

## STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

- Rapid increase of world population has compelled us to adopt new strategies for enhancement of food production in order to fulfill demand of increasing population.
- **Animal husbandry** and **plant breeding** are two major aspects of increasing production of food.
- Besides these, new techniques such as **embryo transfer technology** and **tissue culture** are also of great importance to increase food production.
- **Animal husbandry** is the science of rearing, feeding, caring, breeding and utilization of domesticated animals.
- Domesticated animals which are raised for food, work or profit are collectively called **livestocks** like buffaloes, cows, pigs, horses, cattle, sheep, camels, goats, etc. It also includes poultry farming and fisheries.

### ANIMAL BREEDING

- Animal breeding aims at increasing the yield of animals and improving the desirable qualities of the produce. It is done by two methods : **natural** and **artificial**.

#### Natural breeding

- **Natural breeding** is a type of breeding that occurs naturally among animals. It is of two types : Inbreeding and outbreeding.
  - (i) **Inbreeding**: Inbreeding refers to the mating of more closely related individuals within the same breed for 4 - 6 generations. Inbreeding increases **homozygosity**, so it is necessary for evolving a **pureline** in any animal. Continued inbreeding, usually reduces fertility and even productivity. This condition is called **inbreeding depression**.
  - (ii) **Outbreeding**: Outbreeding is the breeding of the unrelated animals which may be between individuals of the same breed but no common ancestors, or between different breeds or different species. So, outbreeding is of following three types :
    - (a) **Outcrossing** : Outcrossing involves mating between unrelated members of the same breed which have no common ancestors on either sides of their pedigree upto 4 - 6 generations.
    - (b) **Cross breeding** : Cross breeding is the method of breeding superior males of one breed with superior females of another breed. It allows the desirable qualities of two different breeds to be combined. *E.g.*, *Hisardale* is a new breed of sheep developed in Punjab by crossing Bikaneri cows and Marino rams.
    - (c) **Interspecific hybridisation** : Mating between members of two different species produces interspecific hybrids. Interspecific hybridisation is performed only when the sterile hybrid is far superior to either of the parents.

#### Artificial breeding

- **Artificial breeding** is a controlled breeding method done by **artificial insemination**. Artificial insemination involves inseminating the native cows with the semen of superior bulls of exotic or indigenous breeds.

### DAIRY FARM MANAGEMENT

- **Farm management** is the controlled and scientific handling of farm animals in their rearing, grooming, breeding and caring so as to maximise their yield.
- **Dairying or dairy farm management** is one for the upkeep of dairy animals, extraction of milk and preparation of various milk products like cheese, butter, curd, etc.

#### Cattle

- The word cattle includes cow (adult female), bull (uncastrated adult male), bullock or ox (castrated adult male) and steer (young castrated male).
- **Cow** is raised for milk. **Bullocks** have been used in agricultural operations and drawing carts.
- There are 26 Indian breeds of cattle. The cattle breeds are classified into three groups:
  - (i) **Milch breeds** : The cows of these breeds are good milk producing, however, bullocks are of poor quality.
  - (ii) **Drought breeds** : The bullocks of these breeds are good for working but cows are poor milk producers.
  - (iii) **General utility breeds (Dual-purpose breeds)** : The cows of these breeds are good milk producers and the bullocks are good drought animals. They are intermediate between milch and drought breeds.
- The family of domestic cattle is **bovidae**. There are two main groups of bovidae (domestic cattle) *e.g.*, (i) *Bos indicus* are found in India and Africa. They are also called Zebu cattle or humped cattle. (ii) *Bos taurus* are found in Europe and North America and are non humped cattle.
- Some breeds of Indian cattle are, Gir, Sahiwal, Red Sindhi, Nagori, Hallikar and Kanjrej.
- **Exotic breeds** are foreign breeds of animals which are introduced in the country and require special environment, *e.g.*, Friesian - Holstein (Holland), Brown Swiss (Switzerland) and Jersey. They have been hybridized with Indian cows to develop locally acclimatized high performance cattle, *e.g.*, Karan swiss, Sunandini, Jersey-Sindhi, Brown Swiss-Sahiwal, Ayrshire-Sahiwal.
- **National Dairy Research Institute** is situated at Karnal in Haryana. It is involved in production of new breeds of cattle, *e.g.*, Karan-Swiss, Karan Fries, etc.
- For breeding purpose, the best local cows with a good milk yield should be mated with a pure exotic bull which should have high genetic potential.
- **Artificial insemination was first introduced in India at Indian Veterinary Research Institute, Izatnagar, near Bareilly, Uttar Pradesh.**
- Superovulation (more ova and hence more embryos), embryo transplantation and surrogate mothers also help to improve breeds. Deep freezing ( $-190^{\circ}\text{C}$ ) is used for keeping seven day old embryos for several years. They can be transplanted when required.
- Infertility in local breeds of cattle has been overcome through the use of pregnant mare serum **gonadotropin**.

