STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION(PLANT BREEDING)

- 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**.

  Norman Borlaug: Father of Green Revolution.

  M.S. Swaminathan: Father of Green Revolution in India.
- Green revolution was dependent to a large extent on plant breeding techniques for development of high-yielding and disease resistant varieties in wheat, rice, maize, etc.
- "**Plant breeding** is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant".

  Conventional plant breeding has been practiced for thousands of years, since the beginning of human civilisation; recorded evidence of plant breeding dates back to 9,000-11,000 years ago.
- Classical plant breeding involves crossing or hybridisation of pure lines, followed by artificial selection to produce plants with desirable traits the traits or characters that the breeders have tried to incorporate into crop plants are

  (i) increased crop yield and improved quality

  (ii) Increased tolerance to environmental stresses (salinity, extreme temperatures, drought)

  (iii) resistance to pathogens (viruses, fungi and bacteria)

  (iv) increased tolerance to insect pests.
- **The main steps in breeding a new genetic variety of a crop by hybridization are –**

1. **Collection of Variability:**

   Collection and preservation of different wild varieties, species and relatives of the cultivated species. The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called germplasm collection.

   (**Germplasm:** is a living tissue from which new plant can be grown. It can be seed or any other plant part such as piece of leaf, stem or pollen or just few cells)
2. **Evaluation and Selection of Parents:**

   Evaluation is done to identify plants with desirable characters.

   The selected plants are multiplied and used in the process of hybridization.
3. **Cross Hybridization among selected parents:**

   It may produce hybrids that genetically combine the desired characters in one plant.

   This is a very time-consuming and tedious process
4. **Selection and testing of superior recombinants:**

   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, so that the characters will not segregate in the progeny.
5. **Testing, release and commercialization of new cultivars:**

   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.

   In India Indian Council of Agricultural Research, New Delhi [ICAR] carries out the evalutions.

- **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.
- In wheat : **Sharbati sonora** and **pusa lerma** are two important varieties of wheat produced by gamma rays treatment of ***sonora-64*** and ***lerma rojo*** (Mexican dwarf wheat varieties).

APPLICATION OF PLANT BREEDING

(I) Plant breeding for improvement of yield:-

(a) Improvement in 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.

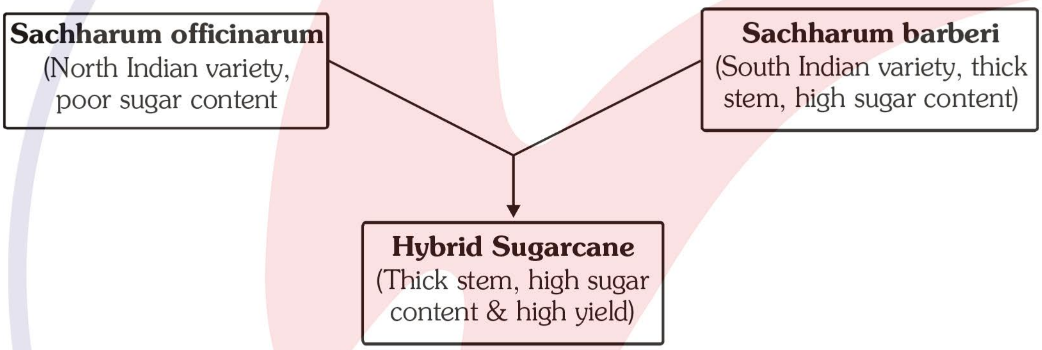
  During the period 1960 to 2000, wheat production increased from 11 million tonnes to 75 million tonnes

(b) Improvement in rice :-

- During the period 1960 to 2000 rice production increased from 35 million tonnes to 89.5 million tonnes.

  IRRI (International Rice Research Institute) Manila (Philipines) and incorporated to produce high yielding early maturing IR-8 and IR-24 varieties.
- IR-36 is the high yielding variety of rice and has solved major food problem in Asia.
- Later better-yielding semidwarf varieties **Jaya** and **Ratna** were developed in India.

