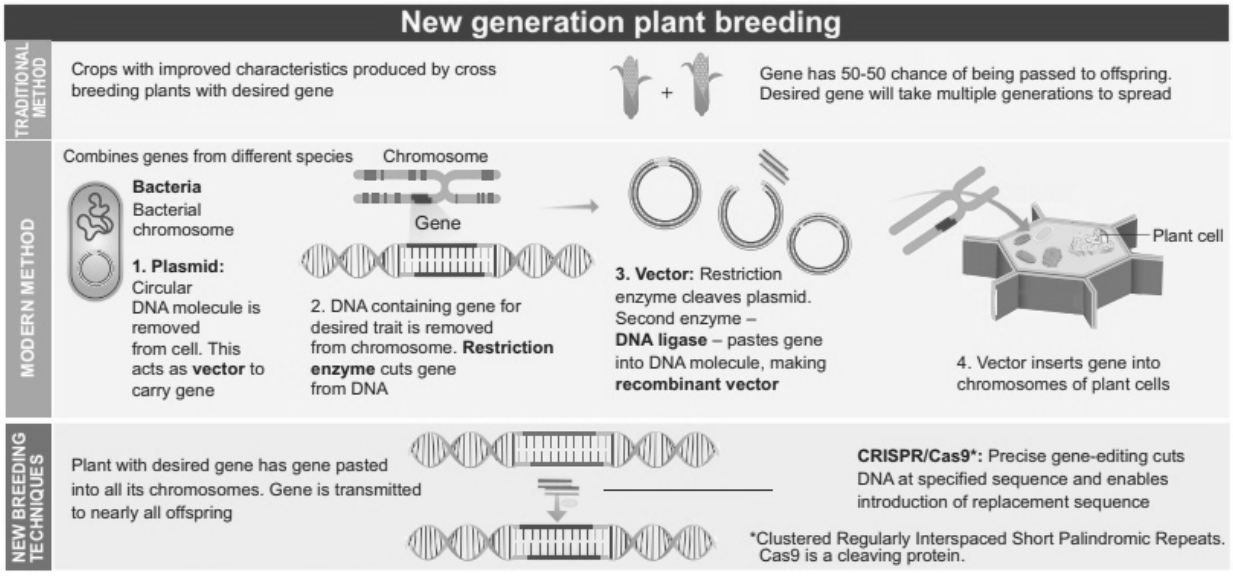


Fig: Sequential development of plant breeding techniques

Selection :

- **This is the most primitive method for crop improvement**.
- This is practiced in crop improvement and it is selection of phenotypically superior plants from a mixed population. This step yields plants that are superior to both of the parents.
- Selection acts on genetic variation, present in a population and produces a new population with improved characters. Selection is of three types-

  (a) Pure line selection

  (b) Mass selection

  (c) Clonal selection

(a) Pure line selection :- The progeny of a single self pollinated homozygous plant is called **Pure line** (term by Johanson) and these pure lines are used in selection method of crop improvement, which is called pure line selection

- Pure line selection is a method of crop improvement in **self pollinated crops (wheat).**
- In this method phenotypically superior plants are selected, these are harvested separately and their produce is maintained separately.
- The seeds so obtained from different plants are shown separately and selection is made for 4 to 5 generation till the desired improvement is achieved. About 10 years time is needed to develop a new variety by this method.

(b) Mass selection :

- This is practiced in cross pollinated crop plants.
- The first step involves selecting plants having desirable character from a given population of plants based on phenotypic characters.
- The seeds of selected plants are then mixed and sown in same field to allow natural cross pollination.
- The plants are selected from this field by eliminating the undesirable ones and saving the best.
- It is done for 3 to 4 generations or more then desired phenotypically similarity can be achieved.
- It takes about 8 yrs. time to develop a new variety by mass selection.

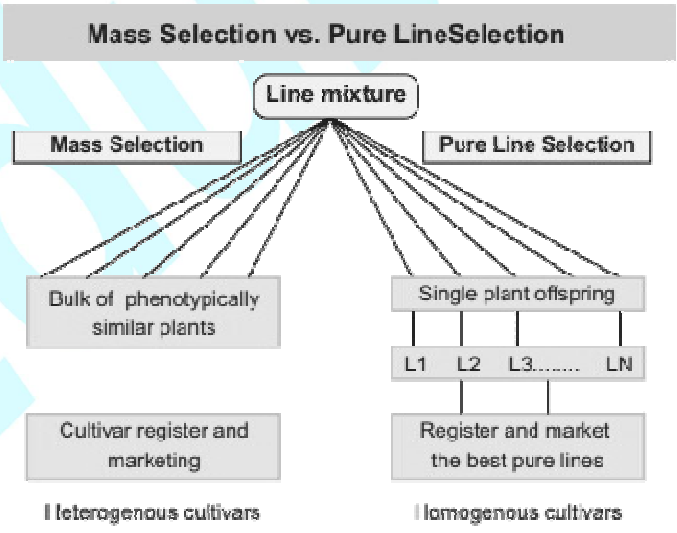


Fig: Mass Selection vs Pureline selection

(c) Clonal selection :-

- This type of selection is applicable to vegetatively propagated plants eg. sugarcane, banana, potato.
- **Clone :-** Progeny of a single vagetatively propagated plant is called clone.

- Here selection is made between **different plant clones** and not within the same plant clone.
- Kuffri Red in potato and green banana of Bombay varieties are produced through clonal selection.

Limitation of clonal selection :-

(1) Only applicable for vagetatively propagated crops.

(2) Creates no new variation

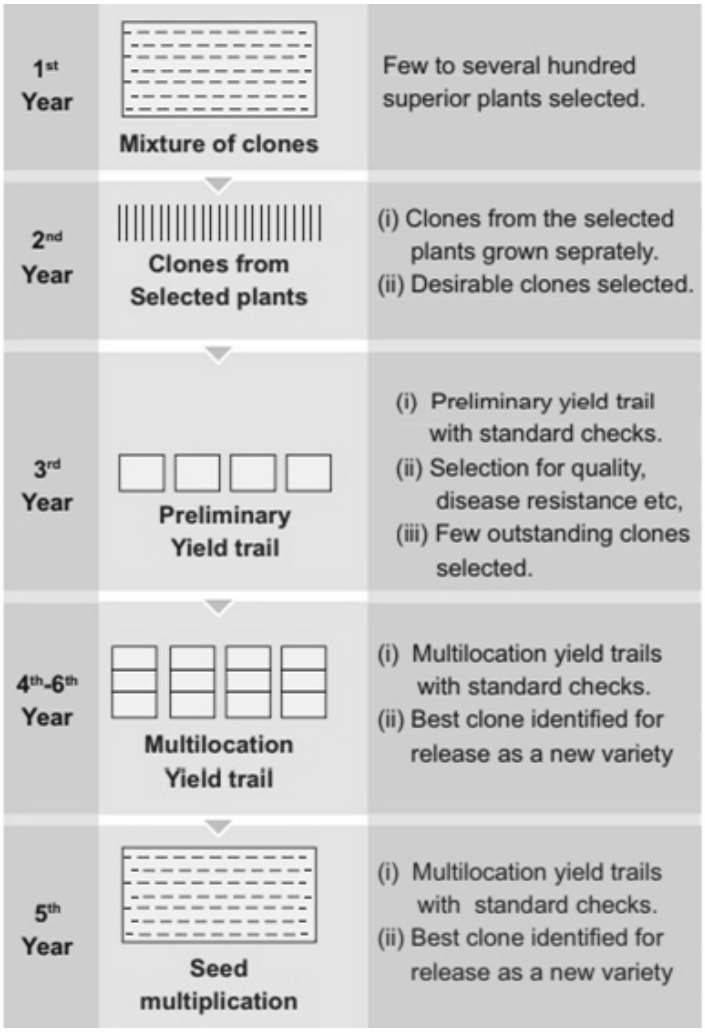


Fig: Clonal selection

4 SINGLE CELL PROTEIN

It is a microbial biomass. This biomass is obtained from both mono and multicellular microorganism.

Single cell protein can be produced using algae, fungi, yeast and bacteria. Commercial production of S.C.P is mostly based on yeasts and some other fungi e.g. **fusarium graminearum.**

(i) SCP may be used directly as human food supplement, or else

(ii) It may be used in animal feed to at least partially replace the currently used protein-rich soyabean meal and fish proteins, and even cereals, which can be divided for human consumption.

- The microorganisms are grown in large fermenting tanks with forced aeration for vigorous cell growth. Microorganisms which can be explored for obtaining SCP are:

  (i) **Algae :** *Spirulina, Scenedesmus, Chlorella*

  (ii) **Fungi :** *Fusarium graminearum, Candida utilis, Trichoderma viride*

  (iii) **Bacteria :** *Achromobacter, Cellulomonas, Methylophilus methylotrophus* (Source of Pruteen) : 250 g of this microorganism can be expected to produce 25 tonnes of protein per day.

ADVANTAGES OF SCP :

The SCP processes and products offer several advantages as listed below :

1. The SCP is rich in high quality protein and it is rather poor in fats, which is rather desirable.
2. They can be produced all the year round and not dependent of the climate (except the algal processes).
3. The microbes are very fast growing and produce large quantities of SCP from relatively small area of land.
4. They use low cost substrates and, in some cases, such substrates which are being wasted causing pollution to the environment.
5. When the substrate used for SCP process is a source of pollution, SCP production helps reduce pollution.
6. Strains having high biomass yields and a desirable amino acid composition can be easily selected or produced by genetic engineering
7. Some SCPs are good sources of vitamins, particularly B-group of vitamins, as well, e.g., yeasts and mushrooms.
8. Mushrooms are considered as delicacy in the human diet.
9. At present, SCP appears to be the only feasible approach to bridge the gap between requirement and supply of proteins.

Production of SCP require carbon source and other nitrogen, phosphorus and other nutrients needed to support optimal growth of the selected microorganism. SCP Process are highly aerobic (except those using algae.) Therefore aeration must be provided

5 GREEN MANURE

- It is a manure prepared from young, green crop plants by ploughing them back into soil.
- Usually, young leguminous crops are used for green manuring because they also increase the nitrogen fertility of the soil.
- The plants commonly used for green manuring in India are : Sunn Hemp *(Crotolaria juncea),* Dhaincha *(Sesbania aculeata),* Cluster Bean *(Cyamopsis tetragonoloba),* Sweet Clover *(Melilotus parviflora),* Cowpea *(Vigna sinensis),* Horse Gram *(Dolichos uniflorus),* Egyptian clover (Berseem, *Trifolium alexandrinum),* Lentil *(Lens esculenta).*
- The plants are rich in nitrogenous compounds because of the presence of nodules on the roots.
  Sesbania rostrata possesses such nodules on the stem (caulinary nodules) as well.
- The plants are slowly converted into manure through the activity of microorganisms. Green manures have all the benefits of farmyard manure.
- Additionally, they increase nitrogenous content of the soil, reduce alkalinity and prevent soil erosion.
- It is found that green manures increases crop yield by 30-50% as compared to farmyard manure.