Sterile and immature cows can be induced to lactate through **stilbesterol**.

- Rinderpest, foot and mouth diseases, anthrax, black quarter, mastitis (inflammation of udder), tympanitis (distension of rumen with gases) and haemorrhagic septicemia are some common diseases affecting cattle.
- Zebu cattle provides us milk, manure, fuel, leather, bone meal, meat and is also used for agricultural operations and transport.

### Indian buffaloes

- Indian buffalo (*Bubalus bubalis*) is a subgenus of the genus *Bos* and is a descendent of the wild species (*Bubalus arnee*) of mainland Asia.
- Buffalo population in India is about 83.5 million (1992 census). It is raised for milk. Buffalo bull is used for agricultural operations and driving carts.
- Buffalo is better than cow in many respects –
  - The average annual milk yield of a buffalo is 491 litres as against 173 litres of a cow in India.
  - Buffalo's milk has about 50% more fat content than cow's milk.
  - Buffalo milk also has higher mineral contents than cow's milk.
- There are seven breeds of buffaloes in India. The best known breeds of Indian buffaloes are the Murrah (Punjab, Haryana, U.P.), Jaffrabadi (Gujarat), Nili (Punjab, Haryana), Bhadawari (U.P., M.P.), Surti (Rajasthan, Gujarat), Mehsana (Gujarat) and Nagpuri (central and south India).

### Sheep

- Sheep (*Ovis aries*) are reared for wool and mutton, mostly in hilly tracts.
- **Deccani** and **Nellore** breeds are raised only for mutton. **Patanwadi** provides wool for army hosiery while **Marwari** yields coarse wool.
- **Nellore breed** (Andhra Pradesh) is tallest breed of sheep in India.
- Four breeds yield good wool : Rampur - Bushari (long course wool), Lohi (good quality wool, also milk), Bhakarwal (undercoat for shawls) and Nali (superior carpet wool).
- Exotic breeds include Merino (Spain), Dorset horn (England), Suffolk (England) and Corriedale (New Zealand). They have been crossed with Indian breeds to improve the quality of the latter.
- Sheep farming is more economical than raising other kinds of livestock because :
  - Sheep do not need special care and facilities.
  - Sheep give 4 products : milk, wool, skin and lambs.
  - Sheep are excellent weed destroyers.
  - Sheep droppings form excellent manure.

– The structure of their lips helps them to clean grains lost at harvest time and thus convert waste feed into profitable products.

- Haemorrhagic septicaemia, foot and mouth diseases, sheep pox, rinderpest, fascioliasis and coccidiosis are some important diseases affecting sheep.