(c) Improvement in sugar cane :-



(ii) Plant breeding for disease resistance :-

<u>A wide range of fungal, bacterial and viral pathogens, affect the yield of cultivated crop species, especially in tropical climates. Crop losses can often be significant, up to 20-30 per cent, or sometimes even total. In this situation, breeding and development of cultivars resistant to disease enhances food production.</u>

DISEASE RESISTANT VARIETIES OF CROPS

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-l	Black rot and Curl blight black rot
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

<u>Resistance to yellow mosaic virus in bhindi (**Abelmoschus esculentus**) was transferred from a wild species and resulted in a new variety of A. **esculentus** called **Parbhani kranti**.</u>

(iii) Plant Breeding for developing resistance to insect pests :-

Insect resistance in host 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.

PLANT BREEDING FOR DEVELOPING INSECT & PEST RESISTANCE

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

(iv) Plant breeding for improved food quality :-

Hidden Hunger: Nutritional deficiency caused by the lack of essential micronutrients particularly Iron, vitamin A, Iodine and Zinc and increase risk for disease, reduce lifespan and reduced mental abilities.

Biofortification: breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats.

Example:

Atlas 66: Wheat variety having high protein content

Vitamin A enriched Carrots, Spinach and Pumpkin

Vitamin C enriched Bitter gourd, bathua, mustard, tomato

Iron and Calcium enriched Spinach and Bathua

Protein enriched beans - Broad, lablab, French and Garden peas

SINGLE CELL PROTEIN

Single cell proteins can be produced from algae, fungi, yeast and bacteria.

SCP is rich in high quality protein and is low in fat content, hence it is a desirable human food.

Some low-cost substrates such as waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage can be used to produce large quantities of SCP.

SCP should also reduce the pressure on agricultural production systems for the supply of proteins and it can **also reduce environmental pollution**.

Some common microbes as SCP producers are:

Cyanobacteria: **Spirulina**

Bacteria: **Methylophilus methylotrophus**

PLANT TISSUE CULTURE

Plant Tissue Culture: refers to the maintenance and growth of the plant cells, tissues and organs on a suitable synthetic medium in vitro and the whole plant could be regenerated from explants.

Totipotency: The capacity to generate whole plant from a cell / explant.

Explant: Any part of plant taken out and grown in a test tube, under sterile conditions in a special nutrient media for initiating a culture.

Culture medium: Nutritive medium in which cells/tissues are grown. It contains sucrose, inorganic salts, amino acids, vitamins and growth regulators like auxins, cytokinin etc.

Eample: Murashigue-Skoog's (MS) media (commonly used culture medium)

Callus: undifferentiated mass of cells.