6 ENERGY CROPS

- In the face of rising prices and shortage of fossil fuel, attempts are being made to use alcohol for running automobiles.
- Both ethanol (ethyl alcohol) and methanol (methyl alcohol) can be used for this purpose.
- Proalcohol programme of Brazil envisages the complete replacement of petrol or gasoline with alcohol.
- Gasohol programme of U.S.A. contemplates 10-15% blend of alcohol with petrol. While Brazil is concentrating on preparing alcohol from Sugarcane, U.S.A. is experimenting with Maize.
- Besides Sugarcane and Maize, other crops which can be used for production of alcohol are Potato, Sugar beet, Tapioca and molasses of sugar industry.
- Growing crops for production of alcohol and other fuels is known as **energy cropping.**

- The existing gasoline engines require only little modification for using gasohol or pure alcohol.
- One problem with employing alcohol as fuel is the **cost of production.** Another problem is the reduction in agricultural land.
- This will reduce the amount of food available for feeding human population

7 PETROLEUM PLANTS

- Nobel Laureate, Melvin Calvin, suggested that the shortage of petrol can be overcome by extracting them from certain plants popularly called **petroleum plants.**
- The plants produce a large amount of **latex.** Latex contain long chained liquid hydrocarbons.
- These long chained hydrocarbons can be used directly or broken to hydrocarbons of chain length similar to the ones present in petrol.
- Petroleum plants belong to families Euphorbiaceae, Asclepiadaceae, Apocyanaceae and Asteraceae.
- The two plants investigated for petroleum products are *Euphorbia lathyrus* (family Euphorbiaceae) and *Brickellia* species (family Asteraceae).
- **Other useful plants are -** *Jatropha curcas* and *Pongamia pinnata*. Limitation : Commercial exploitation of petroleum plants seems to be not yet feasible because the product would be too expensive.
- Fossil fuels are a non-renewable energy source as they take several million years to form through slow geological processes
  - ✓ Fossil fuels include coal (formed from peat) and oil and natural gas (e.g. petroleum)
  - ✓ Biofuels are liquid fuels that are produced from the structural components (biomass) and waste of plant and animal matter
  - ✓ As they are derived from biological processes, they are functionally renewable (provided there is a constant stock of reagents)
  - ✓ Biofuels may use certain industrial wastes as reagents (e.g. CO_2, heat), making them an ecologically sustainable alternative
  - ✓ Biofuels include bioethanol and biodiesel, with efforts ongoing to develop better purification and refinement techniques

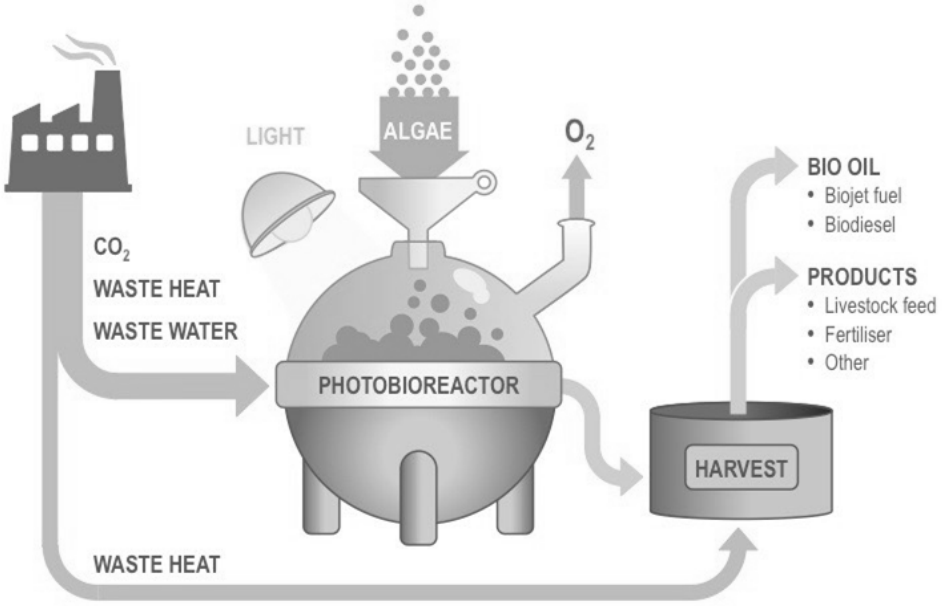
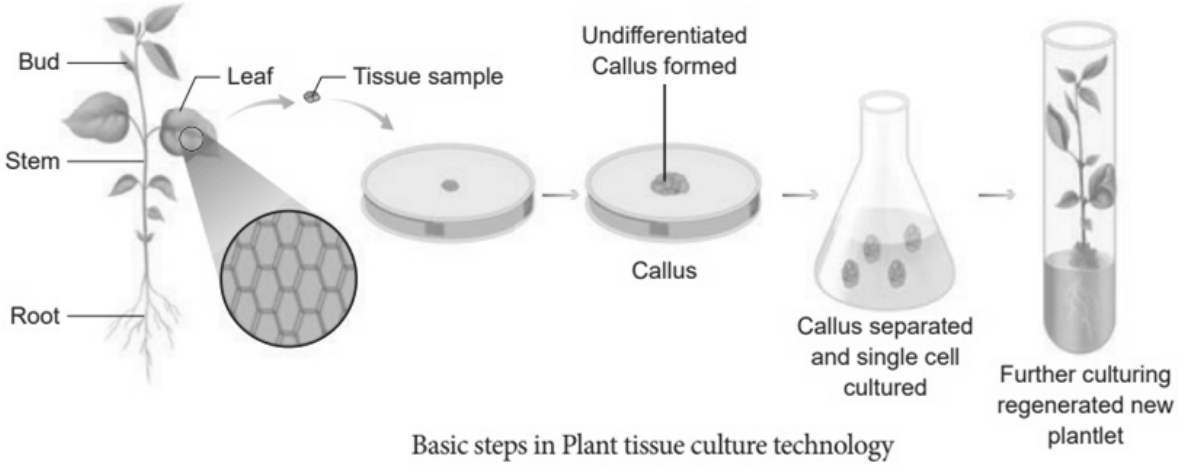


Fig: Biofuel Production (Using Algae)

8 PLANT TISSUE CULTURE

- Tissue culture technique is based on totipotent nature of plant cell.
- Plant tissue culture is the technique of maintaining and growing plant cells, tissues and organs in sterilized culture medium, under controlled aseptic conditions in vitro.



Basic steps in Plant tissue culture technology

Explant $\xrightarrow{\text{Surface sterilization}}$ Surface sterilized explant $\xrightarrow[\text{Medium / Dark}]{\text{Tissue culture}}$ Callus

Callus $\xrightarrow{\text{sub culturing}}$ sub cultured callus $\xrightarrow{\text{Shoot inducing medium}}$ Shooted callus $\xrightarrow{\text{Root inducing medium}}$ Plantlet $\xrightarrow{\text{Hardening}}$ Acclimatized Plantlet in field

Explant :

- Plant part that is excised from its original location and used for initiating a culture. It may be root tip, shoot bud, anther, embryo, ovule etc. Normally undetermined cells of plant are used as explant.

Surface Sterilization :

- The process of treatment of explant with specific antimicrobial chemicals like sodium hypochlorite, H_2O_2, C_2H_5OH, Mercuric chloride etc.

Autoclaving :

- Sterilization of culture media, plastic ware and glass ware by moist heat (steam) at high pressure. It is performed at 120ºC for 15 psi pressure for 20 minute.

Culture medium or nutrient medium :

- Medium, which provides nutrition to explants which is required for normal growth and development of explants.
- Standard culture medium contains inorganic Salts, Vitamins, Sucrose (as a source of energy and carbon), growth regulators (2,4–D, Cytokinins, BAP-benzylaminopurine)
- Growth regulators are required for cell division and organogenesis in explant.
- **Murashige and Skoog's culture medium is the most commonly used culture medium (MS medium).**

Axenic culture :

- Culturing of cell under complete aseptic condition is known as Axenic culture.

Callus : Group of undifferentiated or dedifferentiated cells, which are produced through invitro culture.

Types of Cultures –

(1) Callus culture & suspension culture.
(2) Meristem culture
(3) Embryo culture
(4) Anther culture
(5) Protoplast culture

(1) Callus & Suspension culture –

- **Callus culture –** In callus culture when an explant is placed on a agar containing medium. Many of the cells become meristematic and begin to divide and giving rise to callus in 2-3 week. The agar medium contain growth regulator like auxin 2, 4 –D and cytokinin like BAP.

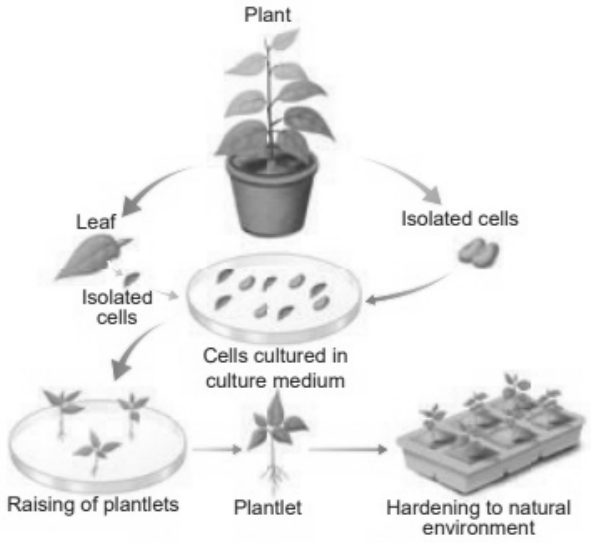


Fig: Organ culture

- **Suspension culture –** In case of suspension culture a single cell or small group of cells placed on liquid medium. The medium normally contains the auxin 2, 4-D. These cells divide and form small groups of cells.
- The suspension cultures are continuously agitated to break the cell mass in to smaller clumps and single cells and also maintain uniform distribution of cells and cell clumps in the medium.
- It also allows gaseous exchange.
- Suspension cultures grow much faster than callus culture.

With passage of time in a culture : -

(a) Cell tissue dry matter (biomass)

(b) The level of nutrients in the medium

(c) The medium volume declines due to evaporation.

- The process of transferring the cell culture into a fresh culture medium is called **subculturing.** It is normally done after 4-6 week when callus develops to its maximum. During subculture only a part of the culture from a vessel is transferred into the new culture vessel.
- **Haberlandt** was first one who grow isolated leaf cells in plant tissue culture medium.
- **Totipotency : -** The ability of a plant cell to regenerate into complete plant.

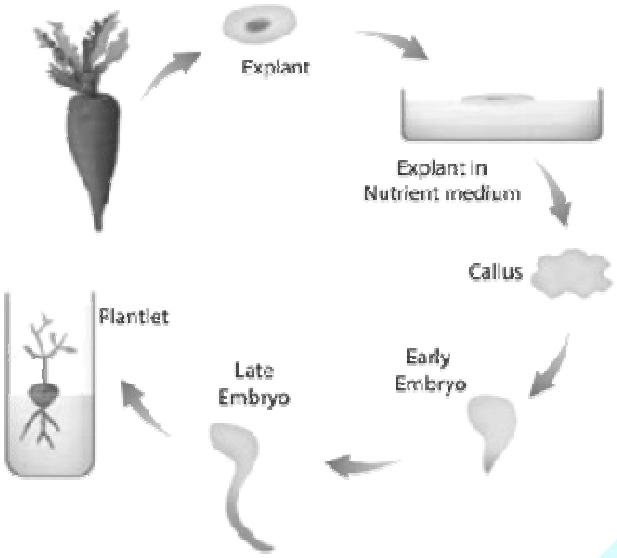
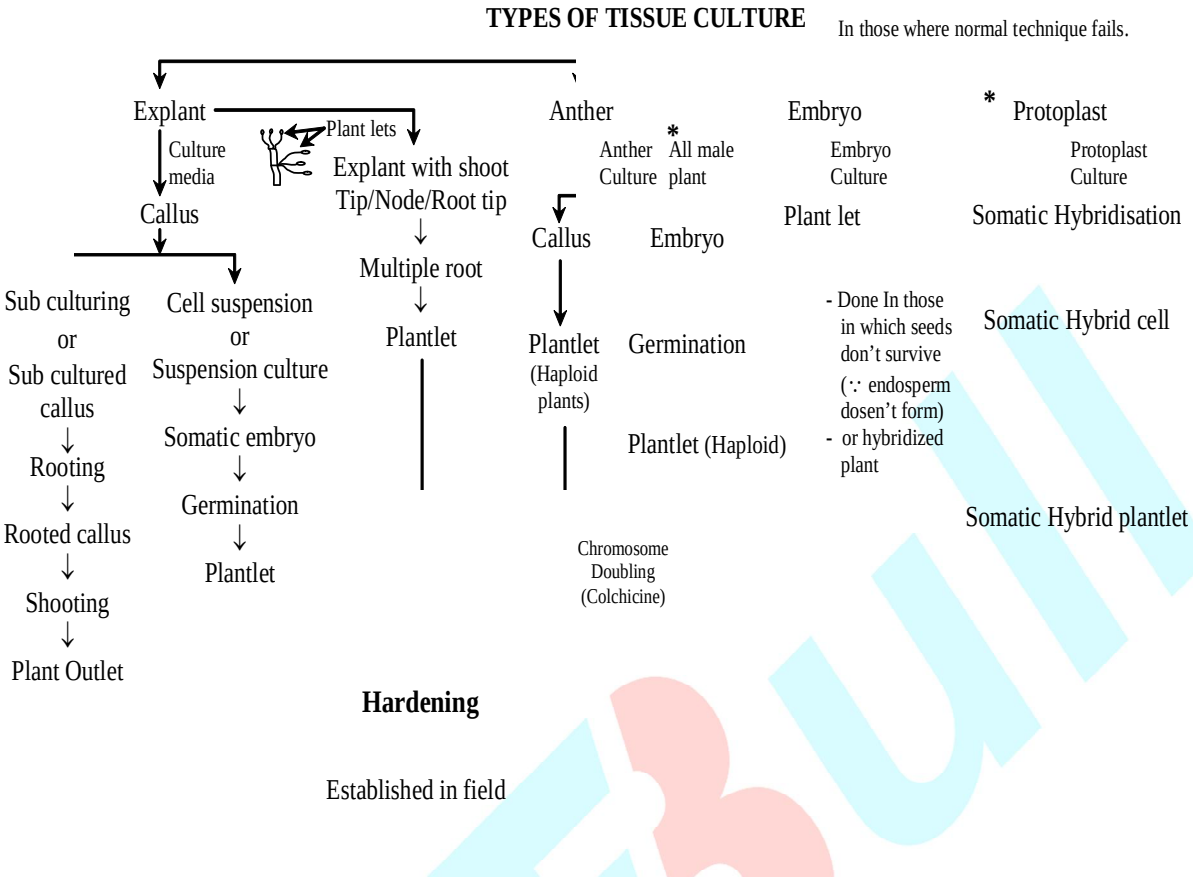


Fig: Totipotency

- The concept of totipotency was given by ‘‘Haberlandt’’ and practical applications of totipotency was demonstrated by **‘‘Steward’’.**
- **Steward** developed a complete carrot plant from a single cell obtained from root of wild carrot.