### Goat

- Goat (*Capra capra* = *C. hircus*) is called **poor-man's cow**. It yields a small quantity of milk. However, the milk carries protein lactoperoxide which is effective against a number of disease causing bacteria. Goat milk is commonly called **Chevon** and usually low in fat.
- **Pashmina** is very fine fibre obtained from Kashmiri goats, commonly used for making famous Pashmina shawls.
- **Common breeds of goats** are – **Malabari** (Kerala), **Berari** (Maharashtra), **Marwari** (Rajasthan), **Beetal** (Punjab), **Jamunapuri** (U.P., M.P.), **Gaddi** and **Chamba** (Himachal Pradesh), and **Kashmiri** and **Pashmina** (Himachal Pradesh, Kashmir and Tibet).
- **Alpine** (Alps), **Toggenberg** and **Saanen** (Switzerland), **Angora** (Turkey) are some exotic breeds of goats.
- **Anglo-Nubian breed** produced by the cross of **Nubian of Egypt** and **Jamunapuri** from India is called the **Jersey cow of goat world**. It provides both milk and meat.
- The government of India has set up **Central Institute for Research** on goats at Makhdoon near Mathura in U.P.
- Goats suffer from some contagious diseases such as goat pox, pleuropneumonia and foot and mouth diseases.

### Poultry

- Poultry is rearing of domesticated fowls (chickens), ducks, geese, turkeys, guinea fowls and pigeons, etc., but it is more often used for fowls.
- Domestic fowl (*Gallus domesticus*) constitutes the major poultry bird.
- Poultry birds exclusively grown for meat are called **broilers** (e.g., plymouth rock), **layers** are for egg production, **cockerells** are young male fowls and **roosters** are mature male fowls.
- Breeds of fowls are –
  - **Indigenous breeds** : Chittagong, Aseel, Bursa, Danki, Tellicherry, Karaknath, etc. Aseel is one of the best table bird but it cannot be raised on commercial purpose because of its poor growth and low fertility.
  - **American breeds** : Polymouth Rock (most popular breed of USA), Wyandotte, Rhode Island Red, New Hampshire.
  - **Asiatic breeds** : Brahma, Langshan, Cochin.
  - **English breeds** : Sussex, Orpington, Australorp, Cornish, Dorking, Red Cap.
  - **Mediterranean breeds** : Leghorn, Minorca, Ancona, Spanish, Andalusian and Buttercup.

- Some important poultry diseases are
  - **Ranikhet disease** (viral disease) : Respiratory disorder characterized by coughing and sneezing.
  - **Marck's disease** (viral disease): Characterized by paralysis in young ones.
  - **Birdflu** (avian influenza) : Caused by H5N1 virus.
  - **Infectious coryza** : Caused by *Haemophilus gallinarum* and is characterised by discharge from nostrils and eyes.
  - **Pollorum disease** : Caused by *Salmonella polorum*. The heart, spleen, liver, kidney, lung and digestive tract are affected.

## FISHERIES

- **Fishery** is a kind of industry which is concerned with the catching, processing or selling of fish, shellfish (prawns and molluscs) or other aquatic animals such as crabs, lobster, edible oyster, etc.
- **Aquaculture** is rearing and management of useful aquatic plants and animals like fishes, oysters, mussels, prawns, etc.
- **Pisciculture** is rearing, catching and management of edible fish.
- There are two main types of fisheries : Inland fisheries and marine fisheries.
- **Inland fishery** is the rearing of fish in freshwater. Important products of inland fisheries are fresh water prawns (*Palaeomon*, *Macrobrachium*) and fish like *Labeo rohita* (rohu), *Labeo calbasu* (calbasu), *Catla catla* (catla), *Wallago attu* (malli), *Clarias batrachus* (magur), *Mystus singhala* (singhara), *Heteropneustes heteropneustes* (singhi), etc.
- **Marine fishery** deals with the fishery aspects of the sea water or ocean. Some of the important marine fishes are – *Hilsa* (hilsa), *Aluitheronema* (sahnon), *Sardinella* (sardine), *Harpodon* (bombay duck), *Stromateus* (pomphret), *Anguilla* (eel) and *Mackerel*, etc.
- **Induced breeding** is a technique whereby fish are stimulated by pituitary hormones injection to breed in captivity. The gonadotropic hormones (FSH and LH) secreted by pituitary gland influence the maturation of gonads and spawning in fishes.
- In India, **Khan (1938)** successfully induced *Cirrhina mrigala* to spawn by injecting mammalian pituitary hormone.
- By products of fishing industry are fish oil, fish meal, shagreen, fish glue, isinglass, squalene and fish fertilizer.
- **Blue revolution** is concerned with fish production in India.