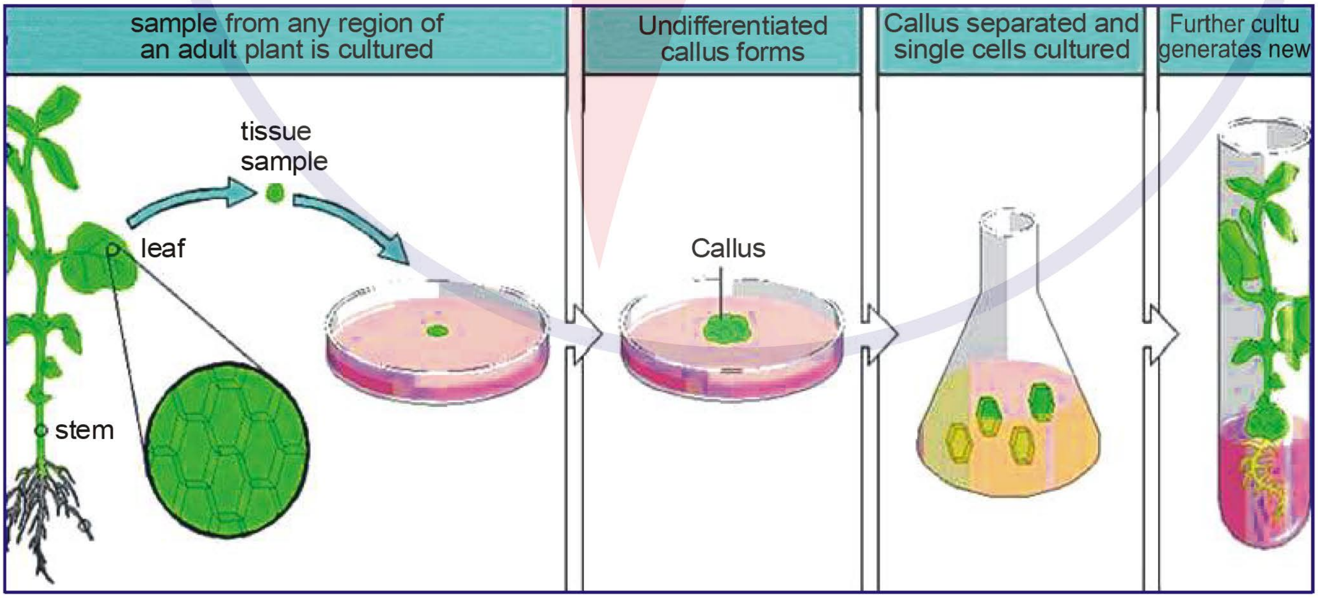
Cytokinin: for shoot formation ; **Auxin:** for root formation

Micropropagation: The method of producing thousands of plants through tissue culture

Somaclones: Each of the plants produced from the tissue culture will be genetically identical to the original plant from which they are grown.

Somaclonal variation :-

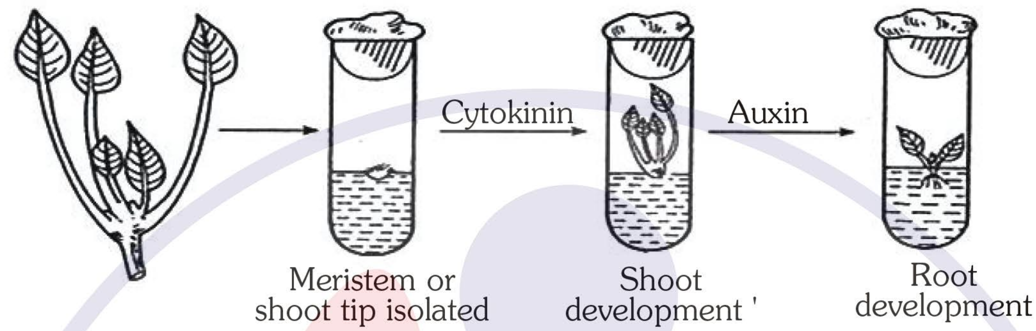
Genetic variation presents among plants regenerated from tissue culture have been termed as somaclonal variation. These variations originated by minor chromosomal aberration, by gene mutation.



Applications of Plant Tissue Culture

1. Recovery of Healthy plants from diseased plants:

By Meristem (apical and axillary) culture: Virus free plants can be Produced



2. **Sometic hybridisation :** by protoplast fusion

Protoplast : Plant cell whose cell wall has been removed

Scientists have even isolated single cells from plants and after digesting their cell walls have been able to isolate naked protoplasts (surrounded by plasma membranes). Isolated protoplasts from two different varieties of plants – each having a desirable character – can be fused to get hybrid protoplasts, which can be further grown to form a new plant. These hybrids are called somatic hybrids while the process is called somatic hybridisation.

When a protoplast of tomato is fused with that of potato, and then they are grown – to form new hybrid plants combining tomato and potato characteristics. Well, this has been achieved – resulting in formation of **pomato**.

* Fusogenic substances for protoplast fusion = $NaNO_3$, polyethylene glycol, Ca^{+2}.