Shoot and root formation :

- The regeneration of root and shoot is controlled by two types of growth regulators.
- The auxin **NAA (Naphthaline Acetic Acid)** promotes root regeneration whereas **cytokinins BAP** promotes shoot regeneration.
- Callus is first kept on medium containing BAP, which initiates shoot formation from the callus.
- When shoots become 2-3 cm. long, the culture is transferred to a medium containing auxin. Roots develop from the lower ends of these shoots and develop into young plant called plantlet.



Plant Regeneration Pathway

From the explants, plants can be regenerated by somatic embryogenesis or organogenesis.

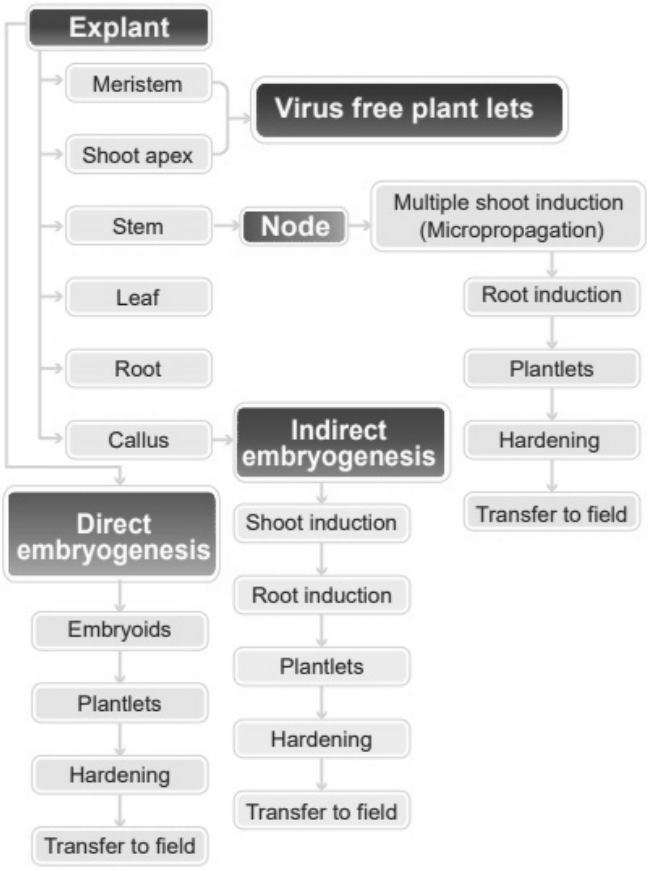


Fig: Flow chart of plant regeneration pathway

1. Somatic Embryogenesis

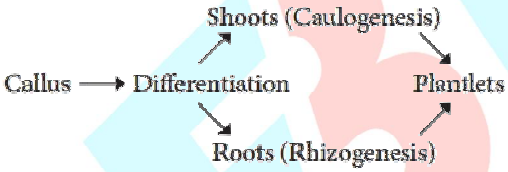
Somatic embryogenesis is the formation of embryos from the callus tissue directly and these embryos are called **Embryoids** or from the *in vitro* cells directly form pre-embryonic cells which differentiate into embryoids.

Applications

- ✓ Somatic embryogenesis provides potential plantlets which after hardening period can establish into plants.
- ✓ Somatic embryoids can be be used for the production of synthetic seeds.
- ✓ Somatic embryogenesis is now reported in many plants such as *Allium sativum, Hordeum vulgare, Oryza sativa, Zea mays* and this possible in any plant.

2. Organogenesis

The morphological changes occur in the callus leading to the formation of shoot and roots is called organogenesis.



- Organogenesis can be induced in vitro by introducing plant growth regulators in the MS medium.
- Auxin and cytokinins induce shoot and root formation.

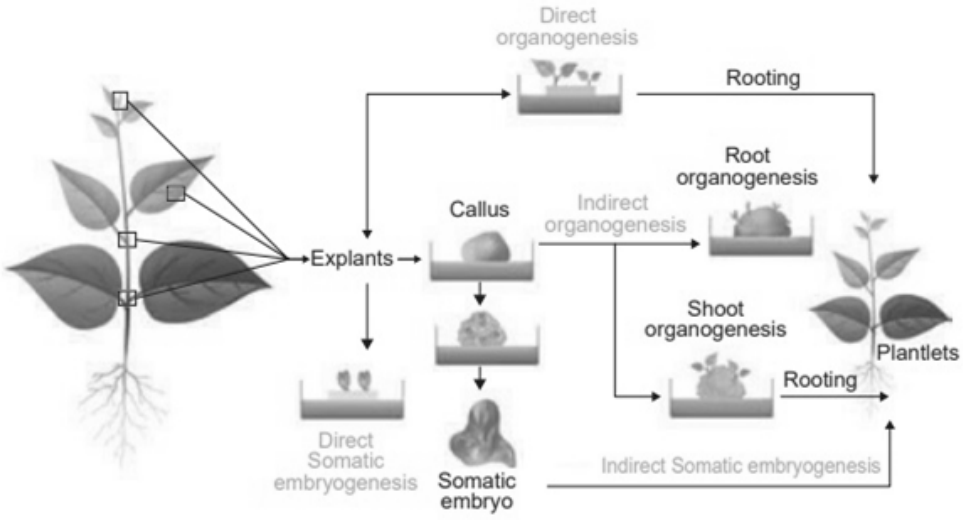


Fig: Plant Regeneration pathway

(2) Embryo culture : Culturing of immature young embryo in in-vitro medium.

Applications :-

Significance of Embryo Culture :

(i) In some interspecific crosses or distant hybridization the endosperm of developing hybrid seeds degenerate very early or not formed so young hybrid embryo which gets devoid of nutrition also dies. In such cases the young hybrid embryo is excised and cultured in vitro to obtain hybrid seedling.

(ii) Seeds of some plants like orchid lack stored food. In such cases embryo culture allows seedling development from the embryos. This method is also used for rapid clonal propagation in orchid.

(iii) In some species seeds may remains dormant due to inhibitors present in the endosperms/seed coat. Embryo culture in such cases allows embryo development by eliminating the inhibitors responsible for dormancy

(3) Meristem Culture

Significance of Meristem Culture : -

- Rapid clonal multiplication.
- Production of virus free plant.
- Conservation of germplasm.
- Production of transgenic plant.

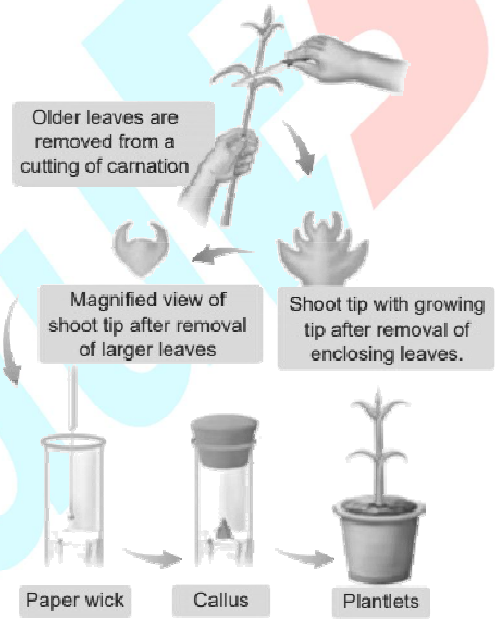


Fig: Meristematic Culture

(4) Anther Culture

Significance of Anther Culture : -

(i) They have single set of chromosome, so even a very small change or mutation can be detected in haploids.

(ii) These haploids are used to produce homozygous diploids (by **colchicine treatment**) and these homozygous diploids are used as parents in crossing.s

(iii) Use of haploids in producing pure lines has reduced the period required for developing new varieties from 10 years to 5 years.

(5) Protoplast culture : -

- **Somatic hybrid :** A hybrid produced by fusion of somatic cells of two species or varieties.
- The process of production of somatic hybrid is **somatic hybridization.**
- **Protoplast :** Cell wall less plant cell is called protoplast.

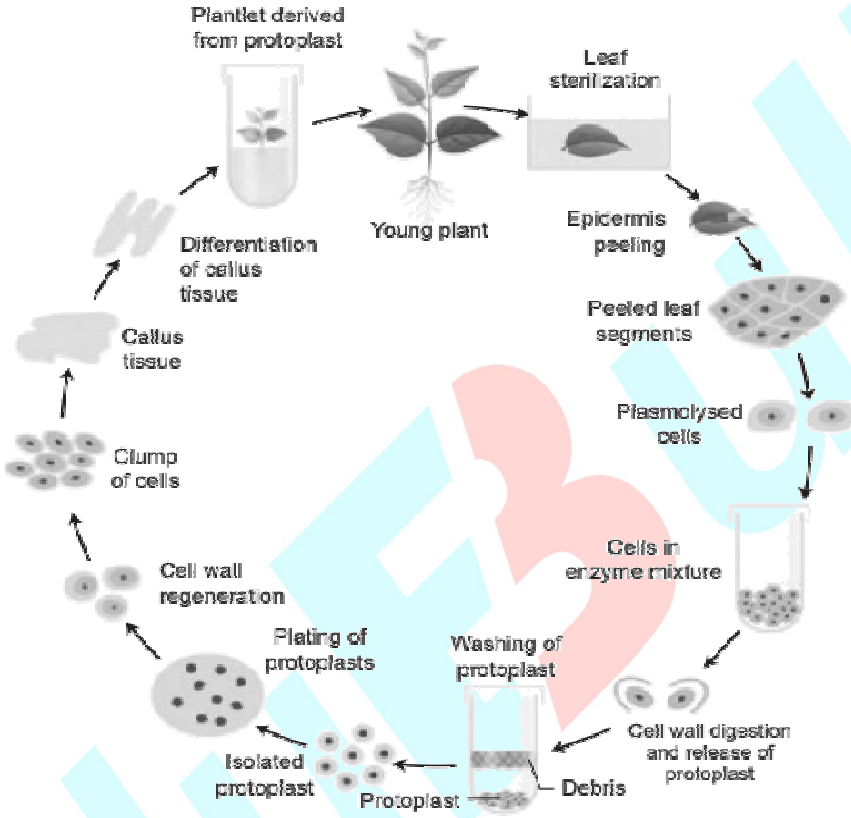


Fig: Protoplast Culture

9 STEPS OF SOMATIC HYBRIDISATION

(A) Removal of cell wall : 2 method

(i) Mechanical method: Old method

(ii) Enzymatic method: New method

- Discovered by-Cocking.
- In this method cell wall is digested by using pectinase & cellulase enzyme.

(B) Fusion between protoplast: 2 methods

(i) Spontaneous fusion : - During enzymatic treatment some protoplast fused together and form multinucleated structure which is called homokaryons or homokaryocytes.

- This is a intraspecific fusion.
- Not very useful in study.

(ii) Induced fusion : -

- Protoplast of two different species are fused together by induced fusion.
- Substance which induced the fusion of protoplast are called fusogen or fusogenic agent.