## SERICULTURE

- Sericulture is the breeding and management of **silk worms** (*Bombyx mori*) for the production of silk at commercial level.
- The eggs of the silkworm moth hatch out within a few days into creamy white rapidly moving **caterpillars**. The

latter feed voraciously on the fresh mulberry leaves and soon undergo a fast growth and are popularly referred to as **silkworms**. The silk glands of caterpillar secrete a sticky secretion which is spun around the worms to form a hard covering of silk fibres, known as the **cocoon**. The silkworm with cocoon is known as **pupa** or **chrysalis**. After one or two days of cocoon formation, the pupae are killed either by drying them in the sun or by boiling them. The raw silk fibres forming the cocoon are then reeled out into silk threads.

- **India ranks third in the production** of silk. Common silk is mulberry silk. **Karnataka ranks first in production of raw silk**. It has shining white yellow colour. Mulberry silk is obtained from *Bombyx mori* which feeds on leaves of **mulberry** (*Morus alba*). Mulberry specially grown for silkworm is called **moriculture**. Other silks are –
  - **Muga silk** from *Antheraea assamensis* feeding on cinnamon and other forest trees.
  - **Eri or arundi silk** from *Attacus* or *Philosamia rechinii* feeding on castor (*Ricinus communis*). The silk is creamy white.
  - **Tassar silk** from *Antheraea mylitta* or *A. paphia* feeding on oak and other forest trees. The silk is coppery colour.
- Common diseases of silkworm are **pebrine** by protozoan *Nosema bombycis*, **muscardine** by fungus *Spicaria* and *Botrytis* and flacherie by virus.

## APICULTURE

- Apiculture or **bee keeping** is care and management of honey bees. Honey bees give us **honey** and **wax**. They are also **good pollinators**.
- Honey bees, these days are raised in **apiaries**. **Apiary** is the place where bees are cultured and bred to get commercial products.
- Common species of honey bees are – *Apis dorsata* (rock bee), *Apis indica* (Indian bee), *Apis florea* (little bee) and *Apis mellifera* (European bee).
- All of them occur in nature as wild insects. However, because of their high economic importance, the honey-bees, especially, *A. mellifera* are domesticated and cultured, *viz.*, reared and bred in **artificial hives**.
- Honey bees are **social insects** living in colonies and exhibiting polymorphism and division of labour.
- Three types of individuals (castes) are found in the colony of honey bees – **queen**, **drones** and **workers**.
- Queen is the **only fertile female** which lays eggs.
- Drones are **fertile males** which mate with queen. Their number in the colony is not much. The **sting** and **wax glands** are absent.
- Workers are **sterile females** and perform various duties of the colony. The worker bees are darker and smallest members of the colony. They have chewing and lapping type of mouth parts, modified for collecting nectar and pollen of the flowers. The abdomen contains the wax glands and the sting.

- **Wax glands**, the glandular area secreting wax lies on the ventral surface of the last 4 visible segments of abdomen. Wax is secreted through minute pores in the form of flat scales. It is masticated by the mandibles before its use for building the "cells" of honeycomb.
- **Sting** is the modified ovipositor of the bees and is used for injecting poison for protection.
- **Royal jelly** is secreted by the maxillary glands of the worker bees to feed young larvae which are destined to develop into future queen.
- **Beehives** or nest of honey bees are formed of a secretion from the wax glands of workers. It consists of two layers of hexagonal chambers of cells. Some chambers are packed with honey and pollen. They are called the **storage cells** and are closed with a lid of wax. In other chambers, young ones are brought up. These are known as the **brood cells**. The latter are of different sizes to accommodate different castes.
- Bee enemies include the wax moths (e.g., *Galleria mellonella*), wasp (e.g., *Vespa*), black ants (e.g., *Componotus compressus*) and bee eaters (e.g., *Merops orientalis* and king crow, *Dicrurus macrocerus*).
- Two common diseases are (i) **Nosema disease** by protozoan *Nosema apis*; and (ii) **Acarine disease** by parasitic mite *Acarapis woodi*.