▪

Fusogenic substance and condition : -

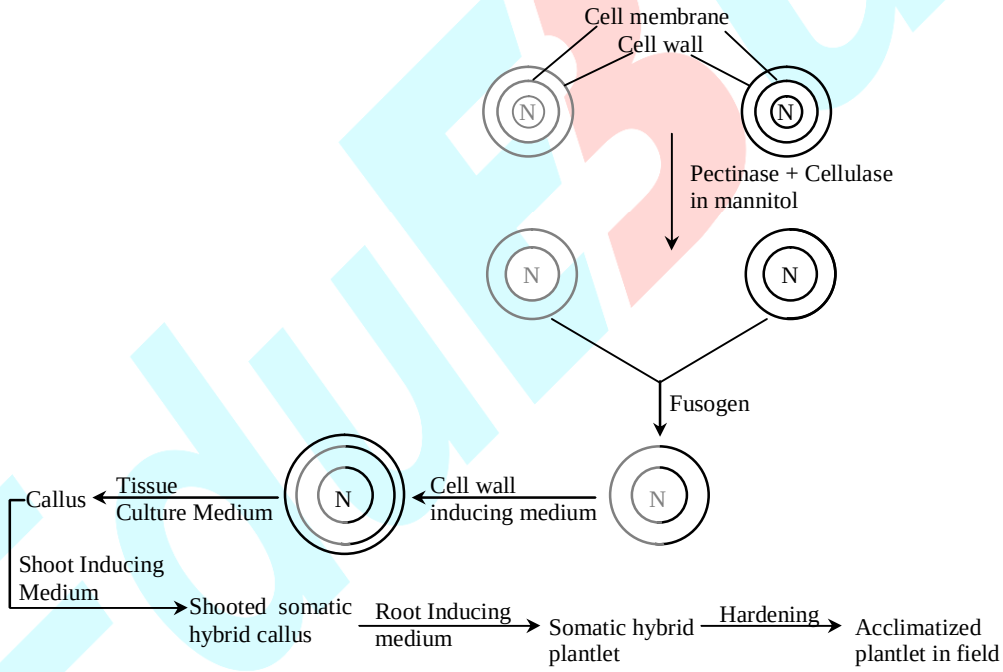
- By treatment of $NaNO_3$
- By treatment of Ca^{+2} ions at high pH
- By treatment of polyethylene glycol [PEG]
- By high voltage electric shock

(C) Culture of the fused protoplast : -

☛ Product of fused protoplast of two different species is called heterokaryon.

☛ Heterokaryons are mainly used in tissue culture.

☛ When the fused protoplasts are cultured on a suitable medium they regenerate cell wall and begin to divide ultimately to produce plantlets.



Importance of somatic hybridisation :

(i) It allows the production of hybrids between different lines and species that can not be produced normally by sexual reproduction.

- **Pomato** is a somatic hybrid between **potato** and **tomato.**
- **Bromato-Brinjal** & **tomato**

(ii) Use of somatic hybrid :

- For gene transfer.
- Transfer of cytoplasm.
- Production of useful allopolyploids.

10 SPECIAL TOPICS

- Somatic hybridisation is also called **parasexual hybridisation.**
- First somatic hybrids were obtained between two species of tobacco ***Nicotiana gluca*** and ***N.langsdorfit*** by Carlson et. al.

CYBRID

- Cybrids posses a nuclear genome from only one parent but cytoplasmic genes from both parents. The process of protoplast fusion resulting in the development of cybrid is known as cybridisation / cytoplasmic hybrids.
- **Formation of cybrids : -** Two methods
  (i) By fusion of nucleated protoplast of one parent to enucleated protoplast of another protoplast.
  (ii) By elimination of one nucleus form heterokaryon.
- **Use of Cybrids :** In plant cell some genetic factors are also present in cytoplasm. During cybridisation these factors fused together and perform cytoplasmic inheritance.

eg. (i) Streptomycin resistant gene is transfer from ***Nicotiana tabacum*** to ***N.silvestrise.***
(ii) Gene of male sterility is transferred in ***Nicotiana, Brassica*** and ***Petunia*** from one-another.

11 APPLICATION OF PLANTLETS PRODUCED BY PLANT TISSUE CULTURE

(I) Rapid clonal propagation of superior lines; e.g. oil palm

- **Clone :** Group of individuals or cells derived from a single individual or cell by asexual reproduction.
- Multiplication of genetically identical copies of a cultivar by asexual reproduction is called clonal propagation or cloning or micro propagation.
- All the cells in culture are derived from a single explant by mitotic division, so all plantlets regenerate from a culture generally, have the same genotype and constitute a clone. These plantlets can be used for rapid clonal propagation of superior lines like oil palm.
- **Two common types of micro propagation are :**
  (a) Multiple shootlet production
  (b) Somatic embryogenesis

(II) Somaclonal variation : Genetic variation presents among plants regenerated from tissue culture have been termed as **somaclonal variation**.

- These variations originated by minor chromosomal aberration or by gene mutation.

- The variation which are stable and have agronomic characters like resistance to diseases and pests, stress tolerance, early maturation, better yields are used in agriculture.
- By somaclonal variations many useful varieties are developed.

  Rusts resistance in wheat.

  Resistance for tungro virus and leaf hopper in rice.

  Resistance for late blight in potato.

  High protein content in potato

Shortening of harvest duration in sugarcane.

(III) To produce transgenic plants :

- Transgene : A foreign gene that is transferred in to an organism by genetic engineering.
- **Transgenic plant/organism** □ plant/organism that contains and expresses a transgene. The cells containing and expressing transgenes can be easily selected in vitro and valuable plants can be regenerated from these cells

Protoplast Fusion/Somatic Hybridisation/Parasexual Hybridisation

- It is fusion of protoplasts of two plants belonging to different varieties, species and even genera. The cells are first treated with enzymes **pectinase and cellulase.**
- These enzymes dissolve the cell wall and as a result naked protoplasts are produced.
- The naked protoplasts are fused by **electrofusion** (high frequency alternating electric field with short current pulses) or **chemofusion** (through sodium nitrate or PEG = polyethyleneglycol).
- It results in hybrid protoplasts.
- The somatic hybrid may have a **synkaryon** (single fused nucleus) or **heterokaryon** (having two unfused nuclei).
- The hybrid protoplast is called **cytoplasmic hybrid** or **cybrid** if one of the two nuclei of this get degenerated.
- The first somatic hybrid was obtained by **Carlson *et.al.*** (1972) between *Nicotiana glauca* and

  N. langsdorfi (species of Tobacco).
- The intergeneric somatic hybrids are **Pomato** (Potato × tomato) and **Bomato** (Brinjal and Tomato).

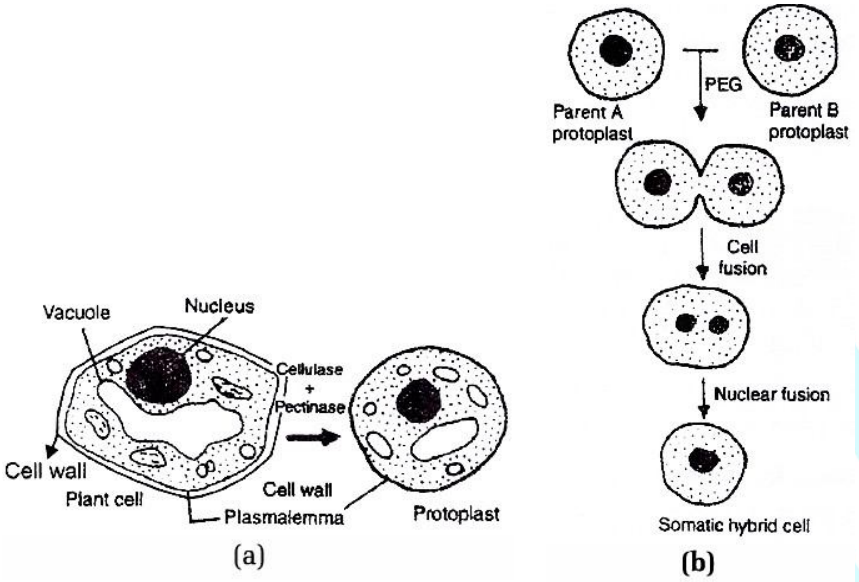


Fig. (a) Protoplast Preparation and (b) Fusion technique

Cellular Totipotency

- It is ability of a plant cell to give rise to complete plant when cultured in a suitable culture medium at appropriate temperature and aeration conditions.
- Each individual vegetative plant cell possess a complete genetic programme required to direct the development of an entire plant.
- The term cellular totipotency was used for the first time by a German botanist Gottlieb Haberlandt (1902). He gave the idea that every plant cell is totipotent.

Applications of Tissue Culture

(i) Can be applied for crop improvement.

(ii) Can be applied for the rapid multiplication of desirable and rare plants.

(iii) Can be applied to obtain indefinite number of plants. (Help in micropropagation)

(iv) Can be applied to obtain virus free plants from shoot apex.

(v) Somaclonal Variations :

- These variations are produced during tissue culture.
- Some of these may be useful and stable *e.g.*, better yield and quality, early maturation, resistance to diseases and pests, etc.
- Some of the significant variations which have been taken up in plant breeding are, high protein content and resistance to late blight in Potato, increased shelf life in Tomato, resistance to rust and high temperature tolerance in Wheat, resistance to Tongro Virus and Leaf Hopper in Rice, short duration in Sugarcane etc.

Pathway engineering involves the manipulation of genetic and regulatory processes to produce metabolites of interest

- Primary metabolites are compounds that are essential to the growth and development of the microorganism (e.g. citric acid)
- Secondary metabolites are compounds that are not directly involved in growth and development (e.g. penicillin)

Pathway engineering optimises metabolic processes to increase yields or produce exogenous metabolites

- Yields can be increased by over-expressing genes involved in a pathway, or blocking expression of competing pathways
- New products can be produced by inserting genes of interest (e.g. enzymes) into established metabolic processes

As a cell requires certain metabolic pathways for survival, increases in yields must be balanced against survival requirements

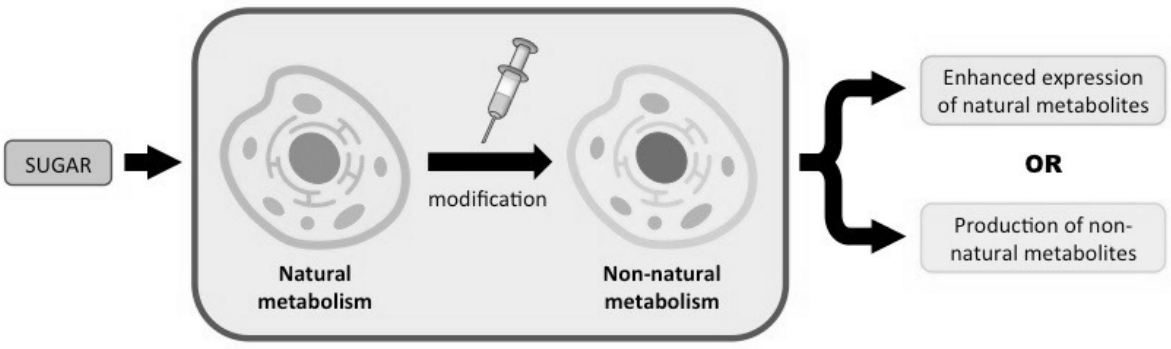


fig: Pathway Engineering

12 DOMESTICATION OF ANIMALS

INTRODUCTION :

Science of rearing, improvement and caring of domesticated animals.

ANIMAL HUSBANDRY' :

- Livestock cattle in particular are useful Indian agriculture.
- Cow, Buffaloes, goats & Sheep are domesticated for milk.
- Many animals as horse cattles, mules, asses, camels, elephants & randiers are used for transport.
- Sheep, rabbit and silkworms provide wool, fur & silk respectively.
- The first animals to be domesticated was dog and second was the goat.
- Huskies are thick coated dogs used by eskimos to draw their sledges.

Livestock -

Domesticated animals, especially the farm animals, kept for profit are collectively called **live stock.**

eg. Cattle, buffaloes, sheep, goat, pigs, horses, camel.

1. Zebu-CATTLE or COW (Bos *indicus*) and buffaloes (Bos *bubalus*)

Cattle and buffalo are most important forms of domesticated animals-they are widely used for –

a. Agriculture operations –

They are main source by pulling carts & wagons.

They are also helpful agriculture operations like ploughing, harrowing, levelling etc.

b. Milk : They provide milk which is an important food having all essential nutrients.

c. Transport : They are used in driving carts for transportation of men & materials.

d. Manure & fuel

The dung provided by them acts as a valuable manure for maintaining the fertility of soil.

It is also used for preparation of biogas.

Dung cakes provide cheap fuel.

e. Leather : Hides obtained from these animals are used for the preparation of leather goods.

f. Glue & Gelatin : Their bones, horns and hoofs yields glue & gelatin.

g. Meat : Beef & Buffalo meat are eaten by certain people.

*** Breeds of cattle -**

There is a variety of breeds of cattle & buffaloes in our country.

All of them differ in general body build, colour, forehead, form and geographical distribution.

The best cattle breeds occur in the drier region of the country. There are 26 breeds of cattle.

* The most **important breeds of milk cows** in the united states of America are **Holstein, Friesian, Jersey, Quernsey, Ayrshire, Brown swiss, Red Dane.**

* **In India the most important breeds of buffaloes are :**

Surti, Niliravi, Nagpuri (ellichpuri), Jaffrabandi, Bandawari, Murrah, Mehsana.

* Depending upon the utility, the cattle are classified into the following groups –

i. Milch breeds	ii. Draught breeds	iii. General utility breeds
(Milk producing animal)	(Used for working)	(Used for safety)

Important breeds of Indian Cattle

1. MILCH BREEDS -	**Distribution**
1. Gir	Raj, Gujrat
2. Sahiwal	Punjab, Hariyana, U.P.
3. Red Sindhi	Andhra Pardesh
4. Deoni	Andhra Pradesh

2. DRAUGHT BREEDS	**Distribution**
1. Malvi	Raj., M.P.

2.	Hallikar	Karnataka
3.	Nagori	Haryana, Delhi, U.P.
4.	Kangayam	Tamilnadu & other parts of South India

3.	**General Utility Breeds**	**Distribution**
1.	Haryana	Haryana, Punjab, M.P.
2.	Ongole	Andhra Pradesh
3.	Kankrej	Gujrat
4.	Thasparkar	Gujrat, Andhra Pradesh

***Feeding of Cattle* :**

In order to get good results cattle should be given a balanced feed containing sufficient quantities of carbohydrates, proteins, fats, vitamins minerals & water.

Feed constitutes two main components i.e., (i) Roughage (ii) Concentrate

***** Roughage contain large amount of fibre which include hay fibre and silage

* The concentrate is a mixture of cereal broken grams, rice polish, cotton seeds gram bran and oil cake moisted in water.

These are rich in protein highly palatable & digestible

In our country, paucity of food & fodder is responsible for low milk production.

Along with underfeeding & overfeeding also affect the productivity of animals.

*** Breeding of Cattle :**

Cattle breeders select & mate best type of cattle for a particular purpose.

The breeding of cattle is done by two methods

i. Natural Breeding

a.Random breeding b. Controlled breeding

ii. Artificial breeding

1. Natural breeding - It is further of two types -

a. Random Breeding -

Here some pedigree bulls are kept along with the grazing cows.

Bulls not selected for breeding are castrated and changed to bullocks.

b. Controlled breeding -

In this type of breeding native cows are crossed with superior quality of imported bulls in natural breeding.

Foreign dairy breeds like Jersey (England), Holstein, Freisian (Holland), Brown Swiss (Switzerland), Ayrshire (Scotland) have been important to give better results.

Hybrid cows require special environment & yield more milk.

Hybrid oxen is also comparatively more active & energetic.

* Some improved hybrids are jersey sindhi, Brown Swiss Sahiwal, Ayrshire Sahiwal etc.

2. **Artificial Breeding -** The introduction of semen (sperm) in the body (vagina) of females, by artificial means is called **ARTIFICIAL INSEMINATION.**

Several cows can be inseminated by semen of a single bull.

* Gestation period of cows is about 9 months & buffaloes is about 10 months.

Cows give **8-10 calves** in complete life span.

Buffalo in actual sense is called **water buffalo (Bubalus Bubalus)**.

Cow is more adapted for dry conditions.

- **Super Ovulation & Embryo Transplantation**

Supervulation is a technique where in a cow is made to ovulate more ova by injection of hormones. Lutinizing harmone (LH)

High quality cow (e.g., more milk producing) is chosen, & is given hormonal injections to induce super ovulation .

Fertilization is achieved by artificial insemination

From this cow 4 to 10 embryos are collected at a time.

Each of the embryo is transplanted into carrier cow (Surrogate mother).

* By deep freezing (- 196°C) it is possible to preserve the seven days old embryo for several years and transplanted when required.
* The embryo can be cut into two & Monozygotic twins can be obtained.
* This embryo transplantation technique can also be used for other livestocks like sheep & goat etc.
* Fertility in local breeds of cattle has been overcome through the use of pregnant mare serum gonadotropin. (LH + FSH)
* Sterile & immature cows can be induced to the lactate through **stilbesterol.**

SHEEP (Ovis Aries) - Today sheep are raised in all parts of the world.

They are reared for wool & mutton, mostly in hilly tracts.

Sheep graze on grass & herbs.

Farm waste, mineral mixture, oil cake and other cattle feeds can also be given.

High Quality soft wool **shahtoosh** is obtained from the animal chiru. (Tibbetian antelope Pantholops nodgson)

A sheep lives for about 13 years.

Breeding of Sheep :

- ✓ Sheep begin breeding at the age of about two years & then have young ones every year.

- ✓ After that sheep feed on tender grass weeds of pasture & hill side.
- ✓ To improve the quality of a sheep cross breeding experiments are usually done.
- ✓ For this purpose, a good quality wool yielding or mutton producing sheep is chosen and cross breed with exotic breed like Dorset, Horn and Merino

Breeds - Deccani & nellore breeds are raised only for mutton.

Patanwandi provides wool for army hosiery

Narwari yields coarse wool

* Four breeds yields goods wool -

(i) Rampur - Bushair (fleece for superior cloth)

(ii) Lohi (Quality wool also milk)

(iii)Bakharwal (Undercoat for shawls)

(iv)Nali (carpet wool)

GOAT (CAPRA CAPRA)

It is also called poor mans cows because it yields a small quantity of milk and feeds on a variety of wild plants even prickly ones.

Goat destroy vegetation & forests if not kept under control.

About 19% of world goat population occurs in India

Goats are reared in open sheds.

Breeding of Goats :

- The wild goat Baluchistan and sindh is the ancestral stock of all breeds of domesticated goats.
- An adult male goat is also called - billy goat or a buck and a female adult is a nanny goat or a doe.
- A goat less than a year is called ***Kid***
- The fine soft wool called **PASHMINA** is the underfur of Kashmir & Tibbet goat.
- Common breeds of goat are malabari, Berai, Bengal Marwari, Beetal, Jamunapuri, Gaddi and Kashmiri Pashmina.

Some breeds of Indian Sheep

Breed	Distribution	Use
1. Lohi	Punjab, Raj.	Milk, good quality wool.

2. Rampur-Bushair	UP, HP, Raj, Punjab, Hariyana	Superior Cloth, Brown Colour fleece
3. Nali	Hariyana, Punjab, Raj.	Superior carpet wool
4. Bhakarwal	Jammu & Kashmir	Undercoat used for high quality Shawl
5. Deccani	Karnataka	Mutton, no wool
6. Nellore	Maharastra	Mutton, no wool
7. Marwari	Gujarat	Coarse wool
8. Patanwadi	Gujarat	Wool for army hosiery

Some Goat Breeds

Breeds	Distribution
1. Gaddi	Himachal Pradesh
2. Kashmiri Pashmina	Hills of Kashmir, Tibbet, HP
3. Jamunapari	UP, MP
4. Beetal	Punjab
5. Marwari	Rajasthan
6. Besari	Maharashtra
7. Malabari	Kerla
8. Bengal	Bihar, Orissa

* **Yak** (***Poephagus grunnies***)

It is reared in high mountainous regions for meat, wool hide milk, transport.

PIG (*Sus sacrofa*)

Pig is the most economical source of meat for human beings.

Pig's meat is called PORK.

Pig's fat is used as cooking medium and for preparation of soap.

Its hide forms leather & it bristles are used for making brushes.

Pigs are susceptible to extremes of heat & cold.

The care & management of pigs is called PIGGERY.

* **Feeding of Pigs** Indigenous pigs survive through scavenging on garbage & kitchen waste & farm by products & human faeces.

Pig keepers raise them on grass. Straw roots and grains.

As they can feed on human faeces, they serve as secondary host for tape worm.

***Breeds & breeding –**

Pig breeding has now started on commercial scale. The improved exotic types, number of which is insignificant is maintained mostly at all the seven regional pig breeding stations of the country.

Domesticated indigenous pigs	Distribution
1. Deshi	UP, Bihar, Punjab, MP
2. Ghori	Manipur, Assam, Meghalaya, Arunachal Pradesh

Exotic Pigs –

1. Berkshire (UK)
2. Large white Yorkshire (UK)
3. Landrace (Switzerland & Denmark)

Elephants *Elephas maximus)

They have poor sight but sense of hearing & smell is highly developed.

African elephants have longer tusks than Asian elephants.

Elephant is the largest land animal.

* The gestation period is 21-22 months.

Puberty in elephants occurs at between 8 & 12 years

Uses -

i. Elephants are used to lift & carry logs of wood across hilly patches and dense forests.

ii. The tusks of elephants provides the precious ivory used for intricate carving by skilled craftsman.

* Elephants may live for upto 90-100 years.
* Feeding - Working elephants are fed straw hay and crushed grain as a supplement.

Daily water consumption is 140-230 litres.

***Horses (Equus equus) :**

Horse is firm footed fast runner, stout & intelligent

Initially it was used for hunting game.

later they were employed for pulling chariots transport & warfare

They are fast learners & faithful pests & able to adopt to all sorts of climatic conditions.

They are reared for racing & polo

They are also used as laboratory animals for preparing vaccines.

Horses are employed in circus too.

Horses are fed on oats barley, grams & hay

Common salt is also added to their diet.

Green grass also be given

As compared to other animals they have a low reproductive rate.

***Important breeds of Indian horses**

Name	Regions	Name	Regions
1. Kathiawari	Raj. & Gujarat	2. Marwari	Raj.
3. Zanskari	Ladakh	4. Spiti	Himachal Pradesh

5. Bhutia Punjab & Bhutan 6. Manipuri North eastern mountains

***Donkeys (equus asinus)**

***Two kinds of donkeys are found in India -**

i. Small grey ii. Large white

The wild ass of Ethiopia and Northern Africa is the ancestor of common domestic donkeys.

***Mules :**

It is a sterile hybrid between male donkey & female horse (Mule)

In difficult terrain, mule is preferred because it is sturdier & more firm than either of its parents.

A cross b/w a female donkey and a male horse (stallion) is called **HINNY**

Army uses two types of mules –

i. General service type ii. Mountain artillery type

* Mules are fed on green fodder crushed gram barely & salt

***Camel (camelus)**

Camel is used for riding, carrying loads ploughing, threshing grains pulling carts drawing water from wells.

Camels hair is used for making warm garments cords & garments cords & brushes.

Desert dwellers relish the camel's milk & meat

Camel's hide is used for making saddles

* There are two kinds of camel –

i. Arabian one humped (camelus dromedarus) ii. Bacterian, two humped (C. Bactrians)

* Disease like anthrax, pneumonia, camel pox & Surra affect camel.

Adaptation in camel (Ship of desert)

1. It can easily lives in desert in sand where lot of food & water shortage persists.
2. It can easily move on hot & slippery sand because it uses whole of foot while walking
3. On sand it can run at a speed of 25 km. per hour.
4. The camel can cover about one hundred km per day if needed
5. It can live without food & water for about 10 days continuously
6. Hump at the back of camel contains fats in the form of reserve food.
7. When shortage of water is there, camel passes very little urine (about 1/2 lit a day)

Poultry

Poultry is the word used for the birds which can be bred for economic purposes.

It includes ducks, geese, turkeys, guinea fowls, pea fowls, pigeons, gualis, etc. for their meat & eggs.

Poultry and poultry products are a rich source of animal protein & right kind of fats for

good health.

In our country poultry mainly means domestication of chickens for meat & eggs.

India stand at 6^{th} place in poultry farming in the world.

In India per capita consumption annually is only 19 eggs and 20 gm of meat.

While the nutritional advisory committee of **ICMR** (Indian council for medical research) has recommended an egg/day/ i.e. 300 eggs/ annum/ person & 180 gm meat/day/person

Poultary Farming

1. Poultry birds are easy to raise & can acclimatize to a wide range of climate condition.
2. They are prolific (highly reproductive and have short life span)
3. Their products are rich source of money Indian breeds lay 60 eggs/year in comparison to exotic breeds which lay 270 eggs/yr.