### Economic importance

#### Honey

- (i) It is a nearly neutral aromatic sweet syrup having 17-25% water, 70 - 80% sugars, 3.3% minerals and vitamins (B<sub>1</sub>, B<sub>6</sub>, C and D).
- (ii) Honey is a natural sweetener.
- (iii) It is used in the indigenous systems of medicine.
- (iv) It is laxative, expectorant and blood purifier.
- (v) Honey is a tonic and immediate source of energy. It is good for children and convalescing persons.
- (vi) It is used in preparation of honey biscuits and honey bread.

#### Bee wax

- Bee wax is used in cosmetics, creams, ointments, paints and polishes.

### PLANT BREEDING

- **Plant breeding** is the genetic improvement of the crop in order to create desired varieties of plant types that are better suited for cultivation, give better yields and are disease resistant.
- Plant breeding is an applied branch of botany. Most of our major food crops are derived from the domesticated varieties. But now due to advancements in genetics, molecular biology and tissue culture, plant breeding is being carried out by using molecular genetic tools.

#### Main steps in plant breeding

- The main steps in breeding a new genetic variety of a crop are :

- **Collection of variability** : Collection and preservation of all the different wild varieties, species and relatives of the cultivated species is a pre-requisite for effective exploitation of natural genes available in the population. A good germplasm collection is essential for a successful breeding programme.
- **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.
- **Cross hybridisation among the selected parents**: The desired characters have very often to be combined from two different plants (parents), for example high protein quality of one parent may need to be combined with disease resistance from another parent. This is possible by cross hybridising the two parents to produce hybrids that genetically combine the desired characters in one plant.
- **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. This step yields plants that are superior to both of the parents.
- **Testing, release and commercialisation 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 fertilizer 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. The material is evaluated in comparison to the best available local crop cultivar – a check or reference cultivar. The development of several high yielding varieties of wheat and rice in the mid-1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the **Green Revolution**.

#### Plant breeding for disease resistance

- A wide range of fungal, bacterial and viral pathogens, affect the yield of cultivated crop species, especially in tropical climates. In this situation, breeding and development of cultivars resistant to disease enhances food production.

#### Methods of breeding for disease resistance

- Breeding is carried out by the **conventional breeding** techniques (described earlier) or by **mutation breeding**. The conventional method of breeding for disease resistance is that of hybridisation and selection.
- The various sequential steps are : screening germplasm for resistance sources, hybridisation of selected parents, selection and evaluation of the hybrids and testing and release of new varieties.

- Some crop varieties bred by hybridisation and selection, for disease resistance to fungi, bacteria and viral diseases are given in the table below.

Crop	Variety	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 black rot
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. Other breeding methods that are used are selection amongst somaclonal variants and genetic engineering.
- It is possible to induce mutations artificially through use of chemicals or radiations (like gamma radiations), and selecting and using the plants that have the desirable character as a source in breeding—this process is called **mutation breeding**. In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations.
- Sharbati sonora** and **Pusa lerma** are the two important varieties of wheat produced by gamma rays treatment of **Sonora - 64** and **Lerma - roja - 64** (Mexican dwarf wheat varieties).

#### Breeding for resistance to insect pests

- Insects and pest infection are two major causes for large destruction of crop. Low nitrogen, sugar and high aspartic acid in maize develops resistance to maize stem borers.
- Breeding methods for insect pest resistance involve the same steps as those for any other agronomic trait such as yield or quality. Some released crop varieties bred by hybridisation and selection, for insect pest resistance are Pusa Gaurav, Pusa Sem 2, Pusa Sem 3, Pusa Sawani, Pusa A-4.