* The feed of poultry birds consists of cereals, millets oil cakes, fish & meat meal, minerals & green vegetables, fish silage, protein concentrate

Hen - Starts laying eggs at the age of 6 months

Then number of eggs produced during winter are more as compare to summer. (temp. effect)

***** The domestic fowl (gallus gallus) can be classified as –

(1) Indigenous (Desi) or Indian breeds -

Aseel, Ghagus, Karaknath, Brahma, Bursa, Black Bengal, Chittagong, Tellicherry etc.

Aseel is best game bird,it is used in cock fighting.

Poultry birds exclusively grown for meat is called **broilers** (plymoth rocks).

* Indian breeds are slow growing, less efficient converters and produce fewer eggs (60/years)

(2) Exotic Breeds - White leghorn, Red Rhode island, Plymoth rock, New Hampshire, Sussex, Barred Plymoth, Austraiorp, Minoreha etc.

HH260 lays more than 260 eggs in a year & its mortality rate is low.

The broilers (bird grown for meat), with high nutritive value have been produced by cross breeding (heterosis)

* **DUCK (Anas)**

Ducks are abundant in southern & eastern parts of India.

It has about 20 breeds.

Common Indian breeds are Indian runner, Syhlet meta, Nageshwari

The exotic breeds include campbell, Pekin, Muscori & Ayleshbury

*** Geese (Anser) -** Two common varieties are brown & white

*** Turkey (Maleagris) -** It is a recently domesticated bird.

The important breeds are British white, broad breasted bronze, Beltsiville small white Narfold

***Diseases of poultry**

1. Viral diseases : Fowl pox, Ranikhet. (New castle)
2. Bacterial diseases : Fowl cholera, Salmonellosis, Coryza
3. Fungal diseases : Aspergillosis
4. Parasitic diseases :
   i. Internal Parasites : - Round worms, tapeworms & threadworms
   ii. External Parasites : - Fowlmite, chicken mite, fleas, ticks etc.

   Majority of the hens start laying eggs from the month of February and continue this practice till August.

   Monsoon period is considered to be the most of suitable time for obtaining chicken from eggs.

Common Diseases of Poultry

Some of the commonly occurring disease of poultry are as follows –

(i) Viral Diseases of Poultry

Fowlpox, infectious bronchitis, lymphoid leucosis and ranikhet diseases are common viral diseases of poultry. Ranikhet (New castle) disease is the most common disease of hens and fowls in which the affected individuals suffer from fever and diarrhea. With the progression of this disease the birds show mucus secretion from their beaks, paralysis of wings and the birds repeatedly moving round.

(ii)Bacterial Diseases - These include fowl cholera, Pullorum, Coryza, Mycoplasmosis and Spirochaetosis.

(iii) Fungal Diseases - Aflotoxicosis, Brooder pneumonia and aspergillosis.

If any of the infectious disease has affected a mass proportion of the chicken & hens, then the best and safer decision, to avoid the fatal consequence, is to destroy the affected individuals. A poultry keeper must be aware about the common diseases so as to ensure the well being of hens and also of man.

13 SERICULTURE

The production of silk from the silk worm by rearing practices on commercial scale is called sericulture. (Sericulture is the rearing of silk worms for the production of raw silk.)

First of all the silk worm were discovered in china by LOTZU EMPRESS of KWANG Ti in 2697 B.C.

In India sericulture is an ancient industry dating back at least to the second century B.C.

In India major silk producing centers are in Assam, Bengal, Madras, Punjab, Kashmir and Karnataka

Silk production in India is 2, 969 tonnes per year

India ranks 3rd in the production of silk. Mysore (Karnataka) is the leading silk producer state.

Type of silk silkworm

a. Mulberry silkworm ***Bombyx mori*** feeds on Mulberry-Mulberry Silk

b. Tasar Silkworm (***Antherea roylei***) - which feeds on oak - Tasar silk

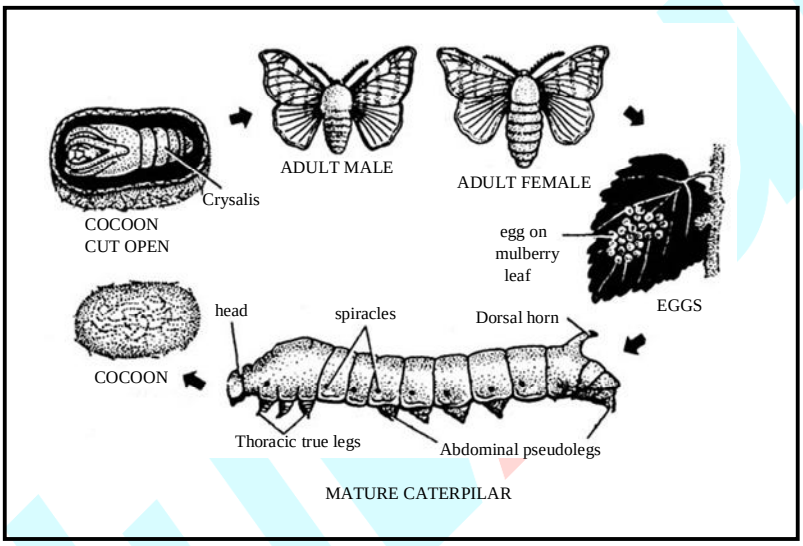
c. Eri or Arundi silkworm (***Attacus ricini***) - feeds on castor - Eri silk

d. Munga silkworm (***Antherea assama***) feeds on oak and other forest trees - Munga silk

Thiopalia religiosa feeds on machilus & focus species - Devmuga silk.

* Silk fibre is a protein produced from silk glands of silkworm.

Silk glands are modified salivary gland of the larvae of caterpillar of the insect Bombyx mori (Mulberry silk moth)



These caterpillar form a cocoon around them

The cocoon are cooked in hot water this process is called stiffing & the silk fibre is unwound from cocoons

* India is the only country in the world having all four varities of silk

*** Life history of silk worm** (*Bombyx mori*)

Adult silk worm is white creamy moth of 5 cm hairy body.

Female lays 400-500 eggs upon leaves of mulberry plants, fertilization is internal.

Hatching in summer takes about 10 days

Larva (caterpillar) has five instar after four moultings (lifespan 25-30 days)

It spines its own silken cocoon

5th instar caterpillar develops salivary glands stops feeding & secrete clear viscous fluid. The secreted fluid comes out through spinneret (a narrow pore situated hypopharynx) and takes the form of long fine thread of silk (1000-1200 metres in 3 days) which hardens on exposure to the air and wrapped around the body of the caterpillar in the form of a covering called as COCOON.

This secretion forms two cases of fibres, cemented together by **sericin** & **carotenoid** pigments.

Entire cocoon is formed within 3 days

Weight of cocoon is 1.8 to 2.2 gm

During metamorphosis of pupa (chrysalis) histolysis & histogenesis occur

Full grown pupa is called Imago.

Adult moth comes out of cocoon after 10-12 days of pupa life

Life span of adults 3-4 days only

Reeling and spinning :

The process of removing the threads from the killed coccon is called as reeling. (Post cocoon processing)

Disease of silk worm :

(1) Maggot disease : Caused by Tricholyga sorbillans (fly).

(2) Pebrine : Caused by Nosema bombycis (protozoa).

(3) Polyhedrosis : Caused by viruses.

(4) Flacherie : Caused by certains viruses and bacteria.

(5) Green muscardine : Fungal disease of silk worms.

* Central sericulture station : Berhampore (W.B.)

* Central research & training institute (Mysore)

14 APICULTURE

- ✓ The scientific method of care & management of honey bees is called APICULTURE.
- ✓ Although bees are very active throughout the year but in winter they become sluggish & are very active in spring.
- ✓ They show polymorphism & good division of work.
- ✓ The diameter of a normal bee hive is about 30-90 cm. In it the number of bees is about 50-60 thousands to one lakh.
- ✓ Bees are pollinators for sunflower, Brassica, apple & pear.

Social Organisation :

A hightly organized division of labour is found in the colony of honey bee.

Each colony has more than 40,000 to 50,000 individual consisting of 3 casts –

Important species of Honey-bees :

(i) Apis dorsata (Rock bee) - It is also named as saarang bee. It is of largest size and produces highest yield of honey. However, It is of highly aggressive nature and migratory species, which is not suitable for rearing by man.

(ii)Apis indica (Indian Mona-bee) - It lives across the whole country of India and is smaller in size than saarang-bee, it is mild in nature, so that it is easily manageable during rearing. Mona-bee yields about 3-4 kg. of honey per hive.

(iii) Apis florae (Bhringa-bee) - This bee is smallest in size and of timid nature. It only yields about 250 gms of honey every hive. Hence is not suitable for commercial purpose.

(iv) Apis mellifera (European bee) - This bee is of mild nature. It yields 9-10 times more honey than mone-bee. It is the most useful bee for commercial purpose. The Italian variety of this species is by far the most important variety.

1. Queen : - It is about 15-20 mm long and its body is about three times larger & 3 times heavier than a worker bee. The legs & wings are short but crop is long. It has ovary which is filled with eggs.

   Only one queen develops from fertilized egg (i.e., it has 32 chromosomes). It feeds on Royal jelly.

   Its sole function is - Reproduction. It lays 2000 eggs everyday. One queen lays approx. 1500000 egg in its whole life time.

2. Drones : - About 100 male bees are present in one hive. These are approx. 7-15 mm long. In these salivary and wax secreting glands strings are absent.

   Like the queen they also depend on worker bees for nutrition.

   Their sole duty to fertilize the queen. Drones are developed from unfertilized eggs so there are only 16 chromosomes present in them.

3. Worker : - Their number is maximum in a hive. These are the smallest bees. Their wings and mouth parts are very strong. Their mouth parts & legs are modified to suck the nectar of flowers and to collect the pollen grains respectively. Pollen basket is present on hind leg (tibial) for collection of pollen.

   Pocket like wax glands are present at base 2^{nd} to 5^{th} abdominal segment.

   Worker bees are sterile females. These are developed from fertilized eggs. Due to high labour the life time of a worker bee is about 6-8 weeks.

Modern method of apiculture :

Modern method of apiculture makes use of artificial bee hive. These are more convenient as these may be reused and can be shifted easily to safer place in adverse weather conditions. In addition to above, these are easy to handle and can be carred in a simple and easy manner.

Procurement and rearing of honey-bees- Male honey-bees (drones) are usually captured in the evening hours while they are swarming. After procurement, they are introduced in the brood chamber of the artificial hive. A with artificial diet containing 2/3 parts of sugar and 1/3 part water, for some days. The queen of the hive needs to be replaced by a new one

every year. The old queen is removed out of the hive. A small amount of the honey from this hive is applied on the fresh queen's body and the same is released into brood chamber. The artificial bee-hives prepared in such manner are placed in open fields or gardens or at some appropriate place.

The site where the hives are placed should be moist and clean. A good flowering crop and other plants as a source of nectar and pollen grains to the honey-bees must be available within the circumference of 1-2 kms from the hive. In the condition of overcrowding of males, some of them including a queen should be removed from that hive. A perennial source of clean water is also essential in the close vicinity of the hive. Honey bees produce honey and wax which are very useful commodities to man. They also play an important role in pollination of agricultural and horticultural fields.

*** history of honey bee**

After fertilization the queen lays about 2000/eggs/days

One egg in each broad cell

The egg hatches in about 3 days

After hatching a white larva (maggot) emerges which is fed by workers

Worker larvae are full grown after 5 days

Nurse bees - From the 4^{th} day all the worker bees provides food which consist pollen & honey to all baby bees.

From the 7^{th} day Royal jelly is secreted from the maxillary glands of worker bees, larva, pupa & queen bee are fed on this royal jelly.

Propolis is a gum like substance which is used by bees to repair the old & destructed parts.

Eggs destined to become drones are unfertilized & are laid in cells of slightly greater diameter than those of workers

The egg hatched in royal chamber is looked after by workers & fed with royal jelly so that is convert into queen.

The time required to produce a queen from egg to adult is about 15-16 days, for a worker - 4 days, and for a drone 24 days

***Nectar collection & Honey preparation**

One worker is ordered to collect 450 gms of honey, it needs 40,000 to 80,000 trips to flowers for nectar & pollen

Nectar is a sugary substance in the flowers.

Nector is stored in the crop

Sucrose is acted upon by the enzymes present in the saliva & changed into glucose levulose & fryctose

The hydrolised nectar is regurgitated by the workers & is stored in the storage cells of bee hive.

Extra amount of water is evaporated by the fanners

This concentrated product is called Honey

Communication by dance : -

Those bees which go out for search of food have highly developed visual & taste sense for correct recognition of route. Bees recognized their route with the help of position of sun & smell of flowers.