#### Breeding for improved food quality (Biofortification)

- It is estimated that more than 840 million people in the world do not have adequate food to meet their daily requirements. Three billion people suffer from protein, vitamins and micronutrient deficiencies. This increases the risk for disease, reduces mental abilities and life span.
- Breeding of crops with high levels of vitamins and minerals or higher protein and healthier fats is called **biofortification** and is the most practical aspect to improve the health of the people.
- Plant breeding is undertaken for improved nutritional quality of the plants with the objectives of improvement in : protein content and quality, oil content and quality, vitamin content and micronutrient and mineral content.
- Maize hybrids that had twice the amount of the amino acids-**lysine** and **tryptophan** and wheat variety with high protein content **Atlas 66** were developed.

- Indian Agricultural Research Institute (IARI), New Delhi**, has also developed many vegetable crops that are rich in minerals and vitamins.

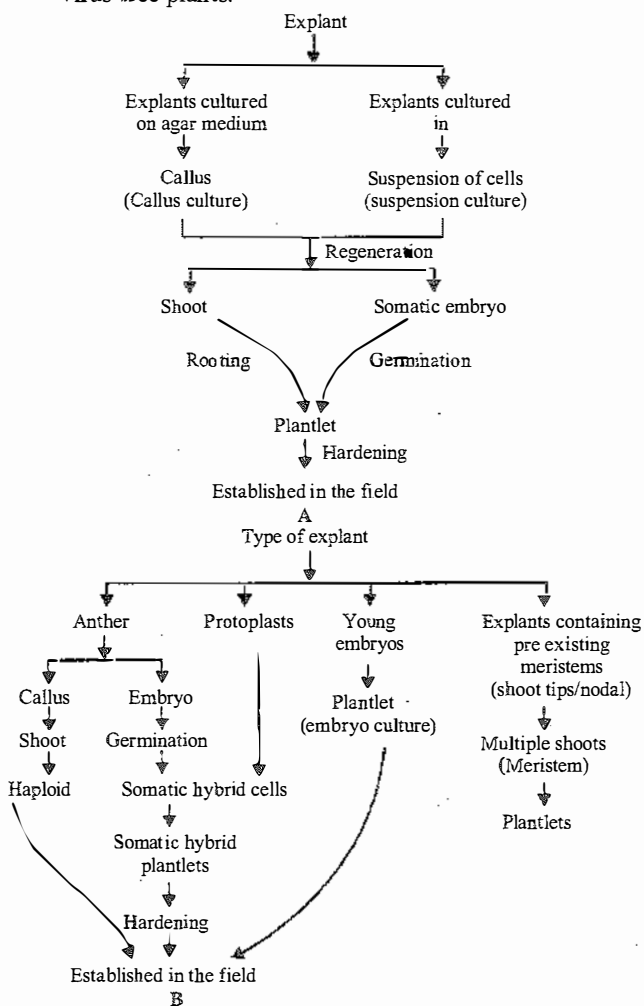
#### Single cell protein (SCP)

- Conventional agricultural production of cereals, pulses, vegetables, fruits, etc., may not be able to meet the demand of food at the rate at which human and animal population is increasing.
- One of the alternate sources of proteins for animal and human nutrition is **single cell protein (SCP)**. It is dried cell of microorganisms or microbes (algae, bacteria, actinomycetes and fungi) used as food or feed.
- Microbes like *Spirulina* can be grown on waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage, to produce food rich in proteins, minerals, fat, carbohydrates and vitamins.
- SCP is rich in high quality protein and is poor in fats. It has been estimated that a 250 kg cow produces 200 g of protein per day. In the same period 250 g of a microorganism like *Methylophilus methylotrophus* because of its high content of biomass production and growth, can produce about 25 tonnes of protein.