Bees communicate with each other so that all other members also find the food source

Ernst spytzner 1788 explains that honey bees have a definite kind of communication medium. This special type of speed is called "Dance of honeybee."

After that Karl Von Frish 1969 also explains the "Dance of honeybee" and he got noble prize for that.

The following type of dances can be seen in honey bees.

1. **Round Dance : -** This dance indicates that the food source is about less than 75 m from a hive. The direction of food source can be identify with the help of smell of flowers which is present on the body of a scout honey bee.
2. **Tail wagging Dance : -** With the help of this dance bees give the information of that food source at a very far distance. In it direction & distance of food source are indicated according to the position of sun. When the honey bee is flying in a straight line it is wagging its tail and wings to produce the sound.

Distance of a food source can be identified with the help of speed of dance, speed of wagging tail & speed of sound.

if the motion is in upper side of a straight line with wagging tail then food source will in the same direction of sun.

If the motion is in lower side of a straight line then food source will be in opposite direction of sun.

Honey - It is an aromatic viscid, sweet material consists of 17% water, sugar protein, minerals vitamins etc.

Its specific gravity is 1.45 to 1.48

i. Water	- 17-20%	ii.	Fructose	-	40-45%
iii. Glucose	- 32-37%	iv.	Sucrose	-	12%
v. Enzymes & pigments	- 2.21%	vi.	Ash	-	1%
vii. Vitamins	- B, B_6, C & D				

Bee wax - It is very useful by product of bee keeping industry

It is obtained from bee hives

This is a secretion of workers bees abdominal glands

It is prepared from a plant substance (pollen) called 'PROPOLIS'

The propolis gives the wax a hardly nature

***LAC CULTURE** Lac is resinous secretion of last segment of Laccifer (Tachardia) lacca or Lac insect

- The insect is parasite lives and breeds on the following host plants

i. Kusum - ***Schleichera oleosa*** ii. Babul -***Acacia nilotica***

iii. Ber - ***Zizyphus mouritanas*** iv. Palas - ***Butea monosperma***

v. Peepal - ***Ficus religiosa*** vi. Mango - ***Mangifera indica***

vii. Sal - ***Shorea robusta*** viii. Fig - ***Ficus carica***

Lac Insect : - They secrete a gum like substance which covered them from all the sides & after that a 1-2 inch thick layer is formed around the branches.

Branches of trees are cut down and then dipped into hot water so that the gummy substance can be separated. It is done for the preparation of Lac.

Now some chemical are also added to prepare the lac which is available in markets.

* In India the largest lac producing state is BIHAR, followed by MP, West Bengal & Maharastra

India produces 75% of the total world production

The lac is a secretory product of lac glands

The secretion covers the body of insect

Lac is used in printing industry, preparation of gramophone records, electrical applicances, in varnish, polish bangles cosmetics lacwax & lacdye

Salient Features of Lac Insect

Lac insect has separate male and female individual which exhibit sexual dimorphism. Males are 1.2-1.5 mm in length and have red coloured body. Males are smaller than females which measure about 5 mm in length. Female posseses delicate body which is oval in shape. Head, thorax, and abdominal regions in a female are not very much distinct. Further, the females are devoid of wings and have a bright red body, It lives in a chamber made of resin.

A female insect lays about 200-250 eggs in its resin chamber. After 6 weeks of egg laying, a first instar larva is hatched out of the each egg. It is also called **nymph.** These nymphs are active individuals, and eventually escape out from the resin chamber. Now these gather on the small twigs of succulent plants. The dermal glands present in the body of nymph secrete lac which dries after its contact with the air. Nymphs continuously derive their nutrition in the form of sap from the succulent plants. After 6-8 months of stable form the nymphs undergo metamorphosis. Now they develop into wingless females (about 70% if

total nymphs) and winged males (about 30% of total nymphs). A lac insect, living on a single host plant, repeates it life cycle twice, one during October-November, and the other during June-July every year.

Lac insect sucks the plant sap by introducing its mouth parts into plant tissue. The quality of lac depends on the nature of host plant. The best quality of lac obtained by the lac insect which have been reared on ber and palas plants. This lac is named as Kusumic lac.

Lac Cultivation

Lac is cultivated by both the methods, viz., natural and artificial methods. However, the artificial method is considered to be more developed and reliable method. In artificial propagation, small twigs of the host plant are tied with the host plant, in a way that the twigs touch the later at many places. This facilitates easy entry of nymphs into another host through swarming. After the propagation, the lac secreted by the insects is obtained at adequate time. This is known as harvesting. The lac produced before swarming is called immature lac or **ari lac,** while that produced after swarming is called **mature lac.**

The lac initially collected is called seed lac which after purification gives button lac. **Kiri lac** is the lac with many impurities. (Obtained from *Keria lacca*)

In India about 2 crores kg of lac is produced every year, which is more than 6% of the total world production.Of the total production of India, 50% is contributed by the Chhota Nagpur region of Bihar. Lac is a very useful material which is used for manufacturing bangels, utensils, toys, polish, varnish and for electrical goods. Ladies in India use lace in colouring material, mahawar, as a cosmetic to make up their feet. Indian Lac Research Institiute, Namkum (Ranchi) engaged in the research and extension programmes to promote and improve the lac culture in India.

*** Composition of Lac**

1.	Resin	-	68-90%	2.	Dye	-	2-10%
3.	Wax	-	6%	4.	Albuminous matter (Glue)	-	5-10%
5.	Sugar	-	4%	6.	Water	-	3%

15 FISHERIES

- Fishes & Other aquatic animals are reared and caught for food which is rich in protein vit A & D
- Pisciculture is rearing catching & management of fishes.
- Culture fishery is the raising of fishes in tanks & ponds.
- Capture fishery is management of catching of fish without actually raising them.
- The per capita consumption of fish in India is estimated at 1.52 kg/yr.

- India is at present the 6th formost sea food producing nations in the world. Blue Revolution is an effort to increase fish yield in India.

* **Cultivable sps. of fresh water fishes -**

* **Indogenous sps***

1. ***Labeo rohita*** (Rohu) - most common carp
2. ***Labeo calbasu*** (Calbasu)
3. ***Catla catla*** (Catla)
4. ***Wallage attu*** (Malli)
5. ***Clarias betrachus*** (Magar)
6. ***Mystus singhala*** (Singhara)
7. ***Heteropneustes heteropneusts*** (Singhi)
8. Channa (Murrels)

***Exotic sps.**

Cyprinus carpio (Common carp)

Ctenopharyngodon idella (grass carp)

Hypopthalmicthys molitrix (Chinese carp/silver carp)

Osphronemus goramy (gaurami)

Tilapia mossambica

***Marine fishes -**

1. Hilsa (Hilsa) - Coastal India
2. Aluitheronema (Salmon) - East & west coast
3. Sardinella (Sardine) - West & South coast
4. Harpodon (Bombay duck) - Coastal Maharashtra
5. Stomaleous (Pomphret) - Indopacific coast
6. Anguilla (Eell), Mackerel
7. Chanos chanos (Milk fish)
8. Mugil (grey mullet)

* For efficient utilization of different type of food in the pond it is necessary to cultivate 2 or 3 types of fishes together.

  This is called composite or mixed farming.

* The major carps catla, rohu & Mrigal form a satisfactory combination in the ratio of 3 : 3 : 4.

  Selection of cultivable fish species is an important aspect of fish culture. Culturable fishes should have a high food value (both in quantity and quality), high reproductive and growth rates, higher disease resistance capacity, tolerance against the environmental fluctuations,

an easy acceptance towards natural and artificial food and should be well compatible to the other fishes present in the pond or the aquatic habitat.

The above criteria are fulfilled only by a few species of fishes, which are called as **major carps.** Therefore, the culture of these fishes are practiced in India at a large scale. At present three main species of the indigenous carps in India are included as the category of major carps. The three species are - **Labio rohita, Catle catla** and **Cirrhinus mrigala.** These species along with certain exotic carp species are cultured together in a fish pond. This technique is called composite fish culture. An appropriate ratio among the individuals of various species is observes at the time of stocking the pond with fishes.

Important Steps of Fish culture

The major steps followed in the fish culture practice are briefly described in following lines –

(i) In the beginning of the culture programme, a suitable site for the establishment of a fish farm, is selected in accordance to the standard criteria a number of ponds of different types are then constructed and a dependable source of water is ensured to supply water into the nursery ponds, rearing or raising ponds and stocking ponds. The size, shape and depth of water in these ponds differ from each other.

(ii) Fishery ponds are usually Treated with lime to maintain an appropriate pH of pond water, Organic and inorganic manure and fertilizer and supplied in the pond encourage the growth of planktons and other organisms that serve as nerve as natural food for fishes (this is called fertilization of pond). It is quite essential to remove the harmful aquatic weeds, predatory fishes and the harmful insects from the pond before introducing fish seed into the pond.

(iii) Fish seed is procured from the natural breeding places of fishes or may be collected from rivers during monsoon season.

(iv) In order to obtain pure seed of the desirable fish species, healthy males and females of a superior fish species are selected. These are then induced to breed artificially by **(Hypophysation)** giving in them the injections of pituitary extract (containing FSH or LH) or of a synthetic hormone like human chorionic gonadotropins (HCG). This stimulates females for spawning and the males to emit milt (containing sperms) on the ova to fertilize them.

(v) The fertilized eggs from the breeding pond are collected and transferred into hatcheries or hatching pits where they hatch to give rise to small **hatchlings** or **sac fry.**

(vi) The Juvenile sac fry are now transferred from the hatcheries into **nursery ponds,** where they develop into **fry.** These fry by feeding on zooplanktons and phytoplanktons, present

in nursery ponds, grow in size and change into fingerlings. Fry are also fed by artificial food.

(vii) The fingerlings in next step, are transferred into **rearing** or **raising ponds** (this is called thinning), where they feed on both natural and artificial food. In rearing ponds, the fingerlings grow upto a size of 15-20 cm long. Now these are transferred into **stocking ponds.**

(viii) In the stocking pond the fingerlings soon become adult an attain table size (edible size) in about 6-9 months. These are given adequate food in these ponds and due care is given to protect them from diseases and other hazardous agents.

(ix) When the fish in pond have attained a suitable table size, the fishes are captured by using fish gears like hooks and lines, drag net, gill net, cast nest. This is called **harvesting.** These fishes are then taken to landing centres from where they are disposed off by selling into market.

Our country has sufficient water resources including thousands of the ponds in rural areas, These ponds may be used for fish culture together with the piggery, duck rearing, goat which this along providing embploment to rural people, may be an additional source of income. (Integrated fish culture)

Certain premier institues in India viz., Central Inland Capture Fisheries Research Institute (CICFRI), Barrackpore (W.B) ; Central Marine Fisheries Research institute (CMFRI), Kochi (Kerala) ; Central Institute of Fresh water Aquaculture (CIFA), Bhubaneshwar (Orissa) and many other institutes, are continuously engaged in the research and extension studies in the field of fisheries to make it more beneficial.

By-Product of fishing industry : -

1. **Isin glass** - It is a high grade collagen produced from air bladder or swim bladder of certain fishes like cat fishes & carps. The isin glass prepared in Russia is of best quality.
2. **Fish oil -** Dry oil is obtained from Salmon & Hersing.

- Semi dry oil from carps. Liver oil contains vit. A, D, E & C.

3. **Fish meal -** It is prepared from wastes of fish oil. Wastes of cod industry is called "White fish meal".

   It contains Calcium (5.36%) phospholipids (3.42%) and iodene. For younger animals it has proved to be a good nutritive diet.

4. **Fish protein -** Used in preparation of ice cream, pharmaceuticals, paints, varnishes, textile, paper and cosmetics.
5. **Fish flour** - It is highly nutritive food and prepared by solvent extraction process easily digested by infants of 3-4 months.

6. **Fish skin :-** of some like shark & rays are used for covering card cases, jewel boxes, scabboards etc. The skin of cod salmon and other fishes are also tanned and converted into leather.

16 ANIMAL BREEDING

Animal breeding aims at improving the genotypes of animals to make them more useful to us. The chief objectives of animal breeding may be summarised as follows : (i) improved growth rate. (ii) increased production of milk, meat, egg, wool, etc. (iii) superior quality of resistance to various diseases. (v) increased productive life, and (vi) increased or, at least, acceptable reproduction rate, etc. Avariety of strategies have been used for breeding of animals. The main approaches for animal breeding, viz., inbreeding out-crossing and interspecific hybridization, are briefly described below, based mainly on the breeding work with cattle.