#### Tissue culture

- Plant tissue culture is the technique of *in vitro* maintaining and growing plant cells, tissues or organs aseptically on artificial medium in suitable containers under controlled environmental conditions. The part which is cultured is called **explant**.
- Embryoids** are nonzygotic or somatic embryo-like structures which are produced by *in vitro* culture and have the ability to form full fledged plants.
- Cellular totipotency is the ability of a **somatic cell/explant** to produce the complete organism. The explants are treated with specific anti-microbial chemicals to make them free from microbes.
- Culture media containing **inorganic salts**, certain **vitamins**, **sucrose** (as a source of carbon and energy) and the desired **growth regulators** is provided that is required for the desired growth and development of the explants.
- By application of these methods it is possible to achieve propagation of a large number of plants in very short durations. This method of producing thousands of plants through tissue culture is called **micropropagation**.
- Each of these plants will be genetically identical to the original plant from which they were grown, *i.e.*, they are **somaclones**. Many important food plants like tomato, banana, apple, etc., have been produced on commercial scale using this method.
- Depending upon the type of explant, tissue culture is called **shoot tip culture**, **multiple shoot culture**, **anther/haploid culture**, **embryo culture**, **embryoid culture**, etc.
- On the basis of *in vitro* growth, plant tissue cultures are of two types, callus and suspension cultures.
- In **callus culture**, cell division in explant forms a callus. Callus is irregular unorganised and undifferentiated mass of actively dividing cells.

- A **suspension culture** consists of single cells and small groups of cells suspended in a liquid medium containing the auxin 2,4-D. Suspension cultures grow much faster than callus culture.
- **Embryo culture** is the technique of taking out young embryos from developing seeds and their growth on culture medium to form seedlings and then young plants.
- When anthers of some plants are cultured on a suitable medium to produce haploid plants, it is called **anther culture**.
- Another important application is the recovery of healthy plants from diseased plants. Although the plant is infected with a virus, the **meristem** (apical and axillary) is free of virus. Hence, meristem can be grown *in vitro* to obtain virus-free plants.



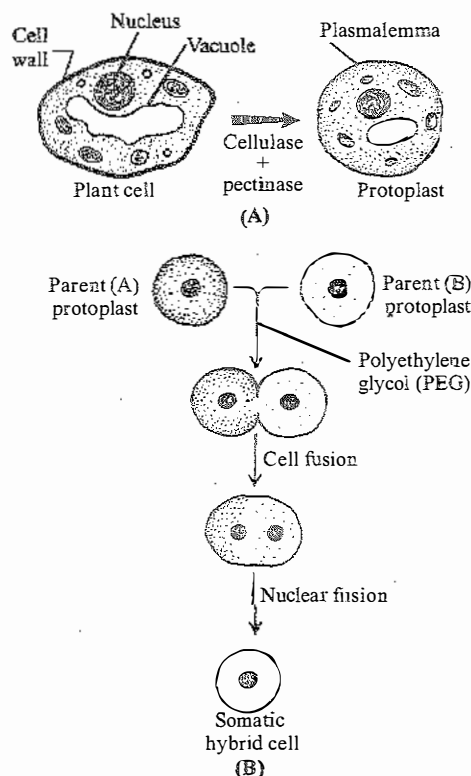
**Flow chart :** Showing the various types of plant tissue culture and recovery of complete plants from them. A. Callus and suspension culture, B. Anther, protoplast, embryo and shoot type.

**Protoplast culture and somatic hybridisation**

- When a hybrid is produced by fusion of somatic cells of two varieties or species, it is known as **somatic hybrid**. The process of producing somatic hybrids is called **somatic hybridisation**.
- First, the cell wall of the plant cells are removed then the protoplasts of the two plants are brought in contact and made to fuse by means of electrofusion or chemicals like

**polyethylene glycol (PEG)** and sodium nitrate. The fused protoplasts soon develop their own walls and then they are called **somatic hybrid cells**.