Inbreeding: -

All domesticated animals have male and female individuals. As a result, they are strictly cross-fertilised, and highly heterozygous. Each domesticated animal species consists of several distinct breeds that differ from each other in several morphological and other features. You are familiar with the important breeds of cows, buffaloes, poultry, etc. Animals belonging to a single breed differ from each other in genotype because of the mode of their reproduction and their heterozygous nature. Therefore, mating between animals of the same breed provides opportunities for genetic improvement

The breeding strategy based on inbreeding is as follows. Superior cows and superior bulls of the same breed are identified and mated in pairs. The grogeny obtained from such mating are evaluated and superior males and females are identified for further mating. A **superior female,** in the case of cattle, is the cow that produces more milk or lactation . on the other hand, a **superior male** is that bull, which gives rise to superior progeny as compared to those of other males. **Inbreeding, as a rule, increases homozygosity**.

Advantage : Inbreeding exposes harmful recessive genes that eliminated by selection. It also helps in a accumulation of superior genes and elimination of less desirable genes. Therefore, this approach increases the productivity of inbred population. Practically every breed was developed by some type of inbreeding.

Disadvantage : But continued inbreeding, especially close inbreeding, usually reduces fertility and even productivity **(inbreeding depression).** Whenever this becomes a problem the selected animals of the breeding population should be mated with such superior animals of the same breed that are unrelated to those in the breeding population.

Cross-breding : -

In this strategy, superior males of one breed are mated with superior females of another breed. Cross-breeding allows the desirable qualities of two different breeds to be combined in a single breed. The progeny animals may themselves be used as hybrids for commercial production. Alternatively, they may be subjected to some form of inbreeding and selection to develop new stable breeds that may be superior to the existing breeds. Many new animal breeds have been developed by this approach.

Progeny produced through cross-breeding may be mated according to various schemes to achieve specific objectives. For examples, cows of an inferior breed may be mated to bulls of a superior breed. In each successive generation, the progeny cows are mated to the bulls of the same superior breed that was used in the original cross. Thus, in 6-7 generations, the progeny will be almost similar to the breed of bulls used for the mating. But these progeny would retain some original advantageous conditions, etc., of the other breed from which the cows were used in the original mating.

Interspecific Hybridisation : -

In this strategy, male and female animals of two different species are mated. The progeny obtained from such a mating are usually different from both the parental species. In some cases, the progeny may combine desirable feature of both the parents, and may be of considerable economic value. An example of this type is **mule,** which is produced from a cross between female horse (mare) and male donkey. Mules are sturdier and hardier than their parental species, that are well suited for hard work in difficult terrains like mountainous regions

17 ANIMAL DISEASES AND THEIR CONTROL

Domesticated animals suffer from a variety of disease. In animals, **disease** may be defined as a state of discomfort associated with an abnormal function of the animal body. Diseases may be caused by mutant genes **(genetic diseases).** Improper nutrition or pathogens. Genetically diseased animals are strictly excluded during animal breeding. Generally, animals are raised on properly balanced diets to avoid nutritional disorders and to ensure optimum performance. Domesticated animals suffer from diseases caused by (a) viruses, (b) bacteria (c) protozoa, (d) fungi and (e) animals, like worms. Such diseases are commonly known as **infectious diseases** because they are caused by pathogenic infections. Many of the infectious diseases are known as **contagious diseases** since they spread to healthy animals by contact with diseased animals, or with the materials that were in direct contact with the diseased animals. Some of the infectious diseases may spread to humans from the animals, e.g., anthrax.

Infections can occur through skin. Digestive tract, respiratory tract, conjunctiva, urogenital tract, placenta,, umbillcus and egg. It is a good policy to implement measures for the prevention of infectious diseases, some of which of which are as follows.

(i) Isolation of animals suffering from or suspected to be infected with an infectious disease :

(ii) Proper disposal of the waste and all materials that were in contact with the diseased animal.

(iii) Proper cleaning and disinfection of the animal house and other materials that were in contact with diseased animal.

(iv) Transfer of healthy animals to a pasture other than that used by diseased animals.

(v) Vaccination of animals.

(vi) Injection of antiserum into healthy animals whenever an epidemic is expected.

(vii) The authorities of the veterinary department should be immediately informed of cases of infectious diseases. This will allow them to initiate measures to prevent the spread of these disease.

BACTERIAL DISEASES

Animal suffer from several bacterial disease. For example, cattle suffer from anthrax. Mastitis, pneumonia, etc.

ANTHRAX :

Anthrax is caused by the bacterium, Bacillus anthracis. This disease is contagious and affects cattle, buffaloes, horse, sheep and goats ; it can also spread to human beings. In animals, anthrax spreads through contaminated feed, water and pastures.

Symptoms and diagnosis : -

In very acute cases, there is increased respiration, and blood-mixed foamy discharge from mouth, nose and anus. In such cases, the infected animals may die within minutes. But in subacute and chronic cases, the infected animals have high fever (up to 41.1°C), and increased pulse and respiration rates. There is discharge of black, shiny and foamy material from natural openings of animals. The infected animals die within 2 to 3 days. The anthrax bacterium uses up the oxygen carried by the animal blood. As a result, the animals die due to a lack of oxygen.

Disease diagnosis can be confirmed by microscopic observation of the bacterium in the blood of patients, or by culturing the bacterium present in the blood on a suitable medium.

Treatment : -

In the case of human beings a suitable antibiotic like ciprofloxacin is quite effective, particularly if used in the initial stages of the disease. But in cattle, ciprofloxacin may be effective only in chronic cases. Streptopenicillin, sulphonamide, orytetracycline &

Anthrax antiserum can also be used with good results. In any case, antiserum should be given to all healthy animals to protect them from the disease.

Prevention and control : -

The general measures for prevention of infectious diseases should be followed. The healthy animals should be vaccinated. Animals that have come in contact with diseased animals should be given antrax antiserum to protect them from the disease.

VIRAL DISEASES

Animals suffer from a variety of viral diseases. For example, cattle suffer from rinderpest, foot and mouth disease, cowpox, etc.

RINDERPEST :

This diseases is caused by a virus and is highly contagious. The virus is present in all the fluids and secretions from the body of diseased animals. The disease spreads rapidly by direct contact with patient animals, through contaminated feed, water, worker and their clothes, and by flies.

Symptoms : -

Initially, the infected animal developes fever (40.0 to 42.4°C), loses appetite, develops constipation, and passes hard faeces that often are covered with blood. In the final stages of the disease, animal suffers from loose motions, and gives off offensive odour. The body temperature declines and may go down below normal. The animal usually dies in about 7 days.

Treatment : -

Treatment is effective only when it is started in the initial stages of the diseases. Injections of sulphamethazine sodium is often effective. Injection of rinderpest antiserum is highly effective, especially when combines with injection of sulphamethazine sodium.

Prevention : -

All the measures for prevention of infectious diseases should be implemented. It is highly desirable to vaccinate The animals against rinderpest. In 1954, a massive vaccinagtion programme was initiated in India. This project has been highly successful, and rinderpest is not longer a dreaded disease.

Foot and Mouth Disease (F.M.D) or Apthous Fever

It is a fast spreading disease of ruminants and artiodactyla. It usually infects tetrapods viz., cow, buffalo, sheep, goat, pig etc. Although it is not a fatal disease, the milk and wool production and working capacity of the infected animals is reduced substantially. Therefore this disease is of economic importance. India suffers a great economic loss to this diseases every year.

This disease is caused by the infection of Picorna virus group. Transmission of disease is mainly by contact with infected food and water. Air infected with this virus can also spread the disease. The viruses may survive even upto two year after the infected animals has been cured.

Symptoms –

Initially there is high fever (104°F – 106°F) for 1-2 days the animal stops feeding and ruminating and becomes lethargic. The infected animal suffers from stomatitis, drooping, salivation, vesicles appear on mouth, tongue, gums, feet and teats. The tongue of the animal drops out and the animal may suffer from mastitis and abortion. The infected animal may die of heart failure. The disease is more dangerous in young cows.

Diagnosis –

The diseases is diagnosed by testing the vesicles and their secretion.

Treatment –

There is no specific treatment of FMD. The vesicles are washed with potassium permagnate solution to prevent secondary infection. After washing some antibacterial powder an ointment is applied on wounds. During this time the infected animal should be fed on soft food. Treating the infected (diseased) animal with antipyretics and antibiotics viz. Tetracycline injection etc. is beneficial.

Preventive Measures –

Healthy animals should be kept away from the infected animals. The calf should not be given the milk of infected cow. Calves should be vaccinated when they are four month old and later on booster doses should be given after consultion with doctor.

DISEASE CAUSED BY PARASITIC ANIMALS

Animals are attacked by a number of parasitic animals, e.g., tapeworm, round worm, flukes, ticks etc. These parasites are mainly of two types : (i) ectoparasites, and (ii) endoparasites. **Ectoparasites** live on the skin, e.g., ticks, while **endoparasites** live witin the animals body e.g., round worm, tape worms, liver flukes, etc. Both types of parasites feed on animal fluids like blood, and interfere with their normal growth and development. Many parasites transmit pathogens and , thereby, help in the spread of the concerned diseases. Some of these parasites, e.g. , tapeworm. Also infect human beings.

Ascaris is an endoparasitic nematode that infects many animals, including humans. Ascaris larvae enter animal body through mouth along with contaminated feed. The larve enter into the intestine tissue, and migrate to liver. Lungs, spleen, pharynx, and kidneys, and re-enter the alimentary canal via oesophagus.They caused damage to all those organs through which they pass during their migratory phase. By the time the larvae reach intestine again, they develop into adult male and female individuals. The adult nematodes

cause wounds. In the intestine and interfere with animal digestion. The affected animals may show symptoms like constipation, diarrhoea and anaemia. In severe cases, the animal may even die.

The female adult of Ascaris lays numerous eggs. Which pass out along with the animal faeces. The eggs, in due course of time, hatch into larvae, which remin associated with grass. Then cattle feed on these grass, the larvae enter alimentary canals of these animals.

Treatment : -

Treatment of Ascaris is based on administration of specific medicines, such as piperax, piperazine, adipate, wormex, etc.

DISEASES CAUSED BY PROTOZOA

Several diseases of animals are caused by protozoan parasites. Examples of such diseases are tick fever, coccidiosis etc.

Tick fever :

This disease is caused by several species of Babesia, a protozoan parasite, which is spread by ticks. In India tick fever In caused mainly by Babesia bigemina. The parasite enters into red blood cells (RBCs) and destroys them.

Symptoms : -

In the acute form of this diseases, animals develops high fever (41.41.7°C) and stop feeding. But in the chronic form of tick fever, there is irregular fever, and constipation followed by diarrhoea. A clear diagnostic feature of the disease is the presence of pear-shaped protpzoan parasite within the RBCs.

Treatment : -

The infected animals are administered suitable medication, e.g., injection of trypan blue, acaprin, or berenil. A single injection of berenil is ordinarily sufficient to cure the animal. In addition, sanitation measures and a suitable insectide treatment are implemented to eradicate the ticks.

Prevention and control : -

Tick fever can be prevented by effectively controlling the ticks. Insecticide treatments are used to eradicated ticks from animals.

Diseases Caused by Fungi

Several types of diseases in animals and birds are caused by different species of fungi. Aflatoxicosis or Mycotoxicosis is one such disease.

Aflatoxicosis

This is a fungal disease which occurs due to feeding on food infected with fungus. Scientists believe that these fungi produce a toxic substance aflotoxicosis. Therefore the disease which arises due to these toxins is called aflatoxicosis mycotoxicosis.

Toxic substance aflatoxin, is produced by Aspergillus flavus and some other species of Aspergillus. These toxins are insoluble in water and are not affected by heat (heat resistant).

Aflatoxin is rapidly formed by fungi in groundnuts, cotton seeds and in some other grains. Infection of fungi occurs by a sudden change in humidity and due to rain.

Symptoms –

Animals suffering from this disease below loss of appetite, decreased, growth, bloody stool, anaemia, lazyness and blindness. Animals move around themselves and develop mental disorders, hydrocoel, ascites etc. A higher death rate is seen in the affected animals.

Diagnosis –

The disease can be diagnosed by microscopic examination of the fungus.

Treatment –

To detoxify aflatoxin, antifungal agents like propionic acid, calcium propionate should be mixed in food and the grain should be kept in sun for 2-3 days. The diseased animal should be given liver tonic, protein and methionine.