- Successful somatic hybrids have also been obtained from different species of *Brassica*, *Petunia*, and *Solanum*. **Pomato** is somatic hybrid between potato and tomato that belong to two different genera.
- **Protoplast technology** has opened up avenues for development of hybrids of even asexually reproducing plants. Somatic hybrids may be used for the production of useful **allopolyploids**.
- Genetic manipulations can be carried out more rapidly when plant cells are in protoplast state. New genes can be introduced (e.g., male sterility, herbicide resistance). Mutations will be easier.



**Fig. Somatic hybridisation.** A, production of protoplast using a combination of pectinase and cellulase. B, protoplasts fusion induced by PEG ultimately yields somatic hybrid cells.

**Applications of plant tissue culture**

- The various applications of plant tissue culture are:
  - The use of plant cells to generate useful products.
  - The useful product is a plantlet. The plantlets are used for various purposes.
  - Plantlets are used for rapid clonal propagation.
  - Transgenes can be introduced into individual plant cells. The plantlets can be regenerated from these cells. These plantlets give rise to the highly valuable transgenic plants.
  - For induction of mutations.
  - For raising stress resistant plants.

**CONCEPT MAP**

**Strategies for Enhancement in Food Production**

Animal Husbandry & Plant Breeding are two major aspects of increasing food production.

**Animal Husbandry**

- It is the science of rearing, feeding, caring, breeding & utilization of domesticated animals.
- The ever increasing demand of food from animals and animal products both in terms of quantity and quality has been met by good animal husbandry practices.
- These practices include (i) management of farm and farm animals, and (ii) animal breeding.
- In view of the high nutritive value of honey and its medicinal importance, there has been a remarkable growth in the practice of bee-keeping or apiculture.
- Fishery is another flourishing industry meeting the ever increasing demand for fish, fish products and other aquatic foods.

**Plant Breeding**

- It is used to create varieties, which are resistant to pathogens and to insect pests. This increases the yield of food.

**Steps of breeding**

- These are:
- Collection of variability
  - Evaluation and selection of parents
  - Cross hybridisation among the selected parents
  - Selection and testing of superior recombinants
  - Testing, release and commercialisation of new cultivars

**Purpose of breeding**

- **For disease resistance**
  - Breeding and development of cultivars resistant to disease enhances food production.
  - Methods include conventional breeding techniques or by mutation breeding.
  - Himgiri, Pusa Swamim, Pusa snowball, Pusa Komal, etc. are some crop varieties bred for disease resistance.
- **For developing resistance to insect pests**
  - Methods involve same steps as those for any other agronomic trait.
  - Pusa Gaurav, Pusa Sem 2, Pusa Sawani, Pusa A-4, etc are some released crop varieties for insect pest resistance.
- **For improved food quality**
  - It is done to improve protein content and quality, oil content and quality, vitamin content, micronutrient and mineral content.
  - Vitamin A enriched carrots, spinach; vitamin C enriched bitter gourd, bathua, mustard; iron & calcium enriched spinach and bathua; and protein enriched beans (Lablab, French & garden peas), are some of its examples.

**Animal breeding**

**Natural breeding**

**Artificial breeding**

**Management of farm animals**

- It includes management of cattle, buffaloes, sheep, goat and poultry.

**Inbreeding**

- It is mating of more closely related individuals within the same breed for 4-6 generations.

**Outbreeding**

- It is breeding of the unrelated animals.

Types

**Outcrossing**

- Mating between unrelated members of the same breed.

**Cross breeding**

- Mating of superior males of one breed with superior females of another breed.

**Interspecific hybridisation**

- Mating between members of two different species.

**Tissue culture**

- It is fast and efficient system for crop improvement.
- It is the technique of *in vitro* maintaining and growing plant cells, tissues or organs aseptically on artificial medium in suitable containers under controlled environmental conditions.
- It is two types: callus and suspension cultures.

**Single cell protein (SCP)**

- It is one of the alternate sources of proteins for animal and human nutrition. It is dried cell of microorganisms or microbes (algae, bacteria, actinomycetes and fungi) used as food or feed.
- SCP is rich in high quality protein and is poor in fats.